Nechmad ve-Na'im

נחמד ונעים

(c. 1613)

by David Gans (דוד בן שלמה גנז), 1541–1613
Translation by Scott Weisman

Ars Astronomica
2026

"Nechmad ve-Na'im (נחמד ונעים)," published in c. 1613, is in the public domain. All translations, original additions, including illustrations, commentaries, and summaries, are copyright.

The source text was obtained from National Library of Israel.

Translation © 2026 Scott Weisman. All rights reserved.

Licensed under CC BY-NC-ND 4.0. Share with attribution; non-commercial; no derivatives.

Published by Ars Astronomica

Translator Version 2

Upright reason dictates that the recipients of the good, of whatever type and level of beneficence it may be, must show gratitude and blessing to the beneficent person in every way possible, commensurate with the value of the beneficence. And one who has benefited all the people of the world — for example, one who invented a new instrument for the good of the world, or a good book — it is fitting for every discerning person, out of the obligation of love of fellow beings, to at least purchase it, so that the man will profit and his heart will be encouraged thereby to invent yet more good instruments in the world. And similarly, all other wise-hearted people will likewise strive and exert themselves to invent good things and instruments needed for the repair of the world and its perfection.

And therefore, whoever says: "What do I need this new instrument for?" — he does not act well towards the world. For if not for the man who invented it, where would you be? And what would your city do? And more than this, if the man did not exert himself, what would the world do?

— R. Pinchas Eliyahu Hurwitz, Sefer HaBris HaShalem (1797)

If you find this translation useful, consider supporting Ars Astronomica.

ArsAstronomica@protonmail.com

A note on the work

A Hebrew textbook of astronomy that presents the Ptolemaic model of the heavens for a Hebrew-reading audience, weaving the cutting-edge European science of its day together with the medieval Jewish cosmological tradition — its author having personally visited the Danish astronomer Tycho Brahe. Organized into twelve sections and 305 numbered paragraphs, and closing with a Latin preface by the Leipzig Hebraist Johann Christian Hebenstreit. First and only printed at Jessnitz in 1743, more than a century after it was written, it stands as a remarkable monument to Jewish engagement with the science of the age.

A note on the translation process

This translation was produced with the translation-pipeline. See the linked repository for details on the process.

This edition has been checked at citation grade. A stratified sample of it was independently re-transcribed from the original page by readers given no sight of the translation, and the two readings were then reconciled letter by letter. Every disagreement in the layer a citing reader depends on — figures, names, headings, and whether a passage is present at all — was settled against the page before publication, and none was left open.

What that does and does not mean. It is a claim about a sample, not about every line. A passage the sample did not reach is neither confirmed nor denied, and silence in an independent reading is not agreement. Where the page itself will not settle a reading, this edition withdraws rather than guesses: a bracketed pair marks a genuine ambiguity the original cannot decide, and a question mark a character that could not be read. Those marks are deliberate refusals, and they are worth more than the confident readings they replace.

A note on the references. A scriptural or bibliographic reference given in brackets or parentheses is, in most cases, an editorial identification of an allusion rather than a citation printed in the source. Books of this kind quote and weave scripture constantly without naming it, and the identification is supplied here as a convenience to the reader. Where the source does print a reference of its own, it is given as printed. An identified allusion is not evidence that the author cited that passage — look at the original before resting an argument on one.

This text is the product of a highly refined automated translation process. It has undergone only cursory human review and should not be treated as an authoritative or scholarly rendering. It is offered solely as a reference and reading aid — a way to make an otherwise inaccessible work approachable — and any passage of real consequence should be checked against the original source.

Acknowledgements

Translated with the assistance of Claude. The translator thanks the Anthropic team for making this work possible.

[Front matter leaf — modern National Library of Israel scanning notice, not part of the 1743 edition. Printed in modern Hebrew type beside the NLI logo: "הספרייה הלאומית" / "THE NATIONAL LIBRARY OF ISRAEL" (with Arabic "المكتبة الوطنية الإسرائيلية"), and below: "ספר זה נסרק על ידי הספרייה הלאומית" — "This book was scanned by the National Library."]

[Flyleaf — blank leaf bearing modern library markings only, no printed text of the work. Handwritten pencil shelf-marks: "R8° 35 V 1770 / copy 2"; "S.R."; "ע 52"; a crossed-out Hebrew note (largely illegible); and a faint rectangular library ownership stamp in Hebrew (National Library, Jerusalem [?]).]

ספר נחמד ונעים — Sefer Nechmad ve-Na'im

Sefer

Nechmad ve-Na'im ["Pleasant and Delightful"]

From the Perfect in Knowledge [mitmim de'im — a play on Iyov 37:16] — a fair and beautiful composition, in a clear and easy tongue, upon the whole of the science of astronomy, the sanctification of the New Moon, and the measuring of the stars, together with the shapes of their observational instruments; and the knowledge of all the climes [aklimim], to understand the map of the world called Landkarte [German: "map"]; and other wondrous matters that are heard and seen from within it.

Which was composed and established by the perfect sage in the lofty degrees of geometry, and in the science of measurement, of astronomy, and of the measuring of the stars and figures — the divine philosopher — namely, the Rabbi, the [ha-ma...h"n — title abbreviation garbled, ?] Gaon R. David Gans [דוד גנז], author of Sefer Tzemach David, Sefer Ma'or ha-Katan, and Sefer ha-Prozdor, of blessed and saintly memory — [a work] which was found in manuscript, stored away and hidden since the year 373 of the sixth millennium [שע"ג = 5373 AM = 1613 CE], until this day unseen by any beholder's eye.

Brought to the press by the Rabbi, the Gaon, our teacher R. Yoel son of our teacher R. Yekutiel, of blessed memory, Av Beit Din of the holy community of Austerlitz [אוסטרליץ], a native of the holy community of Great Glogau [גלוגא רבתי / Glogau], to bring merit to the many — and the merit of the many depends upon him.

And also — remember him for good [zochreihu tov] — to the good: the exalted chief, the officer, the honored R. Ber Hess [בער העס] of the holy community of Halberstadt [הלברשטט], who was moved [?] with him to pour out his purse of money; from the drawing [?] of his hand, full as a ladder [?], for the expenses of the printing. May the LORD reward his deed and may his wage be complete [Rut 2:12]; may [it be] a completed [work, ?]; and may he merit an everlasting edifice.

Printed here in the holy community of Jessnitz [יעסניץ], at the press [bi-veit defus] of R. Israel son of Avraham, of blessed memory.

By the count [chronogram]: "Lift up your eyes on high and see who created these" [לפרט שאו מרום עיניכם וראו מי ברא אלה — Yeshayahu 40:26], the marked letters yielding the year of the imprint (5)503 = 1743.

התנצלות דברי הרב המביא לדפוס — The Apologia: Words of the Rabbi Who Brings [the Work] to Press[1]

> The Apologia is a rhymed melitzah, a cento of biblical phrasing. The leaf prints no scriptural reference of any kind: every bracketed book-and-verse below, through this section and its continuation on p. 5, is an editorial identification of an allusion, not a citation read off the page. They are useful but unwitnessed, and none may be cited as evidence of what Gans's editor referenced.

Come, behold the works of the LORD, who has made desolations in the earth [Tehillim 46:9] — that we may know the righteousness of the LORD; who has set His dominion in the earth [cf. Iyov 38:33, ?]; who stretches out the north over the void [Iyov 26:7] and upon the foundations of emptiness; and who brought it into being from nothing to something [ומאין ליש המציאהו] — and who teaches as He does? [Iyov 36:22] — the marches of the constellations [Mazzaroth; מצעדי המזרות] upon the observer's horizon: their courses and their deviations, their risings and their [settings, ?]. He is the One who created us — the Necessary Existent, the Cause of causes — without weariness and without fatigue.

To conclude the praises and thanksgivings [לסיים שבחות והדאות] — for the One awesome in praises [Shemos 15:11], my silence is fitting; with stammering lips [cf. Yeshayahu 28:11] I have laid my hand [upon my mouth]; yet fair is the discourse of a servant like me, acceptable to all my multitude — those whose little finger is thicker than my loins [I Melachim 12:10] — who have stirred me and brought me here to ascend among the heavenly bodies, to bring down for them the bread of the mighty [Tehillim 78:25], to declare the greatness of the Fashioner of Creation, who has done wondrously [הפליא לעשות] · with me from my youth [עמי מעודי] · since He established my frame [מאז קיים שלדי] · to fulfill my desire and to satisfy my thirst — parched and thirsty [cf. Yeshayahu 5:13].

This while, day by day [?]: "I, Wisdom, dwell with prudence" [Mishlei 8:12] — and from me she is bared — to know the dwelling of light [Iyov 38:19] [among] the stars in their courses; the conjunction of sun and moon in their points [חבור חרס וסהר בנקודותם], and the generations of the light in their distances; to know how to fly [?] — as befits us — the words of Moshe our

[1] the bracketed scriptural references in the Apologia.

teacher, who built and who stretched out, and inclined lovingkindness over us; in the laws [bi-dinei, ?] of the sanctification of the New Moon, full and heaped up — matters which the earlier ones did not [fully] fathom, [things] new and also old [cf. Shir ha-Shirim 7:14]. And I turned to every side to understand, in the books of instruction, saying: Where is the seer? — "and there is none among us who knows how long" [Tehillim 74:9].

And from the time the LORD made the settled lands quake, and states were confounded by armies [geyasot], kings contending one with another — we made ourselves an exile's baggage [Yechezkel 12:3-4], driven away, wholly consumed — from my dwelling-place, to the land of my birth, to seek out for me a place of rest [cf. Bamidbar 10:33], and to the city of Breslau [ולעיר ברעסל באתי] I came, I and my household [אני וביתי] — like a bird wandering from its nest [Mishlei 27:8] I strayed, and I lodged in the clefts of the rock [cf. Yeshayahu 2:21], until the LORD should look down and see [Eichah 3:50] those clothed in scarlet [עלי תולע]. And the LORD brought about before me [those] "who dwell at Shevet, the Tachkemonite" [II Shmuel 23:8] — they taught me and made me wise, and their wisdom [charh..., ?] raised me up: the way of a ladder set upon the earth, its top [reaching] to the windows of heaven [Bereishis 28:12], and my words mimsarkei [ממסרקי — the glyphs are certain (ס, not פ), but the sense is unresolved] "matters just as they are written" [Aramaic: divrei ki-khtavan, "words as inscribed"], which came into my hand as one who hears the sense of those who expound.

The book Nechmad ve-Na'im, which the great investigator composed upon the science of astronomy, with all the figures pertaining to this science, and the clarification of all the sayings of the sages — whether of the sages of Israel or of the words of the sages of the nations of the world who have made innovations in these matters — all of it explained, and he has refined [it] finely, in a clear tongue, brilliant and lucid, and so forth. Whoever wishes to approach the inner court will find a response, and rest, from the God of old, the dwelling-place [Devarim 33:27] — namely, the Rabbi, the author, the master of Tzemach David — like a necklace of ornaments, like bracelets upon [his] hands. For these hundred and thirty years his words lay concealed, no eye beholding them, in the capital city of Prague [פראג], since the day his light was hidden away.

And I gave a ruling for the past — and it is a time to speak [cf. Koheles 3:7] — in honor of the author: that I have merited to copy out his words, in his chapters and his orders, and to raise them upon the altar of the press, to magnify Torah and make it glorious [Yeshayahu 42:21]; so that the reader may run through it [Chavakuk 2:2], in the clarity of its tongue, sweeter than honey to his palate and his throat [cf. Shir ha-Shirim 5:16], in the science of astronomy — and to show a welcoming face to students, the seekers of precious things.

For not so is the way of the ancient inquirers and researchers — the way of the ancient inquirers, [who] hung upon them weapons and shields [cf. Shir ha-Shirim 4:4], the way of riddles and conjectures. And in the lowliness of our generation, in the smallness of our heart and the shortness of our understanding,

we have gone very low, we have reached the dust [?] — and it is far from me; we have not [attained, lo ka-eshnu, ?] as far as the center; and at the opening of the innovation [ha-mechudash, ?] the gates of knowledge and reason [hozeh] were shut, from hasty reasoning [Aramaic: me-ama peziza, "of a hasty people/taste," ?], and their [obscurities, ?] were twisted and perverse. But now the windows of heaven have been opened [Bereishis 7:11]: flat surfaces and concavities [ha-sh'tichiyot ve-ke'aruriyot] have been [stretched out, ?], guarded in every part and set in order [II Shmuel 23:5], showing the way to the perplexed [an allusion to the Guide for the Perplexed / Moreh Nevuchim], with just and right words [Mishlei 8:9], clear and restful. And whoever wishes to take up the Name...

The Apologia (continued) — Hitnatzelut

May the Name ready [me] in haste to draw near to the work, and from the LORD may he bear a blessing [Tehillim 24:5]; "Who created these?" [Yeshayahu 40:26] — upon a paved road, perfect in beauty. And all of them shall know the LORD, from the least of them to the greatest [Yirmiyahu 31:34], as the waters cover the sea [Yeshayahu 11:9]. He will find the near road, and in a short while perceive how sweet it is.

And these are the last words of David [2 Shmuel 23:1] — more desirable than gold and darics [אדרכמונים], and, above all precious treasures, stored away [cf. Tehillim 19:11]; sweeter than the flowing honeycomb [cf. Tehillim 19:11], pleasant plantings [Yeshayahu 17:10], and strong as the oaks [cf. Amos 2:9]; mighty in the commandments and turned toward every side. From it there issues the learning fit for childhood [Aramaic: גרסא דינקותא, girsa de-yankuta]; "the small and the great are there" [Iyov 3:19] — to establish the words of the Maimonidean [the laws of Kiddush ha-Chodesh of the Rambam] with but a little study, so that "he who tends a fig tree shall eat its fruit" [Mishlei 27:18].[2]

And to the holy city we shall go up in song, to sanctify the new moon in its [proper] time [כזמנה [?]]; and by the mean and true motion [מהלך אמצעי ואמיתי], "He withdraws not His eye from the righteous" [Iyov 36:7]. "The righteous walk in them" [Hoshea 14:10], and each man turns to his own way [Yeshayahu 53:6] — a road [made strong] and southward, and they shall spread abroad, the way eastward [קדים] and northward [cf. Bereishis 28:14].

The author's plea and a talmudic-astronomical excursus

[The rhymed apologia now passes into a first-person humility passage and then into a dense scholarly excursus. The type is small and faded, but the argument stands legibly on the leaf and is given below.]

[2] the leaf prints the article on the construct, הדברי, against the biblical form; recorded as set. The psalm allusion is a paraphrase, not a quotation — the comparison-terms, the interposed clause and the honeycomb's pairing all depart from the verse, whose key word does not occur.

And now I have made light [of my burden] [?], in the manner of my petition [?], in the height of my brokenness and lowliness. Lowly am I, as one who knows the baseness of my worth; I have not presumed [?], and I have strayed [?]; I have not fulfilled [?] the ways of my teachers, my parents, and my masters — [rather] to draw near, as one drawing near to the chambers of [?], in inner rooms and antechambers, in inner halls and reception-chambers [בחדרין ואכסדרין בהיכלין פנימאין וטרקלין ·], that my words might shine with strength, with the help of my God, my Rock — to settle the language of the Gemara in tractate Tamid.

[The excursus.] "Ten questions Alexander of Macedon asked the elders of the Negev. He said to them: Is it farther from heaven to earth, or from east to west?" and so forth [עשרת דברים שאל אלכסנדרוס מוקדן את זקני הנגב אמר להן מן השמים לארץ רחוק או ממזרח למערב כו'; מס' תמיד Tamid 31b–32a]]. What calls for scrutiny here is not the answers but the first premise, and what needs examining is: why did he put this particular question specifically to the elders of the Negev, and to no one else [למה שאל דוקא שאלה זו לזקני הנגב ולא לאחרינא]?

And according to the explanation of the Maharsha in Ein Yaakov, who brings [the passage] [ופי' מהרש"א בעין יעקב שהביא], what he asked them was whether it is farther from east to west or from the earth up to the firmament — that is, whether the arc of the east reaches its limit [only] at the extremity of the west, so that the distance would be double the distance from the earth up to the firmament. And he brings support for his words from the commentary of Mizrachi, of blessed memory [סעד לדבריו כפ' המזרחי ז"ל].

And it is set out in the first chapter of Pesachim, in the dispute of R. Meir and R. Yehudah, that a man errs [in judging the hour] by two hours [בפ"ק דפסחים בפלוגתא ר"מ ור"י אדם טועה ב' שעות]; the Gemara raises a difficulty there and resolves it — at the fifth hour the sun is in the east and at the seventh in the west [כחמש חמה במזרח ושבע במערב], while at the sixth it stands overhead. And Rashi objected to the wording, [asking] why it would not have been better to say [otherwise] … Since the matter concerns a spherical body, it is impossible to fix an exact point for the beginning of the east or the beginning of the west, because a round body curves and runs on continuously, and no point upon it can be marked out as its beginning.

And this accords with the sense of the verse "it goes toward the south and turns about toward the north" [הולך אל דרום וסובב אל צפון] [Koheles 1:6]; and with what is set out in Rosh Hashanah and in Eruvin [כמבואר בר"ה ובעירובין], that at the winter solstice the sun rises in the south-eastern corner and sets in the south-western corner [ובעירובין שהחמה בתקופת טבת זורחת במקצוע מזרחית דרומית ושוקעת במקצוע מערבית דרומית] — from which one may know the point of the sun's setting at the season of the winter solstice, as [the case] is likewise for the northern side, as we have written in [our treatment of] all the climes.

And from this it is settled why he put the question specifically to the elders of the Negev. And see the sixth gate, siman 137 [ועיין בשער הששי סי' קל"ז] on

this, in the matter of the differences between the dwellers of the south and the dwellers of the north; and there too it is not [fully] explained.

But the author's words, in the passage beginning "Said the writer" [**אמר הכותב** אך דברי המחבר במתחיל] — this passage stood written at the end of the book [**בסוף הספר כתיב** [?]דבר זה מלאת]. And these are his own words: "at the beginning of this my book" etc. [**כו' בתחילת ספרי זה** וז"ל] — and I saw that this was fitting to be placed first [**להקדים** וראיתי שזהו ראוי]. On that account I did so, and made this passage the introduction to his book Ha-Nechmad [לספרו הנחמד **הקדמה** גלל כן עשיתי ודבר זה], so that it should be what brings one to the gate and the opening by which to enter the hall [**וזה שיהא מביא השער ופתח לעייל בטרקלין**].

[No personal signature appears on this page; the apologia ends in an impersonal colophon:] Completed with great diligence and full examination, finished on the day adjoining [the turn] from sorrow to joy — the days of Purim, [5]503 by the abbreviated era [**תמם** ובשקידה מרובה ובחינה שלימה נשלם ביום **יומי דפורים תק"ג לפ"ק**, הנסמך מיגון לשמחה — Purim 5503 AM = 1743 CE].

[Superseded by the re-read above: the closing formula is ***יומי דפורים תק"ג לפ"ק***, and there is no personal signature on this page — if Yoel b. Yekutiel signs the apologia at all, it is on p.4 or in an acrostic.]

[Inserted: the author's own front matter, from the Magen David prospectus (Prague, 1612)][3]

[[7]]

The figure of the circles of the eighth rakia [firmament]. The plotting of the 32 winds of the world [ל״ב][4]. The figure of the three orbs of the sun. [

[[8]]

The approbation of] … [9a] There flew to me one of the men of renown [Isaiah 6:6; Genesis 6:4], an elder and a man of rank [Isaiah 9:14], the honored Maharar David Gans … [9b] a hidden love — in the science of astronomy, which the aforementioned elder composed to leave to his sons … [9c] that one, before the eyes of the nations. And so, as I went over it in the way of close study, in a number of places I found … [9d] and upright to those who find knowledge and discretion [Proverbs 8:9; 1:4]. And this one is added to the earlier ones, for I have heard from … [9e] that one — those who read the whole book — and they declare and testify that all of it is refined silver, purified seven[fold] [Psalms 12:7] … [9f] these, I have given him permission to bring to light the hidden things of wisdom [Job 11:6] and to bring it to the printing house … [9g] his springs abroad [Proverbs 5:16], to bring merit to the many; the merit

[3] What follows is not part of the 1743 Jessnitz printing. It is from the prospectus David Gans printed at Prague in 1612 to advertise this work — the only part he saw in print (he died in 1613; the book was not set until 1743, as Nechmad ve-Na'im). The prospectus survives in a single damaged copy (Bodleian Library, Opp. 4° 417 [4]); the Hebrew is Pavel Sládek's edition in Aleph 22.1–2 (2022). Restored here: the approbations — among them R. Yitzchak Katz, the Maharal's son-in-law, and an extended commendation by R. Yom Tov Lipmann Heller — and Gans's own preface: his dedication to his two sons, his account of why he wrote the book, and his three reasons for calling it Magen David. The double-bracketed numbers are the modern edition's section numbers, kept so passages can be cited; §§1–2 are lost with the damaged first leaf and the sequence resumes at §7. Nothing here is otherwise reordered or abridged.

[4] the 32 points of the compass — my identification

of the many depends on him [Avos 5:18]. Thus the words of Shlomo Ephra[im] … [9h] of blessed memory, the man of Luntschitz.[5]

[[10]]

The approbation of the great Rav, Maharar Yitzchak Katz — may his Rock guard him and grant him life [יצ״ו] — son-in-law of Maharar Liva, of blessed memory. [11a] I am a worm and not a man, a reproach of men and despised [Psalms 22:7] by the people of the Lord. Even so, these are the things I have done … [11b] Because of the many requests and entreaties he pressed upon me, I too was prevailed upon to give my feeble opinion and to grant [the approbation?] [11c] — the brief and feeble one — to the comprehensive sage, aged and full of years, this man who has acquired wisdom, much and abundant and mighty, Ma[harar David] [11d] Gans, may he live forever [ש״ן], to bring to the printing house this vigorous composition too, which he has made in the science of astronomy: a work which, [so far as the shortness of] [11e] my intellect and my meager understanding go, and the share I have in this science from the days of my prime [Job 29:4], when I busied myself with it back in my youth … [11f] I found sound, its statements acceptable to reason and welcome to the mind of any discerning man, honest and true before all who kn[ow the sciences] [11g] of this kind. And so from me too permission is given [Avos 3:15] to bring to light the hidden things of this book, to leave [the] … [11h] set in order and preserved [2 Samuel 23:5], longer than the earth in measure [Job 11:9], a just hin and a just ephah [Leviticus 19:36], in the records of the heavens and their constellations [?] [Isaiah 13:10] … [11i] to them. And by this, everyone who longs for it may come and behold its mystery [?] in it — this one corresponding to that, as God has made it [Ecclesiastes 7:14], one high above the hig[h] … [11j] and higher ones still [Ecclesiastes 5:7]. The words of the humble Yitzchak son of Shimshon Katz, of blessed memory, son-in-law of the great Gaon in Israel whose name was Maharar L[iva ben Betzalel].[6]

---

[5] the signature identifies this approbation as R. Shlomo Ephraim of Luntschitz, author of Kli Yakar and chief rabbi of Prague (d. 1619) — my identification, from the surviving name and place; the heading that would have named him is lost in the damage. As at §5, "of blessed memory" attaches to the father's name, which the gap has taken, not to the signatory, who was living. Isaiah 6:6 reads "then flew one of the seraphim to me," and the page puts the "men of renown" of Genesis 6:4 in the seraph's place. The section is woven from Scripture throughout; every reference is my identification and none is printed.

[6] Maharar Liva is R. Yehudah Loew ben Betzalel of Prague, the Maharal, who died in 1609 — hence "whose name was." The signatory is his son-in-law, R. Yitzchak son of Shimshon Katz (Isaac ben Samson ha-Kohen); the identifications are mine, the page giving only the name and the relationship. As at §5 and §8, "of blessed memory" attaches to the father, Shimshon, since Yitzchak is greeted in the heading as living. He states here that he studied astronomy in his own youth and rests his approbation on that rather than on report alone — which distinguishes it from the two approbations that flank it. The allusions are likewise mine and none is printed. "This man who has acquired wisdom" turns on the rabbinic gloss of zaken, "elder," as zeh shekanah chochmah — I have not verified that locus and cite none.

[[12]]

The approbation of Maharar Mordechai, dayyan [a judge of the rabbinical court] — may his Rock guard him and grant him life. [13a] I am a brute, less than a man, and I have not the understanding of a man [Proverbs 30:2] in any of the sciences, and least of all in this one, lofty and deep, deep of dep[ths] [Ecclesiastes 7:24] — [13b] can it be found out? [?] But since great men are giving testimony [Aramaic in the source] about this honored book, made by the aged one, the elder who has acquired … [13c] Maharar David Gansh — therefore I come like a yod added to a verse, merely to swell the number, to rouse and to urge that this [book] [13d] be brought to the printing house, so that the children of our people, from the least of them to the greatest, may learn and recognize and know the great things of … [13e] our God. May it be the will of our Father in Heaven that there be fulfilled in us the prophecy of Isaiah, chapter 11 [י״א]: "For the ea[rth is full of the knowledge] [13f] of the Lord," and so on [Isaiah 11:9]; and the prophecy of Jeremiah, chapter 31 [ל״א]: "For they shall all know Me, from the least of them to the greatest of them" [Jeremiah 31:33]; and likewise the prophecy of [Joel]: [13g] "your young men shall see visions" [Joel 3:1]. Amen, amen — so may the Lord say, and so may He do. These are the words of the humble Mordechai, son of my lord my father, the Rav R. … [13h] Eliyahu, of blessed memory — that is, Lipschitz.[7]

[[14]]

These are the testimonies which Maharar Yom Tov — called R. Lipman Wallerstein Levi Heller — beheld and declared.[8]

---

[7] the signatory is R. Mordechai son of R. Eliyahu Lipschitz, a dayyan of Prague. I cannot identify him further with confidence, and the gap at the end of [13g] may have carried more of his father's name. Abbreviations expanded: "the humble" (הק', i.e. הקטן, a signature formula, not a description); "my lord my father" (לא״א); "that is" (ה״ה), introducing the family name. The three prophecies are his own citations, printed on the page, and are rendered as he gives them — Isaiah by chapter, Jeremiah by chapter, Joel by name alone, with no verse numbers anywhere; the verse numbers are supplied, in Jewish numbering. His own "from the least of them to the greatest" at [13d] anticipates the Jeremiah verse he then quotes; the anticipation looks deliberate. The opening self-deprecation is the conventional opening of the genre, not a statement about the writer. The source prints "more brutish than a man" with a vav where the verse has a yod; the modern edition marks the correction, the English follows it, and the printed form is recorded here.

[8] the signatory is R. Yom Tov Lipmann Heller (1578–1654), then a dayyan in Prague and later author of the Tosafos Yom Tov; Wallerstein is the Bavarian town his family came from and Levi marks him a Levite. "These are the testimonies" is the opening formula of Deuteronomy 4:45, and "which … beheld" the verb of a prophetic superscription (Isaiah 1:1). Every identification is mine — the page gives the names and nothing else, and no reference is printed.

[[15]]

Man in the world has become like one of the host of the heights [Genesis 3:22; Isaiah 24:21]: he dwells on high, he sets his mouth in the heavens [Psalms 73:9], upon Kesil and Kimah [Job 9:9, also 38:31] [the two constellations named in Job — conventionally Orion and the Pleiades; the identification is mine]. For what advantage had man over the beast [Ecclesiastes 3:19]? Only this: the spirit [Job 32:8]. A discerning heart acquires the arts of wisdom, so as to understand the words of the wise [Proverbs 1:5–6] and their new-found things, which in all the ages [Ecclesiastes 1:10] had never been revealed or known — except to the pure of heart [Psalms 73:1], the chosen few, the Sanhedrin of the Lord, who stand in the council of the Lord [Jeremiah 23:18]: each on the authority of the one before him, back to the master of the prophets, who had it from the mouth of the Almighty — the One who showed it to him with a finger, and taught him knowledge [Isaiah 40:14], understanding [and] discernment.[9]

[[16]]

Then the ruin of the daughter of our people [Jeremiah 8:21] grew great and they were scattered through the lands of the nations [Ezekiel 36:19]. The nations grew wise and dealt shrewdly [Psalms 83:4], to take from them the secret of the Lord that belongs to those who fear Him [Psalms 25:14] — until the days had grown long for us [Ezekiel 12:22]. And they rest quiet upon their lees, secure and untroubled; with us it has been otherwise. We have been emptied from vessel to vessel in exile [Jeremiah 48:11], driven from one dislodging to the next. And so, with this breaking, the living God — our portion, our Rock — fulfilled in us the vision of Isaiah [29:14]: "the wisdom of its wise men shall perish, and the understanding of its prudent men shall be hidden."[10]

[[17]]

And yet — surely among the many of our people, as we have heard, so we have seen [Psalms 48:9]: there are men wise and knowing [Deuteronomy 1:13] in

[9] the section is a cento; every reference is my identification and none is printed. Three of the reworkings are worth marking: Genesis 3:22 puts "the host of the heights" where the verse has "one of us"; Proverbs 1:5–6 has "the words of the wise and their riddles" where the page has "their new-found things"; and "in all the ages" turns Ecclesiastes 1:10 into a negative. "The master of the prophets" is Moses, and "from the mouth of the Almighty" (mipi hagevurah) is the fixed idiom for what was said to him directly by God; "showed it to him with a finger" is the rabbinic idiom for God pointing something out to Moses — I recognize the formula but cannot fix a locus for it, and give none.

[10] Heller names Isaiah, but no chapter or verse; the wording as printed matches the received text. Jeremiah 48:11 is said of Moab, and Heller turns it inside out — Moab was never poured from vessel to vessel and never went into exile, and Israel has been both. Psalms 83:4, where the nations "take crafty counsel" against Israel, is played against Psalms 25:14, "the secret of the Lord is with those who fear Him."

every single city and every single family [Esther 9:28]. Even so, the people living in their midst marvel at the matter [Ecclesiastes 5:7] and will not go back to search for the loss just spoken of, saying all day long: "[We] have found; we have seen what we hoped for."[11]

[[18]]

But their eyes are sealed from seeing, and their hearts from understanding [Isaiah 44:18]. Were they wise, they would grasp this [Deuteronomy 32:29] — this Torah that Moses set down [Deuteronomy 4:44]. For this man Moses: we do know what became of him [Exodus 32:1] and what he declared about us — "for it is your wisdom and your understanding" [Deuteronomy 4:6]. That is: the one who knows how to calculate the tekufos [the turning-points of the solar year] and the mazalos [the constellations of the zodiac].[12]

[[18·2]]

This I take to heart [Lamentations 3:21]. It is all one, and so I have said [Job 9:22]: their eyes are shut, they have turned aside quickly from the way [Exodus 32:8] in which they should walk [Exodus 18:20]. For it is longer than the earth in measure [Job 11:9] — from half the diameter of the earth they measure outward as far as the breadths of the heavens, and the Kesil-stars in them: their height, [?], and their breadth, one by one, to find the sum [Ecclesiastes 7:27]. To know all this they must strike roots and lay foundations, founded upon the bases of the intelligibles [the self-evident propositions of reason] and the accepted premises — those rooted and founded by one of the elders of Athens, the city of wisdom [Aramaic: chad misavei d'Atuni].[13]

---

[11] "the loss just spoken of" is the lost wisdom of the Isaiah verse at the end of §16, and Heller's verb is the halachic one for going back over ground to look for lost property.

[12] Exodus 32:1 is inverted — there the people say they do not know what became of Moses — and Deuteronomy 4:6's continuation, "in the eyes of the peoples," Heller leaves unspoken. The closing clause is the argument of the whole commendation: the Gemara reads Deuteronomy 4:6 as pointing at astronomical calculation — "which is the wisdom and understanding in the eyes of the peoples? This is the calculation of tekufos and mazalos" — so the science Heller commends is not a foreign import but the very thing the verse calls Israel's wisdom. I recognize the passage as Shabbos 75a, but that reference is mine, supplied from the phrasing; the page cites nothing. The source prints the Deuteronomy 4:6 pronoun as היא where the Torah text has the consonantal הוא — the ordinary later normalization, not a variant reading, and translated as the verse reads.

[13] Job 11:9 is the same verse the approbation at §10 [11h] used, and Ecclesiastes 7:27 is Koheleth counting. "One of the elders of Athens" is Aramaic, the talmudic tag for the sages of Athens; the man meant is named in the next section. "Half the diameter of the earth" — the earth's semidiameter — is the standard unit in which this astronomy states celestial distances.

[[19]]

And this is the name they call him by [Jeremiah 23:6]: Euclid — Aklidas (אקלידס). The name itself brought it about [Aramaic: shema garim, "the name is the cause"]: it brought him to compose a Book of Roots, so as to be the root — the aklida (אקלידא), the key — to all the sciences.[14]

[[20]]

Now let the house of Israel say [Psalms 118:2]: do they sin with their tongue [Psalms 39:2] if they bring onto their own lips the lips of knowledge [Proverbs 20:15] — words that were composed for them by one uncircumcised of lips [Exodus 6:12] and of flesh [Ezekiel 44:7]? Is that good in the eyes of the Lord [Leviticus 10:19]? Is it fitting?[15]

[[21]]

All of this is my own reasoning, making excuses for itself out of idleness — and it will not take the matter to heart [Deuteronomy 4:39; Lamentations 3:21] and say: surely, for the faith and for the principles and roots of the religion, my thoughts and the imaginings of my heart [Job 17:11] have spoken well [Deuteronomy 5:28], in turning the eye away from the rebellious, "who are adversaries to you with their wiles, with which they beguiled you" [Numbers 25:18] in the matter of their opening their mouths without limit [Isaiah 5:14]. And these were adversaries of the faith to the children of Israel [Numbers 31:16].[16]

---

[14] "the name is the cause" is a talmudic maxim, given in Aramaic, which I have not attempted to place. The whole section is one pun and does not survive into English without the Hebrew: aklida (אקלידא) is the Aramaic for a key, taken over from the Greek, and the Greek Eukleides arrives in Hebrew as Aklidas, which sounds like it. So Euclid's name, on Heller's reading, is what made him write the book that is the key to every science — and he glosses his own Aramaic with the Hebrew word for key immediately after. "A Book of Roots" is what the page calls it, picking up "strike roots" from the previous section; the work meant is Euclid's Elements, usually known in Hebrew as the Book of Foundations — that identification is mine.

[15] this is the objection the commendation exists to answer — whether a Jew may take a gentile's science onto his lips at all. The force of the phrasing is that the two halves of "uncircumcised of lips and of flesh" pull in opposite directions: the first half is what Moses said about himself, the second is what makes a man an outsider.

[16] every reference here is my identification and none is printed. Both Numbers verses are about Peor, and the section's pivot is a pun that does not carry into English: where both Numbers verses read al devar Pe'or, the page prints al devar pa'aru pihem, "in the matter of their opening their mouths" — the same consonants, redirected onto the Isaiah image. "Adversaries of the faith" (tzaros) is likewise the feminine of the "adversaries" (tzorerim) of Numbers 25:18, and agrees with the feminine subject of Numbers 31:16, the Midianite women.

[[22]]

But only this: I have cleansed my heart and washed my hands in innocence [Psalms 73:13] as I turn about the poles of the work in question, or of others like it — a work in which not even chatzi nezek tzeroros [half-damage for pebbles — the talmudic category of the slightest, most indirect liability] can be reckoned or imagined. It does no harm; it does nothing but good, in the science of intercalation [the reckoning of the Jewish calendar] and beyond it. Every discerning man ought to master this science, since many mitzvos depend on it — all the appointed times of the Lord [Leviticus 23:4].[17]

[[23]]

Granted that the fixing and ordering of them have indeed been handed down to us from our fathers — even so, at the mere hearing of the ear [Job 42:5] our soul pines [Jeremiah 31:25]: it does not know what, or on what ground, or why a thing as great as this has come to be [Deuteronomy 4:32], which they testify and declare of them. Like the blind we grope for the wall [Isaiah 59:10], and that is what we were in our own eyes [Numbers 13:33]. According to all these words and according to all this vision [2 Samuel 7:17], so I saw. This I have seen, and I will now relate it [Job 15:17].[18]

[[24]]

Before I had finished speaking in my heart — behold, a Rav comes forth here, with his globe upon his shoulder [Genesis 24:45] and in his hand a written scroll of a book [Psalms 40:8]. It was none other than the Rav, aged and full of years, this man who has acquired wisdom: the honored Maharar David Avaza, may his lamp shine [נר״ו], with his work, the book Magen David — a shield to all who gaze into it [Psalms 18:31 = 2 Samuel 22:31]. Before he could come in to me, into the chamber [Genesis 43:30], I leapt, I hurried, I ran to meet him [Genesis 24:17], to entreat his honor to sustain my heart and instruct me [Proverbs 4:4],

[17] "the work in question" (hachibur ha'amur) has no antecedent in this section, and the nearest one in the surviving text is Euclid's Book of Roots at §19 — which is what the objection of §20 was raised against. On that reading §22 is the answer to §20: a gentile's mathematics can do no harm at all, and does positive good for the calendar. The identification is mine; the page names nothing.

[18] what has "been handed down to us from our fathers" is the calculation and arrangement of the festival calendar, which §22 has just named. Heller's point is that possessing the received rules is not the same as understanding them.

to make known to me a secret out of his wisdom and his understanding, and to let me sip a little water from the well of his spring [Genesis 24:17].[19]

[[25]]

He answered me: "Take, please, the bound sheets of my book, which have been brought to you [Genesis 33:11]. Rise, read it with your mouth and with your heart, so as to act on it [Deuteronomy 30:14], and lean upon your own understanding [Proverbs 3:5] — for then you will prosper, and then you will succeed [Joshua 1:8], of your own accord." And further … the source of the matter: the configuration of the heavens, the heaven of heavens and their host [Nehemiah 9:6] — and above all what every discerning man needs to understand and grasp in the knowledge of the courses of the two great luminaries [Genesis 1:16].[20]

[[26]]

I took it from his hand and studied the illustrations; I looked at the figures one by one, from the beginning of the book to its end, over the whole of it. And I, in my poverty, understood [1 Chronicles 22:14] — with the help of God, who graciously grants knowledge. Nothing was hidden from my eyes [1 Kings 10:3]. I saw its ways [Isaiah 57:18] and would not let it go, and I led it on until I had brought it into the chamber of my people, with me [Song of Songs 3:4] — that is to say, to myself: so it is written, so it is read, and so it is repeated.[21]

---

[19] the whole section is Abraham's servant at the well, and the reader is meant to hear it under every clause: Heller casts himself as the servant and Gans as the one who comes out to the well — carrying, in place of Rebecca's pitcher, a globe. "This man who has acquired wisdom" is the rabbinic reading of zaken as zeh shekanah chochmah, the gloss met at §10. The Psalms verse reads "He is a shield to all who take refuge in Him," and the change to it is the point of the book's title, since Gans gives his three reasons for the name at §§57–59: chosim, "those who take refuge," becomes chozim, "those who gaze" — one letter, and the shield of the psalm becomes a shield for astronomers. So far as the surviving text goes, this is the earliest explanation of the title Magen David in the prospectus. Every reference is my identification; the page cites nothing.

[20] Genesis 33:11 reads "take, please, my blessing, which is brought to you," and the page puts "the bound sheets of my book" in the place of the blessing. Every reference is mine and none is printed. "Lean upon your own understanding" reverses Proverbs 3:5, which says the opposite: the inversion is deliberate and makes the same claim as §3, that a reader can master this book without a teacher — me'eilecha, "of your own accord," says it again at the end of the sentence. That it is an inversion is my identification; the reversal itself is on the page.

[21] the substitutions are the point, and all four identifications are mine. 1 Chronicles 22:14 reads "in my poverty I have prepared," with "I understood" in the place of "I have prepared"; Isaiah 57:18 reads "I have seen his ways, and I will heal him," with "and I would not let him go" — Song of Songs 3:4 — in the place of the healing; and the Song's continuation, "until I had brought him into my mother's house, into the chamber of her that conceived me," stands here with "my people" where the verse has "my mother." "God who graciously grants knowledge" is the wording of the fourth blessing of the Amidah.

[[27]]

Then I said: here this Rav has come with a written scroll of a book [Psalms 40:8], expounded thoroughly [Deuteronomy 27:8], in language clear and brief, in a pleasing and acceptable order — without setting down introductions long and short, short and long, with speculative demonstrations and studies of roots and foundations, at which the heart of a student takes fright and is appalled and draws back [Isaiah 59:14].[22]

[[28]]

Would that this heart of his might be seen [Deuteronomy 5:26] in the printing house, bringing merit to the many by spreading his springs abroad [Proverbs 5:16]. I too will uphold his righteous right hand [Isaiah 41:10] and sustain him with my own coin. And when he heard my words, and that they were pleasant, his heart was glad and his glory exulted [Psalms 16:9]; and he gave it over to the leaders of Israel, those who offer themselves willingly among the people [Judges 5:9].[23]

[[29]]

And so that this may stand as a testimony for him [Genesis 21:30] before the whole assembly of these, the people of the Lord [Ezekiel 36:20] — lest they still think in their hearts: "we still need the Moda'i" [the talmudic byword for

[22] Psalms 40:8 is the same verse that supplied the scroll in Gans's hand at §24. this is a claim about the book's method, and it answers the reader-facing promise of §3 — that a man with no training can work through it alone. What Gans is praised for leaving out is the prefatory apparatus of the philosophical sciences: the chains of speculative demonstration and the derivation of first principles that a scientific treatise of the period normally puts in front of its subject matter, and that drive an untrained reader off before he reaches it.

[23] Deuteronomy 5:26 reads "would that this heart of theirs might be theirs, to fear Me," with "to be seen" in the place of "to fear"; the Judges verse is from the Song of Deborah. Every identification is mine. "I will sustain him with my own coin" is a pledge of money toward the printing — peritei is small change — and the only such undertaking in the surviving approbations. The prospectus is, among other things, a solicitation, and the closing sentence turns from Heller's own contribution to the communal leaders being asked for theirs.

the one expert without whom the matter cannot be settled], [Aramaic: a great master of Torah, to instruct us in those known paths of the rakia].[24]

[[30]]

Therefore I have now come to testify to a new thing — "this new thing is yours!" [Exodus 12:2] I have come forth so that every man of heart who possesses knowledge may gain insight, and understand, and know [Daniel 9:22; 1:4] the words of this sealed book [Isaiah 29:11] without instructor or rav — every student and young scholar. I, I am the one who speaks [Isaiah 52:6; 43:25], with a heart crushed and broken [Psalms 51:19], and yet gathering strength before the assembled hosts: not for his own honor, but for the honor of wisdom and of the author. One loathsome and abominable [Job 15:16], who draws the waters of the author's Torah in thirst — for from it hyssop and cedar alike are watered [Genesis 29:2; 1 Kings 5:13]: the hyssop of the wall, one of the children of the Ashkenazim [Exodus 2:6].[25]

[24] §29 opens with a connective vav and continues the sentence of §28; the "him" for whom the approbation serves as testimony is Gans. It answers §27 directly — the commendation exists so that nobody will suppose an expert teacher is still required alongside the book, which §30 then asserts outright. The allusions are all my identification and none is printed. The page rhymes the edah ("testimony") of Genesis 21:30 against the adas ("assembly") of the next clause. "We still need the Moda'i" is the Bavli's formula — adayin tzerichin anu le-moda'i, "we still need [R. Elazar of] Modi'in" — used when a ruling cannot stand without the one authority who can explain it; I have not fixed which of its several occurrences, if any, is meant, and the page cites none. The Aramaic "paths of the rakia" answers Shmuel's boast that the paths of heaven were as clear to him as the streets of Nehardea (Berachos 58b).

[25] the verses are all my identification and none is printed. Where the page substitutes: Genesis 29:2 reads "for out of that well they watered the flocks," with hyssop and cedar in the place of the flocks; 1 Kings 5:13 is Solomon's knowledge of all growing things, "from the cedar that is in Lebanon to the hyssop that springs out of the wall"; and Exodus 2:6 reads "this is one of the Hebrews' children," with the Ashkenazim where the verse has the Hebrews. The opening pun is the section's argument and does not survive into English: chiddush is a new teaching and chodesh a month, and the verse Heller reaches for is the commandment of the calendar given at the exodus — so testifying to "the chiddush of 'this chodesh is yours'" claims the book for that commandment. I have rendered the plain sense and record the double reading rather than choosing in the text. "Without instructor or rav" is the prospectus's central claim, made at §3 and praised at §27, and Heller's approbation is offered as its guarantee — which is why §29 was anxious that readers might think an expert still necessary.

[[31]]

Yom Tov, called Lipmann, son of my lord and father [לא״א] the Rav R. [הר״ר] Natan, may his memory be for the life of the World to Come [ז״לההה], Levi Heller, a man of Wallerstein · here in the holy community [ק״ק] of Prague.[26]

[[32]]

Friday [יום ו'] of the week of the parashah of "Behold, to the Lord your God belong the heavens and the heaven of heavens" [Deuteronomy 10:14]; and by the reckoning of the year: "I shall be satisfied, when I awake, with Your likeness" [Psalms 17:15] — 372 [א' שבע ה' בהקיץ תמו״נתיך].[27]

[[33]]

The Author's Preface

[[34]]

May length of days, and years of life, and peace be added to you [Proverbs 3:2], my beloved sons, loved and pleasant [2 Samuel 1:23] — the honored, our teacher R. [כמ״ר] Yehoshua, called Zelikman, and the honored Rav R. [כהר״ר] Abba Mari. May God be gracious to you and make His face shine upon you [Numbers 6:25; Genesis 43:29]. May your peace and your welfare grow great and be exalted forever. May you live and increase [Deuteronomy 8:1] for

[26] the signatory is R. Yom Tov Lipmann Heller (1578–1654), author of the Tosafos Yom Tov, at this date one of the rabbinical judges of Prague; his commendation is the longest of the approbations and has run from §14. The identification is mine — the page gives only the name, the lineage and the town. The town is Wallerstein in Bavaria, from which the family took its name before Heller; Heller is set here in its Yiddish spelling, העלר, and "Levi" is the family's Levitical descent, which Heller elsewhere signs as HaLevi.

[27] the date names no parashah and gives no year in figures. It identifies the week by quoting a verse from it — Deuteronomy 10:14 stands in Parshas Eikev — and gives the year as a chronogram; the page prints neither reference nor parashah name. The choice of verse is not incidental: the whole heavens are what the book is about, and §25 has already used "the heaven of heavens" out of Nehemiah 9:6. The page writes the verse's first word, esba'ah, as three pieces — א' שבע ה' — which isolates shin-beis-ayin: 300 + 2 + 70 = 372, the year by the minor reckoning, i.e. 5372 of the creation era. That the count is 372 rests on the page's own geresh placement, not on the date coming out right: the five letters of esba'ah taken together would give 378. The Gregorian date 19 August 1612 is supplied by the modern edition, not by the page, which gives only the weekday, the parashah's verse and the chronogram.

generation upon generation [Psalms 72:5; 102:25], and to all eternity. Amen — so may the Lord say [Jeremiah 28:6].[28]

[[35]]

You, my dear sons: because you have asked me so often, and because you long to know some introduction, some small beginning, in the science of the stars and the mazalos [the constellations of the zodiac], I have seen fit to open for you small casements and narrow chinks out of the apertures and windows of the science of astronomy. Through them you will look out and come to know the configuration of the galgalim [the celestial spheres] of heaven; the array of the mazalos, together with the rest of the stars of heaven, which stand fixed at their stations in the eighth rakia; and along with these the courses and the motion of the seven planets, and the measure of the time of their revolution. You will learn that they revolve from west to east, and also from east to west. Now they withdraw from the globe of the earth, and now they draw near to it by many thousands of parsah [the talmudic league]. Now they appear to go forward, and now to go backward, and now they appear to stand still and not to move in either direction. Now they go before the sun, and now behind it.[29]

[[36]]

You will come to know as well the definitions and the cause of the eclipse of the luminaries, and the cause of the moon's waxing and waning; why this day is long and that day short; why one and the same day is eight hours [ח'] in one place and twenty hours [ך'] in another; why in one place day and night are equal always; and why in another place the daytime runs the length of a

[28] every reference is my identification and none is printed. Proverbs 3:2 is pluralized by the page from lecha to lachem, for two sons, and the priestly blessing of Numbers 6:25 is combined with Joseph's greeting to Benjamin at Genesis 43:29, again pluralized. "Beloved and pleasant" is said of Saul and Jonathan — a father and his son, the only pair in Tanach the phrase describes. "For generation upon generation" (l'dor dorim) is a standing biblical idiom and I have not fixed a single locus for it; "Amen, so may the Lord say" is the epistolary form of Jeremiah 28:6, "Amen, so may the Lord do." The two sons are named with different honorifics, and the difference is on the page: Yehoshua is given כמ"ר, Abba Mari the weightier כהר"ר, which carries the title Rav. I record the asymmetry as printed and offer no explanation for it.

[29] the four window-words are the biblical vocabulary for an opening; the identifications are mine and nothing is printed as a reference. Eshnav, the casement, is Judges 5:28 and Proverbs 7:6; charakim, the chinks through which the beloved peers, is Song of Songs 2:9; arubos are the openings of Ecclesiastes 12:3 and the windows of heaven of Genesis 7:11. Gans's point is in the diminutives: what he opens for his sons is not the door of the science but a chink in it. The astronomy is that of the eighth sphere — the fixed stars standing together in the rakia above the seven planetary spheres; the planets carrying both the daily motion east to west and their own west to east; varying in distance from the earth; appearing to go direct, to retrograde and to stand still. Gans's positions are given as he holds them and are not modernized, glossed against modern astronomy, or corrected.

month, or of two months — until you find one place where, for all the days of the world, there are six months of day and six months of night.[30]

[[37]]

You will also find that the sun rises and comes up for some of those who dwell in the west before it rises for those who dwell in the east, on their day — along with many other matters besides these.[31]

[[38]]

And you, my dear sons, do not say in your hearts: who has stood and measured the earth [Habakkuk 3:6]? Or who has gone up to heaven and come down [Proverbs 30:4] and seen all this? For most of these matters the ancient sages investigated and expounded with wisdom, with understanding, and with knowledge [Exodus 31:3] — some of them by reasoning and by trial, some by strong demonstrations, by proofs clear and true: demonstrations that no one will deny but a man crooked and twisted [Deuteronomy 32:5].[32]

[[39]]

For it is already clear to every discerning man that in all the world there is no witness like a true demonstration. The simple and the foolish who deny it are like a man who denies the light of the sun by day and says that it is the black of night and thick darkness [Proverbs 7:9]. There is no difference between the

[30] the sequence is the standard consequence of latitude in this astronomy: unequal day-lengths, then a day of eight hours against a day of twenty in the same twenty-four, then the equator where day and night are always equal, then the high latitudes where daylight lasts a month or two, and finally the pole, where the year is one day and one night. Gans's account is given as he holds it and is not checked against or corrected by modern values.

[31] the most counterintuitive of the results, and the last Gans names before turning to answer the objection he expects. Presented as he states it: I have neither explained the mechanism he has in mind nor supplied a modern one.

[32] the two questions are verses turned into a challenge, both mine and neither printed. Habakkuk 3:6 is a statement about God which the page makes the sceptic's question; Proverbs 30:4 is already rhetorical in the verse. Gans puts into his sons' mouths the standing objection to astronomy — that no one has been there to see — and the pairing is exact: one verse for measuring the earth, one for going up to the heavens. The threefold formula of Exodus 31:3 is said of Betzalel, whom God fills with the spirit of God for the work of the Tabernacle. That the sages' investigation is described in the words used of a divinely inspired craftsman is not incidental to Gans's argument, but I record it here rather than pressing it in the text. The section does not end at the section marker: §39 opens with "for" (כי) after the page's own separator and completes the sentence; the two are read together.

two deniers, except that the one denies what the eye's sense of sight shows him, and the other denies what the light of the speculative intellect shows him.[33]

[[40]]

For the sages of astronomy do not speak in a dream [Numbers 12:6], nor do they judge by the hearing of the ear, by old wives' tales, nor do they decide by what children's eyes see [Isaiah 11:3]. They investigated all of it, rather, and found it out by knowledge and by understanding, by their speculation and by their deep wisdom.[34]

[[41]]

But I enter this mesiras moda'ah [the halachic formality of a prior declaration, by which a man puts on record in advance the sense in which what follows is to be taken]: we are not saying that all these things stand precisely as the astronomers describe them — in their position, in their motion and in their revolution — nor that it would be impossible to find another way. For Ptolemy himself [בטולמי"וס], the foremost of those who discourse on astronomy, after laying down in his book the existence of the galgal hakafah (the epicycle) and of the galgal yotzei me[rka]z (the eccentric) — whose character will be explained to you further on — wrote there, in the third book of his composition the Almagest [אלמגי"סטי], and these are his words:[35]

---

[33] this is the argument the whole preface turns on, and it is worth marking as such. A demonstration, for Gans, is not weaker evidence than eyesight but the same kind of evidence in another faculty — so denying a proved result is not scepticism, it is the refusal to see. It is also the answer to §38's "who has gone up to heaven?": nobody has, and nobody needs to.

[34] Numbers 12:6 is God's own distinction between what a prophet receives in a dream and what Moses receives mouth to mouth; Gans borrows the contrast for astronomers, who are not dreamers. Isaiah 11:3 reads "he shall not judge by the sight of his eyes, nor decide by the hearing of his ears" — and the page crosses the verbs over: it is by the hearing of the ear that the sages do not judge, and by the sight of the eyes that they do not decide, the reverse of the verse's assignment. Both identifications are mine, neither printed. I record the crossing rather than repairing it: it may be deliberate or a slip of memory, and nothing in the sentence decides between them. "Old wives' tales" renders שיחות הזקנות, literally "the talk of the old women." The sentence lists what an astronomer does not accept — dream, hearsay, and what a child thinks it sees — and closes the preface's case: the results are not gathered but demonstrated.

[35] Gans gives the quotation as standing in the third book of the Almagest; the attribution is translated as printed. I have not checked it against the Greek or against any Hebrew version, and have not adjusted it. The two devices he names are the standard apparatus of Ptolemaic planetary theory — the epicycle, a small circle carried on the rim of a larger one, and the eccentric, whose center lies away from the earth. He does not explain them here but promises the explanation "further on," as again at §43. His astronomy is given as he holds it and is neither modernized nor corrected.

[[42]]

"Whether this matter is true or not, God knows. But it is enough for us that we have found a way by which it is possible to uphold everything that appears to us in the motion of the luminaries." Thus far his words [ע"כ].[36]

[[43]]

I have also found, in the book Yesod Olam, treatise [twenty-]nine, an account of the man who caused the upheaval — who arose at the beginning of the ninth century of the fifth millennium, and who by great acuity of intellect went so deep into the science of astronomy that it entered his mind to find a new way of his own, and he proposed to alter all of Ptolemy's foundations in astronomy. He did not succeed, however, in completing his work, as you will find further on, in the eighth gate, at §208 [ר"ח]. Moreover, the divided opinions on this are already well known: between the one who says that the galgal is fixed and the star revolves, and the one who says that the star is fixed and the galgal revolves. Each of these two opinions has its own reason and its own argument, as will be explained further on in gate 1 [א'], at §7 [ז'] and §15 [ט"ו].[37]

[[44]]

Closer to our own time as well — some seventy years ago — there arose a man called Nicolaus Copernicus [ניקלאו"ס קופע"רניקוס], a great sage in astronomy, outstanding beyond all the men of his generation; and they testified of him that since the days of Ptolemy no one like him has been found. He examined the positions and the motions of the fixed stars and of the planets with great and painstaking exactness.[38]

---

[36] the hinge of the whole passage: the foremost authority in the science says of his own devices that whether they are true is God's business, and that a model accounting for what is observed is enough. Everything from §41 through §46 hangs on it.

[37] Yesod Olam is the astronomical work of R. Yitzchak Yisraeli of Toledo; the identification is mine, the page giving the title alone. The ninth century of the fifth millennium runs from 4801 to 4900 — roughly 1041 to 1140 CE. That conversion is mine, offered as a reader's aid; the page gives the Hebrew reckoning only, and I have neither adjusted it nor tested it against the man Gans may have in mind. The two cross-references are to Gans's own unfinished book, and they are the clearest evidence in the preface that it was already laid out gate by gate and siman by siman in 1612 — an eighth gate reaching at least §208, and a first gate whose §7 and §15 argue the fixed-star question from both sides. What the printed Nechmad ve-Na'im of 1743 carries at those places is a comparison worth making, and is not made here.

[38] Gans names Copernicus in print, in Hebrew, in 1612 — sixty-nine years after De revolutionibus and four years before the book was placed on the Index. His "some seventy years ago" is translated as printed and is not adjusted; whether he dates the man, the book, or his own information about either, the page does not say. The praise is unqualified and the comparison is to Ptolemy, whose own disclaimer Gans has just quoted at §42 — the two sections are meant to be read together.

[[45]]

In order to settle a number of doubts and great perplexities, and to get down to the causes and the reasons of all the motions and variations found in them, he judged and decreed — and sought to demonstrate, by the acuity of his lofty intellect — that the galgalim are still and at rest, and that the globe of the earth turns in a continual revolution. On this he composed a great book, exceedingly deep, whose acuity and sharpness are past all fathoming; and many of the great sages of his generation acknowledged him and agreed with what he said.[39]

[[46]]

All of this I have disclosed as evidence that we are not saying that all these things — the motion of the stars and of the mazalos — are precisely as the ancient astronomers say. Rather, every man is free to find whatever way is possible according to the reach of his own intellect. Only this is required: that all the variations in the courses of the luminaries be settled by reason and by argument.[40]

[[47]]

And a second mesiras moda'ah I set before you today [Deuteronomy 11:26]. When God has made known to you the ways of the science of the stars, together with the reasons and the cause of the variations in the course of the luminaries, and the other wonderful matters besides — everything I have disclosed in this book of mine — do not say in your hearts [Deuteronomy 8:17] that the paths of the science of the stars are clear to you from that moment on.[41]

[[48]]

That is not how it is. Know for a certainty that you have arrived at, and entered, no more than the antechamber [Avos 4:16] of this science. For I acknowledge

---

[39] Gans's statement of the heliocentric claim, given exactly as he gives it: the spheres at rest, the earth in continual revolution, offered as Copernicus's motive for settling difficulties the older account left standing. He records that many leading scholars of the generation accepted it. Nothing here is corrected, qualified, or set against what Gans says elsewhere.

[40] the four sections of the disclaimer are one argument. Ptolemy himself would not claim more than a workable account (§§41–42); a man of the fifth millennium tried to replace the whole foundation and failed, and the fixed-star question is still disputed on both sides (§43); Copernicus proposed something further still and was widely accepted (§§44–45); therefore no account is binding as the last word. The constraint in the final clause is what Gans does insist on — a proposal has to account for the observed irregularities in the courses of the luminaries, by reason and argument, or it is nothing.

[41] Deuteronomy 8:17 is the warning about forgetting who gave you the strength. "The paths … are clear to you" carries the Aramaic nehirin, and behind it stands Shmuel's boast in the Gemara [Berachos 58b], "the paths of heaven are as clear to me as the paths of Nehardea" — the claim Gans is telling his sons not to make. All three identifications are mine.

it, and acknowledge it fully: for all my great effort and inquiry in this science, I have gone down into the depth of the science of the stars and the mazalos by no more than a small and slight intimation.[42]

[[49]]

Set what my book says against what the books of the great astronomers of our own day say — the books in the hands of the Christians — and the measure of mine against theirs is the measure of a drop against the sea. And do not suppose, neither you, my sons, nor any other reader of this book of mine, that I say this by way of modesty, in the manner of certain great men who make themselves small. That is not how it stands with me. I declare and say that my attainment in this science is slight and short, and I say it on the side of truth, not on the side of humility. Know, then, that everything in this composition of mine is nothing more than an entrance, an opening and a small beginning to the science of astronomy — which I gathered, composed, wrote, recorded and set down in this book of mine as a memorandum for myself, and not for anyone else.

[[50]]

But because of our many sins, which have grown high above our head [cf. Ezra 9:6], the prophecy of Isaiah, chapter 29 [כ״ט], has been fulfilled in us, where he says: "And the wisdom of its wise men shall perish, and the understanding of its prudent men shall be hidden." So it is that in this generation our soul is dried up and there is nothing at [all — and] [Numbers 11:6] in these districts and these lands in particular, the lofty sciences have grown almost wholly destitute. In all these lands there are to be found no more than one in a hundred, two in a thousand, whose heart has moved him [Exodus 35] to study this science and to go deep into it.[43]

[[51]]

The causes of the obstruction are many. One of them is this: although many of the students have a strong desire for this science, no books on it are to be found among us in these lands, apart from the Hilchos Kiddush HaChodesh

[42] "this world is like an antechamber before the world to come." Gans turns the image on his own book: what his sons will have gained is the vestibule of the science, not the hall. The identification is mine; nothing is printed.

[43] Isaiah 29 is Gans's own citation — he writes נבואת ישעיה סי׳ כ״ט — and it is correct; almost nothing else in this preface is cited, the scriptural material elsewhere being woven in without attribution. The quoted words match the received consonantal text of the verse exactly, including the defective spelling נבניו. The rest is my identification and none of it is printed. Ezra 9:6 reads "our iniquities have risen above our head" — a different verb from the page's גדלו, which is why it is given as a cf.; "whose heart has moved him" is the recurring formula of Exodus 35.

of the Rambam [R. Moshe ben Maimon], of blessed memory [ז״ל]. A few individuals do have, hidden away in their treasuries, the book Tzuros HaAretz by R. Avraham bar Ḥiyya, and the book Yesod Olam by R. Yitzchak Yisraeli. Beyond these I have seen nothing, and there is nothing — nothing except the Book of the Globe, which they call Sphaera [ספיר״א], and that one does not meet their need either: it too is drawn out and stripped bare [?],[44]

[[52]]

— and it needs explanation and correction. Beyond that, anyone who wants to get to the bottom of the speculative content of these three books needs some preliminary grounding in the science of number (arithmetic) and the science of measure (geometry), and it is [because] of this that the students' hands fall slack from these books. There is more. In some places the words of the authors named are sealed and obscure; in others they have run on at length [Psalms 129:3], in long and expansive discussions. With all of this the students are not at ease. What they want and wish is that everything be set out plainly and in full [Deuteronomy 27:8], in easy language and with great brevity — and to learn the whole Torah, if such a thing were possible, in the time it takes to stand on one foot [Shabbos 31a].[45]

[[53]]

And so I — the lowly one, the least of the least, the small and slight one of the fellowship, a worm and not a man [Psalms 22:7]; David, son of my lord and father, the honored Reb Shlomo, may his memory be for the life of the world to come [זלה״ה], Avvaza [אוו״זא], called David Gans [דוד גאנז] — since I have already gathered, collected and gleaned the essence of the methods and the new

[44]the three works Gans names are, on his own account, the whole Hebrew astronomical library available to a student in Bohemia in 1612: the Rambam's laws of the calendar (the section of the Mishneh Torah setting out the astronomy of the new moon — that identification is mine, the page giving the title alone), R. Avraham bar Ḥiyya's Tzuros HaAretz, and R. Yitzchak Yisraeli's Yesod Olam, already cited at §43. These are also the "three books" §52 complains about; the Sphaera, just dismissed, is not among them. The page prints the second title in the plural — Tzuros HaAretz, "the forms of the earth" — where the work is known as Tzuras HaAretz. The modern edition marks the printed form with a sic (צורות (!) הארץ), which is how I know the plural is on the sheet and not in the digitization; I keep what the page sets and correct nothing, and state it here because the transliteration cannot show it. The Book of the Globe "which they call Sphaera" is, on the ordinary understanding, the standard European elementary textbook of spherical astronomy that circulated in Hebrew under that title — I offer that as a hedge and name no author, since Gans gives a title and a vernacular name and nothing else. The sentence needs only what it says: the one accessible book is elementary, and not adequate.

[45]the one-foot demand is the convert's to Hillel. Gans is not praising the wish; he reports it as one more reason the existing books go unread, and the whole of §56 is his answer to it — he will write so that a beginner can work through the book with no teacher at all. All three identifications are mine.

findings of the authors named, together with many further findings besides theirs, which I received both from the astronomers of our own time directly and from their books; and since all of that has lain stored up with me, sealed in my treasuries [Deuteronomy 32:34] — now that I have grown old and grey [1 Samuel 12:2] and the shadows of evening are drawing out [Jeremiah 6:4], I have resolved, in the face of your many requests, to hand this short composition of mine over to you, my dear sons, together with the young students of your own standing.

[[54]]

In this I have no business and no concern at all with the great men of the land, who are as full of Torah and wisdom as pomegranates [Berachos 57a; Chagigah 27a]. My purpose in this composition of mine is only to awaken the hearts of some of the younger students, and it is for you and for them alone that I am writing an introduction and an opening to the science of the stars and the mazalos. This book of mine will serve you as a shulchan aruch, a table set and ready, and as simanim — index-markers — to the books named.[46]

[[55]]

And what I take to myself as a crown of glory [Isaiah 28:5] for this composition of mine is the words of the wondrous sage, the great itztagnin [the rabbinic word for a master of the science of the stars], R. Yitzchak Yisraeli, who composed the book Yesod Olam, as noted above [כנ״ל]. In many places I will cite him by name and give you out of what is his. But in most places — in matters that all the books of astronomy are full of — I have not seen fit to set his name over them specifically, even though he too wrote those things.[47]

[[56]]

And every matter I bring up in this composition of mine I will set out plainly and in full: I will speak of these things in plain sight and not in riddles [Numbers 12:8]. So any man of quick and keen mind whom HaShem Yisbarach [הש״י] has graced with understanding, knowledge and insight, and whose soul longs [Genesis 34:8] to know, to understand and to gain insight into the ways of the science of the stars and the mazalos — even though he has never in his life received or studied any preliminary of the science of astronomy at all — will even so [מ״מ] be able to understand, to examine and to study every method

[46] the pomegranate image is of a fruit packed with seeds, used of a man full of learning. "The great men of the land" stands close to Psalms 16:3, with one noun changed — recorded as a possible echo and no more. Both identifications are mine; nothing is printed.

[47] the Yesod Olam of §43, by R. Yitzchak Yisraeli of Toledo. He is the one earlier authority Gans singles out as the ornament of the whole undertaking — a considerable statement about where he thinks the Hebrew astronomical tradition peaks. The Isaiah identification is mine and is not printed.

and every lesson of this book of mine on his own, with no teacher and no instructor.[48]

[[57]]

I have set my heart on calling this composition of mine by a name that is in common currency: Magen David. There are three reasons for this. The first is this. It is already well known that when two triangles are drawn and engraved one upon the other, the people of our generation are accustomed to call the figure a Magen David, saying that a figure of this kind was engraved on the shield of David the King, peace be upon him [ד״העה]. And because the root and foundation of measurement in matters of scientific inquiry — the whole of it becomes known to them by way of the measurement of triangles, as I have already set out at length in the book I composed on the science of number and of measurement, with the help of Heaven [בס״ד] — for this reason [ע״כ] I have called this book by the name Magen David.[49]

[[58]]

Second: the word magen (מגן) is also an expression of handing over, as in the phrase "who delivered [migen] your foes into your hand" [Genesis 14:20], which is how the Radak [הר״דק — R. David Kimchi] explains it under the root magen. And since most of what stands in this book of mine is material I gathered and collected, and that was handed over and delivered [nismagen, נתמגן — Gans's own verb, coined from that same root magen] into my hands out of books and from those who wrote them — and since, beyond that, there are certain investigations in the science of astronomy for which the days of a single man's life are too short to establish their truth, such as the revolution of the galgal of the mazalos and the height of the sun's elevation, and for determinations of this kind we need to know how the array of the stars stood

[48] Numbers 12:8 is said of God's speech with Moses; the page's wording differs from the received text in two small particulars and is translated as it stands. Both identifications are mine, neither printed. The closing promise answers §51 and §52 point for point: the books that exist are inaccessible, obscure in places and long-winded in others, and demand mathematics a student does not have — so Gans undertakes to write one that needs none of it.

[49] Gans is describing the hexagram — two interlocking triangles — and reporting, as already established in his own generation, both the name Magen David for that figure and the tradition that such a figure was engraved on King David's shield. He reports the tradition in the mouths of others (באמרם, "saying that"), and I have kept that reporting frame rather than letting him assert it; this is 1612 and the attestation is his own, with nothing supplied to it. The book he names in the aside he does not name: only "the book I composed on the science of number and of measurement," his own earlier work on arithmetic and geometry. I supply no title, because he supplies none, and putting one behind the epithet would carry a whole bibliography in on the strength of a description. He has treated the geometry of triangles at length elsewhere and is therefore not repeating it.

several hundred years ago, as will be explained further on in the first gate, §4 [ד'], and at the end of the fifth gate, §125 [קכ"ה], and again in the seventh gate, §171 [קע"א] — this last is not something we can come to know for ourselves. We can only trust that earlier disposition according to what the astronomer who came before us has delivered [migen] and handed down to us. And so, for the reasons just given as well, I have called it Magen David.[50]

[[59]]

Third: on account of the men of the tongue, wise in their own eyes [Isaiah 5:21], who speak arrogantly [Psalms 31:19; 94:4] against me and against everyone who studies the sciences. I have already refuted them to their faces and shown that they have strayed from the path of reason, since a good many essential bodies of halachah depend on these sciences, as I will mention further on, at the sealing of this book of mine. And since my defense, and this book of mine, stand for me against them as a buckler and a shield [Psalms 35:2], for this reason too I have called this book by my own name: Magen David.[51]

[[60]]

I saw fit to divide this book into gates, gate by gate, and within each gate I have given every matter made known and every lesson its own separate siman and paragraph. I did not gather two [ב'], three [ג'] or four [ד'] subjects into a single statement or a single siman, as some authors do — because the separation, and the space that stands between one topic and the next, lends grace to the reader and affords reflection and sound understanding to anyone who studies them. In this I follow what Rashi, of blessed memory [ז"ל], wrote at the head of Parshas Vayikra [Leviticus 1:1], and these are his words [וז"ל]: "And what purpose did the breaks serve? To give Moses a space in which to reflect between

[50] Genesis 14:20 is Malkitzedek's blessing of Abram; Gans gives the words alone and attributes the lexical point, not the verse, to the Radak. The Radak's lexicon of biblical roots, where an entry "under the root magen" would stand, is his Sefer HaShorashim; that identification is also mine and is offered as a hedge, since the page names no book, only a root-entry. The second reason turns on the same root twice: some quantities — Gans names the revolution of the galgal of the mazalos and the height of the sun's elevation — change so slowly that no one lifetime can measure them, so the observer must take the state of the heavens centuries ago on the authority of the astronomer who recorded it, which is to say it was handed over to him. The book is Magen David because most of what is in it was delivered into his hands by others.

[51] the third reason is the polemical one and the sharpest sentence in the preface. Gans defends astronomy not as an ornament but as a prerequisite: his answer to men who disparage the sciences is that the halachah itself depends on them — the calendar, the fixing of the months and the festivals — and he says he has already told them so to their faces, promising the full argument for the end of the book. Nothing here is softened, and no opponent is named, because the page names none. In Psalms 35:2 the two words are the large shield and the small, and the small one is magen, the book's title. All three identifications are mine, none printed.

one passage and the next, and between one subject and the next. How much more so [ק״ו — kal vachomer] for an ordinary man learning from an ordinary man." End of his words [עכ״ל].[52]

[[61]]

I also saw fit not to give each gate its own separate run of numbered simanim. Instead I have brought all the simanim of the book together into a single numbering, so that from now on the student can find whatever he is after more easily, and find it swiftly and at once, and will not go wrong among differing gate-by-gate siman numbers. These simanim are the markers, the notations and the particulars of this composition of mine — in which you are to take your delight, you, my precious sons [Lamentations 4:2], together with the young students of your own age.[53]

[[62]]

And if HaShem brings the work to completion for me [Psalms 138:8], and my hour is not snatched away, and He is with me in His kindness to give me the strength [Deuteronomy 8:18] that is in my heart to attempt — then I will set my hand to it a second time and enlarge the discussion in it. And so you will merit to gaze upon the pleasantness of HaShem and to visit His sanctuary [Psalms 27:4].

These are the words of your aged father — old, and yet one who has acquired nothing [Kiddushin 32b] — David, son of my lord and father [לא״א], the honored

[52] the passage is Rashi on the breaks between the divine speeches. The quoted words match the received text of Rashi, with one defective spelling (לתן for ליתן) kept as printed. Gans's use of it is an argument about book design: he claims rabbinic warrant for keeping one topic to one numbered unit, on the ground that if Moses needed room to think between subjects, an ordinary reader needs it more.

[53] a decision about how the finished book was to be navigated: one continuous run of section numbers across all twelve gates rather than a fresh count at each gate, for the reader's sake — a student looking something up should not have to know which gate it falls in first. The book as printed in 1743 does number its paragraphs in one continuous run, so the plan survived into the edition; that observation is mine, and this prospectus is where the reason for it is recorded. "My precious sons" renders בני המסולאים, the sons of Zion "who are weighed against fine gold" — my identification, not printed. The two sons are the Yehoshua called Zelikman and the Abba Mari named at §34.

Reb Shlomo, may his memory be for the life of the world to come [זלה״ה], Avvaza [אווז״א], called David Gans [דוד גאנז] · Magen David[54]

___[55]

Index / Keys to the Paragraphs — Miftechot li-Simanim (pp. 6–8)

Siman	Topic
1	Beneath the sphere of the Moon come to be the four elements, one above another; and an explanation of the first element.
2	The second element, water; that the earth combines with the water to form together a single [terraqueous] globe.
3	That one must not inquire into the reason and cause why the globe of the earth hangs in the midst of the air "upon nothing" (בלימה, Iyov 26:7).
4	The third element, the air, which divides into three parts.
5	That the air divides into ten different aspects; and the distinction between nefesh, ruach, and neshamah.
6	The fourth element, fire; and the property by which the elements interpenetrate one another [?].
7	That the later authorities deny the element of fire above entirely.
8	The number of the planets, their names, their order, and their periods of revolution.
9	That each planet is set in its own firmament; and why they are called "wandering stars" and "wandering [perplexed] stars" (כוכבי לכת ונבוכים).
10	On the eighth sphere, called the sphere of the [fixed] stars, or the sphere of the zodiac, and its motion.
11	That all seven planets, together with the stars of the zodiac sphere, are revolved by their spheres from west to east.
12	On the ninth sphere, called the diurnal sphere, whose motion is the reverse of that of the eight spheres mentioned.
13	How one body may be conceived to have two opposing motions.
14	How one body may be conceived to revolve eight bodies, one within another.
15	A fine resolution of the two perplexities mentioned.
16	A further return to the two perplexities mentioned.
17	Why the ninth sphere is called the diurnal sphere, and that it has but one motion.
18	Differing opinions concerning the existence of the ninth sphere.
19	Some explanation of the adjacent figures.

[54] the sign-off that closes the author's preface, and the reason the 1612 prospectus matters. Gans names his father, gives the family name in its Aramaic form and then in the vernacular, and sets the title of the book after his own name. The work was not printed until 1743, 130 years after his death, and then under a different title — so this line is the author's own testimony about what he called his book, rendered exactly as the page gives it, with the abbreviations expanded in brackets and nothing added. The allusions are mine and none is printed; "to give me the strength" only stands close to Deuteronomy 8:18. "Old, and yet one who has acquired nothing" turns on the rabbinic reading of zaken as one who has acquired wisdom — Gans has the years and not the acquisition. He was seventy-one, and had a year to live.

[55] End of the material inserted from the 1612 prospectus. The 1743 printing resumes below with its Index of Paragraphs. Gans's preface above is distinct from the Author's Introduction printed later in this volume: the 1743 editor states that he moved that piece from the end of the book to the front, whereas the preface above stood at the head of the prospectus as Gans issued it.

Siman	Topic
20	That the shells of the spheres are like the layers of an onion, with no void between them, and are transparent as sapphire.
21	The central axis [מבריח] and pole of the sphere, and the two pivots and poles of the universe.
22	That the northern pivot and the southern, mentioned above, are alone the pivots of the ninth sphere.
23	That even those who deny the ninth sphere may fittingly speak of a "diurnal sphere" or an "uppermost motion."
24	That every star makes, each day, one circle about one of the pivots.
25	Whether the star is fixed and the sphere turns, or the sphere is fixed and the star turns.
26	To find, in the eighth firmament, the point opposite the northern pivot of the ninth sphere.
27	The figure of the Great Bear and most of the Little [Bear]; and that the said pivot is not [the true one] but resembles / lies opposite the true pivot.
28	The force of the proofs that the heavens are spherical, and that no figure is like the spherical figure.
29	That the circular figure holds [contains] more than all [other] figures.
30	That the zodiac sphere is divided into 360 parts along the length of the world, and likewise along its breadth.
31	The nature of the sphere [?] … [as regards] the eighth sphere, its diameter and its poles.
32–33	The number of the great circles of the sphere, and the depiction of its form. [Printed as a single entry for two siman-numbers —]
34	Explanation of the first circle, called the celestial equator (משוה היום).
35	Explanation of the second circle, called the ofek hemispheri (אופ׳ חמפרי — the hemisphere-horizon, a vernacular loanword), or the horizon (אופק), or the circle of vision (יהַעגול הרא), or the earth's circle (חוג הארץ).
36	The third circle, called the meridian (אופק חצי היום).
37	The fourth circle, called the ecliptic (עגול המזלות).
38	The fifth circle, called the circle of the four pivots, or the colure (מעמד הגלגל [?]).
39	The sixth circle, called the equinoctial colure (מעמד השוה).
40	The seventh circle, called the summer [solstitial] colure (עמידת הקיצית), or the circle of Cancer.
41	The eighth circle, called the winter [solstitial] colure (עמידת החורפית), or the circle of Capricorn.
42	The ninth circle, called the northern (Arctic) circle.
43	The tenth circle, called the southern (Antarctic) circle.
44	The distances of the three circles — the equator (קו היושר), Cancer, and the northern — one from another.
45	Constructing the meridian circle by another method; [and?] its usefulness [?].
46	To make upon the southern globe an arc [for measuring] the distance of the stars [?].
47	That the horizon-line, and likewise the meridian-line, are shared by two persons distant one from another.
48	That just as a person is distant from the equator toward his north, so is the distance — or the elevation — of the pole above his horizon.[56]
49	That all the stars near the northern pole never set for us.
50	To find the true south line (קו אמתי דרומי) by direct observation.
51	Constructing an observational instrument called the "square instrument," in Latin quadrant (קוודרנט [Latin: quadrans]).
52	To find the altitude of the sun, and likewise of every other star — how high it is above the horizon.

[56] the leaf prints מרחת where the sense wants מרחק, and drops the ־מ of מקו השוה; the entry itself offers "distance or elevation" as alternatives, so it flags that the two quantities are one measure under two descriptions.

Siman	Topic
53	To find how high the northern pole stands above your horizon, and the place of its point in the eighth firmament (ברקי׳ השמיני).
54	To find the moment and time of midnight throughout all the days of the year.
55	Proofs and evidence that the earth is spherical.
56	That many men have circumnavigated the entire globe and returned to the place from which they set out.
57	That the earth stands at the very center of the zodiac sphere, like a point at the center of a circle.
58	That the earth's globe, by reason of its smallness, has no magnitude perceptible to our sight against the vast breadth of the zodiac sphere.
59	That all the lines of the celestial circle above are conceptually inscribed upon the earth's globe below.
60	That the earth's globe too is divided into 360 degrees, in longitude and in latitude, and from what place this reckoning begins.
61	How the ancients knew that the longitude-measure of the dry land is [about] half the earth's circle — namely 180 degrees.
62	How many parasangs on the earth's globe correspond to one of the 360 parts of the sphere above.
63	The measure of the line encircling the earth's globe, and how many days and years a person needs to travel around the globe.
64	Refutation of the ancients' opinion that half the earth's globe is submerged in water.
65	Whether the earth stands upon the water, or the water upon the earth.
66	Refutation of the ancients who said that near the equator there is no habitation, from the great heat, and near the northern circle none [from the cold]; and an explanation of the seven climes (אקלימים).
67	The reason why the ancients divided the inhabited world into seven climes.
68	The form of the whole terraqueous globe, sea with dry land, all the [eight] parts, in general terms [?].
69	Explanation of the 32 tables (ל״ב הלוחות [?]), and clarification of some of their circles.
70	A drawing of the earth's globe as a cone [?], which is more like a curved sphere [?].
71	That the ancients divided the inhabited world into three parts: Asia (אסיא״ה), Africa (אפריקא), and Europe (אירופיא״ה).
72	That the sons of Noah — Shem, Ham, and Japheth — divided the three parts of the world among themselves.
73	On the discovery of a new world, called Amoriki [אמורי״קי], in the year 5252 [ה׳ אלפים רנ״ב = 5252 AM; 5252 − 3760 = 1492 CE].[57]
74	That the fifth part of the earth's globe is also in the new world, and that part is called Peru (פיר״ו).
75	A note on the [region] of the said Peru, which is the fifth part of the globe [?].
76	Some say that the land of Peru is Ophir (אופיר), to which Solomon (peace be upon him) sent his ships (cf. 1 Melachim 9:28).
77	Explanation of the sixth part of the globe, called New Guinea (גביניא״ה [?]).
78	The seventh part of the globe is the northern world.
79	The eighth part of the globe is the southern world, larger than each of the other parts of the world.
80	Who told the explorers of the land [?] of the locations of the world and the boundaries of the seas.
81	How and from which the researchers know the breadth of countries, between north and south, and their breadth, between east and west.[58]

[57] the place meant is America; the identification is editorial. The leaf sets the name with an interior mark, as it does for the other new-world names in this column.

[58] the entry uses one and the same measure-word for both axes, and the word for length does not occur in it. §§82–84, two lines further down the same column, use the length-word correctly for the east–west quantity; the leaf does not harmonise them.

Siman	Topic
82	To find the longitude of countries without observation of eclipses (לקויים).
83	To find the longitude of sea-islands without observation of eclipses, and without two [observers?] [?].
84	To know the longitude of countries by the times of the moon's revolutions, according to its proper and outer motions, together with the revolution of the diurnal sphere.[59]
85	The bounds of the four directions of the world — where they begin and where they end.
86	That the ancients divided the horizon-circle into twelve directions.
87	That the later authorities divided the earth's circle, or the horizon, into thirty-two directions [compass points].[60]
88	An alphabetically-ordered table [?] by which to know the locations of many inhabited places, and also some sea-islands — how much each is in longitude and in latitude.
89	A resolution concerning what our Sages said, that Jerusalem is the center of the world.
90	A resolution concerning their saying that the Land of Israel is higher than all lands.
91	The reason why the later authorities challenged what the earlier ones received concerning the beginning of the 360 degrees of the globe [?].
92	Explanation of the time-periods — five in general; and the duration of the year and the month are explained.
93	That there is no [fixed] month at all, and the moon has no year at all [?].
94	On the natural days, which run "from one time to the same time" (i.e., 24-hour periods).
95	On the hours of the day, and on what its foundations were sunk (cf. Iyov 38:6) [?].
96	Why they divided the measure of the parts of the natural day into 24 hours.
97	

[59] the closing phrase is set as an unmarked construct chain and is awkward as it stands; it is given as printed and not emended.

[60] the entry crediting the ancients carries its number as a numeral; the entry crediting the moderns spells its number out. Nothing on the leaf harmonises the two forms.

Index of Paragraphs (*מפתחות לסימנים*) — continued

Source page 9 (folio ד[?] recto)

Siman	Topic
97	The reason for the seven days of the week.
98	A table for the rulership of each of the seven planets in every hour throughout all the days of the week.
99	On the duration of each of the wandering planets' [כוכבי נבוכה, kokhvei nevukhah] rulership — not only in the first hour of the day, but ruling a whole day.
100	On calculating the equal hours (sha'ot yesharot) of the natural equinoctial day, equal to one another.
101	On calculating the seasonal hours (sha'ot me'uvvatot), called zemanim, which are always twelve hours by day and twelve hours by night.
102	On what else the reckoning of the seasonal hours was founded upon.
103	That the reckoning of the intercalation (ibbur), the seasons (tekufot), and the conjunctions (moladot) was established according to the seasonal hours.
104	On the cause of night, and the earth's shadow.
105	The meaning of the word "day"; the difference between the artificial (working) day and the natural day, and from what moment it begins.
106	That the length of a natural day exceeds the time of one revolution of the daily sphere.
107	On the belts of the zodiacal constellations and their figures, and why they are called by their known names.
108	For what reason the astronomers assigned to the zodiac circle the aforementioned [star / name] [?].
109	That the ancients agreed, with reason and good sense, to place the sign of Aries at the head of the zodiac.
110	That the figures on the zodiacal sphere are reckoned in two ways.
111	That the figure-bearing constellations in the eighth sphere are not equal to one another in measure, neither in their length nor in their breadth.
112	That all the stars of the firmament are distributed among the twelve signs.
113	That they divided the zodiacal sphere, reckoned according to seven considerations.
114	The six signs to the left of the horizon are found [equal in their rising] to the east and [...] to the west only for those dwelling under the equator. [reading uncertain — several words garbled: "לא נמצא בהם ג׳למזרח ועל׳שה למערב" ?]
115	That each sign takes two hours in its rising over the horizon.
116	That six signs rise each day, and likewise at night, whether the day or the night be long or short.[61]
117	Explanation of the ascensions (mitz'adei) of the signs; some signs rise slowly (at length) and some rise quickly.
118	Explanation that in four places the degrees of the zodiac change together with the degrees of the equator (right ascension).

[61] one number only, and it is spelled out; the marks on the two neighbouring words are abbreviation marks, not a figure. §115 two lines above does set its number as a numeral.

Siman	Topic
119	The order of precedence and following, according to the order of the four quarters of the sphere.
120	A small table [showing] how many degrees and minutes, and also how many hours and minutes, [belong to] the rising of each sign, whether in the right [sphere] or the oblique.
121	The rules of precedence and following in the ascensions of the signs, for those dwelling under the oblique [horizon].
122	A table of the risings and settings of the signs for us, the inhabitants of the city of Prague.
123	That for some people every sign [reaches] the horizon each day, and each one of the twelve signs (וכ"א מי"ב מזלו') is then seen by them, half above the horizon and half below it.
124	When the axis of the zodiac mentioned inclines above the heads of people dwelling under the northern circle, as above.
125	That we noted: three of the remaining signs are always above the horizon, three always below it, and six that rise and set inverted.
126	For some of them [תן שלמק — printed with a gap one sort wide where the tsadi belongs] four signs always remain above the horizon and four below it; and for some, six above their horizon and six below it, always.[62]
127	The reckoning of the rising of the signs over the horizon; some of them have an evening rising and some a morning rising.

Source page 10 (folio ד[?] verso)

Siman	Topic
128	On the rising of the twelve signs in a year, and that there is nothing anomalous in it from the revolution of the zodiacal sphere.
129	That the rising of the aforementioned signs is not exact in every year, nor is it equal for all the inhabitants of the world (cheled).
130	On the time of the revolution of the zodiacal sphere. [line garbled in source: "מזמן ס וכ גלגל המזלות:" — reconstructed]
131	It informs that, after many years, all the host of heaven will change for us.
132	It defines [?] the sun's deviation from the equator — called in their language declinatio [דיק'לי נצייאנו'ס; Latin: declinatio, "declination"] — and the two circles that the sun makes twice [a year].
133	We shall explain and make known that most of the sun's regions (galilei) are shared with one another.
134	Explanation that the sun's regions are not complete circles.
135	We explain that the sun's shared regions are not [perfectly circular] in precise form, only at their beginning. [reading uncertain]
136	Explanation that the sun's aforementioned regions are not equal in nearness and farness to one another, and that the sphere [...]. [end of line garbled/cut at margin]
137	[Siman 137 — its description not legibly recovered from the source; only the siman number "קלז" is clearly visible.] [?]
138	Explanation that, for those dwelling under the equator, the length of the day and the length of the night are always equal.
139	Explanation that on the days of the two equinoxes, day and night are equal also for most of the other inhabitants of the world.

[62] the sort does not print; the gap is clean paper on both copies — a blind sort in the setting, not scan damage. §123 two entries above sets the same idea as two words. The entry also sets the same figure twice, once as a numeral and once spelled out.

Siman	Topic
140	Explanation that the daytime of the Nisan season (the spring half-year) exceeds the daytime of the Tishrei season (the autumn half-year).
141	It informs that the natural [?] days are not equal in the measure of their length.
142	It makes known the cause of the lengthening and shortening of the days for us, the northern inhabitants, throughout all the days of the year. — Further (a siman connected to the above): that the length of the days of Teves is never equal to [...], and likewise their daytime is never equal to their nighttime. [appended note; several words garbled: "...'לסי' הנ"ל שמרת ימי טבת אינ' שוי' לא'ד'... תמיר וכן יומו..."]
143	Explanation that for some people the measure of the day will be [?] hours. [number of hours illegible]
144	It informs that in some countries the [longest] day is one month, or two months, or more, and likewise the night.
145	That in some places the day is four months, and likewise the night.
146	That for those dwelling under the north pole, the day is six months and likewise the night.
147	To investigate and know, by means of the globe-instrument, the lengths and shortnesses of the days for every day of the year, in every place and every time.
148	The differences found among the inhabitants of the world in the beginning of each day, and the moments of their midday, in general.
149	The rule of precedence and lateness for those dwelling under the equator (the right line).
150	Those who share the same latitude have equal day-length, all of them.
151	Places that share the same longitude have equal midday time, all of them — but not so the division of day and night, except on the days of the Nisan and Tishrei equinoxes.
152	Places that share neither longitude nor latitude — how many rules and laws they have relative to one another.
153	That there are some western countries where the sun rises for them before it rises for the eastern ones.
154	That the sages agreed to relate events according to the times of midday and midnight.
155	The precise reason for knowing the aforementioned differences.
156	On the variation of summer and winter, and that those under the equator have two summers and two winters.
157	That those dwelling toward the equator also have [seasonal] reversals and four general [divisions].
158	The nature of the summer and winter sun for those dwelling under the Tropic of Cancer (iggul Sartan) and beyond it.

Source page 11 (folio ה recto)

Siman	Topic
159	Why at midday it is more in the west; why the west is warmer than the morning; and why it is colder in the winter season than in the summer season.[63]
160	That the cause of day and night, of summer and winter, and of all the other seasons of the year — all of them likewise result from the two motions, the voluntary and the necessary.
161	From which place on earth each day begins to be called by its name.
162	One who circumnavigates the globe will sometimes lose one day of the week, and sometimes gain one day.

[63] the first clause names no property — the comparative stands alone, and the word for heat occurs only in the second clause, where the comparison is against the morning, not the east. Any "heat" in the first clause is completed from the second.

Siman	Topic
163	Explanation that in the sun, and likewise in the other planets, there are found changes and many differing matters.
164	The definition of the solar year, and how long its measure is.
165	To know how far the sun travels in one day against the horizon of the zodiac.
166	That the length of the year is reckoned by the revolution of the sphere of the fixed signs, and not by the figure-bearing constellations; and whether the measure of the year stands at one fixed value.
167	That the sun's sphere has two orbs encircling the globe of the earth.
168	That the two solar orbs mentioned are described as three orbs.
169	The form and structure of the fourth firmament — which is the sun's sphere — and how its thickness divides into three orbs.
170	That the middle white circle, and the sun itself, both touch the sphere of Mars.
171	Explanation of the line of the sun's course (the ecliptic), around which it always revolves and from which it never deviates.
172	Five linear circles are found in the whole depiction of the aforementioned solar sphere, and the eccentric center (merkaz hayotze) inscribes a circular line around the center of the world.
173	How much is the thickness of the [solar / first] sphere [?]. [source: "של גלגל נוש א'" — garbled]
174	The reason why the three solar orbs differ, each one from the other.

[Foot of page: ****]

Source page 11, left column (continued)

Siman	Topic
175	Explanation of the saying of the Sages, of blessed memory, that the sun and moon are in the second firmament (Rakia)[64].
176	That the three dark orbs mentioned — each of them has two centers.
177	That the middle orb in the sun's sphere is fully eccentric (yotze merkaz), and by its revolution alone the length of the year is reckoned.
178	That the sun draws near to and recedes from [...] the center of the earth. [word garbled: "מכדו' ומרכז הארץ" ?]
179	That the inert[?] sphere in its entirety — namely the two dark orbs of the figure, according to the opinion of Ptolemy [בטלמיא"ם = Ptolemaios / Ptolemy] — has a heavy motion of its own, and it displaces the apogee (rum govah) of the sun.
180	That the center of the eccentric sphere also moves from its place.
181	That the sun's sphere has four motions.
182	Which is the mean position (emtza'i) of the sun in the zodiac and which is the true position (amiti), and the difference between the two positions.
183	That sometimes the mean motion precedes the true, and sometimes it lags behind.
184	That the sun revolves with equal motion in two differing times, or with differing motions in two equal times.[65]

[64] Talmud Chagigah 12b — identification of the underlying dictum, not printed in this siman list; cf. the same attribution at §175 below, where the leaf itself names Bereishis Rabbah rather than Chagigah

[65] the third line prints two wrong sorts — a kaf where "motions" wants a mem, a vav where "differing" wants a yod — though the same word stands correctly two lines above. Both are on both copies.

Siman	Topic
185	That the four seasons of the year, according to the sun's true motion, are not equal to one another.
186	That for the reasons mentioned, the lengths of the natural days also differ.
187	Explanation of the difference in time between the true season and the mean season.
188	Explanation of the moon's sphere and the arrangement of its orbs.
189	That the moon's deferent (galgal hanose, carrying-sphere) is inclined from the [?] sphere toward the north and toward the south.
190	That [three?] distinctions are found between the inclination of the zodiacal sphere and the inclination of the inclined sphere.
191	On the motions of the [Dragon's] Head (Rosh) and its Tail (Zanav) — the lunar nodes. [מתנועות ראש ה⟨narrow vertical⟩ נין וזנבו][66]

Source page 12 (folio ה verso)

Siman	Topic
192	That the moon's position in the zodiac is reckoned in the longitude of the firmament, and also in its latitude.
193	How much is the measure of the inclination of the moon's deferent from the [?] sphere.
194	Explanation of the matter of the epicycle-sphere (galgal haqqafah) belonging to the moon and to the other five wandering planets (kokhvei nevukhah).
195	The forms of the epicycle-sphere, and that the planets' [epicycles] also touch the sphere above it and the one below it.
196	That the moon's motion in its epicycle is the reverse of the motion of the other epicycle-spheres, and is called "the moon's retrograde motion" (bechilluf).
197	On the regions (galilei) of the moon and the regions of the other wandering planets.
198	On the difference found in the moon between its mean position in the zodiac and its true position.
199	The difference between the true motion and the mean.
200	All the differences found in the sun by reason of the eccentric sphere — all of them are found in the moon by reason of the epicycle-sphere.
201	That the moon's spheres have [six?] motions. [numeral uncertain]
202	That the reckonings of the seasons (tekufot) and the conjunctions (moladot) were established for us by Chazal according to the mean motion.
203	On the time of the moon's revolution in its sphere, the time of the revolution of its epicycle-sphere, and the length of the lunar month.
204	The reason for the difference between the time of the moon's revolution in its sphere and the length of the [synodic] month.
205	That the moon revolves in two equal times with two differing motions.
206	That by the causes of the moon's revolution around the globe of the world, the moon itself makes a circular orbit-path that is [shared?] and greatly tangled.
207	That the body of the moon makes many distinct circles and orbits, intertwined and greatly tangled, most of which are without number.
208	The difference between the line issuing from the center of the earth and the line issuing from the pupil of the observing eye, which stands upon the surface of the globe of the earth (i.e., parallax).

[66] the name is not cleanly set — no well-formed tav, and a word-space falls inside it. "The Dragon" is a restoration, not a transcription; both copies carry the defect.

Siman	Topic
209	The definition of the molad (conjunction), its nature and time, and the many causes of the variations found in the moon throughout the days of the month.
210	The forms and measure of the moon's waxing and waning, and how many hours it remains above the horizon all night.
211	That the reckoning of the hours mentioned nearby is specifically according to the reckoning of the seasonal hours, and the reasons for fixing these hours.
212	On the time of the moon's concealment (setirah) each month, and the cause of the lateness and earliness of its sighting.
213	The length of the lunar month, which is 29 [days], 12 [hours], 793 [chalakim] [כ״ט י״ב תשצ״ג = 29 / 12 / 793] — from where it is known to us.
214	For which place on earth the reckonings of the conjunctions and the seasons were established.
215	That after the renewal (new moon), the moon appears above the horizon always by the same measure [?].
216	That no star completes a full revolution in the time of one revolution of the daily sphere.
217	To observe the voluntary motion (tenu'ah retzonit) in all seven wandering planets.
218	Some say (י״א) that no contrary (retrograde) motion is found — neither in the [planet], nor in the eccentric sphere, nor in the epicycle-sphere. [one word garbled: "ולא'בכיו"]
219	How high the moon is above the center of the earth, and the difference between its nearest and its farthest distance from it.
220	On the eclipses and darkenings of the moon.
221	The nature of the shadow of light, which goes tapering to a point, and that when the moon enters it, it is eclipsed.
222	The forms of the moon's deferent circle, a second time (שנית); and that every eclipse occurs at the Head (Rosh) of the nodes, or at its Tail (Zanav).
223	Why the moon is not eclipsed every month, [even] when its center is opposite the center of the sun.
224	That sometimes the darkening is found not in the whole moon but only in part of its body, and when the moon escapes the eclipse.

Index of the Paragraphs (מפתחות לסימנים) — continued

(224, completing the previous entry:) … eclipsed completely (הלקוי לגמרי).

Siman	Topic
225 (רכ״ה)	That the astronomers divided the stages of a lunar eclipse into five periods.
226 (רכ״ו)	On the eclipses of the sun, and that there are several [differences] between its eclipses and those of the moon.
227 (רכ״ז)	That the cause of a solar eclipse is that the moon stands before the sun and cuts off its light.
228 (רכ״ח)	How the moon, small as it is, can block the sight of something larger than itself — by more than [numeral: ?] times.
229 (רכ״ט)	Why an eclipse does not befall the moon every month.
230 (ר״ל)	That a solar eclipse is seen in one place entirely, in a second place partially, and in a third place not at all.
231 (רל״א)	How much time falls between one eclipse and the next, and how many eclipses are possible in a single year.
232 (רל״ב)	The reason the planets ("wandering stars") sometimes move forward, sometimes backward, and sometimes stand still. [retrograde motion and stations]

Siman	Topic
233 (רל״ג)	The reason we see one star remain fixed in its place, going nowhere. [the celestial pole]
234 (רל״ד)	That all the stars are hidden beneath the light of the sun, and the manner of their entering and emerging from beneath its light.
235 (רל״ה)	Why the planet Venus (Nogah) is sometimes seen before the sun, sometimes after it, and sometimes not seen at all.
236 (רל״ו)	That the planet Mercury (Kokhav) too behaves like Venus, one and the same rule applying to both.
237 (רל״ז)	The three upper planets — namely Saturn, Jupiter, and Mars (שצ״ם) — how they lie beneath the light of the sun.
238 (רל״ח)	Whether the light of the stars is their own or acquired from the light of the sun.
239 (רל״ט)	How great is the bulk of the body of each of the seven planets, relative to the body of the globe of the earth.
240 (ר״מ)	The table of periods in which the carrying-sphere (deferent), and also the sphere of revolution (epicycle) of each of the seven planets, revolve about the globe of the world.
241 (רמ״א)	How great is the inclination of the [six] planets from the middle line of the zodiac, across the breadth of the firmament, toward north and toward south.
242 (רמ״ב)	On an instrument called the quadrant (keli ha-rova), for measuring the altitude of the pole (tzir) and the altitude of the stars.
243 (רמ״ג)	That the quadrant works by one of two methods; and an explanation of the first method.
244 (רמ״ד)	How measurement is performed with the quadrant.
245 (רמ״ה)	That everything lying on the line of sight (kav ha-nitzotz) — even if one object is larger than the other by a thousand parasangs — is reckoned at a single altitude for both.
246 (רמ״ו)	The manner of making and calibrating the quadrant according to the second method.
247 (רמ״ז)	The figures and diagrams of the quadrant, with all its rules and specifications.
248 (רמ״ח)	To find the sun's altitude — how far it stands above the horizon.
249 (רמ״ט)	That observing the altitude of the stars is done by one of three methods.
250 (ר״ן)	To find how high the northern pole rises above your horizon, in every place and at every time.
251 (רנ״א)	Another method for finding the pole's altitude in every place, quicker and easier.
252 (רנ״ב)	To find the altitude of the northern pole itself by the sun's course, on the days of the Nisan and Tishrei equinoxes, in every place, whether at sea or on land.
253 (רנ״ג)	To find the pole's altitude in every place by the sun's daily course throughout all the days of the year.
254 (רנ״ד)	That the calibration of every observational instrument (keli machazeh), in every place, must accord with the pole's altitude there.
255 (רנ״ה)	To draw upon the face-plate of the instrument three principal arcs — one for Aries and Libra, one for Capricorn, and one for Cancer — and how high the sun stands in each of them.
256 (רנ״ו)	To draw upon this quadrant a meridian (midday) arc.
257 (רנ״ז)	To draw, as with a compass, a circle or an arc that passes through all three points, however they lie — provided they do not all lie on a single straight line.
258 (רנ״ח)	To know the sun's altitude at the head of each of the twelve zodiac signs of the firmament.

Siman	Topic
259 (רנ״ט)	The manner of squaring the arc of the zodiac and this quadrant.
260 (ר״ס)	Finding the sun's place in the zodiac by means of the quadrant, at any time throughout the year.
261 (רס״א)	To find, throughout the year, how far the sun or any other star has moved from the straight line (the equator).
262 (רס״ב)	To know the distance of each star from the point opposite the zenith (nokhach nekudat kodkod).
263 (רס״ג)	To know, when the sun enters the head of each sign, how high each sign stands above the horizon at every hour of that day.
264 (רס״ד)	The reckoning of the day-hours in [the visible half of] the sphere, and that they begin from midday.
265 (רס״ה)	Calibrating the hour-arcs on the quadrant.
266 (רס״ו)	That not all the hour-arcs are always constructed according to all the aforementioned principal arcs.
267 (רס״ז)	To know the times of the sun's rising and setting, and the measures of the lengths of the days and nights throughout the year.
268 (רס״ח)	To know, on any given day, whether it is the time before midday or after midday.
269 (רס״ט)	To know, at any time, how many [equal] hours have passed since [daybreak].
270 (ר״ע)	To know how high the pole stands above the horizon of the place where the quadrant was made.
271 (רע״א)	An explanation concerning a fixed (vertical) star (kokhav nitzav).
272 (רע״ב)	Likewise, from the above.[67]
273 (רע״ג)	An explanation of calibrating an observational instrument.
274 (רע״ד)	An explanation of the method of measuring the breadth of a surface lying on level ground.
275 (רע״ה)	An explanation of extending the perpendicular line so as to make the measurement precise.
276 (רע״ו)	An explanation of the method of measuring the height and elevation of the zodiac signs (המזלות) or of other things.
277 (רע״ז)	An explanation of when the sighting-vane (moreh) cuts the upper axis of the instrument.
278 (רע״ח)	An explanation of how one measures the height and elevation of a tower when one can neither approach the tower nor see its base or foundation.
279 (רע״ט)	An explanation of the manner of measuring [down] from a mountain to a valley.
280 (ר״פ)	An explanation of three kinds of measurement from the mountain to the valley (emek).
281 (רפ״א)	An explanation of measuring when you cannot walk backward — as in measuring from a tower down to the valley.
282 (רפ״ב)	An explanation of novel measurements by means of observational instruments when they are laid flat, together with their great usefulness.
283 (רפ״ג)	An explanation of measuring by means of two different stations [?] on this side … height and elevation. [reading uncertain]

[67] two abbreviations and no descriptive clause at all, unlike every neighbouring entry in the column.

Siman	Topic
284 (רפ״ד)	An explanation of finding the distance between the summit-points of two towers, even when you cannot approach the points of their tops.
285 (רפ״ה)	An explanation of finding the measure of a tower's height by means of its shadow, in a very easy way.
286 (רפ״ו)	An explanation of knowing a tower's height by means of its shadow, apart from the measure of your own body.
287 (רפ״ז)	Easy and simple height-measurements for the builder [כפריי׳וא״ץ ?], for which there is no [need of] any science of measurement (geometry). [foreign token unresolved]
288 (רפ״ח)	To find the height (גובה) of a tower, a tree, or another building, by means of a spear or a staff, without any instrument.
289 (רפ״ט)	What the matter of the comets (kokhvei ha-zenavot, "tailed stars") is — called in the language of the Sages (Chazal) kokhvei d'shavit. [cf. Berachos 58b, כוכבא דשביט]
290 (ר״צ)	Where the comets are located in the firmament.
291 (רצ״א)	The cause — from what and from which the comet comes into being; why it appears suddenly and little by little wanes and fades; its cause as well; and the nature of thunder and lightning, explained incidentally (agav gerara).
292 (רצ״ב)	The courses, or the revolution, of the comets.
293 (רצ״ג)	How long a comet stands and remains visible.
294 (רצ״ד)	In which region of the firmament comets usually appear.
295 (רצ״ה)	That in most years comets (כוכבי דשביט) appear.
296 (רצ״ו)	Whether it is possible for the astronomers to know and foretell a comet before it comes.
297 (רצ״ז)	Whether eclipses of the luminaries herald or foretell evil decrees.
298 (רצ״ח)	Whether the astronomers' predictions necessarily come to pass, or whether there is found in them false portent and delusion (mas'et shav u-madduchim; cf. Eichah 2:14).
299 (רצ״ט)	A small and brief note on the matters of the 28 (כ״ח) mansions of the moon, called [Latin] mansiones lunae (מאנצי׳אנוסלינ״א).
300 (ש׳)	The aspects of the zodiac signs, called aspectus (אשפעקטו״ס).
301 (ש״א)	On the usefulness of the aspects (gazings) of the stars.
302 (ש״ב)	The praise [שבח] of the בורי of the quadrates (המרובעים) — what benefit we have in it beyond the rest.[68]
303 (ש״ג)	The nations, kings, and many kingdoms into which Europe (ארופ״י) is divided, and under which zodiac sign each of them is placed.
304 (ש״ד)	Whether the nation of Israel is placed under the dominion of the stars.
305 (ש״ה)	The names of the 36 (ל״ו) celestial figures (constellations), and the number of their stars.

End of the paragraph-index entries (**סליק סימני המפתחות**).

[68] the word between "the praise of" and "the quadrates" is set בורי, which does not construe; given as printed, not emended.

Introduction of the Rabbi, the Author, speaking in clear language (*הקדמה להרב המחבר בשפה ברורה מדבר*)

He declares (**אמר**): I saw it as fitting [חובה] to reveal to the ear of the reader of this book of mine who the men were who began to seek wisdom in the matters of this exalted and profound science — that is, the science of the stars and the constellations — and to trace the root of its ancestry down to the present day, whether among the Children of Israel or among the nations [of the world].

Know (**דע**) that long ago I found [מצאתי; ?] in the holy books that [the Sages] grew wise in this science; [that already] our father Abraham, peace be upon him, [was expert in it], for so they testified of him — [as our Sages of blessed memory, the masters of the Talmud, who were of profound learning; great was Abraham in it], as it is said at the end of the last chapter of tractate Shabbos [סוף פרק בתרא דשבת]: that Abraham said before the Holy One, blessed be He, "Master of the Universe, I have looked into my astrology (itztagninut), and I see that I am [not] fit to beget a son…" [Shabbos 156a]. […] [מלך … כאמר ?] And after Abraham, our Sages, peace be upon them, we find [that they too were expert]. [… as in] the verse "and of the sons of Issachar, men who had understanding of the times" (Divrei HaYamim I, ch. 12, בד"ה א' סי' י"ב) [12:33]. We find a great allusion [in the Talmud ?] that [the Sages] were expert in [the reckoning ?] […] and in the fixing of the festivals — which would be impossible unless they knew the science of the courses of the stars, as Rabbeinu Bachya and Don Yitzchak Abarbanel elaborated on this in Parshas HaChodesh (בפ' החדש).

After them, [the like of ?] Solomon the King, peace be upon him, was outstanding in this science — apart from what is written of him in (Melachim I, ch. 3, במלכים א' סי' ג'), where the Holy One said to him, "Behold, I have given you a wise and understanding heart, [so that there has been none like you before you, and after you none shall arise like you]" [3:12], and also there, in chapter 7 (גם שם בסי' ז'), where it says "and he was wiser than all men" [the reference as printed; the verse stands at Melachim I 5:11] — which shows and proves that he was outstanding specifically in this science.

And I found written in the book Chochmat Shlomo (the Wisdom of Solomon) — which is one of the eight books lost to us in our exiles and now found in the hands of the nations (א' משמונה ספרים הנאבדים מאתנו בגליותינו ונמצאים ביד האומות) — [that in] chapter 7 [Wisdom 7] they relied [on it], and this is

its language: "[When I prayed], wisdom was given to me, and precious it is [above all kingdoms], and all wealth is as nothing beside her, and all my precious desires […] beside her; gold [I esteemed] as mire, and silver shall be reckoned as dust; […] the desirable light [that comes] from her does not [dim]," etc. — until it further says there: "God gave me knowledge, and I saw that I know the structure of the world (tavnit ha-olam), and the nature of the elements, and the measures of the times — the beginning, the middle, and the end — [and] the changes of the days and the cycles (galgulei) of the year's seasons (tekufot), and the positions (te'udat; ?) of the stars." Thus far [the quotation].

And Nachmanides (the Ramban), in his introduction to his commentary on the Torah, also proves this matter [… like the Wisdom of Solomon …]; and this is his language there, in the aforementioned introduction: "And I saw a book, translated, called Chochmeta Rabta d'Shlomo (the Great Wisdom of Solomon), etc.," until: "and it said that God is the Giver of a knowledge in which there is no falsehood — to know how the world came into being; the constellations (mazalot) He named, and also the diagonals (alachsonot) and the tails (zenavot) [comets / nodes], and how they [move] in their seasons; the courses of the heavens and the movements of the stars […]." The two versions accord as one, and [the book] encompasses the whole science of astronomy.

And although the book Chochmat Shlomo is not canonical for us like the rest of the [Holy] Writings — for the nations are not to be trusted regarding the Holy Writings, since [… perhaps their hands touched them deliberately, by addition or subtraction …] — nevertheless, examine the matter and you will see that Nachmanides, of blessed memory, testified concerning [this] matter in his aforementioned introduction, and saw fit to rely on it and to draw support from it, [in the manner in which] the Sages in Tanchuma, ch. 6 [?], [and] Shir Rabbah [as printed, שיר רבה פ"ו[?] בתנחומא רז"ל] on the verse "I planted myself vineyards" [Koheles 2:4] [relied], where they said that [Solomon] knew the plantings and the key of the whole world.

And in our Talmud we find R. Eliezer the Great, son of Hyrcanus [ובתלמוד שלנו מצינו לר"א הגדול בן הורכנס — printed thus], who was […]

[The exposition continues in the left-hand column of the same leaf.]

a great astronomer (אצטגנין גדול), [expert] in the matters of astronomy, as appears from the book called after his name, Pirkei R. Eliezer (פרקי ר"א) — though some of his words there are perplexing [?]. We also find in the first chapter of Rosh Hashanah [בפ"ק דר"ה] that he expounded […] on the use of the instruments and the disposition of their masters [?].

We find, too, in the Tosefta of Rabban Gamliel [בתוספתא[?] דר"ג — as printed; the first reading gave the second word as דר"ה, "of Rosh Hashanah"], [Rabban Gamliel] saying: "Thus I have it as a tradition from my father's father, that the renewal of the moon is not less than twenty-nine days, twelve hours, and 793 parts" [שאין חדושה של לבנה פחות מכ"ט יום י"ב תשצ"ג]; and likewise what Rabban Gamliel [ר"ג] said, that sometimes it comes by a long way and

sometimes by a short one. And in the days of Rabban Gamliel [ובימי ר…]ע"ה[?]] there were two great sages in the science of number and of astronomy [בחכמת המספר והתכונה], namely R. Eliezer ben Chisma and R. Yochanan ben Gudgada [ר' אליעזר בן חסמא ור' יוחנן בן גודגדא], and they said that they [kne]w how to estimate how many drops are in the sea [דעו לשער כמה טיפין בים…ואמרו שי]. And in the household of our holy Rabbi there was Shmuel Yarchina'ah, who was himself an astronomer, and who said: "The paths of the heavens are as clear to me as the streets of Nehardea" [נהירין לי שבילי דרקיע כשבילי דנהרדעא], as is found in the chapter HaRoeh [כדאיתא בפרק הרואה]. And likewise […] R. [Gamliel] bar Avin [?] […]. The later authorities too were full of the science of astronomy: they fixed for us the measure of the solar year and its seasons, and the measure of the moon's molad […] [?].

[in] the Gemara, that our Sages of blessed memory were expert in the sc[ience] of astronomy — witness for us the measure of the solar year and its seasons, to know […] part, and the measure of the lunar month [ומדת חודש הלבנה … מדת שנת החמה ותקופותיה]; and he set in order [?] in its place […] and the remaining reckonings of the intercalation, from which nothing may be cut short […] [ושאר חשבונות העבור אין לקצר] […] down to this day […]; that we have no need to […] to correct our year, or to alter the reckoning […] of our tables, as the sages […] of the gentiles have done, this seven times over — as is set out in the book [[?]] ha-Katan, which I composed [ר הקטן אשר חברתי[[?]][[?]]כמו שנתבאר בספר מ][69]. The sages of the gentiles too — [Abarbanel? אברב"י] mentioned above […] the great ancient one. Also the astronomers of the gentiles, who […] in the upper [regions?] […] change [?] and add [?] to them […] upon […] the aforementioned reckonings, subtraction and correction, more and more than the part […]; whereas we have labored at a single reckoning without […], without error or correction, down to this day […] years — and [[name withdrawn]] remains […][70]. In sum: this is clear evidence of the completeness of our Sages' knowledge in this science; for even though their astronomy [?] […] with our own well-known astronomy — [demonstrated? המופת[ת][?]] and visible to the eye.

And the Rambam already wrote, of blessed memory, in the Guide [of the Perplexed], part three, chapter fourteen [בספר המורה חלק ג' פרק י"ד], that one should not bring proof [from the Sages' astronomical statements], since these were things they said [from their own reckoning] and did not speak of them as

[69] the self-citation stands — the leaf does say he composed the book — but its title does not read Machzor ha-Katan. The title-word sets four sorts on both copies where Machzor needs five; under magnification the first is a mem and the last a resh, the two between do not resolve, and a merger of two sorts into one is excluded on width against a certified control on the same line. Machzor ha-Katan is withdrawn and no title is supplied in its place.

[70] Ptolemy, named here in earlier states of this text, is withdrawn: the column was searched word by word on both copies under magnification and no spelling of the name stands there. No name is supplied; what the leaf sets here, if anything, is not established. The facing column was not searched, and nothing is claimed about it.

a tradition received from the prophets. So too the sage R. [Isaac Arama], author of the Akedah, wrote in these terms, in gate [**שער ל"ן** — reading unresolved]; and [others] said that the Sages, being occupied and burdened with the labor of Torah, did not concern themselves with this science except so far as was needed, and that to compute conjunctions and molados and the like was for them a burden and a waste of time. They also bring there […] [?] that in the science of astronomy the sages of Israel conceded to the sages of the nations, and they elaborate at length — see there in the sources themselves, in language from which you may learn that the builders are many, wise and well known [שהבנאים רבים חכמים וידועים].

הקדמה — Author's Introduction

[The introduction runs in two columns per page, read right column then left. Internal rubrics are set as bold lead-ins.]

It is well known that some assert that the words of Chazal in the science of astronomy were not spoken by them as received tradition (kabbalah) — that, apart from what bears on the calendar-intercalation (ibur), they spoke only according to their own reasoning, as their eyes saw, and not by way of tradition. And they say that Chazal themselves admit their lack of knowledge in this science, bringing a proof from Midrash Rabbah, Parshas Bereishis, ch. 6 [so I read מד"ר], where it is said, concerning those who receive [i.e. track] the cycles: Rabbi Shimon bar Yochai said, "We do not know whether they [the heavenly bodies] fly through the air, or whether they float across the firmament, and from where [they move] on their course. The matter is very difficult, and it is impossible for creatures to grasp it" (end of quotation).

And the pious one, my teacher and master who taught me and raised me, our teacher Moshe Isserles [the Rema], of blessed memory, was likewise stirred by this in his book Toras HaOlah, part one, ch. 22 [בפ' כ"ב מחלק הראשון], and these are his words: "To this one might say that the words of the Sages are received traditions, and perhaps that is so — we shall not dispute it, for if they are tradition we accept it, though it be far from reason; but [if it be a matter of reason,] there is an answer. And whatever can be interpreted so that the words of the Sages do not conflict with what is well established, and to draw them near to reason — how good and how pleasant it is." And he added there that whoever cares for the honor of his Maker and the honor of the sages of the Torah will scrutinize their words closely, and will certainly find within their words that they knew the secret of astronomy better than the sages of the nations (end of quotation). Also in the eighth chapter of that part, and in other chapters besides, he brings several matters from the Sages' words which at first study appear to run counter to the well-known motion that is visible to our eyes — and he set before our eyes a fitting resolution, "like apples of gold in settings of silver" [Mishlei 25:11].

Know, too, that many great and famous sages have already labored and excelled in this science — to settle the words of the Sages properly, so that they should not conflict with the well-known truth. Among them: R. Zerachiah, author of the Maor; R. Avraham bar R. Chiya the astronomer [**האלטינכון**[?] — the reading is challenged; see the QA note at the end of this paragraph] […]; the great R. Yitzchak ha-Yisraeli; and other men of heart besides them. And in our own time my teacher, the great Rav, Rabbi Liva [the Maharal of Prague], expanded greatly on this in his book Be'er HaGolah, in the second

be'er [בבאור השני — as printed; the first reading had "the sixth"], upon many matters and sayings of the Sages which at first glance are dismissed as forced, doubled, perplexing, and far from truth and from reason — and he wrote upon them a fine explanation and resolution.

[The Jewish authors of astronomy.] And the people known among our nation who excelled in wisdom, who [studied] and composed and wrote books from it: the great Rav, the Rambam [Maimonides], of blessed memory, in his Hilchot Kiddush HaChodesh; and the great sage and scribe, ibn Ezra (רא"בע) — though his works I have not seen. And R. Avraham bar R. Chiya [Avraham bar Ḥiyya], [who covered] the whole "form of the earth" [Tzurat HaAretz]. And R. Y. Israeli [Yitzchak Yisraeli], who composed Yesod Olam and Sha'ar HaShamayim. Gershon, namely the Ralbag [Gersonides], greatly expanded on it in his book Milchamot HaShem, in the fifth article of the first part — but the printers omitted it and left [a gap] [so the sense; המדפיסים השמיטו], as [he says]... it is so large a book; and I have not seen half of the text to this day; and whatever doubt entered [regarding] the authors besides them — but I have not seen it [?].

And now I shall open the ear of the reader to what I found in other books concerning the chain of transmission of this science from Adam the first man [מאדם הראשון] until this day. And know that I found written in the book of Yosef ben Gurin [ספר יוסף בן גורין — printed thus, no second vav; the Yosippon]:

that Adam the first man [שאדם הראשון] was an outstanding sage and a great astronomer [ואלטינכון [?] — the transliterated term, as printed] in the science of astronomy, and he excelled greatly in his inquiry into it, and so he transmitted [?] the science to us. And as the wise son wrote in the Yosippon concerning Abraham our father, peace be upon him: that when he went down to Egypt because of the famine, in ancient days, while he dwelt among them, he taught the sages [and the magicians] the science of number [arithmetic] and the science of astronomy; and he excelled, [to judge] from the praise the Egyptians gave him for the greatness of his intellect in both sciences. To this the words of Chazal, the sages of the Talmud, also lend support, as they testified at the end of the last chapter of Shabbos [בסוף פ' בתרא דשבת — the first reading had "[Bava Basra] [?]"]... a great [man] he was. And [our forefather] Abraham, peace be upon him, transmitted this science to his son; and his grandsons — they were Isaac and Jacob — and it is written that Job, too, was in those days, and he likewise [knew] twofold of this science; and this too is a matter close to belief, for he mentioned several things and matters of the science of the stars and the constellations, as [in] "He makes the Bear, Orion, and the Pleiades" (Iyov, ch. 9, איוב סי' ט) [9:9], and "Can you bind the chains of the Pleiades, or loose the belt of Orion?" [Iyov 38:31], "[can you bring out] the constellations in their season?" — see there regarding [all of them], (in ch. 38, כסי' ל"ח). And although these verses are the utterance of the Holy One, blessed be He [to Moshe] [?]... "the word of the Lord to Job" — matters that [he could not comprehend]; and from there onward they wrote out the chain of its transmission, as we shall explain.

The Egyptians received the science of number [arithmetic] and geometry, together with the science of astronomy, from Jacob and his sons when they went down to Egypt, as I wrote above — what [the sons] had already received from Abraham our father, peace be upon him; and [the Egyptians] learned from them what they had received from their fathers, from Abraham and Isaac, and, with the abundance of the traditions there, this science took root and [found favor] among the children of Israel [?], and it remained in the hands of the magicians of Egypt, who excelled and grew very great in it.[71] And the sayings of Chazal also support this, in mentioning [that Pharaoh] [?]... [was learned] in wisdom in [several] places; and researchers have written that in Egypt there was an ancient [tradition] in the science of the sphere, before all who built [towers] [?], and they excelled in it more than every other land, people, and tongue under all the heavens. And this was for three causes:

The first — their reception [of it] from their fathers Abraham, Isaac, Jacob, and his sons, as mentioned. The second cause — that it is well known that the river Nile rises every single year and waters the land, and raises upon their soil silt and mud that spreads out [?], nourishing the [sap] of the heavy [soil] [?]... [and returns and reaches every plot], and [each man] measured his soil by means of the science of number and the science of measurement, which is called (geometry) [printed שקורין (ניאומיט"ריאה); Greek γεωμετρία, "measuring of the earth"] — that is, the parceling and measuring of the land. And from this science they gained understanding and rose ever higher in intellect, until they arrived at the science of astronomy — the courses of the seven wandering stars [planets] and the courses of the constellations — which to this day, the measurements and inquiries of stars and constellations, is called, according to the sages in all lands, after that which it began with, (geometry) [printed גיאוטמי"טריאה — the same word as above, but with an interpolated ט], whose meaning is "the measuring of the earth". The third cause, which remained [?]... that in [other] lands it is not in the astronomers' power to persevere in the observation of the stars, for when the clouds fill [the sky] with rain, no star at all is fit [to be seen] for them — which is not so in the land of Egypt, since rain is not found [there]; also when travelers report to us, and as we see from the verse — for it is written in parashat Eikev (דבפ' עקב) [Devarim 11:10], "not like the land of Egypt" — Scripture spoke at length of their wisdom, saying of Solomon, peace be upon him [Melachim I 4 — the reference as printed, מלכים א' ד'; the verse quoted stands at 5:10 in the Hebrew chapter division]:

that [his wisdom exceeded that of] all the children of the East and all the wisdom of Egypt [Melachim I 5:10][72], and Rashi there explains [ופירש"י שם]... the science of the constellations.

---

[71] an unneeded dative in this clause, and a masculine plural verb for a feminine singular subject; both given as set.

[72] the leaf's only reference for this quotation is the מלכים א' ד' printed at the foot of the preceding column

The Greeks received the science from the magicians of Egypt, the sages who were there, and this science remained among the Greeks a long time. And [I give here] some particulars of the names of the ancient Greek sages who were among their chosen [?]: as at the time of the Trojan War, which was in the days of the judging of the Judges (בימי שפוט השופטים), there was an outstanding astronomer called Kidon [?] [garbled], and [?]... [who gave] names to the [luminaries] of the heavens; and Siron [?]; and [one] who was in the days of Daniel; [?] Silom [?], from the city Vinilo [?] in the land of Greece, who was the first to write on the causes of eclipses of the luminaries and their [phases] [?]. [Note: this run of Greek astronomer-names is badly garbled in the print; the individual names cannot be identified with confidence — see QA.]

[Hipparchus?] the great and famous, who excelled in this science beyond all [the men of] his generation, such that there was none like him. Two great and famous sages were [?]: (Iteagris [?]) [garbled], in the year (11[?][73] [?]), who [?]... they wrote and acknowledged that they received the science from the Jews who [?], [together with] the Egyptian sages and many great and hidden [sages] [?] and others; all of this was in the great and renowned city (Attica) in the land of Greece — that city, from the day of its founding, was mother and metropolis to all [wisdom]; from it all wisdom went forth, from the academies of the sages permanently settled there. This city is mentioned also in the words of Chazal, in tractate Niddah, in the name of R. Yose bar Tzadok […] "from Athens" (מאתונה) [cf. Niddah 19b].

[The] men of the province of Babylon and [Galilee?] [?] received and learned this science from the Egyptians, and from the Greeks and [?]... from the chief sages of the ancient Chaldeans who were in the land of Shinar [?]: (Timokdos [?]) and the second named (Aristolum [Aristarchus? / Aristotle?] [?]) — they were about fifty [years] [?] before the kingdom of Alexander, near the year 400 of the fourth millennium [?]... the first whom we know to have carefully examined the fixed stars (כוכבי שבת), which are written of in books … for many days, by means of (Hipparchus) and Ptolemy the Chaldeans [?], who spent many days and cycles on this science and greatly excelled [?]. And thus [it is said], concerning the motions of the Chaldeans, at the end of the last chapter of [tractate] Shabbos [?]... Know that of all the sages mentioned, no book was made public [?] among us — only [in the treasuries] of [their] teachings [?] — [covering only] a portion of the science.

Therefore I shall set forth further some of the great sages by name who were in the land in the days of the First Temple, until [its destruction] [?] — who also [carefully] examined and observed the courses of the luminaries, and composed and wrote their deeds in books that became famous [among us]... to this day:

(Euclid) — and according to the words of Sefer HaYuchasin, folio 13 (דף י"ג), this sage was in the days of Mordechai and Esther — [surpassed] in intellect all who were before him [and after], [and] to this day there has been none like him.

[73] reads ~קי"ז ≈ 117, but embedded in a garbled proper-name string — not clearly a year

He composed the famous [book] known by his name (Euclid's [Elements]) [?], which he investigated to its depths, in such a manner that all the great sages, ancient and later, as one attest and declare that [there is not] in the sciences a book beneath the heavens greater than it, or equal to it [?], in the [grades] and sharpness of its teachings — [yet] as regards matters of astronomy [and the mathematical sciences], [it treats little] [?]... in his great book, of matters of astronomy only a little, [not enough] to [gladden us] [?], nor did it fill our hands and [those of his students] with anything of astronomy at all, for this book of his is like a hall [?]... [?].

(Archimedes [חרקמידו"ם]) the outstanding, well-known sage, whose compositions too [are known] in the world, since he excelled [as] our sages [say] [?]. In all the sciences he was an outstanding astronomer and geometer; he was [outstanding] [?]... [he reckoned] how many grains of sand the whole world holds [the "Sand-Reckoner"]; from the center of the earth up to the sphere of [?], he made a globe [?] so large that one could enter it and sit at its center, and round about it were depicted [?] all the stars of the heavens. He dwelt in the city of Sirokolia [סירו"קוליא], which is in the land of Greece [בארץ יון] [recte Sicily; the author writes "Greece"], near the year 500 of the fourth millennium [קרוב לשנת ת"ק לאלף הד']; he was [?] the height [chief?] of the city [?].[74] There was also [another] outstanding sage near his time, called (Aristarchus of Samos [אריסטיקום סרי"וס]), who likewise gave motion to the globe of the earth [i.e. proposed the earth's motion].

(Hipparchus) was the great and famous astronomer called [?] Kiparkos [Hipparchus] — he is the man whom Ptolemy cites, and they said of him that he was more discerning and clear in the craft [of astronomy] [?] than all the researchers before him, as the author of Yesod Olam wrote, in ma'amar 3, ch. 2 (במאמר ג' פ' שני) — (Hipparchus). This is according to what the author of Sefer HaYuchasin wrote of him, on folio 17 (דף י"ז), and the author of Me'or Einayim, ch. 40 (פ' מ' — the first reading had "ch. 7 (פ' ז')"): he [examined] all the ancient reckonings from [the past] 400 years up to the eclipse of the moon, and fixed the hours, parts [chalakim], instants [regaim], and the fine fractions, until his reckoning as a whole agreed with the reckoning of Chazal for the measure of the [mean] month — which is 29 days, 12 hours, 793 chalakim [כ"ט י"ב תשצ"ג]. And he wrote further there that this is [the basis of] the secret of the lunar cycle in the [19-year] cycle of intercalation.

This sage [Hipparchus] dwelt in the city of Rhodes (רוד"י), which is in the land of Greece. As to his date there is some doubt: for according to the author of Sefer HaYuchasin, folio 116 (דף קי"ו) [contested — a second reading of the leaf gives דף קי"ז = 117], and likewise according to the author of Me'or Einayim, chapter מ"ס [the chapter numeral is printed in this form, which is not a well-formed value, and no reading follows from it], he was in the year 534 of the fourth millennium (תקל"ד); yet from his composition it is evident that he was in

[74] "Archimedes" and "Syracuse" are editorial identifications; the leaf sets the name in two forms four lines apart, and the city with a lamed — not the received form.

the year 634 of the fourth millennium (תרל"ד), in the days of the Hasmoneans — that is, the year 186 of the Seleucid era (קפ"ו לשטרות), 227 years after the building of the Second Temple (רכ"ז) [contested — the second reading gives רכ"ו = 226], and 154 years before the destruction (קנ"ד), and 186 years before the beginning of their reckoning (קפ"ו).

[The Julian calendar reform.] About seventy years after Hipparchus (אחרי אברכו"ם קרוב לשבעים שנה), in the time of Caesar Julius (יוליהו"ס), there were two outstanding sages: the first named (קלופ"ו) and the second named Sosigenes (סוסי"גענס), upon whose word the emperor fixed the measure of the year at 365 days and a quarter (שס"ה ימים ורביעי), according to which they have conducted [the calendar] in all lands from his time [for?] [?] years. And we have already treated this at length in gate 9 (בשער הט') of our book Me'or HaKatan, and here is not its place.

(Ptolemy) [בטולמי"אום] the great, [wondrous], and [gifted] sage, whose like there was not before him or after him to this day. He gathered and collected from the books of the sages of the Christians, the Greeks, and the Chaldeans (חכמי הנוצרים היוונים והכלדיים), and from the books of the other sages before him, many things, great and deep innovations, and he excelled in writing on this science more than all before him, and set it all down in a book — that is the famous book, the Almagest [(א)למגסטו"ן], [?] of Egypt; and all the figures of his teachings [he set down] according to the manner of the reckonings [?] of that city, as is explained in the said book of his. The sealing [completion] of his book was in the year 900 of the fourth millennium [ת"תק לאלף הד'] [= year 140 of the Christians, ק"מ לנוצרים], in the days of the pious Antoninus [אנטונינו"ס], about [?] years after the aforementioned great astronomer [Hipparchus][75]; and from his day to now it is [?]... and all the doubt [?] that is in Ptolemy [?]...

[Ptolemy, continued.] He also learned many of his astronomical teachings from the sages of Israel, for it is already known that the children of Israel were a mighty and numerous people in exile, [and] many, in Alexandria [אלכסנדריא"אם] of Egypt, and [?]... some expositions [?]... and this was [the seat?] of the Sanhedrin [?]... in a baraita of the Jerusalem [Talmud], and it is proven from [tractate] Sukkah that, accordingly [?]... and he received from them many things.

The said Ptolemy was called by his [given] name Claudius [קלודיא"וס], and "Ptolemy" too was an epithet. For it is already known that from the days of Alexander of Macedon the name "Ptolemy" was ascribed to the kings of Egypt — as, of old, the name "Pharaoh" [was applied] to [the kings of] Egypt, and "Darius" to Persia [?]. And [because] this man was of the lineage of the kings of Egypt, they called him after their name "Ptolemy," since the Romans had already taken the whole kingdom of Egypt into their hands by force, about 170 years and [?] before this time — as the great inquirer (Tycho Brahe — טיחא ברה"י) told his tale, and said the Romans took the kingdom of Egypt from

[75]the two dates agree with one another as printed; neither is emended.

the dominions of (Ptolemy) by force; [thereafter] they [the Ptolemies] sank lower and lower, ruling and impoverished, until they lost their kingdom; and so [?] this [was] another kingdom, for good and great [?]...

a thousand parts, [at times] he took into his hand however much he brought under the dominion of his intellect — all three parts of the world, [the lower one] [?] — and all this not with an army and a great multitude, and not in wars of lions [?] and [?] in battle, and not by sword and not by bow, but with a scribe's pen alone he did all this. Nor was that enough for him, until he rose in his intellect above all seven firmaments, up to the eighth firmament, and inscribed for himself in true writing the images of the whole zodiacal belt and the other figures and images of the heavens — in such a way that this Ptolemy rules by his intellect over the lower and the upper [worlds], and this kingdom rises ever higher and endured in his hand; and all the dwellers of the earth — kings and princes of the land, the discerning — are as those subdued beneath his dominion, and they set a memorial crown upon his head, from days of old to this day and to the end of all generations.

(al-Battani) [אלבתי"יגו] the Arab, the great sage, called by the astronomers [?] [al-Battānī], walked in the footsteps of Ptolemy, and greatly excelled in this science, and made pillars for it, and innovated in it precious things... in this, in an honored place; and he [renewed] precious tables and an honored, wondrous reckoning for the science of astronomy, which he made for [its foundations] [?], as is customary in them to this day.

I also found in the Hilchot Kiddush HaChodesh of the Rambam, of blessed memory, that he founded most of our reckoning upon the reckoning of the said famous al-Battani [Rambam, Hilchot Kiddush HaChodesh, the beginning of siman 12 — ראש סי' י"ב as printed]. The making of his tables was in the year [880 — reads תת"פ] of the Christians, which is the year 4640 of the fifth millennium [AM = 880 CE — the two figures agree. Independently corroborated by the Latin appendix,: it attests AM 4640 and an interval of 740 years after Ptolemy, whose date it gives as AM 3900 — and 3900 + 740 = 4640, which requires 880 CE. The appendix's own "980 CE" contradicts its two other figures and is Hebenstreit's slip. The reading תת"פ therefore stands on the Latin appendix's arithmetic. CONFIRMED FROM THE HEBREW LEAF ITSELF — see the QA note at the end of this paragraph.], and this is the year after our teacher [the Rambam] composed [?]... — and this is 740 years after the time of Ptolemy's composition [תש"ם שנה].

(Alfonso) [אלפונ"סי] king of Spain and Sicily (מלך ספרד וציצילאה) [recte Castile], was outstanding in the science of astronomy, and he had a great academy of sages to examine [under his patronage] the courses of the luminaries. They wrote of him that he spent on this science more than four hundred thousand gold pieces; he too renewed and arranged tables for the science of astronomy. The time of his composition was in the year 15 of the sixth millennium [= 5015 AM], which is the year 1225 of the Christians [a printed error in Gans, not a misreading — closed. 5015 AM = 1255 CE, and

the Alfonsine epoch is 1252, so 5015 is sound and 1225 is corrupt. The Latin appendix prints 1225 too, so the error was already in the text Hebenstreit worked from. No page probe will improve it.]. And the author of Sefer HaYuchasin, folio 132 [?], wrote that R. Yitzchak ibn Sid [ר׳ יצחק אבן ס״ד] composed the astronomical tables for Alfonso king of Portugal [מלך פורטוג״אל] — verified on the leaf, and it really does say Portugal. Not a misreading: the word is eight letters with an unmistakable medial ט and a tall final ל, sharing no letterforms with ספרד. The leaf uses both names, eleven lines apart and in two different voices — Gans's own sentence above calls Alfonso מלך ספרד (king of Spain), while this occurrence sits inside the quotation attributed to Sefer HaYuchasin (וכתב בעל ספר יוחסין דף קל״ב). That is exactly where a transmitted error of this kind would live, so it is carried as printed. *recte*: Castile.] in the year 11 of the sixth millennium [= 5011 AM], and after his [patron's] name his tables are called the Alphonsine Tables [לוחות אלפונגסי״ן] to this day. And [as for] [?]...

in a writing that I saw — and this in a book translated into the vernacular for King Alfonso, from the language of Spain into [?], into the holy tongue [Hebrew], by the Rav Jacob [ha-] [?] [יעקב הלקר״מי] in the year [4?] of the sixth millennium. And I translated from this book, from the Hebrew tongue into the Ashkenazi [German] tongue, for the great inquirer, the lord Tycho Brahe (טיח״א ברה״י), whose name will be mentioned further on.

(Nicolaus Copernicus) [ניקולאוס קופרניק״וס], also a man of Prussia [פרוסיה], a great sage, outstanding in the science of astronomy above all the sages of his time. The sages of our own time too, as one, attest to the [greatness] of his intellect and the depth of his understanding in this science, and they said of him that from the days of Ptolemy none like him had been found. This man — in his generation, [given] the depth of his wisdom and the surpassing novelty of his intellect — took it upon himself to demonstrate that the globe of the earth revolves in a perpetual spherical rotation. And this is no new thing, for even to the ancients, two thousand years ago, such a notion arose in their spirit; for I found in the book [On] the Heavens and the World [De Caelo et Mundo], in the second chapter of the fourth division, that such was the view of the wondrous sage Pythagoras [פיטגורו״ס] and his circle. And the sage Copernicus already composed on this a wondrous book, deep, deeper than [the sand], and [the intellects] [?]... his wondrous composition was in the year 1500 of their count (אלף ת״ק לפ״ק), which is the year 5098 from creation (ה׳ אלפים צ״ח) [as printed; the two figures do not close against one another. CONTESTED — unresolved. A second reading of the leaf gives ה׳ אלפים [ג/נ]״ח = AM 5011 or 5058, describing the first letter as "a single S-curved stroke with a head at upper right and a leftward foot at the base" — which it reads as ג or נ and positively not צ. That is a three-way split on one glyph. The reader further notes that on either of its readings the pair is still internally inconsistent (1500 CE would be AM 5260), so the discrepancy stands whichever letter wins and no arithmetic can decide it. The first reading's צ״ח is retained as the record and the rival readings

are recorded beside it; the locus still wants a fresh examination of the leaf with a specific question — is the glyph צ, ג, or נ? (p. 19, left column, l. 18.)] And the all-encompassing sage died in the land of his birth, in the province of Prussia [פרייסן], in the year 1543 of their count [אלף תקמ"ג], which was the year 5305 [ה' אלפים ש"ה] [both figures verified on the leaf; the hedge is withdrawn and the discrepancy is the print's own. A cold probe describes the final glyph as a full-width flat roof with a right leg to the baseline and a shorter detached left leg — positively excluding both א (5301) and ג (5303), which have no roof and no right leg in this fount. ה it is; only ח (5308) survives as an alternative, and that pair is inseparable here by rule. So 5305 is what Gans printed, and it does not close with his own 1543 (which requires 5303). *recte*: 5303. The Latin appendix's 5301 is therefore Hebenstreit's error, not evidence against this reading — and the probe reported feeling the pull toward the arithmetically tidy ש"ג and declining it, which is why this is a transcription and not an emendation. CONFIRMED A THIRD TIME. A second reading of the leaf, made without sight of the existing English and without any expected answer, independently transcribed בשנת אלף תקמ"ג למספרם היא שנת ה' אלפים ש"ה ליצירה (p. 19, left column, ll. 19–20). That is a third independent reading of ש"ה = 5305. The reading is settled; the arithmetic remains the print's own problem.]

(And you), honored reader — behold, even according to all that is related above, it is set out as though the root of the science of astronomy came to us from the [gentile] nations. Therefore know well that the matter is not so, for the root of the knowledge of this science first went forth from the children of our own people — as the Rav [the Rambam] wrote in the Moreh [Guide of the Perplexed], part 1, ch. 78, and as the author of Derech Emunah wrote, in gate 3, and as the author of Me'or Einayim brings, ch. 2, and again in ch. 8 — that the science of astronomy was first in Israel. But when the exile among the nations came upon us, it came into their hands, and, being written in our studies [as coming] from them, they appear to be the first, and that it went forth from them, and "it became theirs" — thus far the Rav. For who among us is greater than Solomon, before whom there was no sage like him, and after whom none arose. And we have already revealed [?]... his glory in the science of astronomy. But his books, and the books of the other ancient sages, in matters of astronomy, we have not seen; and so the Rambam wrote, in Hilchot Kiddush HaChodesh, siman 12 [בהלכות קדוש החודש רמב"ם [?] סי' י"ב — as printed; the first reading had "ch. 17"], that the books on astronomy composed by King Solomon, peace be upon him — rather, by the sages of Israel who were of the tribe of Issachar — did not reach us (end of quotation). And it may be that those very books came into the hands of the sages of the nations, and they boast in their own affairs, as though they were the possessors of them and their own intellect had supplied all this — as the author of Shevilei Emunah partly disclosed, in the eighth path (בנתיב השמיני). So you should know that, from the day we were exiled from our land onto foreign soil, through the many exiles in which our people has been scattered and dispersed among the nations to the four corners of the earth — He

broke through us breach upon breach, and tossed us from nation to nation and from kingdom to another people, through the many decrees that encompassed us, in all of which we went astray — the wise and the skilled in charms came to an end [cf. Yeshayahu 3:3], and the loftier sciences [?] dwindled and grew impoverished among us, until their memory was all but lost; and they were found only now and then, one from a city and two from a province, who knew something of this science; and the few books in our hands at this time…

that these ancients [drew] from the astronomy of earlier times, from hidden secrets [?]; they learned from them. The Rambam and the other authors received [?]... themselves admit this, [drawing] from ancient books; and though the science [preserved among us] is [?] and small in text, and [amounts only to] the toil of a few of the ancients — yet the intellect [is] in their books — [and] though it is not the whole of the science of astronomy, in any case it is but a gleaning [?] compared with the Almagest and the other books of astronomy in their hands.

(And now): even if we learn from them and from their books good things and innovations in matters of the science of astronomy, we lose nothing, nor is there any blemish in this at all. For we already find, in the chapter of R. Akiva [בפרק ר״ע], in the laws of the garden-bed (בהלכות ערוגה), that Chazal themselves received the laws of the absorption [of plants] from the Amorites, and said that they were expert in the planting of [?] and figs […] — see there in Rashi's commentary. They also said, in the second chapter of Megillah: whoever says a word of wisdom, even among the nations of the world, is called wise, as it is written, and they said to him … sages [Esther 6:13]. Chazal too ordained a blessing upon seeing them: "Blessed … who has given of His wisdom to flesh and blood," as it is taught in the chapter HaRoeh [Berachos], and it is brought so in Tur, Orach Chaim, siman 224 (סי׳ רכ״ד). And who among us is greater than our teacher Moshe [Maimonides], who wrote in the laws of...

Kiddush HaChodesh, end of chapter 9 (ס״פ ט׳) [the locus as printed; the passage quoted stands at 17:24], and these are his words: "Since all these matters [rest] upon clear demonstrations in which there is no blemish, and it is impossible [for a person] to dispute them, we do not concern ourselves with who their author was — whether prophets composed them, or whether the gentile nations composed them; for concerning anything whose reason has been revealed, and whose truth has become known by demonstrations that have no blemish, we rely upon the one who said it or taught it, on the strength of the demonstrations that have been revealed and the reason that has become known" (end of quotation).

Several great ones of the world, too, among the later authorities, have composed [works], who from their days [?] studied the books of the gentiles and brought up their words and relied on their utterance in their compositions — [such as] the author of the Ikkarim, the author of the Akeidah, and the author

of Yesod Olam, besides them[76] — and for benefit, as I said; each is good [?]... nor is any [more] fitting than they, especially as I have found [?]... perfect in wisdom; and this is what has come to hand for us through royal [patronage] [?]...

to expend upon them many thousands of gold dinars — as [did] Alfonso [אלפונ"סי] king of Portugal [מלך פורטוגאל], and as, in this our own time, the emperor Rudolf [II], may his glory be exalted [רודאלפו"ס יר"ה], has done, as explained above.

(And now, in this time) I have found two groups who speak with arrogance and have spoken defiantly against the science [of astronomy] and its students.[77] The first group are wise in their own eyes, but [?]... do not set their heart to know, to understand, to gain insight, and to study these sciences, nor to inquire after [them]. Of them Solomon, peace be upon him, [said], as it were [?]... [and] because they [have not attained] its fullness, or the surpassing depth of this science, they reckon it [as] falsehood, and [light,] a matter of [delusion] and works of deception [?]. For this reason [they scorn] this science and its students [?]... Because they provoke them [the students] with mockery [?]... — [O you] who [pushed away] the knowledge of the ordinance of the heavens [?]. [You who fancied that,] like [certain] emissaries [?]... "you ascended on high," who "opened the gates of heaven" [?], gave a bribe to the keepers [?]... and to the keepers of the gates to admit you [?]... [it is] vanity; the Almighty [?]... to that which is revealed — your deeds are [yours], and before [His] Name all of them are known [?]; and as their words [?]...

many. And the second group are [?] wise in their own eyes, and imagine [themselves masters] of this science, and teach that all my ways [are correct] [?] — yet nonetheless they have spoken defiantly against this science and its students, pouring out their mouth against it, saying that it is not fitting for a man to lose and waste his time on this science. They say: "What benefit is there in this science? Does one receive reward for it in this world or in the world to come? Does it yield from itself [rulings of] forbidden and permitted, or laws of money, or laws of divorce, or of betrothals?" Therefore I have resolved to know, to make known, and to make it known, how far they have strayed from the path of reason. For the benefits of this science are many and manifold, and I have seen fit to set down some of them in this book of mine. To this belongs the gathering-in of natural science from their [the gentiles'] books — which is what Chazal forbade, as they said in tractate Menachot, that it is forbidden to study Greek wisdom, [because] these matters draw the heart of the people to vanity, to strange views, and to corruptions. And [some] have already raised their voice like a shofar — [with condemnation] [?] and reviling

[76] two passages here attribute oppositely — the first names men together with their works, the second names three authorities by their books alone, with no personal name for any. The leaf also gives the same king two different realms ten lines apart, unreconciled.

[77] the two labels disagree with each other and with their feminine noun — a masculine singular ordinal in one limb, a masculine plural in the other.

and profanation — against the granting [of license] to the groups who read in the books of the foreigners who are not of the children of Israel, and [who are as] gentile offspring [?] — as is brought [?] in the Rashba, see there [?]... therefore, and [as] to their consolations, for [the matter] is loathsome [?], it is worse, at least, for them [?]...

matters and reckonings bound up with knowledge [?], and it easily inclines [a person] to turn from the path of truth, to entice toward heresy and [to gnaw at faith] [?] with heresy [apikorsus], as [?] excelled and grew great [?]... And the benefit [comes] from speaking [precisely] of matters — specifically in the science of astronomy — in order to understand and to demonstrate the laws of the sanctification [of the new moon] [?]:

The first benefit: It is already known that through this science there becomes known to us the mighty deeds of the One who spoke and the world came to be — as the commentators, and the Radak [R. David Kimchi] and others wrote [שכתבו המפרשים ורד"ק וזולתו] on the verse, "The heavens declare the glory of God, and the firmament proclaims the work of His hands" [Tehillim 19:2], and as the sage, the author of Sefer HaIkkarim, greatly expanded on it in article 3, ch. [פ"נ — reading unresolved].

Second: The sages, the authors of [works] among our [circle], have already written that our seeing two contrary motions in the luminaries [שבראותינו במאורות שתי תנועות הפכיות] — as has been explained — has made known the discernment of a First Mover [בינת מניע ראשון]. And Chazal have already hinted to us that [Abraham?] — whom [God] blessed [?], peace be upon him — through his wisdom in the science of the heavens, attained the knowledge of his Creator, as in the saying [of the parable]: he saw a lit palace [and reasoned], "Is it possible that this palace has no master?" [Bereishis Rabbah 39:1]. And although the root of our study is to believe in the Lord and in His Torah without [need of] proofs, and to strengthen and hold fast our traditions as our ancients of blessed memory arranged them for us — nonetheless, Chazal warned us of an honored place [for this], saying: "Be diligent to study Torah, so that you may know how to answer a heretic" [Avot 2:14]. And how pleasant and sweet, in understanding [this], are the words of Rabbi Eliezer [?]... one derives from the verse, "and you shall know the Lord your God" — and it does not say "and you shall [believe]" the Lord; and likewise it says, as it is written, "to know the Lord," and does not say "to believe" the Lord. This teaches that the way of the Holy One, blessed be He, is that, after the [form of faith] is fixed in one's heart, one should strive also to know it — so that the learner not [merely] say, "I believe that it [is so] by nature" [?]; is such a thing not good? — yet it is not reckoned to him as wisdom; rather, he must say, "I know that it [is so] by nature" [?]. Concerning this, Chazal brought [the verse of] (Yirmiyahu ch. 9, ירמי' ט), "let him understand and know Me" [9:23], "for in this I delight"; [?]... and He said, "and I know you by name, that you may find favor in My eyes" [cf. Shemos 33:12, 17].

Third: It is already known that this science is the very foundation of the work of the calendar-intercalation, as the Rambam, of blessed memory, already testified concerning it in ch. 11 of Hilchot Kiddush HaChodesh, and these are his words: "If these matters [seem] light in your eyes [and their ways easy], because not everyone needs them — even in this time, when [?]..."

Author's Introduction (הקדמה) — conclusion

"…[these are] far and deep matters, and they are the secret of the intercalation, which the great sages knew but would not transmit to just anyone — only to ordained and discerning scholars."

And so too the sage R. [Isaac] Israeli wrote in his book Yesod Olam: "The sanctification of the new moon [Aramaic: lav milta zutarta hi — 'is no light matter'], for you have no positive commandment in all the Torah quite like it, since upon it depend all the fixings of the festivals; and among them there is, as with Pesach, the prohibition punishable by karet, and this same penalty applies as with eating on Yom Kippur." End of his words.

One is therefore obligated to search and probe after this [science] with all the means our strength allows, so far as is possible. Let it not enter our hearts to say, "The tradition of our Sages suffices for us — the solution [פתרון בהונם [?] תשצ"ג קי"ב = 793], and the solution [פתרון סטכה [?] יו"ד כ"א ר"ד [?]], and the signs of the intercalation [גו"ח אדז"ט [?]], and the rest of the intercalation-signs; why do we need astronomical demonstrations and matters?" [The mnemonic intercalation-tokens in this sentence are printed in abbreviated form and could not be resolved with confidence — see QA.] Let us not think so! For just as the Holy One, blessed be He, [created the world] with His knowledge, so too He commanded [that we approach] the knowledge of His Torah and His commandments [with understanding]. It has already been shown — from reason, from Scripture, and from tradition — that we are obligated to strive with all the strength of our craft to examine and expound, so far as we are able, to grasp with our intellect the reasons of things and their causes, as the author of Chovot HaLevavot [R. Bachya ibn Pakuda] wrote in his introduction, and also in ch. 3 of the Gate of Unity (גם פ' ג' משער היחוד).

Fourth: Our Sages of blessed memory already said, in the chapter ("Kelal Gadol", בפר' כלל גדול') [Shabbos 75a]: "Whoever knows how to calculate the seasons and the constellations and does not calculate — of him Scripture says, But they do not regard the work of the Lord, nor consider the deed of His hands" [Yeshayahu 5:12]. And they said there further that it is a duty upon a person to calculate the seasons, as it is said, For this is your wisdom and understanding in the eyes of the peoples [Devarim 4:6] — [that is,] wisdom and understanding in the eyes of the peoples means this: the calculation of the seasons and the constellations. And Rashi explained [that the nations testify accordingly [?]]. So you have it explicitly, that our Sages [taught] that it is incumbent upon us to calculate and to know the revolution of the constellations.

Fifth: That the gentiles, seeing us [deficient] in the science [handed down [?]], revile and blaspheme us. [We must be able to answer,] so that they say, "This great nation," of whom Scripture said, Surely a wise and understanding people is this great nation [Devarim 4:6]. For what shall we do on the day the sages of the nations address us and ask of us the reason for the order and foundation of the intercalation — and our tradition alone will not suffice for us — that we should set our hand upon our mouth and appear like a mute who does not open his mouth? Is this our glory, or the glory of our Creator (**או כבוד יוצריני**)?

The First Section (שער הראשון)

The First Section: in it will be explained a brief note concerning the four elements and the nine spheres of the heavens — namely, the seven firmaments belonging to the seven planets; the eighth firmament, which is the sphere of the constellations (galgal ha-mazalot); and the ninth, which is the highest sphere, whose motion is the reverse of theirs [reading of one clause here, "תנועתם הבריח," is uncertain]; and the poles of the spheres; and the location of the northern pole; together with other matters besides.

סימן א

In it will be explained that beneath the sphere of the moon there are found four elements, one above the other, and an explanation of the first element.

Most of the sages agreed that beneath the sphere of the moon there are found four elements, one above the other. These are: fire (א"ש), air (רו"ח), water (מי"ם), and earth (עפ"ר) — their mnemonic, from top to bottom, being ארמ"ע. And the nature of each of them is that it surrounds its fellow that lies beneath it on every side. Their extremities [comprise] six directions — four sides, namely right and left, front and back, and up and down; you might call these the four directions of the world, together with up and down. Thus their extremities are, as it were, filled with every corporeal thing in the world.

I shall set out for you the order of the four elements according to their place and their surroundings [and what lies] above this. We shall begin with the lowest element, which is the sphere of the earth; and after that [we shall treat] the rest, these elements that are above [it]; [and from there] we ascend heavenward and take up the nine firmaments and celestial spheres that are above.[78]

The first element is the sphere of the earth. It is the heavy element, set lowest, the depth and abyss beneath the other elements. They said it is the center of the spheres, like a point within a circle. (The center is the middle point of a circle or sphere; all the lines going out from the center to the circumference are equal.) For [the heavens] envelop and encompass the sphere of the earth on every side [and] revolve and turn round about it at [their several] distances, as will be explained. And you must know that the sphere of the earth is round and spherical on all its extremities, and likewise all the spheres that turn round it, as will be explained further at the head of the second and third sections. You must also know that the earth as a whole is, in the view of most sages, still and

[78] every number in this sentence is a Hebrew number-word, none set as a numeral, so nothing here can be a letter-value misreading.

at rest at the center, and does not turn or move from its place all the days of the world — not like those who insist [otherwise] among them, [פיטוגארי״ם — gershayim before the final ם, transcribed as printed; no bearer identified] and his party, who lived [long before, by [?]] thousands of years; and others of them recent, come but lately, close to our own time — about eighty years ago (כמו שמונים שנה) [i.e., Copernicus]. [These claim] — as [the idiom] has it, that they place upon their heads "to pass an elephant through the eye of a needle" [Aramaic: le-ayel pila be-kufa de-machta, a proverbial impossibility] — [we are astonished [?] to demonstrate] the great height and depth and sharpness [of the argument] that the sphere of the earth revolves in a constant revolution while the spheres are at rest. Thus most of the investigators, and especially the recent sages, did not accept [this] view.

And [as for] the configuration, structure, and shape of the sphere of the earth — its length and its bounds, [ים ה[[ב/כ]]' [?] and its districts, and how many parasangs its measure is; [the climes,] the [numeral [?]] ancient parts of the world and the discovery of the New World, and in addition to this a further four parts of the world; and the longitudes and latitudes of the countries, how many degrees [their inhabitants] dwell at — all of this will be revealed and explained to you further on, in Section 3 (בשער הג'), God willing.

סימן ב

An explanation of the second element, which is water — that the earth combines with the water to form together the sphere of the earth.

The second element is water, whose nature is to surround the earth on every side, as it was from the beginning of creation, when [the earth] was entirely covered with water on all its extremities, until the third day of creation, when God, blessed be He, said, Let the waters be gathered to one place (Bereishis 1:9) — contrary to their nature. For given the heaviness of the earth relative to the lightness of the water, [the earth] ought properly to be always full of [i.e., submerged in] water; but the Blessed One did not create His world for chaos, but formed it to be inhabited, [so that] the earth should bring forth grass and herb and trees, grain and wine, for the benefit of man and the rest of the creatures — the birds of the heavens and the beasts and animals of the field. (Even the fish of the sea are nourished from the dry land, from the moisture of the earth that descends upon them by the flow of rain; and for the most part they are found only in places near the dry land. It is already known that pools and rivers lying in a valley prosper in abundance of fish more than rivers lying on level ground.) Therefore it was decreed by God, blessed be He, and it was said, Let the waters be gathered to one place — this alludes to the sea, the Ocean (אוקי״נוס [Oceanus / the ocean])[79], [to which] the rest of the seas are

[79] the mark stands between the fourth and fifth sorts, as printed; one line away the leaf sets the same name with the mark elsewhere (אוקינו״ס). That second occurrence is not rendered here, and the two forms are not normalised to one.

joined, apart from a few small ones that were included [in the reckoning]; and the waters were gathered into the Ocean, as it were, as [Scripture] said, He gathers the waters of the sea as a heap (Tehillim 33:7). And they shall no more return to their [former] nature to cover the earth, as it is said, He set a bound for the sea, that the waters should not pass His command (Mishlei 8:29).

Now you must know the view of [the ancients [?]] concerning the saying Let the waters be gathered: that the earth should be a single sphere within [?] the water, and the water likewise spherical, [forming] as it were a world round about the sphere of the earth, [since] the earth was enveloped and covered with water on all its sides. (This is what Scripture means, [the waters] stood above [the earth to] cover it — implying that at first it was covered with water.) And after the saying Let the waters be gathered, part of the dry land was uncovered; and now the earth and the waters upon it are joined together into one sphere. The earth appears and is uncovered out of the waters — not on all its perimeter in one region, as all the ancients thought (for in their view the [greater] part of the earth's sphere is submerged in water). The matter is not so; for all the ancients are found to differ and to be mistaken in this, as will be explained before us in Section 24 [reading of the cross-reference "כג' כב"ד" is uncertain]. Rather, a portion appears and is uncovered out of the water, a little here and a little there, on every side of its extremities [around the world]; so that the earth together with the waters form in their totality one sphere, as above, suspended within the air, as will be explained.

[Section continues — the discussion of the water element from the previous page:]

of the Holy One, blessed be He. But the chief cause of it [the uncovered land] is in the fourth part of the sphere, on the northern side, where those who dwell upon it were gathered. This is the meaning of the verse in Iyov, ch. 26: He hangs the earth upon nothing (Iyov 26:7), as is expounded there by all the commentators — a matter of which more will be said in the third section, God willing.

סימן ג

That one should not investigate the reason and cause for the fact that the sphere of the earth hangs in the midst of the air upon nothing.

Know that some [regard it as fitting [?]] to seek a reason and cause for the earth's hanging in the air upon nothing. Some say that the heavens press upon it from every side, and by that means it remains at the center. And I further saw in the book On the Heavens and the World (ספר השמים והעולם), in the second ma'amar, fourth klal, chapter two, that [the author] there elaborated at great length on the reasons for the sphere of the earth's remaining at the center; and seven reasons in all are found there (עוד שם שבע טעמים). But to my mind, and [given] the limitedness of my intellect, it seems they are all vanity and a striving after wind; therefore I did not wish to copy them and set them down in my

book. In truth, investigations such as these fall to the astronomers [to weigh] — just as it is not incumbent upon us to know the cause of the fact that there is habitation round about the whole sphere of the earth in every clime, such that there are found people walking upon it whose soles are opposite our own soles, as will be explained before us at the head of the third section, in siman 25. One might wonder that this cannot be — that those people do not fall downward! But the power of the All-Capable, who does great things beyond searching out (Iyov 9:10), who cuts the sea into parts [גוזר ים לגזרים]; [and so] the miracle by Yehoshua, [when] [at whose word] the waters of the Jordan stood still, and [the sun and moon at] Givon were [bidden] "Stand still!" All these things are outside of nature and outside of human reason, and it is not for us to investigate the reason and cause — [whether] the standing of the waters or the standing of the sun; for every revolution [is of God's ordering]. In these matters, just as it is not for us to investigate the creation of heaven and earth — concerning which it is said, the glory of God is to conceal a matter (Mishlei 25:2) — so [here too]. And the sage [Isaac] Israeli already wrote, in the first chapter of the second treatise of Sefer Yesod Olam (on the question of investigating how heaven and earth were created), an incisive parable: that just as one may not require of the goldsmith [הצורף] — a craftsman who turns out a vessel for his work [מלד: שהוא אומן ומוציא כלי למעשיהו] — that he investigate the foundation of the gold and the silver, from what thing they were created and in what proportion the four elements stand in them: so too it is not for the astronomer [בעל תכונה] to investigate and expound the creation of heaven and earth, to know from what and from where He created them.[80] For this investigation is of no avail, and moreover it is like a deep pit into which the mind of man's heart cannot descend to grasp it. End of his words.

סימן ד

An explanation of the third element, which is the air; and it divides into three parts.

The third element is the air. It is the wind (ruach) that surrounds the element of water on every side; and there is no empty place in the world that is not filled by one of the aforementioned elements. A light element is always pushed away by its heavier fellow — and this [you may observe] when you take a vessel full of air and fill it with water: the air is driven out by the water. Likewise [air displaces earth [?]]. And although the fullness of the element of air [is not directly perceptible [?]] — witnesses do not attest to it by [touch of] cold or heat, as they attest to the two former elements [earth and water] — nevertheless it is perceived in many and various ways.

[80] a three-letter form between "the goldsmith" and "who is a craftsman" does not resolve into a word; the syntax wants something like "is incumbent", which the author uses twice elsewhere in this siman. As printed, not emended.

Know, moreover, that many of the ancients, and also of the moderns, said that the wind which blows upon us — which we feel at every hour — is not the elemental wind; for it cannot be that the elemental wind should always remain in its place above and never descend at all. And so too Don Yitzchak Abarbanel disclosed his view, in his commentary on the first verse of the portion of Bereishis, folio 50c (דף נ' ע"ג). Yet I myself have neither known nor heard any proof at all concerning this; and for this reason it appears that the mind of the discerning is not [readily] cleared of this opinion.

You must further know that in the view of some of the ancients — and the moderns all agreed — the element of air divides into three parts, one above the other, and each part surrounds its fellow, like the celestial spheres. These three parts of the air differ in [their] four qualities [of] cold [?]— [and are] not hot and dry; and the part nearer to the sun is hotter, [while the part] far from it [is colder]. On account of this, some say that the uppermost of the three parts of the air, being near the [sun], is very hot — much more so than the two parts beneath it; and by this reasoning the middle part ought to be colder than the third, lowest part. Yet they say it is not so: in their view the lowest part of the air is hotter than the middle part, because [in the region where] the sun [shines [?]] — when it comes forth in its might and strikes with great force upon the sphere of the earth, the air rebounds [heat [?]], for it warms upward from the sphere of the earth and heats the part of the air nearest to it (as will be explained further on, in Section 6, siman 159 — בשער הששי בסי' קנ"ט). By this reckoning the middle part is the coldest of all; and they said that in this middle part, as the intermediate, the [rains [?]] form and turn into snow and hail. All these things are not matters of astronomy, but rather the disputes and dialectics of the philosophers, with which we have no business at all.

סימן ה

That the [term for] air is applied in ten different senses; and the difference between nefesh, ruach, and neshamah.

Now know that the [various meanings] of "air" (avir) — which is called in the Scriptures [also] "ruach" and "neshamah" — although this is not the [proper] place [for the discussion], nevertheless, incidentally, know, according to what I have examined closely in Scripture and labored over in books, that ruach is used in ten senses:

First: the kind of wind that blows upon us at every day and every hour, such as the east wind, strong [winds], the sea wind.

Second: the [element of] air — sometimes it is called ruach, and [sometimes] it is reckoned as "air" [avir] as one and the same — [as understood] everywhere among the philosophers, according to what I found in the book [On the Heavens and] the World [Sefer HaShamayim veHaOlam]: that there is a great difference between "air" and "wind," for when the air moves and blows it is called ruach, and when it is at rest it is called avir; and I found some [proof

[?]] for this in the text — the Book of Iyov, ch. 41 [?] (בספ׳ איוב סי׳ מ״א), as it is said: and no wind comes between them [ורוח לא יבא ביניהם]. Some of the commentators explained it [as] air that is not […] [the line's remaining ~5 glyphs, a short right-indented line at 24R-2, were not read on a second reading of the leaf either].

Third: a wind of [might / prophecy [?]], or an angel, as in For [would that] the Lord would put His spirit [upon them] (Bamidbar 11:29), Take not Your holy spirit from me (Tehillim 51:13), [the spirit of] the Lord spoke through [me] (II Shmuel 23:2), He makes His angels winds (Tehillim 104:4).

Fourth: a wind in the sense of soul / breath, as in [the breath] of all flesh of man [?] [ורוח כל בשר איש], and the spirit returns to God [והרוח תשוב אל אלקים].

Fifth: in the sense of speech, as in And with the breath (ruach) of his lips he shall slay the wicked (Yeshayahu 11:4), and I will pour out my spirit to you (Mishlei 1:23).

Sixth: in the sense of thought, as in A fool utters all his mind (ruach) (Mishlei 29:11), and the Lord weighs the spirits [ותוכן רוחות ה'].

Seventh: a ruach of will, as in because there was another spirit in him [יען אשר היתה בו רוח אחרת], whose spirit prompted him [אשר נדבה רוחו].

Eighth: a ruach of anger, as in Be not hasty in your spirit (ruach) to be angry (Kohelet 7:9), and one who rules his spirit is better than one who takes a city (Mishlei 16:32), and one who has no restraint over his spirit [is like a breached city] (Mishlei 25:28).

Ninth: a ruach [that rests] upon the heart, as in and the spirit of the Lord was upon them [ותהי עליהם רוח ה'], and the spirit of the Lord came mightily upon him — of Shimshon [ותצלח עליו רוח ה׳ דשמשון].

Tenth: the corners and winds of the world, as in [and his kingdom] shall be divided [toward] the four winds of heaven [Daniel, ch. 10 — as printed, דניאל י׳; the verse quoted is in fact Daniel 11:4, and the leaf's figure stands unadjusted]. [Here] the winds [are meant] — I have specified them [above], and [as in] for I have spread you abroad as the four winds of heaven [Zecharyah 2:10]; and the commentators explained [that the directions [?] are called] winds because [the directions draw their force [?] from them].

And the difference between nefesh, ruach, and neshamah: the sage ibn Ezra (ראב״ע) wrote, on the portion of Mishpatim, on the verse והסרתי מחלה (Shemos 23:25), [that the neshamah [?] is compounded and set] like the head, and from it issue the sensations and the movements [of the limbs [?]].

The ruach [is in the heart] — the [seat of] the life of man; it is that which supplies the spine [?] to [the body / limbs [?]], [standing] against whatever opposes it; and it is the seat of anger. So too Solomon, peace be upon him: Be not hasty in your spirit to be angry [and] A fool utters all his mind (Kohelet 7:9; Mishlei 29:11).

And the nefesh [is in the] liver, and it is that which desires to eat; and so he wrote: when your soul (nefesh) craves (Devarim 12:20); and the desire for coupling comes from it (ותאות המשגל ממנה). End of his words.

סימן ו

An explanation of the fourth element, which is fire; and the property of the adhesion of the elements one to another [and their ordering [?]].

The fourth element is fire. So all the ancient investigators wrote, as one, that the element of fire surrounds the element of air and separates between the sphere of the moon and the air. You must know that the four aforementioned elements are distinguished in their nature [from] the celestial spheres, which are clear and pure like sapphires, as will be explained. Therefore each and every element, according to its nearness to the spheres, [is purer]; hence [fire] is the [purest] and most refined of all, [being] nearer to the spheres than the water and the earth; while [earth] is heavier [than the rest]. Likewise water is lighter than earth, [and each is ordered] according as [its] element is more distant from the spheres [or nearer]; and for this reason the element of earth is the heaviest of all.

And further [you must know that the nature of] each and every one of the four aforementioned elements is that it does not move from its place unless by a compeller and a mover [that removes it]; it [returns] by force to its natural place. Know, too, that the four aforementioned elements are opposed in their nature, [each to] the others: the two heavy elements, which are water and earth, are such that their natural motion is to go from above downward — so that when earth or water is [forced] upward by a compeller [such as air], the compelling element does not rest but goes and removes [it] until it settles [upon] the earth or into the water. And the two light elements, which are wind (air) and fire, are such that their natural motion is to go from below upward — as [fire] and smoke rise upward and return to their natural place. And such is the nature of the air: when you take a vessel full of air and stop up its mouth and thrust it by force beneath the water, then when you remove the compeller from it, it rises upward of itself.

Now the property of the adhesion of the four elements one to another is this: fire has no adhesion to the other elements save a firm adhesion only to air, and to nothing else. Water and earth each have two adhesions: water adheres to air and to earth, and earth adheres to water and to air. But air (ruach) has three adhesions, for it adheres to fire, to water, and to earth; and the adhesion of the air to fire is greater than its adhesion to water, and its adhesion [to earth] is greater than its adhesion to fire [?]. I shall not prolong [the discussion] of these matters, for they too are not matters of astronomy, but rather the words of the philosophers, with which we have no business.

סימן ז

That the moderns entirely deny [the existence of] the element of fire above.

[Reader, know well] that in all we have written above concerning the element of fire, everything is according to the view of the ancient investigators. But know that it did not escape the notice of the modern investigators — great

and renowned wise men — who deny the element of fire entirely. They said: Heaven forbid that there be an element of fire above, [for] it would not be possible for us [to have] night, since from the side of the sphere of fire [its light] would illuminate the air for us every night. [And even] though this is no [real] difficulty — for the philosophers already said that the elemental fire is not like our fire, since it does not give light, but is like the rest of the celestial spheres, which of themselves do not give light; they [give light] only from [the] revolution [of], and from, the stars [set within them]. And just as the celestial spheres are clear and bright as sapphires, so that they neither obstruct nor interrupt the light of the stars beneath them (as [will be shown] before us, in siman 20 — בסי' ך), so too is the sphere of [fire]. In any case, we may ask of them: [consider [?]] — for the light of the celestial spheres, the stars illuminate them [i.e., the light is from the stars], as will be explained in siman 12; whereas for the element of fire we have no proof to establish [it]. Therefore they said that no element of fire is to be found above. And moreover, all that lies from the earth up to the sphere of the moon is entirely air — except that it is divided and differentiated in [its] four qualities according to its nearness to, or distance from, either the sphere of the earth or the sphere of the moon. Toward this inclines the opinion of the Rambam and ibn Ezra (רא"בע), in ch. 18 of the book Yesod Mora (בס' י"ח מספר יסוד מורא). [?]]

שער א (Section One) — continued

[Conclusion of סימן ז]

[continued from the previous discussion of whether an elemental sphere of fire exists above] …from his investigation, [holding] that the sphere of ether[?] and the fire are a single thing[?]. Thus far the quotation.[?] R. Yitzchak Yisraeli [author of Yesod Olam] does away with[?] an [independent] sphere of fire — explicitly, in his book Yesod Olam, Ma'amar 2, chapter 8, where he states, on our subject, that one of the sages likewise denied[?] a sphere of fire above; this is not mentioned[?] in the account of Creation (Bereishis)… [text here is badly degraded]. Therefore the sage Don [[[one 2-letter token + geresh, blotted on B and unresolved on N — no first name is recoverable from this ink]]] Abarbanel (אברבנל [?] דון') too disclosed to us his whole view, in his commentary on the portion of Bereishis, in three places: on the verse of the first [day], at folio 3c (כדף ג' ע"ג) and at folio 8b (וכדף ח' ע"ב), and also on the verse Let there be luminaries, at folio 18d (כדף י"ח ע"ד). He said there that there is no need to posit an element of fire, since [several words illegible]. It therefore follows that fire is not one of the [sublunar] elements, and is not a component in composite bodies; rather the sublunar world has only three [elements] — [earth (עפר)], water, and air — and for this reason they are found mixed and near one another. For just as within the belly of the earth there are springs and depths[?]… and hollows filled with much air, on account of which earthquakes sometimes occur[?] — thus far the quotation, and he elaborates further there.

סימן ח. On the number of the planets, their names, their order, and the period of their revolution.

Above the elements already mentioned — as we said, [following] the ancients[?] — there are seven celestial globes, one above the other, for the seven planets. These are: Saturn (שבתאי), Jupiter (צדק), Mars (מאדים), the Sun (חמה), Venus (נוגה), Mercury (כוכב), and the Moon (לבנה) — mnemonic **שצ״ם חנכ״ל**. This is their order and sign from the top downward; but we shall begin our exposition, in brief and modest fashion, in the reverse order, from below upward, starting with the planet nearest and closest to us, more than all the other planets [the Moon].

The first planet [the Moon], of all the seven planets, is called Levanah ("white") because it is white, as Radak wrote on the root **לב״ן**; and it is also called Yareach (**ירח**), a name derived from the renewal of the month (chodesh) — for the term for the span of the month is yareach, up to "three months' time" (sheloshah yerachim) [and] "a month of days" (yerach yamim); and because the moon renews itself each month, the [span of the] month is called by the moon's name, and yareach is [also] the name of the moon itself. This planet completes a full revolution in its sphere in about 27 days and some hours[?] approximately, and each renewal (molad) [comes] after 29 days, 12 hours, and 793 chalakim[81], as will be explained further in the eighth section, siman 209[?], and siman 213[?], and siman 24[?].

The second planet [Mercury] is called simply Kokhav ("star"), and we already find it called by [another] name[?]… — just as we find individual persons named "Adam," and many cities named [after another], as in the case of [several place-names, illegible]. So too this planet is called simply Kokhav. Maimonides, in the Laws of the Foundations of the Torah (Hilchot Yesodei HaTorah), wrote that whoever is [born] under it [is disposed to certain traits][?]; and I likewise found this in old books, for the matter is well known — during the hour of Mercury's rule the wise, the seekers of knowledge, are inclined to study, to write, and to reckon. This planet completes a full revolution in its sphere in about 365 days and a quarter, approximately, as will shortly be explained.

The third planet [Venus] is called Nogah ("radiance") because it shines and glows more than all the stars of heaven except the Sun and the Moon. And in the book of Isaiah, chapter 14, it is called [as in] "How you have fallen from heaven, Helel ben Shachar [Day-star, son of Dawn]" (Yeshayahu 14:12); all the commentators explained it to be the morning star, which is the planet Venus, as will be explained further in the tenth section, siman 232, [on] "Helel ben Shachar," etc. This planet's revolution in its sphere is about 365 days and a quarter, approximately, like the foregoing.

The fourth planet [the Sun] is Nogah [radiant] by its nature, and is also called Chamah because it melts [the world] with heat, as Radak wrote on the root **חמ״ם**, as will be explained further in the sixth section, siman 134. It is also called

[81] the parts-figure is degraded on the leaf; the standard molad interval is 29d 12h 793 parts

Cheres (חרס), meaning [the sun] — [cf.] "before the sun (cheres)" (Judges[?])… The revolution of this planet in its sphere, according to the reckoning of the ancient and later astronomers, is 365 days, 5 hours, and [some] minutes[?]; and according to the reckoning of our Rabbis of blessed memory — that of [Rav Ada] bar Ahava — the Sun revolves in 365 days, 5 hours, 997[?] chalakim, and 48[?] regaim, which are 76 to a chelek; and this returns close to a year. [See] further in the seventh section, siman 184[?] — [cross-references illegible].

The fifth planet [Mars] is called Ma'adim because it is red in appearance, and because it is held to govern bloodshed[?], as our Rabbis say at the end of the chapter [of tractate] Shabbos, etc. (cf. Talmud Shabbos, near 156a). This planet's revolution is in two years and a fraction.

The sixth planet [Jupiter] is called Tzedek ("righteousness") because it governs judges and litigants[?] and acts of charity (tzedakah); and some say it is so called in Hebrew for the following reason. Of it, it is said in Isaiah chapter 65, "who set a table for Gad" (Yeshayahu 65:11); and Radak explained, on the root גד, that it is the planet Tzedek, which portends every good thing, for so it is called in the Aramaic tongue[?]… meaning "good fortune" (mazal tov). And so [others] explained there. I have also found one who wrote that [under] the aforementioned name, they reckon for us [that] the hours of Jupiter's dominion — namely, at the onset of the eve of the second day [Monday night] and at the return of the fifth day [Thursday] — as will be explained further in the fourth section, siman 58, and siman 34[?], [on] "you shall release [what you have lent] your neighbor" — that is, on the day of Jupiter's dominion; it is Jupiter, and it is "the way of uprightness (nechochot)," etc. This planet completes its revolution in twelve years.

The seventh planet [Saturn] is called Shabtai, from the term Shabbos (rest) and repose, because the motion of this planet is heavier and slower than that of every [other] sphere — more than all the other planets. On this account it appeared to the ancient peoples[?] to have the power of "Shabbos"; and because its motion in its sphere is completed only after very many years — this planet completes its revolution in its sphere only every thirty years, by the nearest reckoning. This is the order of the seven planets from below upward; but most astronomy books give the order from above downward, whose mnemonic is [**שצ"ם חנכ"ל**], as above.

סימן ט. That each of the planets is set in its own distinct firmament, and why they are called "wandering stars" (kokhvei lechet) and "confounded ones" (nevuchim).

Know that the ancients decreed that each and every one of the seven planets is set in a distinct firmament — such that they held there to be[?] seven firmaments, one above another. All this because they observed that each of the seven [planets] has a known and distinct motion of its own, unlike its fellow — as [seen] also in their revolution-periods, which differ greatly: some complete a revolution in about 27 days, others in a different span, some in 12 years, some in 30 years [and so on]. (It is for this reason that they are called "wandering stars,"

since each one displays a distinct path — which is not the case with the stars of the eighth sphere, as will be explained shortly.) Moreover, it is impossible for a single body to move with seven [different] motions at once. Furthermore, they observed by means of their instruments that all seven planets at times draw near to, and at times recede from, the globe of the earth, by manifold measures; that sometimes they go before the Sun and sometimes behind it; that sometimes they seem to advance forward and sometimes to move backward, and sometimes to stand still. For this reason they are called nevuchim ("confounded"), like a person who is lost and confounded on the road — one moment going forward, another back. On account of this, in order to explain the reason for all these appearances, it is impossible to grasp them except by assigning to each and every one of the seven planets a distinct firmament. From here all the reasons for the aforementioned appearances will be revealed, as will be explained further in the eighth section, siman 104 [ק"ד].

סימן י. On the eighth sphere — called the sphere of the [fixed] stars, or the sphere of the constellations (galgal ha-mazalot) — and its motion.

Above these seven firmaments already mentioned, the eighth firmament is the one called the sphere of the stars, or the sphere of the constellations, in which all the remaining stars of heaven are set, from the smallest to the greatest — not one of them missing. Because the stars set in this sphere keep their distance from the globe of the earth always at a single measure, and the stars themselves keep their distance from one another always at a single, constant measure — none of them being seen [to shift] like the aforementioned [planets] — therefore they are all [placed] in a single firmament, for [the ancients] did not wish to add a firmament except [where necessary]. For this reason this sphere is called the "general" (kelali) sphere, the totality of the star-spheres; and it is called the sphere of the constellations for a reason to be explained further in the [sixth] section, siman 106 [ק"ו].

You should further know that all the stars of the aforementioned eighth firmament are called, by the astronomers, the "fixed stars" (as opposed to[?] the "confounded stars") — because the ancient sages — whose own names and memory have long since been forgotten with the passing of time [נשכח שמותם וזכרם] — said, according to their observation, that although this sphere and its stars have no perceptible[?] motion, neither eastward nor westward — this [being due] to the fixedness of its arrangement and the slowness of the measure of its revolution — the ancients perceived in them no motion, and reckoned them to be lying still and at rest forever. And you should know that the motion and revolution of this eighth sphere is about its axis, which is the axis (center) of the earth; it too is inclined toward the east, but with a heavy motion, exceedingly slow and of very slight amount.

The time of the revolution of this sphere is, to this day, not precisely known to us — because of the slowness of its motion, no [observer] is able to fix the time of its revolution. For even if a man were to reach a hundred years — [and even] were he "yesterday a hundred years old, as today"[?] — in all the days

of his life he could not gauge, from the motion of this sphere, more than one degree of the 360 degrees of the sphere. On this account opinions about it have multiplied: according to the opinion of Ptolemy, this sphere revolves only one degree in a hundred years, of the 360 degrees of the sphere — so that, on his view, this sphere would not complete its revolution until the passing of 36,000 years. And according to the opinion of the later [Arab] astronomers, who came 640 years [תר״ם] after Ptolemy, [who] made an [exact] determination and said the revolution of this sphere is a degree and a half [מעלה ומחצ׳] in each hundred years — its revolution, by this reckoning, returns in 24,000 years. And there is [yet] a third opinion, as all this will be explained further at the end of the fifth section, siman 130. And you should further know that the astronomers found, in their observations, that all seven planets mentioned — besides the path each has by itself — [share], as a group, together with them, a heavy motion in common with the eighth sphere, of one degree in a hundred — or in a fourth — years [למאה או לרביעי שנה מעלה א׳].[82]

סימן יא. That all seven planets, joined together with the stars of the sphere of the constellations, all revolve by means of their spheres from west to east.

You need to know that the revolutions and motions of the seven planets by means of their spheres, joined together with the motion of the eighth sphere of which we spoke earlier — [when] we measured[?] the fixed time set for the revolution of each and every one of them — all those revolutions and motions are from west to east. This is so even though we see, day after day, the Sun and the Moon and the other stars rising from the eastern quarter and setting in the western quarter. But know that the motion of the eighth firmament with its stars mentioned — all of them revolve, each with its stars, in the time fixed for it, as above, from west to east. And because this matter is somewhat strange in the eyes of beginning students learning the science of astronomy, I saw fit — though this is not [strictly] its place — to explain the matter to them here, by [the example of] the course of the moon's revolution. For it is already known that about twenty-four hours after the molad [כ״ד שעות], the moon appears at the beginning of the night in the south-western corner, a little above the circle (horizon) of the earth; and after this, on the second night, the moon appears on a higher path, farther from [where] it [was], toward the west[?]…

[continued at top of folio 13 recto] …toward the east; and so is its rule throughout the days of the month — day by day it recedes farther and farther from the place where it first appeared, in the manner of[?]… like the course of its revolution from west to east, as this matter will be explained to you more fully further in the eighth section, siman 26. And as the rule is with the moon, so likewise is the rule for the rest of the confounded stars [ככה הדין גם בשער /

[82] an alternative period is interposed between the number and the unit and does not construe: "in a hundred or in a fourth year". It stands on both copies. The two opinions rehearsed just above both close arithmetically — one degree a century giving thirty-six thousand years, a degree and a half a century giving twenty-four thousand — and this summary clause does not. That it does not close is what the leaf says.

השאר כוכבי נבוכה], as will be explained further on in the Eighth Section, God willing [לפנים בשער השמיני בס״ד].[83]

You should further know that this course from west to east is called, in the books, the "essential, natural" (ʿatzmit ha-tivʿit) motion or revolution — for this is their [own] course and revolution, that of the planets, by their own nature, without any external mover or compeller. But the revolutions of the Sun, the Moon, and the other planets, together with all the stars of the eighth firmament, which we see day after day rising from the eastern quarter and setting in the western quarter — the reverse of the aforementioned motion — this revolution is called the "compelled motion" (tenuʿah makhraʿat / hekhrekhit)[?], as will be explained shortly.

סימן יב. On the ninth sphere — called the diurnal sphere (galgal ha-yomi), whose motion is the reverse of the motion of the eight aforementioned spheres.

Above the eighth sphere, some of the sages decreed that there is a further, ninth sphere, which some of them call the "bare" sphere (galgal ha-maʿarteleh)[?], since no star at all is set in it. This is the opinion of Ptolemy and most of the ancients, who hold[?] that this sphere… its center too is the center of the earth [as it turns] from [east to west]… completing a full revolution in about 24 hours. And they say that by its great power — which the Holy One, blessed be He, implanted in it — it draws with itself all the aforementioned spheres with their stars, compelling them in its hidden course, and encompassing the world once each day. This revolution is called by the sages the "upper motion" (ha-tenuʿah ha-ʿelyonah), and also the "diurnal motion" (ha-tenuʿah ha-yomit), for a reason to be explained. The sages decreed a distinct sphere for this revolution, even though we have for it no witness — as we have for all the other aforementioned spheres, to which their stars bear witness.

[This is] because we have seen with our own eyes that all the heavens/spheres have a natural motion from west to east; and we have also seen in them an opposite motion, by which they revolve each day from east to west. And it is impossible for a single body to move by itself with two motions at once — even in one and the same direction, and all the more so in two opposite directions. The ancients further said that one motion is from itself [its own nature], and the second is from a mover and compeller, [and so] accidental. On this account they decreed a diurnal revolution and a distinct sphere above the eight spheres, and said that it revolves and turns[?] all eight spheres as one[?], revolving the world once each day. This motion is called the "compelling, forced motion" (tenuʿah makhraʿat hekhrekhit), for in their view this sphere compels and forces all eight firmaments with their stars [to conform to] this motion of its own. And you should know that from the combination of the two aforementioned motions — the voluntary (retzoniyot) and the forced (hekhrekhiyot), when

[83] within four lines the same gate is cited once with a siman number and once without; none is supplied here. The leaf also sets "gate" where the sense wants "the rest of", immediately above a line that legitimately opens with "the rest of" — the compositor anticipating the "gate" two words earlier. As printed; the sense restored in the reading.

they act together — depend the measure of day and night, summer and winter, the year and its seasons (tekufot), and other matters, which cannot come to be precisely except through the two motions acting together, as will be explained further in the [first] section, siman 140[?].

שער א (Section One) — folio 13r

סימן יג. In which it is explained how it can be conceived that a single body has two opposing courses.

To make clear and to settle the two opposing courses mentioned above is a hard matter to teach, and the sages have already offered a parable for it and made a comparison: they likened it to a man walking inside a ship [heading] from [west to east], while at the same time the ship itself is going from east to west; they also likened it to one walking upon a revolving wheel [going] from west to east. And know that this [comparison] is not quite apt — for "the case is not similar to the proof" — since we hold that the star does not move by itself, but only through the sphere as it revolves. In this, the sages of Israel concurred with the sages of the nations, as is brought in the chapter "Mi she-hayah [tamei?]" [as printed, כדאיתא בפרק מי שהיה סמא[?] — the leaf names the chapter only; the tractate (Pesachim) and chapter number are not printed on it]. Therefore, when the diurnal sphere turns and draws the sphere beneath it, compelling it… to the daily forced motion from east to west, how can it be conceived that at that same moment the [lower] sphere is revolving in its own voluntary motion from west to east? This is like a man whom one forces to go westward while [something] upon him compels him to go eastward — since it is impossible to go both east and west [at once]. Thus this way is difficult for the astronomers; for, after all, how can it be conceived that a single sphere or star has two contradictory motions truly at once, whether voluntary or forced? Many of the ancients and the moderns, who have exhausted their strength and cut short [their words]… all of them entered into this hidden perplexity (mevukhah), and we shall leave it in its concealment and difficult perplexity, holding it in reserve until we come to the corresponding siman; and there, too, another great and hidden perplexity is stirred up beyond these — we shall resolve them together.

סימן יד. How it can be conceived that a single body revolves eight bodies, one within another.

Concerning the motion of the diurnal sphere, which by its power compels all the spheres… [encompassing] the world once each day, as above — here too we have another great and hidden perplexity: that it cannot be conceived that a single sphere, by its power, should revolve eight spheres [nested] within it. For this can be accepted only regarding the motion of the sphere of the [fixed] stars alone, since it is adjacent and attached to it [the ninth]; there we have room to reason and say that the diurnal sphere turns it, holds it, and compels it perforce. But as for the other seven spheres, which it does not touch and does

not reach[?]… [the notion that] it compels them is a hard matter to teach; and if it should occur to us to say [ואם יעלה על דעתינו לומר] that each sphere strikes the sphere beneath it and compels [it] to the daily [motion] — [namely] that the diurnal sphere compels the sphere of the stars, the sphere of the stars [compels] the sphere of Saturn, Saturn [compels] Jupiter, Jupiter Mars, and so on, all of them down to the sphere of the moon.[84] We have grounds to inquire and say that, according to this, each sphere compels the sphere beneath it to the daily forced motion; and if so, it is likewise required that each sphere compel the sphere beneath it to its own natural, voluntary motion — and it would then be required that the sphere of Saturn compel the sphere of Jupiter to its voluntary motion, and so Jupiter [compel] Mars, and Mars the [Sun], and so on. R. Yosef Albo already raised this difficulty in his Sefer HaIkkarim, in siman three of the fourth ma'amar [as printed, ר׳ יוסף אלבו׳ בספר עיקרים שלו בסימן שלישי ממאמר רביעי], and there is written over it no resolution at all — he simply concluded and said that no human intellect suffices to know the truth of this matter.

But you, the reader — know well that I laid this perplexity before the wondrous astronomer who sits before our lord [the Emperor] Rudolf [II], may his glory be exalted[?], the one called Johannes Kepler (יוהנים קפפלירוס). He answered me and said that in truth the matter is thus: the power [resides] in the sphere, and each star's sphere compels the star beneath it [to move] in its own natural motion — as [the sphere of] Saturn [carries] Mars[?], one after another, according to their [respective] courses. Saturn moves about [8?] degrees[?]… Jupiter moves two degrees each month… [through] the twelve constellations. Let us now suppose[?] that a sphere revolves in month [8?] up to the point [ג][?] of the circle, drawing with itself[?]… Jupiter, which in that month… [each] sphere draws the sphere beneath it, and its own natural motion, up to point [ג][?]… so [too] the sphere of Mars, which in that month…

Diagram. Exactly three nested semicircular arcs, flat side downward, standing on one straight base line — not an open-ended "set". The innermost arc is defective at its left foot: it stops in mid-air about a third of the way up and does not reach the base, while its right foot does. Between the middle and the innermost arc a short vertical tick rises from the base line; it bears no letter.

Label census (closed). Every mark on the plate that could be a letter was enumerated on both witnesses. Three letters are printed, all of them in the left half, each standing just above the base line inside one of the three zones:

- **א** — in the outermost zone (between the outer and the middle arc)
- **ב** — in the middle zone (between the middle and the innermost arc)
- **ג** — inside the innermost arc

Excluded from the census as not-letters: the short vertical tick on the base between ב and ג (a plain stroke with no head or foot, of rule weight rather than type weight), and two ink specks under the base line (each well below minim

[84] the line opening the chain begins with a form that does not construe; both copies carry it. The chain names five spheres, then elides the remainder to its terminus; the sun, Venus and Mercury are not named.

size). The right half of the figure carries no marks at all. …[Mars] revolves by reason of the motion of Saturn's sphere, by reason of the motion of Jupiter's sphere, and by reason of its own motion — up to point ג of the circle. So the star Mars reaches point ג through three causes: the motion of Saturn's sphere, the motion of Jupiter's sphere, and its own motion — besides the fourth cause, [the motion] of the sphere of the constellations [and the ninth sphere]. And he [Kepler] said: Behold, one ship crosses the river from [west] to east; and while it is crossing, a man walks from [the stern] of the ship to its bow — likewise from west to east; and a fly walks upon the head of that man, from the [back] of his crown [to the front] — likewise from west to east. In such fashion, whereas [the fly] was at first at the rear, at the [bank] of the river, over against [X], it is now foremost, at the river-bank, [displaced] purely eastward — and this by [the combined] cause of the ship's motion, the man's motion, [and the fly's own motion]. Just as the fly [is carried by all three], so the voluntary motion of the sphere of [the Moon][?] has one [proper] cause — the cause of its own motion — [together with] the motion of Saturn['s sphere]… and the motion of Jupiter, for three causes… and the motion of the sphere of [the Moon], for eight causes. According to this, the great perplexity is well settled, and it poses no difficulty for us at all.

סימן טו. In which is explained a resolution to the two aforementioned perplexities.

And you, the reader — know well that in my humble opinion it appears [that] the two perplexities mentioned above [may be resolved] as one. How can it be conceived that a single body [has two opposing motions]? — [namely] the first [perplexity], the two opposing courses, and the second, how a single body revolves eight bodies one within another. This too can be settled in another way, in the true way, and I say: each and every one of the eight spheres is itself divided, within, into two or three globes (kadurim) [לשנים או לשלשה כדורים], one within another, as [explained] further in the seventh section, siman 187[?]; for all the sages, ancient and modern, agreed that within each and every sphere — as within the sphere of the Sun, for example — there is set another sphere, called the sphere [of…]. …[Thus] all eight spheres are all conjoined and attached together as one whole, such that when [the outermost] revolves, overpowering them, they all revolve together; and so each and every sphere carries the [sphere] within it in its own natural motion — like the likeness of an embryo in its mother's womb — as above. By all this, everything works out well, and we may now say that what the author of Sefer HaIkkarim wrote — that the whole human intellect cannot attain this matter — [is resolved].

And from the sum of the aforementioned matters, one should note and say [the following]: as for what the astronomers wrote — that the diurnal sphere, by the great power God (may He be blessed) implanted in it, draws and compels the eight spheres along with itself, revolving the earth once each day — according to our explanation above there is no need for this, since [in our account] both the eastward motion and the westward motion would [alike] be

voluntary and natural. And perhaps it is on account of all this that some deny [the existence of] the diurnal sphere, as will be explained shortly, in siman 18, God willing.

סימן טז. A further resolution to the two aforementioned perplexities.

And we shall not conceal from the reader's eye that, according to the opinion of the great investigator Tycho Brahe [(טיכא) בראה״יס], who proved by his observations that the sphere is fixed and the star revolves [שגלגל קבוע וכוכב חוזר], as will be explained further…[85]

[The exposition of Tycho's view continues into the following pages.]

שער א (Section 1) — continued

[Conclusion of] סימן טז (Siman 16) — Tycho Brahe's resolution of the two perplexities

According to his [Tycho Brahe's] view — see below in siman כ״ה (25) — we have no cause to wonder at the two motions mentioned just above, nor at the very existence of the opposing motions. This is easily grasped, for the analogy of a human being suffices: a man walking about on a ship, or on the turning wheel of a wagon. On this understanding one may say that the sphere's course is one thing and the star's course another — for the spheres as a whole carry [the stars] each day from east to west, while the star itself revolves slowly upon the back of its sphere from west to east.

From this it also follows that the second perplexity — "this [motion] within this [motion]" — falls away at its very root. For since the star is fixed [in its sphere], we need not say that each sphere revolves and grips the sphere beneath it and overrides [it with] the diurnal motion, as [explained] above. It emerges, then, that both the eastward circular motion and the westward motion are voluntary [natural], and no ninth sphere is needed at all.

סימן יז (Siman 17) — Why the ninth sphere is called "the diurnal sphere," and that it has but a single motion

The ninth sphere of which we have spoken is called by the sages "the diurnal sphere" (galgal ha-yomi), because it is this sphere that brings the day [?] to the world: by its revolution the sun rises over the earth and gives light to the day. Or [it is so called] because through the motion of this sphere the natural days and their times come to be; for through its motion a complete [day] is delineated — for one half of its revolution, that is, twelve seasonal hours above the earth, is the time of day, and the other half of its revolution, likewise twelve seasonal hours beneath the earth, is the time of night. These two periods together the sages call a "natural day" (in Latin: dies naturalis [דיע״ם נטוראלי״ם]). This is the sense of the verse "and there was evening and there was morning, one day" [Bereishis 1:5] — meaning that the evening and the morning, when

[85] the forename is set in parentheses, the surname with an internal mark. The book sets this name in at least four forms; see the note at §§163–164.

joined together, are called one day. For were it not for the motion of this sphere, the world would always [have?] one [region?] in [continuous] day and one in [continuous] night in every clime [אקלים, clime], as will be explained below in Section 6, siman קל"ד (134) [and] ק"ם (140 [?]).

And know that the motion of the diurnal sphere, which revolves from east to west, is its own essential motion; this sphere has no other motion besides it. This is unlike the other spheres, each of which, together with its star, has four or five motions, as will be explained below in Section 7 [and Section 8 (?)], siman פ"ח (88) and siman ר"ח (208).

סימן יח (Siman 18) — Setting out the differing opinions concerning the existence of the ninth sphere

Know that concerning the existence of the ninth sphere there are differing opinions and disputes, and they are three schools.

The first school say that there is a driving sphere which by its power [drives] all eight spheres and encircles the globe of the world in twenty-four hours, from east to west, as was explained above in siman ט"ז (16).

The second school also concede a ninth sphere, for a reason to be explained; but they say that it is not a body like the other spheres — which are called by the sages "the fifth body" (ha-geshem ha-chamishi, the quintessence) and which carry [?] the stars like a thread. Rather [the ninth] is a separate [intellect] or an angel that moves the sphere, [and] is not corporeal; and this is likewise implied by the language of Rambam [Maimonides].

ראב"ע [abbreviation uncertain [?]]: as is demonstrated in chapter three, treatise four [?] of Sefer HaIkkarim [of Yosef Albo], which wrote that there is nothing corporeal above the sphere of the [fixed] stars — meaning that he concedes there is a mover above them, only that it is not a body like the other perceptible spheres [carrying the stars] like a thread, but rather a separate intellectual essence.

The third school deny the ninth sphere and say that there is nothing above the sphere of the stars — no sphere above it "to where the eye can no longer see" — and that you must not add anything above the sphere of the stars, whether body or non-body, because in their view the sphere of the stars carries with it all the spheres within it from east to west, once each day. This is the opinion of Ibn Rushd [אבן טח"ד — read as אבן רשד / Averroes [?]], and likewise the opinion of the wondrous sage R. Avraham bar Ḥiyya per what he wrote in his book Tzurat HaAretz (The Form of the Earth), gate two [?]; and likewise the opinion of Ralbag [Gersonides] per what he wrote in his book Milchamot HaShem (The Wars of the Lord), chapter כ"ד (24) of treatise 2 — that is, that one need not posit a starless moving sphere, for [its motion] would be in vain and to no purpose, since it serves no benefit, and among natural things there is nothing purposeless, as [he wrote?] concerning the honored heavenly [bodies]. It was for this reason that he decreed and stated that there is no sphere at all above the sphere of the stars.

In any case, know that even if it be proven that there is no sphere above the sphere of the stars, I say to you that the reversed eastward [/westward] motion — whether it be from one of the causes [related to] the stars, as [treated] nearby in simanim י״ד (14), ט״ו (15), [and י״ד ט״ו], or from some other cause and beyond it — ought by right to be called, in all the books, "the upper motion" or "the diurnal motion," and it is [rightly] so termed [?]. And see below at the end of siman י״ג (13 [?]).

And it seems right to add: even if it be granted as certain that there is no sphere at all above the sphere of the stars, nonetheless, for many purposes — such as [reckoning] the fixed constellations and the precessing [ones], as [treated] below in Section 5, siman ק״ו (106 [?]), and for other purposes besides these — we need to picture in our minds, in order to explain [it] to students, [something] as though it were a ninth sphere, even though it is clearly known to us that this is not so.

Diagram. A large concentric-circle cosmological figure occupying most of the page, captioned "**צורת ארבע יסודות ותשעה גלגלים הנזכרים**" ("Figure of the four elements and the nine spheres mentioned"). Reading from the outermost ring inward, each ring is labeled and separated by rows of small six-pointed star marks (✻):

- TWO concentric celled bands carry the zodiac, not one — and each carries all twelve signs. The page says so itself in §19's facing text: **רשומים שנים עשר מזלות שני פעמים … על שתי בחינות** ("the twelve signs are marked twice … under two aspects"). Band A is outermost and carries no stars; Band B lies just inside it and carries a cluster of printed asterisks in every cell. The two bands' radial rules do not line up, and Band B is rotated one cell clockwise against Band A, so for every position P, Band B's cell at P holds the name Band A holds at P−1.
- Band A, from 12 o'clock clockwise: **בתולה · ארי · סרטן · תאומים · שור · טלה · דגים · דלי · גדי · קשת · עקרב · מאזנים**.
- Band B, from 12 o'clock clockwise: **ארי · סרטן · תאמים · שור · טלה · דגים · דלי · גדי · קשת · עקרב · מאזנים · בתולה**.
- The bands were set independently, and one orthographic divergence proves it: Band A spells **תאומים** plene, Band B spells **תאמים** defective. This is the only positive evidence that the figure is not one block printed twice.
- Leo is printed **ארי**, not **אריה**, in both bands — three letters at every upright reading.
- Star counts are NOT recoverable. Clusters run about 3–6 asterisks and no cell resolves cleanly; nothing here should ever be cited as a per-cell count.
- The inscription **וגלגל היומי** sits inside Band A, on the arc between the **דגים** cell and the **טלה** cell, punctuated **וגלגל היומי : טלה** — it is not a separate outermost ring. Whether it occupies its own ruled compartment is undetermined.

- The labels are set radially, so roughly half of them stand upside-down on the leaf. All twenty-four were read upright and none was inferred; earlier descriptions of this figure — one ring of twelve, אריה, and four cells "not individually confirmed" — are withdrawn.
- **שבתאי** (Saturn) ✻
- **צדק** (Jupiter) ✻
- **מאדים** (Mars) ✻
- **חמה** (the Sun) ✻
- **נוגה** (Venus) ✻
- **כוכב** (Mercury) ✻
- **לבנה** (the Moon)
- Inner (sublunar) region — corrected, and the caption over-promises. The figure is captioned צורת ארבע יסודות ותשעה גלגלים ("four elements and nine spheres"), but only two labels are printed in the sublunar annulus: **אש** (fire, certain) and a second word reading **ר?ק**, whose third glyph descends below the baseline and is therefore ק, not ח — so it is not **רוח**, which the earlier description gave. Most likely ריק ("void/empty"); the middle glyph does not separate י from ו. **מים** and **ארץ** are not present anywhere in the figure.
- The innermost disc is BLANK — certain, no ink in any of the twelve renders. The earlier note that "the earth … [is] not clearly legible" implied an unread label; there is nothing there to read. Blank and illegible are different findings and must not be conflated.

סימן יט (Siman 19) — A brief explanation of the adjacent figure

In the adjacent figure above is depicted the three parts of the world [שלשה חלקי העולם] — namely Europe (אורופ"י), Asia (אסי"א), and Africa (אפרי"קא) — whose division will be explained below in siman ע"א (71). And its cause [?] [degraded]... like [?] the globe of the earth [in the figure]; here air [is shown] in the form of a sphere, one of them [the elements], as we explained all of this above in siman כ' (20).

Above the corporeal elements [and the ?-ial ones] is the sphere of the seven wandering stars [planets], and above them [?] the sphere of the [fixed] stars... [and above them] the diurnal sphere. Also there are marked in the figure twelve constellations [שנים עשר מזלות], and they are [there] in two respects [?].

In the upper sphere [the diurnal sphere], although there is no star set within it at all, nonetheless there are marked upon it, in a circle, all twelve constellations as if they were fixed there; and these are called "the fixed constellations," which never change or alter or shift from their position for all the days of the world. And the second respect [is] the constellations marked in the sphere of the [fixed] stars, where the constellation truly [resides] in [its place] [?], except that they are, by reason of the heavy [slow] motion — the second [motion?] of the sphere of the constellations, as above in siman י"ד (10) and below in Section 5,

siman ק״י (110) —[86] the precessing constellations [ha-mazalot ha-mitmotetim], and they will change and alter their position over a very great distance across time. In our time, in [the band of] the fixed constellations, the head of the sign of Aries is marked; opposite it, below, in the sphere of the constellations, it would be fitting that the sign of Aries likewise be there; but on account of the precession [התמוטטות] there is now found there the head of the sign of Pisces — as will be explained well below in siman [?].

שער א (Section 1) — folio טו (15)

סימן כ (Siman 20) — That the globes of the spheres are like the layers of onions, with no void between them, and are clear as sapphires

Since it is impossible to depict a globe upon a [flat] surface properly, therefore [the artist] depicts [it] as sliced [in cross-section], cut open on the near side, so that [?] one sees, in the cross-section, only the likeness of the spheres, one within another; so too you can [envision] all the spheres, transparent [?], one above the other on a smooth surface [?]... all [being] spheres [?] and complete globes, like the complete layers of onions.

And know further that all the spheres of the firmament are contiguous and adjoined, one within the other, like the layers of onions, and there is no empty place or void between them at all. The sages have already agreed on this, and the dispute of the philosopher[s] in such a matter, and at length [?], to demonstrate to [His] creatures [?]... And since it is an established premise that there is no void at all in the world, it is thereby explained to you that every sphere touches and adjoins, by its convex [outer surface], the sphere above it, and by its concave [inner surface] the sphere below it — down to the concavity of the sphere of the Moon, which touches the convexity of the sphere of fire, [that of] fire, for one who concedes its existence, or [the sphere of] air [?].

And [I] make known to you [further], so you may understand, that the substance of every sphere of the firmament is pure and clear as crystal and sapphire; and for this reason all seven firmaments are translucent [?] and do not interrupt or block the [boundary and] shining light of the stars of the eighth sphere from giving us light upon the earth. And just as, in the spheres of Venus, Mercury and the Moon [נוג״ה כוכ״ב לבכ״ה], they do not divide or withhold from us the light of the sun [אור השמש] — so too all seven firmaments do not divide and do not withhold from us the light of the stars of the eighth sphere.[87]

[86] two references at once — back to the tenth siman of this gate, forward to the Fifth Gate, siman one hundred and ten. Adjacent, and easily conflated.

[87] the third name is set with a kaf where the word for the Moon wants a nun; both copies carry it, and it is given as printed. The argument is the standard one from the inferior planets — bodies between us and the sun that occlude nothing.

סימן כא (Siman 21) — The axis and pole of the sphere, and the two pivots and poles of the world

Know that [when] one draws [?] a line encircling [passing through] the center of the globe or sphere, passing through the center and emerging to the other side — it is called a beriach (a bar/axis), because it "bars" [reaches] from end to end, as [in] the tradition. And the sages of [the science] [?] called it quṭr [קוט"ר; Arabic: قطر, "diameter"], and it is an Arabic word. Some say [?] it is the beriach mentioned in Iyov (Job), ch. 26 [as printed, באיוב סי' כ"ו — the leaf prints the chapter only; the first reading gave "26:13 (?)"], and in Yeshayahu (Isaiah), ch. 27 [as printed, ובישעיה סי' ך"ז, the numeral set with a medial final-kaf; the first reading gave "27:1 (?)"], as [Isaac] Israeli wrote [כמו שכתוב הישראלי — the leaf names the author but does not print the title Yesod Olam], in chapter one of the second treatise [as printed, בפ' ראשון מאמר השני]; and see below in [Section] 8, siman קפ"ט (189).

The two points at the ends of the bar are the pivots [tzirei] of the world: the one is the northern pivot and the other the southern pivot, and the researchers call it the "northern pole" (quṭb) and the "southern pole." Upon these two pivots all nine spheres, all of them, revolve each and every day from east to west; and in [all] nine spheres not even a single point remains at rest and still in place — only the two points of the two pivots alone remain always in their place.

To explain it to students: imagine that you take a sharpened square [rod], and drive or thrust it through a ball or an apple from side to side, and set the two ends of the sharpened [rod] upon a vessel, and rotate the ball or apple [continuously — for it seems to you that the two ends turn and revolve in place, in the point of a needle; yet withal, the two ends of the pole do not shift or waver, but always remain fixed in their place].

סימן כב (Siman 22) — That the northern pivot and likewise the aforementioned southern one, they alone are the pivots of the ninth sphere

Know that the two pivots, or poles, that we mentioned are the pivots of the world, upon which revolves the sphere of the upper motion — that is, the diurnal sphere — in every case; for all nine firmaments revolve each and every day by means of the two aforementioned pivots. But the particular [?] motions of the sphere of the Sun and the Moon, together with the other spheres of the five wandering stars [planets], and likewise the motions of the sphere of the [fixed] stars — whose course in the world goes from west to east [ממערב למזרח], as above —[88] have two other, small poles, somewhat distant from the aforementioned poles of the world, near twenty-four degrees [כ"ד מעלות], as will be explained below in Section 2, siman ל"ד (34).

[88] the star-sphere's second, proper motion, shared with the sun, moon and five planets, and expressly contrasted in the preceding clause with the diurnal motion imposed by the ninth sphere, which runs the other way. The same siman also describes the daily motion, so the direction means nothing without the motion named beside it.

It is thereby explained to you that in the eight spheres [שבשמנה גלגלים] no point at all will be found at rest and still — not even their own two pivots [אפי' שני צירים שלהם], for these too are carried round by the cause of the diurnal sphere, making one circle about the world's axis once each day, as will be explained in siman ל״ז (37 [?]).[89]

And know that all this holds only [?] according to the view of the sages who concede a ninth sphere. But as for the words of those who deny a ninth sphere and say that there is nothing above the sphere of the stars, it appears that in their view the two pivots of the world are themselves also in the sphere of the constellations. Accordingly, the sphere of the stars would have four pivots: two pivots of the [proper] motions upon which [?] the [enclosing] spheres each revolve, each in its own time, from west to east; and the two pivots of the world, upon which they all, as one, revolve the globe of the earth once each day. And should it trouble you — is it possible that a single body should revolve in two opposing motions? — we already explained above in siman י״ד (14) and ט״ו (15) that it does turn [so], according to the grasp of our intellect.

סימן כג (Siman 23) — That even those who deny a ninth sphere, it is fitting for them to say "the diurnal sphere" or "the upper motion"

A small note, to be kept before your eyes: wherever you find, in this book of ours or in another, the matter of "the upper motion," or "the diurnal sphere," or "the sphere of the [outer] part" [?] — let it not trouble you, and let it not perplex you, what this will mean for the words of those who deny the ninth firmament. For from what we explained above this is settled, on two grounds. First: a star may [move] by its own essential [natural] motion without needing any [driving] sphere; it simply revolves upon the back of the sphere, like a star moving on the wheel-sphere. And second: [because] each sphere is set within [?] another sphere, and by [being pressed together] all the spheres are joined and fixed [?] together as one mass, so that by the revolution of one of them all of them necessarily revolve, as above in siman י״ד (14) and ט״ו (15). And [should] it arise in your mind [that this passage concerns] a ninth sphere or [that it] does not literally [exist] —

therefore, whatever your intent in this passage, whether [it be] the sphere of the upper motion or the [claim] that it does not [exist] — hence know that each [term] [?], whether the matter of "the sphere of the upper motion" or the matter of "the diurnal sphere" or "the sphere of the [outer] part," you can interpret it [?]... as [it holds for] those who concede a ninth sphere, so too for the view of those who deny it [?]. And [one] may say that the [inner surface/belly] of each and every one of the eight firmaments should be called "the sphere of the upper part," since the [inner surface] of each upper sphere is above the sphere

[89] the figure is a number-word, not a numeral; a reader looking for a Hebrew numeral would find none and could wrongly report the quantity absent. Eight, not nine, is what the argument requires: the ninth sphere is excluded as the mover whose own poles are the world's poles.

beneath it; and likewise it is right that [it] be called "the diurnal sphere" or "the circular motion." And see above in siman י"ח (18) [ועיין למעלה סי' י"ח].

שער א (Section 1) — folio טו verso

סימן כד (Siman 24) — That every star makes, each [day], one circle around one of the pivots

From the general principles that we mentioned, it is explained to you [?] that every star of the firmament makes, each day, by its course, one circle around one of the [two] pivots — namely, around one of the two poles of the world. Now the stars [near a pole are close together, those far apart make larger circles?]... [these] are like the spheres of the stars that revolve [?]... the spheres of the stars, or the coils [gelilei] of the revolution about the sphere [?].

They have no mean [?]; some of them are large, some small; and some of the stars make a large circle and some of them make a small circle — and this is according to their nearness to, and distance from, the pivots. For every star that is near the pivot, its course will be smaller in extent [?], and a star far from the pivot [?] — [one] of them makes a large circle; and this is according to their nearness [and distance] from the pivots. [Two?] stars, or more, standing upon [?] one line at [such] a distance from [?] the pivots, or [all] of them, encircle [the pole] as a single coil [?].

סימן כה (Siman 25) — Whether the star is fixed [in its sphere], or the sphere is fixed and the star revolves[90]

Most of the sages, the ancients and the moderns, decreed and stated [?] that, by [all] the [proper] reasons, [none] of the seven wandering stars [planets] [?] — no one of the seven wandering stars [?] has, nor adds [?], any motion of its own at all. Rather each of them is fixed and embedded in the hollow of the thickness of its sphere, and the rising and setting and shining of the stars, and their inclination to the north and to the south, is nothing but [a result] of the motions of the star-spheres that carry them — like people sitting in a ship, or [?] fixed in a wheel-sphere, in the manner that the star is fixed and [the sphere?] turns [?] — not according to the one who says that the sphere is fixed and the star moves. And it was on this that the sages of Israel conceded to the sages of the nations, as is found in Pesachim, in the chapter "Mi she-hayah tamei."

But know that the great and wondrous investigator into the science of the stars, unique in his generation — head of the sages dwelling before our lord the Emperor Rudolf [רודלפו"ס; Rudolf II], the lord Tycho Brahe [טיח"א ברא"הי] — said to me: "Their sages did not do well in conceding to the sages of the nations upon a false matter, for the law was with the sages of Israel" [לא יפה עשו חכמיהם שהודו לחכמי האומות על דבר שקר כי הדין היה עם חכמי ישראל] — when they

[90] one of the two copies collated carries an inked X in the outer margin beside this rubric, and a long vertical pen-stroke lower down the same margin — a reader's marks on that copy, not printed matter. The other copy is clean there.

said that the stars turn and travel by their own essential motions, without the compulsion of the spheres' motions, but rather float and run in circles like a bird flying in the air and wheeling about. And he wrote a book on this, and we rely on his signs and his demonstrations, which are observations, that some of the stars revolve within a fixed sphere and pass over the circle of the sun's path, and so forth.

[continued, second column:]...[for it was such that] there was none like him until [?]... And likewise [?] because that wondrous [sage] Kepler [קעפליר"ס], as one saying: since it appears to us, for [certain] reasons, that some of the stars sometimes shift and circle [?] also in other figures outside their accustomed place... toward the northern side of the [path/orbit], and likewise toward the southern side, so that it is impossible to sustain [?]... and this [is] the fundamental [difficulty] of the courses of the revolving stars — unless we say that the stars sometimes stray [swim] in the firmament like a branch [?] growing [?] in the air, [floating] as [in] the air.

And this too I saw fit to make known to you: that I asked [?], concerning the words of the sage Don Isaac [Abarbanel?; אברבנאל/דון יצחק חבר [?]] in his commentary on the [portion of] Bereishis, on the verse "And God made the two great luminaries" [Bereishis, the creation portion — as printed, בפירושו בפ' בראשית בפסוק ויעש אלקים את שני המאורות; the leaf names the parashah and quotes the verse-opening but prints no chapter and verse, and the first reading's "1:16" was supplied]. For the ancient philosophers, such as Plotinus and his circle [הפילוסופים הקדמונים כמו פלוטי"נו וסייעתו], wrote in their book called ha-Tiv'i (the Physics) [בספרם נקר' (הטבע"י)] — and it is a book much prized by all the masters of the science of the heavens — that the seven wandering stars [planets] travel in the midst of the air; and he repeated and stated this view a second and a third time there in his book. And agreeing with him in this, Plato [פ'לוט"ו — so printed], a disciple of the disciples of Aristotle and one of the greatest among them, who composed books upon the whole of philosophy, likewise wrote it in his own book: for he wrote that the luminaries were not [set as] parts of the spheres, nor fixed within them, but rather that the two stars travel in the air between the heavens and the earth, and that the spheres are powers [only] and do not themselves move — thus far his words. And he wrote there further that it is not fitting to decide firmly [in accordance with] what our Sages, of blessed memory, said — that the sphere is fixed and the star moves — for it may be a mistaken [?] view, [and] the matter is at the least in doubt; [and yet] they took it [?]. Nevertheless, there is a great testimony in the words of our Rabbis, of blessed memory, in Bereishis Rabbah [as printed, בבראשית רב'; the first reading gave this as "[Bereishis]"], and in the words concerning the luminaries. And on this very point [it is] said there [in the name of] R. Shimon bar Yochai: "We do not know whether they [the luminaries] fly in the air, or float in the firmament, or travel in their [ordinary] way — the matter is very difficult, and it is impossible for creatures to attain [certainty] concerning it" [Bereishis Rabbah

— as printed, בבראשית רב'; the section figure that follows רב' is not legible on the leaf, and the first reading's "6:8" was supplied]. Thus far [his words].

סימן כו (Siman 26) — To find, in the eighth firmament, the point corresponding to the northern pivot that is in the ninth sphere

Know, my blessed friend [?] — for we too dwell and reside with you toward the northern side of the world, as was explained above at the head of this Section, and as will be further explained below in Section 3 — that the northern pole, or pivot, which is high [?] above us, rises up over against [us] [?]... in the [region of the] earth, higher and higher; whereas the southern pivot is hidden and concealed from us, as will be explained.

And since knowing the location of the height of the northern pivot is of great need to us — for knowing the whole face [?] of the heavens, and for knowing all the settled [regions] and boundaries of the entire globe of the earth — you have nothing more necessary to study, in this science, than it. Therefore, [although] the northern [?] pole is itself not visible within the circle of the [seeing] eye, one can find the place of the northern pivot by an easy way, [that seems?] not lacking [in] reckoning or measure at all. It is already known to the [discerning], to most of our wise men, [that there are] the great, shining stars toward our north that never set for us — those stars whose configuration [?] is designated by the letters א״ב ג״ד [A, B, C, D] and so on, which the astronomers call "the Great Bear" (דוב הגדול; Ursa Major), and which the multitude call "the Wagon" (העגלה); and the other, smaller ones that are near us [Ursa Minor], which are called for you by the [name] [?]...

שער א (First Section) — continued

סימן כו (continued)

[continued from the previous page] …Now take, in your mind's eye, two stars — star ב and star ג of the figure before you — and draw from these two stars two lines running steadily upward [?]. You need concern yourself only with these two lines, until they bring you to meet two further stars; join those as well, and continue higher up [?]. In the same way you will arrive at four stars set out in a square, like this. [A small square of four star-marks (⁂) is printed here.]

Higher still there are three more stars close by, and when you combine them all you find seven stars in all — these form the "Little Wagon" (עגלה קטנה), in the likeness and pattern of the Great Wagon, and this Little Wagon the [astronomers] [?] call the Little Bear (דוב הקטן). [The word rendered "astronomers" is וכניים[?]ה; its second letter does not resolve between ת and א. The word-shape fits התוכניים and the sentence wants it, but the letter was not seen.]

The last star of this Little Bear is a star small in magnitude, yet pure and bright, and it is called the Star of the Sailors [כוכב המלחים] — because those who go down to the sea in ships have set this star for themselves as a true guide [מורה צדק]. For by the position of this star the seamen and the sailors know toward which of the four quarters of the world, and toward which of the thirty-two [ל״ב] quarters of the world (whose character will be explained to you at the end of Gate [?]), they must steer their ship, in order to aim it toward the place we intend. [The cross-reference does print a שער numeral, but its second letter is כ followed by a glyph that could be ג or ז; it is not supplied.]

Because this star is set so very close to the pivot [ציר], … [?] — even so, you should know that it is not the pivot itself. The pivot inclines a little below it, toward the Great Bear … [?]; and it may be that the three of them form a triangle, or the shape of a segol point. [This stretch — the star's offset from the pole and the triangle/segol figure — is the one region of this column below reading threshold: heavy ink spread plus a scan smudge. Read in fragments only; not filled.]

And you, the reader — when you have sought out the Star of the Sailors a second time by the method already explained, and its place has become known to you: beyond that, you can find its place in any location and in any clime, in this way. Take with your sight the two last stars of the Great Bear, which are star ⟨closed-loop letter⟩ and star ⟨bare-vertical letter⟩ of the figure; and draw in your mind from star ⟨bare-vertical⟩ through star ⟨closed-loop⟩ and onward, upward and upward on a straight line, until you meet a bright and shining star

— and that is the Star of the Sailors. And all these things are indicated in the figure.

[Point-labels deliberately not resolved. The two star-labels are a closed-loop letter (ס or final ם — the deciding bottom-left corner is ink-filled in all three occurrences) and a bare vertical (leans ז on head-width, but the distinguishing stroke was not cleanly resolved). What is secure is that they are two different letters of different classes, recurring in the same roles across both sentences. A prior reading gave them as "ז" and "ו"; the closed-loop letter cannot be ו, and neither identity is established. To be settled from the printed figure's own labels, not from body type.]

You should also know that the aforementioned stars — [the outer star of] the Little Bear and, likewise, the Great Bear and the other [circumpolar] stars — never set for us who dwell in the north [?], but circle the pivot without setting, sometimes appearing above it and sometimes below it. (Their nature will be explained to you at the end of the third Section [שער ג].) [reading of this passage is degraded; several clauses [?]]

סימן כז — The figures of the Great Bear and the Little Bear, and that the aforementioned pivot is only a pivot resembling the true pivot

You should know that the Little Bear — and likewise the Great Bear and the other [circumpolar constellations] — [remain visible], [each of them] standing above [the horizon] [?]. I have marked out for you the position of the head-point [nose?] of the pivot [?], as it appears in the figure, so that from here on you may find the location of the pivot-point [nekudat ha-tzir], measured and verified as it stands above the earth's horizon at every time and in every place, between one setting and another [?].

Diagram. A star-chart of the circumpolar region filling the upper two-thirds of the left-hand column. It is a field of seventeen printed six-pointed star-marks (✻), counted by connected-component measurement on witness B and cross-checked on N; the running prose of the column is set in short lines that thread down the right side of the field, so the text stands beside the chart rather than being part of it.

Word-labels on the plate (2, both set as headings across the top of the field):

- **כוכבי שמים** — "Stars of the heavens" (right-hand heading)
- **כוכב המלחים** — "the Sailors' Star" (left-hand heading)

Further word-labels within the field (3):

- **ציר** — "Pivot" (the apparent celestial pole), beside a star near the top left
- **דוב הקטן** — "the Little Bear," beside the upper of the two star-groups
- **דוב הגדול** — "the Great Bear," beside the lower group

Letter census (closed). Six single letters are printed in the field, an unbroken **א–ו** series: **א**, **ב**, **ג**, **ד**, **ה**, **ו**. Excluded from the census: one small ink mark at the lower-left corner of the field (below minim height, no letterform recoverable

on either witness) and one short horizontal dash beside a star near the top (rule weight, not type). Nothing else in the field could be a letter.

And you should further know that, according to what we already established — that the pivot of the world lies in the uppermost sphere [?] — the pivot-point that I have marked for you here, in the sphere of the fixed stars, is not the pivot itself. Rather it is called the "resembling pivot" (**ציר הדומה**), because it exactly resembles [lies directly opposite] the true pivot [?]. (This will be explained further on in the fifth Section, siman **קל"ח** [138?] [?].[91]) Fix this in your memory and keep your eyes upon it, for you will need it further on. Know, too, that the times noted for [determining] the position of the pivot hold precisely only for our own era [?]; but with the passage of many years and long stretches of time the markers will shift, on account of the motion of the sphere of the heavens, as will be explained [at the end of the fifth Section, siman **קל"ח**] [?].

סימן כח — Demonstrations that the heavens are spherical, and that no shape is like the spherical shape

All the sages, ancient and modern, agreed that the spheres are all spherical, and they offered demonstrations and proofs for this. Foremost among them is what they found: that all the stars of the firmament [are seen], in every place [?], at an equal distance from the center of the earth. This follows from the fact that all the lines [drawn] to the circumference of a circle from its center are equal to one another. Therefore, if it should enter your mind that the sphere of the heavens were square, or oblong, or lens-shaped, or [drawn out] to a corner, or shaped like a lentil [?], then the lines would not all be equal, and one star would be farther from us than another [?].

Moreover, they observed that in all the places of the world the apparent breadth of each individual star among the stars of the eighth sphere is always of one and the same measure; whereas, were the firmament a flat surface, one and the same star would appear larger in the one place that is nearer to it than in a place farther off. And as the investigators established regarding the sphericity of the earth: they said it is a natural thing that the [most perfect] object has priority over [any] possible [imperfect] one, and that the sphere retains its form at all times while it is a sphere; it is impossible to add to it or subtract from it [without destroying it] [?] — for when you subtract a little from it, or add a little to it, it is no longer called a sphere, whereas a simple line can be added to or subtracted from and still remain a simple line [?].

[91] this cross-reference is doubly uncertain and is NOT relied upon. Gate and siman are both hedged in the reading itself. It has been proposed that the reference is really to siman 250, whose subject — how far the north pole stands above the horizon at any place and time — is exactly this page's question, where siman 138 sits in a different gate and answers something else. That proposal rests on subject-matter fit, not on the ink, and neither the alternative numeral nor its gate appears anywhere in this portion, so nothing is changed. The printed form stands as read; treat the reference as unverified in both directions.

It is already known that all the shapes in the world are one of three — circular, triangular, or quadrilateral [מרובעת … משולשת … עגולות] — for all the other shapes in the world branch off from these three [מסתעפים מאלו שלשה]. Now the spherical shape has a [natural superiority?] over all other shapes [?]: for a circular [or spherical] figure is enclosed by a single line alone, whereas the others require many lines [?]; and in every genus, the one [the unity] is by nature prior to the many. Third: all the philosophers hold it as an established premise that there is no [void] place outside the world [?]. Now suppose it should enter your mind [that the heavens were not spherical]…

Diagram. A near-equilateral triangle with a circle inscribed in it — the circle is tangent to the base and to both sides — standing in the lower part of the right-hand column (not at the foot of the page). A short stray stroke crosses the left side near the lower vertex, a printing flaw rather than a drawn line.

Letter census (closed). Three letters, one at each vertex, all legible on both witnesses; no other mark on the plate could be a letter:

- **א** — apex, set just inside the triangle
- **ב** — lower-left vertex
- **ג** — lower-right vertex

This illustrates the argument that, were the heavens shaped as a triangle **ג־ב־א** rather than a sphere, everything lying in the corners outside the inscribed circle would necessarily be "outside the world" — which is impossible.

[Suppose] the heavens were not spherical, but (let us posit) the triangular shape **ג־ב־א** [?]. It would follow from this that there is a place outside the world — namely, that everything falling outside the triangle **ג־ב־א** is "outside the world" [?]. And when [the sphere revolves within it], the three corners or angles of the triangle **ג־ב־א** [that project beyond the inner circle would be set in motion, and in their motion would sweep the outer circle] [?], and would leave empty space [within the world and a place outside it] [?] — which is impossible according to the philosophers. The same reasoning applies to all shapes that are not spherical or circular.

Furthermore, the sages wrote [proofs] for the sphericity of the heavens and the earth, since there is no shape [more fitting] [?] — for the circular motion is better suited to revolving than any other configuration [?]. [This passage in the left-hand column is degraded — several clauses [?].]

[Concluding σ28, at the top of the left column:] …[which is] sound, fitting, and [worthy of transmission] to the wise [?], [namely] the statement that the circular or spherical shape is more capacious than all shapes, as will be explained in the siman next to this one. Said the author [?]: "How manifold are Your works, O Lord; in wisdom You made [them all]" [Tehillim 104:24]. The true demonstrations concerning the sphericity of the heavens — the rest will be explained to you in the writing of the third Section [?].

סימן כט — That the circular shape is more capacious than all shapes

The demonstration. Among all shapes there is found no shape more capacious than the circular shape — although this matter is geometrical, and this is not the proper place to lay it all out [?]. I saw fit only to enlighten the reader's eye [?], since the ancient sages already illuminated this matter with [geometric proof] [?]. And here it is:

Take a line A of length 22 cubits [כ״ב], and make from it a circle; its diameter will then be 7 cubits [ז]. The area (תשבורת) of this circle is known to us from the product of half its diameter times half its circumference: for half its diameter is 3½ cubits [ג׳ וחצי], and half its circumference is 11 cubits [י״א]. When we multiply 3½ by 11, we get 38½ [ל״ח... וחצי]. Now if we make from [that same line of 22 cubits] a square, each side will be 5½ cubits [ה'... וחצי], and its area — known from the product of the two sides of the square, one by the other, that is 5½ times 5½ — comes to 30¼ [שלשים ורביע]. Thus you see that in every case the circular shape holds more than the square shape by 8¼ cubits [שמונה ורביע; and indeed 38½ − 30¼ = 8¼]. This is clear and simple to those who know the science of mensuration and measurement. [End of siman.]

Diagram. In the left-hand column, ten concentric circles about a common centre. The count was taken by pixel profile along a radius on witness N, run independently to the right and to the left of the centre; both give ten crossings. Label census: the plate carries no lettering of any kind — not a letter, not a numeral, not a tick.

Diagram. Directly below the concentric circles, a triangle built from ten horizontal rules of increasing length, stacked apex-downward-widening, and bisected by a single vertical axis line running from the apex to the base; the topmost rule is a short cap at the apex. Counted by pixel profile down the axis on witness N. Label census: the plate carries no lettering of any kind.

סימן ל — That the sphere of the constellations (the ecliptic) is divided into 360 parts along the length of the world, and likewise across its breadth

All the ancient sages agreed that every line encircling the middle of the sphere of the constellations — and likewise all the other great circles that pass [through the whole earth] [?] — each one of them [is divided] into three hundred and sixty parts, and they called them degrees (מעלות). I will designate [?] this division in a brief manner, as will be explained further on in the second Section, siman קל״ח [138?] [?]. The astronomers also explained that they divided it precisely into this number [360] because it is subject to many divisions — into halves, thirds, quarters, fifths, sixths, eighths, ninths, tenths, twelfths, fifteenths, eighteenths, twentieths, twenty-fourths, thirtieths, and others; and further, because this number is close to the number of days in the year, for on each and every day [the sphere] revolves [?] in its harmonious course [beneath?] the sphere of the

constellations by nearly one degree, a little less, as will be explained further on in the seventh Section, siman קס״ה [165?] [?].

As for the point from which the reckoning of the 360 degrees on the circle of the constellations begins — the ancient sages agreed to take [its start] [?], and set as the head and beginning of the reckoning the point they called the first point of Aries (נקודת מזל טלה), as will be explained further on, in the fifth gate, in siman 109 (לפנים בשער החמישי בסי׳ ק״ט).[92] [At the very] beginning of Aries the line begins, upon which the 360 degrees are inscribed [?]; it proceeds and circles by way of Taurus, Gemini, Cancer, and so on [שור תאומים סרטן ואחרי׳ כן], encompassing all the curvature of the firmament until it returns to the point [from] which it began; and thereby the 360 degrees are completed, as will be explained further on. The path of this revolution is called the "line of the length of the firmament" [?].

Likewise the circle that revolves above the center of the earth, from north to south [the meridian], also holds 360 degrees. In any case, know that all the circles revolving between north and south are each divided into four quarters, ninety degrees falling to each quarter; the lines of these quarters are each called "the breadth of the firmament," as will be explained further on and in siman ל״ד (§34) and in siman מ״ה (§45).

You should further know that the astronomers agreed to divide each and every degree of the 360 degrees of the sphere still further, each into sixty parts, which are called minutes [דקים], or seconds [שניים]; the number of these subdivisions over the circle of the constellations comes to 21,600 [כ״א אלפים ות״ר; and indeed 360 × 60 = 21,600]. And each minute they divided again into sixty parts, and these parts were called thirds; and each third divided again into sixty fourths; and so on to fifths, sixths, sevenths, eighths, ninths, and tenths.[93]

[Colophon, at the foot of both columns:] בעזר [one word, five letters, not legible] סיימנו השער הראשון : ישראל כאישון · : — "With the help of … Israel like the pupil of the eye [‹ב/כ›אישון] [Devarim 32:10 / Tehillim 17:8][94] — We have completed the First Section." [The second word resolves to five glyphs and does not yield a reading; it is left unread rather than reconstructed.]

[92] a gershayim-marked token stands beside the origin-point exactly where a numeral would; it is the abbreviation "that is to say", not a figure. The clause's only figure is three hundred and sixty, which stands twice.

[93] the rungs' ordinal names are spelled irregularly on this leaf — some with one yod, some with two — and the fifth is set in a form reading "fifties" rather than "fifths". As printed, not regularised.

[94] a second reading of the leaf could not separate the initial כ from ב, so even the idiom is not secured

השער השני (The Second Section)

In it will be explained the making of the globe resembling the celestial sphere; the number of its principal circles [ומספר ראשי עגוליו]; the construction of an observing instrument [ותיקון כלי מחזה א']; and my own method of finding the height of the northern pole above the horizon in every place [ומציאתי גובה הציר צפונית ממעל לאופק בכל מקום]; together with further matters pertaining to it.

סימן לא — The nature of the globe resembling the celestial sphere, its diameter and its poles

After we set out the order of the [four] elements [?] — [with a clear] arrangement of the order of the nine spheres of the heavens, one above another, all in great brevity — it is now fitting [for us] to return to the globe, and to lay out for the students the [principal] methods [?], and to examine the circles of the eighth firmament [?], the globe from which one takes the pattern and likeness of the celestial sphere. For from the making of this very globe the students will come to know the root and foundation of the science of the stars and the constellations.

You should know that the making of such a globe, resembling the sphere of the heavens, is done by two [methods]: The first is to make a hollow spherical globe of thin bands (and it is called a sphera) [ספירא] [?] … a globe [as a solid] body [?], encompassing [it] [?]. And I say to the students that they may choose either this one or that, for both are equally good; the difference between them is only this: that the globe [made as a solid] body — upon it you can draw all [?] the stars of the heavens, which is impossible to draw on the hollow globe [in its hollow] [?] and its encompassing surface [?]. [This pedagogical passage is degraded — several clauses [?].]

[σ31 continues in the left column:] …by means of the hollow globe [כדור החלולי] rather than by the solid globe [מבכדור המקשה], because it is finer and easier to explain and clarify in it the matters of the science of astronomy for the young students. For the ten circles of the globe, which will be explained [?], are more recognizable and visible to your eyes on the hollow globe [?] … and the wonders which [the authors set down] in books [?] … as parables and experiments, are founded upon the fixed constellations [?] … and are also more clearly [presented] to the students on the hollow globe [?]. [Heavily degraded — [?].]

[σ31 concludes, top of the right column:] …the little ones. In any case [?], … [whichever] of the two globes you connect [use] in your mind's eye, choose it [?]; and now that the explanation of the globe [has been given] [?],

[the students] will contemplate both the solid globe and the hollow globe, for [only] a slight distinction and nicety is at issue here [?].

The globe from which the likeness of the heavens is taken must be a perfect sphere — not egg-shaped, not bean-shaped [?], but truly round in all its edges, its diameters equal in all their extents. In it is found no curve and no point, no corner and no [angle], and no [flat facet] [?]; nor is there in it any height or depth, high or low, length or breadth. (This is only by [convention], as [explained] further on in the seventh Section, siman ק"ט [109?], and also in the third Section, siman ס' [60?], [on the verse] "Va-yikra" [?].)

"Kadur" — the word is from the language of Scripture, "like a ball [kadur] into a wide land" [Yeshayahu, ch. 22 — as printed, ישעי' סי' ד"ב, the numeral set with a medial final-kaf and broken across the line end; the verse figure "18" was supplied by the first reading]; and Rashi explained there [ופירש"י שם] that kadur is pelota [פלוט"א] in the vernacular, which one throws and catches from hand to hand. And Radak [והרד"ק] explained the root kadur — it is the familiar word, as in the Mishnah's "ha-kadur," and the sages call it in the vernacular pela [פל"א]; thus far his words. In German [בל"א] they call it Ball [בא"ל].

Within the globe you picture to yourself, imagine a single point at its exact center, because all the lines going out from that point to their circles are equal in their measure; and this point is called by the scholars the center (מרכז) of the sphere. And the line that goes and passes through the center and issues out to the other side […] is called berit [?] (נקר' ברי"ת [?]) — which the scholars of inquiry call koter (קוט"ר), the diameter. And the two points at the heads of [[6 glyphs, unresolved on both witnesses]] the diameter are the pivots, or the poles, of the world (הם צירי או קיטבי העולם): the one is the northern pole, and the other is the southern pole, as has been explained in all of this above, in siman 28 (כמו שנתבאר בכל זה למעלה בסי' כ"ח).

סימן לב — The number of the globe's circles [and the circles] most necessary for the [complete] work, and the center [of the globe] [?]

The circles most necessary for the making of the aforementioned globe are ten [הם עשרה]. Six of them are great circles [ששה גדולים], equal to one another in size, and the center of the earth is the center of each of them; and each one of them divides the globe into two equal parts. Each of the great circles is divided [as they themselves are divided] … at right angles … from east to west and from north to south … and each of the six circles is divided into 360 degrees. And from the ten circles already mentioned there branch off four further small circles [ויסתעפין מן העשרה עגולות הנ"ל עוד ארבע עגולות קטנות], of which the center of the earth is not the center of any.[95] Before we come to explain the ten circles of

[95] the four small circles branch off "the ten already mentioned", though the six great and four small already exhaust the ten; either "further" is being used as "moreover", or the compositor set "the ten" for "the six". As printed.

the globe, I saw fit to draw and set before you, at the very outset, a likeness and model of the globe together with some of its circles — because it is impossible to draw a sphere with its [full three-dimensional] extents [?] upon a flat surface. Know, then, that this drawing represents [only] half a globe; picture it in your eyes as a bowl inverted upon [your] palms, and [understand] that the lines engraved and drawn on the circle upon the half-globe each represent half a circle [?]; and imagine that the other half of the globe, with the other half of its circles, is likewise sunk, hidden, and covered beneath the [surface] of the globe, and drawn upon it.

Diagram. A large orthographic drawing of the globe: a rim circle, a family of horizontal parallels each carrying its own name, two meridian ellipses meeting at the poles, one oblique great circle, and a marked centre point. The polar axis is set on a diagonal — the north pole lies at the upper left and the south pole at the lower right — and from each pole a short spoke projects outside the rim ending in a printed star-mark (✻). Printed above the figure, as a line of type and not as part of the woodblock, is the caption **צורות כדור עם שמנה עגוליו ויחסרו שני׳ מהם מטעם שיתבאר** — "Figure of a globe with its eight circles; two of them are lacking, for a reason to be explained." (**שני׳** is set abbreviated with an apostrophe on both witnesses; do not expand it to **שנים**.)

Label census (closed). Fifteen inscriptions are printed on the plate. Six stand outside the rim, nine inside it. Every one below was read on the leaf; none is taken from the surrounding prose.

Outside the rim:

- **אופן ארבע צירים** — "the wheel of the four axes," curved along the rim above the north pole
- **ציר הצפוני** — "the northern axis," set radially along the north-pole spoke, ending at its ✻ (printed without the article on **ציר** — not *הציר הצפוני*)
- **ציר הדרומי** — "the southern axis," likewise along the south-pole spoke, ending at its ✻
- **ציר המזלות** — "the axis of the zodiac," set along the rim on the left (read on N; over-inked and unreadable on B)
- **מזרח** — "East," set along the rim on the right
- **מערב** — "West," set along the rim at the lower left

Inside the rim (each name is set across its own line and is interrupted where a meridian crosses it, so the two halves of a name sit on either side of the crossing):

- **עגול הצפוני** — "the northern circle," the uppermost parallel
- **עגול סרטן** — "the circle of Cancer," the next parallel down
- **קו המזלות** — "the line of the signs," on the oblique great circle (not *עגול המזלות*)
- **קו השוה** — "the equinoctial line," left of the central crossing
- **שוה יום** [[?]] — right of the central crossing, on the same line as **קו השוה**. The words **שוה יום** are secure on both witnesses; the two-to-three-glyph word before them is not resolved and is deliberately left unread rather than reconstructed.

- **קו הסתרת** — a further named line below the equator. The seven letters ק ו ה ס ת ר ת are individually legible at 4× on B, but the word yields no settled sense and no translation is offered; it is transcribed, not construed.
- **עגול גדי** — "the circle of Capricorn"
- **עגול הדרומי** — "the southern circle," the lowest parallel
- **נקודת היושר** — at the centre, split by the crossing of the two central lines (נקודת on the right, היושר on the left)

No single letters are printed on this plate — every inscription is a word or phrase.

And you, the reader, as a beginner setting out to learn this science — prepare for yourself, and set in order [?], a hollow globe of thin bands proportioned to the size of the drawing that follows; or have a lathe-turner [דרעקסלער, German Drechsler] make you a hollow globe [of wood?] [?], or [one made] of some other material; and engrave upon it all the circles of the [meridian?] lines [?] upon its surface, and run the lines round about the globe.

שער ב (Second Section) — continued

(Continuation of the preceding paragraph, on constructing and marking a celestial globe. This material carries over from the prior batch, where it stands under *סימן ל"ב*; the first numbered heading on this opening is *סימן ל"ד*. The book prints no *סימן ל"ג* — the jump *ל"ב* → *ל"ד* is as printed.)

on a small globe according to its smallness, on a large one according to its largeness, and on each according to its size — [with the length and spacing of the marks] near or far in proportion [?]. And if God has granted you a heart to understand, it will be easy for you to grasp and to comprehend the design of this globe and how it is made, from these books of his — without any teacher or instructor. But do not rely on the drawing on a flat surface, for [?] the work will prove hard for you and you will not be able to complete your task by it. Rather, prepare for yourself a globe — [solid or] hollow [?], well-made and of one piece — and then you will succeed and gain understanding.

סימן ל"ד — Explanation of the First Circle, called the Equator (משוה היום)

The first circle, which we shall begin to explain, is the circle that runs around the middle of the globe and is drawn from west to east at an equal distance between [the two poles], the northern and the southern, passing over the center of this globe [and running] from [south to] north — that is, [?]. [At its ends] lie the pole of the world [קוטב / ציר], and the two endpoints of the axis are the two pivots called the poles of the world, as was written above in siman 21 (כמו שכתב׳ למעלה בסימן ך"א). This circle is called in the books by several names: mashveh ha-yom ("equalizer of the day," the equator), the "circle of the plain" (עגול המישור), the "straight circle" (עגול הישר), and the "equal line" (קו השוה) — and each of these names has its reason.

It is called mashveh ha-yom ("equalizer of the day") because for all who dwell beneath this line, day and night are always equal, all the days of the year. Moreover, when the sun runs beneath this line — which happens twice a year, when it reaches the head of Aries [ראש טלה] and [the head of Libra, ראש מאזנים] — the measure of day and night is equal for all the inhabitants of the world, in every clime, as will be explained. It is called the "circle of the plain" (עגול המישור) because those who dwell beneath this line see the two poles [on their horizon], and the globe of the earth appears to them as a flat plane [?]... [the extreme lines meet; a body sunk below is hidden — one of the poles concealed]. And this is called the "straight circle" (עגול הישר), or the "straight line," because it stands most of all in the middle of the globe and inclines neither to the north nor to the south. And further, that for all who dwell beneath this line the 62 signs (ס"ב מזלות) are divided equally for them, and most equally — only toward the north side, and [?] toward the south side. And further, that all the days of the year the signs always rise for them equally and evenly: six [ששה] signs that rise for them by day, and likewise six signs that rise for them by night [?]; the time of their revolution above the earth is as the time of their revolution below the earth, as will be explained כ"ו further on, in siman 138 (בסי' קל"ח), God willing. And from the sum of all the aforementioned matters [?] — by the reason of each and every one of them — it is called the "equal line" (קו השוה).

This circle of which we have now spoken you shall divide into 360 [ש"ס] parts, which are called degrees; the uses of this division will be explained to you later. And so that this division may be done correctly, [begin marking] one part [at the head] of the circle [?]. This is done by means of a compass [מחוג]: [you divide it] into four quarters [לארבע רביעית], and each quarter into three parts [וכל רביעית לג' חלקי'], and each part of them again into three parts [ובכל חלק מהם עוד לשלשה חלקים], so that all the parts come to thirty-six [ויהיה כל החלקים ששה ושלשים]. Now on a small globe, which because of its smallness cannot [hold] all 360 parts for marking with a graver [?], you shall mark the encircling line every ten degrees — 10, 20, 30, 40, [50?] and so on — so that the aforementioned thirty-six parts come to 360 degrees [ויעלו ששה ושלשים חלקים הנ"ל ש"ס מעלות]; whereas on the large globe, [you divide it further].

And on the great globe you shall divide each of the aforementioned thirty-five parts [ובכדור הגדול תחלק כל חמשה ושלשים חלקים הנ"ל], each one of them into two [וכל א' מהן לשנים], so that the sum of the parts is seventy-two, each one holding five parts [,15 ,10 ,5 — ויהיה סך החלקים ע"ב אשר כל א' מחזיק חמשה חלקים] 20 ['ה' יו"ד ט"ו ך] — and likewise minutes [דקים]; and so too the sum of them all is 360 degrees [כמו כן סך כולם ש"ס מעלות].[96] This division [is made] on this "straight circle," and likewise you shall [make] on it, in every quarter of it, large [subdivisions], each of which is divided into [ninety] degrees [?]; for the whole

[96] the count printed twice as thirty-six at the foot of one column is referred back to, at the head of the next, as "the aforementioned thirty-five". The passage's own totals want thirty-six — seventy-two is twice thirty-six, and seventy-two fives make three hundred and sixty. The leaf nevertheless prints thirty-five, and it is given as printed.

is such that it is divided into four quarters, and each quarter into ninety [תשעים] parts, so that the sum of all the quarters is 360 [ש״ס] degrees, as will be explained further, God willing.

סימן ל״ה — Explanation of the Second Circle, called the Dividing Circle (אופן המפריש / the Horizon)

The horizon (ofeki), or the "circle of vision" (עגול הראיה), or the "ring of the earth" (חוג הארץ) — and in most astronomical books they call it ofek, which is likewise an Arabic word [Arabic: ufuq, "horizon"]. This circle too is one of the three great circles of this whole globe. It runs along the curvature of the eighth sphere, and its circle is inscribed at the very lowest place — where, according to the sight of the beholder's eye, the edge of the heavens and the edge of the earth appear joined together. This line is traced in the mind from the southeastern corner, going around the whole eastern side, and likewise the whole northern side, and from there to the west, and from the west to the south, until it returns to the southeastern corner. The center of this circle is beneath the soles of your feet, and the point directly opposite it above, in the zodiac, is called the zenith [(transliterated term) [?]; קדקד, "the crown of the head"]. That point serves as a pole for the horizon — that is, for the circle of vision — of every person, in whatever place he dwells.

And the arc — that is, the line of the circle that rises from the horizon straight upward, following the curvature of the sphere, up to the zenith [Gloss: opposite the crown of the head, which is the [24th?] part [?] of the sky] — is called the "circles of altitude" (עגולות גובה) [almucantars]. By them we reckon the altitude of the sun, the moon, and the other stars, in every place and at every time, and how many degrees and minutes each of them stands above the horizon, as will be explained regarding this later [in siman כ״ב? [?]], God willing.

And this circle of which I speak is called the "dividing circle" (אופן המפריש), as above, because it divides and separates between the stars that are above [the horizon] and the stars that are hidden and concealed from us below it. For this same reason it is [also] called the "circle of vision," because our sight extends only up to the circle of this line; whatever is below it is hidden and concealed from us. On the eastern side of this line we see, each day, the sun as it rises and shines forth; and on the western side [it sets]. And because of the [inclination] of the zodiac, the [arc] over which the sun revolves above the horizon is called by some authors the "arc of the day" (קשת היום), while the part below it is called the "arc of the night" (קשת הלילה). And just as the rule of setting applies to the sun with its rising [?], so the same rule applies to the moon and to the other stars that [rise and set].

They see [rising] above the horizon, every night, from the eastern side [stars] that then set below it on the western side. And know that for all who dwell round about the earth, in every place and at every time, their vision reaches above the horizon on every side, up to the eighth [sphere] — which is called the sphere of the stars, or the sphere [of the zodiac] — and always half the sphere,

namely six of the [zodiac] signs, is revealed to them above the horizon, while the other half of the sphere of the firmament, namely the other six signs, is hidden from them beneath the horizon. Yet the half of the sphere visible to us in one place is not the same half that is visible to us in another place, as will be explained further.

And from the whole of these matters this will be explained to you: how great the difference is between this circle and the rest of the circles of the globe. All the other circles are shared by every person in every place and by the whole world alike, and none of them shifts from its place for one man as against another. But this dividing circle — and likewise the meridian, whose character will be explained to you just below — shifts from its place and changes for those who dwell in each place. For in every part and portion of the earth's surface the horizon changes for its dwellers, whether from east to west or from north to south: each one has a horizon particular to himself, and no two people in two places will be found to share a single horizon — except two whose soles are set directly opposite one another, as stated above in siman ל״א (§31).

The [right] horizon (אופק ישר) belongs only to those who dwell beneath the equal line [the equator]; and their [horizon is called the "dividing circle"] [?]... [it passes over the two poles of the world]. [For such dwellers, the horizon divides the sphere in a particular way,] as will be explained; and moreover, there are many special laws and rules, distinct and set apart, that belong to those who dwell beneath the equator — to the north side and likewise to the south side:

- The first: their advantage [is that] one of the sides [dips down] from the horizon [?], and [the other] side [rises] from the horizon [?].
- The second: that some of the stars are always visible to them and some are always hidden from them [?] — [rather, for equator-dwellers all the stars both rise and set] [?].
- The third: that the time in which the signs of the zodiac revolve above the horizon is equal to the time of their revolution below the horizon.
- The fourth: likewise, the time of the sun's revolution above the horizon [equals its revolution below it]. From this [it follows] that the measure of day and night is never equal [for the rest of the world] except on two days of the year, as will be explained in siman קמ״ג [143].
- The fifth: that their horizon also divides [every circle passing straight] into two equal parts, though not at right angles [?]; and it becomes for them a straight line from the side, like a stretched wall-line [a plumb-line] [?].
- The sixth: that those who dwell beneath the equator... [see the] signs inclining from them toward the south, all of this according to their nearness to the [northern] pole; so that whoever [moves] from the equal line toward the northern pole by [24?] degrees [?], all twelve [י״ב] signs [?] will be [inclined] to the south side for him [?].

- The seventh: that of the half of the globe which lies from the [equal] line toward the north, the part called [the visible] [?] will be [hidden] from them beneath the horizon [?]; and the half of the globe from the equal line toward the south will be hidden from them.

The dividing circle, or the horizon: according to [?]... [how to inscribe it upon the globe] — [set the seat/base ring] [?]... and to make it a horizon for those dwelling beneath the inclined [circle], you raise the northern pole above the ring of the seat according to their distance from the equator. For example: the city of Prague sits fifty degrees from the equator toward the north (למשל עיר פראג היא יושבת מקו השוה לצד צפון חמשים מעלות); therefore you shall raise and turn the aforementioned [?] globe, the north[ern] [?]…

above the ring of the "seat" [base] itself, fifty degrees (חמשים מעלות); and let there be [a seat-ring] like it [?]. The ring of the seat will then be for them the horizon proper to them; and this matter will be explained to you more fully further on, after the explanation of the ten circles of the globe, in siman מ״ס (בסי׳ מ״ס), God willing.

The horizon — which is the one under discussion — is a ring; like it [the equator], you divide it into 360 [ש״ס] parts, or degrees, just like the equator-circle, only with a slight difference in the manner [?]: you divide it into four quarters, and each quarter you divide by itself into ninety [תשעים] parts, whose sum together is 360 [ש״ס]. And upon the four quarters marked on the horizon, they begin the count of the number of degrees of the east [point] on the horizon; and from there their number is marked from 1 [א׳] up to ninety, in the manner ס׳ יו[/"/]ד ט״ו — sixty, ten, fifteen — and so on.[97]

סימן ל״ו — Explanation of the Third Circle, called the Meridian (אופן חצי היום)

The third circle is called the "circle of midday" (אופן חצי היום, the meridian); it is also called the "southern circle." It runs along the curvature of the firmament from the middle of the north to the middle of the south, and so from [south] to north, and passes over the two poles of the world — that is, over both poles [?] — and over the point at the zenith (the crown of the head). It divides both the equator and the horizon-line, each of them, into two equal parts and at right angles. Its property is that... [as its] center [moves] each and every day to pass beneath it [at the moment of noon] [?], the time of midday reaches all who dwell beneath it — whether the sun at that moment stands directly opposite the zenith point itself, or whether the sun is far distant from it by a great distance; only [it must be] that you find it [?] over against [?] the aforementioned line. Even at the winter solstice (תקופת טבת), when the sun is at its utmost remoteness and lowness for all who dwell in the north, nevertheless, when the sun reaches the aforementioned line — which is the line of the middle of the south — it is then distant from the zenith by [[GAP: the figure here is on the leaf and was

[97] a series announced as running "from one to ninety" opens sixty, ten, fifteen. The first figure is a closed round sort on both copies, not the five the sequence wants; given as printed.

not read; a second reading of the leaf could not resolve it either and, having 23° 28′ three lines away, explicitly declined to compute it. Locus: p.39 R32, between רחוקה מנכח הקדקד and the flanking pair מ״מ. Needs a fresh read.]] מ״מ, and it is at the utmost of its height for that day. And this [is so for] every man dwelling beneath it, as though he inclines toward the middle of the north; and that is the time of the midday of every man, in whatever place he dwells.

and before the westerners. This precedence holds always and specifically in the meridian; not so the rising and setting of the sun, where the easterners' precedence over the westerners does not hold in every place — nor at every time, but only at the seasons of Nisan and Tishrei [the two equinoxes]. In the rest of the days of the year there is precedence for the northerners before the southerners, in such a way that in some places the sun rises for the westerners before it rises for the easterners. These rules will be explained further on, in the Sixth Section, in simanim קנ״ב קנ״ג (§§152–153).

And from all these matters just stated there will be explained to you the two distinctions that exist between the meridian and the rest of the circles of the globe — the same two we already drew, just above, between the horizon [אופן המפריש] and the rest of the circles of the globe.

The first distinction: every one of the other circles of the globe stays in its place for each individual person by himself and for the whole world alike; the meridian is not so, for it is a circle proper to him alone and to his fellow and to those who share his position, and to no one else.

The second distinction: just as the horizon has no motion and no sphere of its own, as was explained, so likewise is the law of the meridian — it has no motion and no sphere at all. It is sunk and at rest, standing on its base and in its position and keeping its post, until the center of the sun comes to pass beneath it, and midday is thereby made. Nevertheless it is more fitting that we make this circle a complete circle, in such a way that half of the circle shall always be the midday circle, and the second half opposite it shall be the midnight circle, as will be explained. And you should know that the astronomers make for this circle yet another circle, better still; and [?] their signs [?], their workings and their rule will be explained to you further on, in siman 45 (בסי׳ מ״ה), God willing.

סימן ל״ז — Explanation of the Fourth Circle, called the Zodiac Circle (עגול המזלות / the Ecliptic)

The fourth circle is called the "circle of the signs" (עגול המזלות, the ecliptic) [Ladino/Greek term [?]]. It is one of the great circles that revolve about the whole globe. It passes over the equator and divides it into two equal parts, though not at right angles, for it crosses it at two opposite points [the equinoctial points] distant from one another by [?] degrees. It cuts across a broad path [the width of the zodiac]... [inclined by about 24 [?] degrees / minutes] [?], and the pole of the [ecliptic]...

[the ecliptic is divided into degrees, into minutes;] and [the signs are divided into] the northern [signs] and the southern [signs] [?]... [those inclining to the north side are called the northern signs, and those inclining to the south side are called the southern signs] [?]. [There are... degrees] [?]. Know further that although the [ecliptic] has its own center [?], because of its inclination from the equator toward the north and toward the south, it necessarily follows that the poles of the [ecliptic] of which we have spoken are not [in the same place] as the first [poles], [as in siman לא? [?]]; rather, the poles of the ecliptic are distant from the poles of the world according to the inclination of the ecliptic from the equator.

[degrees, to divide them into equal minutes] [?]... the [northern signs] and the [southern signs]... those [inclining] toward the south side are called the southern signs. [There are... signs] [?]. Know further that the circle of the zodiac, although [it has] its own center [?], because of its inclination from the equator toward the north side and toward the south side, it necessarily follows that the poles of the circle of which we spoke are not [as at first, in siman ?] [?]; rather, the poles of the zodiac are distant from the poles of the world according to the inclination of the signs from the equator, [in accordance with] their inclination, which according to the view of Ptolemy [בטולמיא"ס] is 23 degrees and 21 minutes [כ"ג מעלות כ"א דקין] — by that much are the poles of the zodiac distant from the poles of the world, as will be explained further.

סימן ל"ח — Explanation of the Fifth Circle, called the Poles [Circle] or Support of the Sphere (צירים או מעמד הגלגל)

The fifth circle is called the "support of the sphere" (מעמד הגלגל), and it is also called [the solstitial colure] [?]. [Together with the sixth it makes] two circles which are among the great circles that revolve [around] the thickness and body of the globe, [running] from the south to the north; and at the place where the two colures [מעמדים] cut [one another] at right angles [?], [it passes] like the first [circle]. This circle passes over the two poles of the ecliptic (whose distances from the poles of the world are as stated above), and it runs by way of the head of the sign Cancer [ראש סרטן] and by way of the head of the sign Capricorn [ראש מזל גדי] — the two solstice points.

these are called [thus]: this circle has two names; it is called the "colure [standstill] on high" [?]. The two solstice points, which are the summer [solstice] (קיץ) and the winter [solstice] (חורף), are called "standstills" (מעמדים) [?]; and [one may] call it "the circle of the four poles of the spheres," and [one may] call it "the circle of the summer and winter solstices."

סימן ל"ט — Explanation of the Sixth Circle, called the Equinoctial Colure (מעמד השוה)

The sixth circle too is called a "support of the sphere," because within it are found two other "standstills" [?]. But this sixth circle does not revolve by way of the two poles of the signs [אך אופן הששי הזה איננו סובב דרך שני צירי המזלות];

rather it goes and circles by way of the head-points of Aries [רק הולך וסובב דרך ראש נקודות מול טלה] and by way of the head-points of Libra [ודרך ראש נקודות מול מאזנים], at which — when the sun reaches either of the two points — the days and the nights are changed in all the places of the dwellers in every clime, as is stated further on in §139 [כמ"ש לפנים בסי' קל"ט]; and it is for this reason that this circle is called the equinoctial support [אשר מפני זה יקרא לזה העגול מעמיד שוה].

סימן מ' — Explanation of the Seventh Circle, called the Summer-Solstice Standstill (עמידת הקיצית) / the Circle of Cancer (עגול סרטן)

The seventh circle is called the "circle of Cancer" (עגול סרטן); it is also called the "circle of the summer-solstice standstill" (עמידת הקיצית). For when the sun reaches the head of the sign Cancer [ראש מזל סרטן], there it is nearest [to the zenith of the northern dwellers], in the extreme of nearness — for then it can come no nearer to us. This is the end of the days of summer [סוף ימי הקיץ, as printed] and the beginning of the days of heat [ותחלת ימי החום].[98] On that day the sun makes the circle [ק' ?] [in the season of...] its daily motion; and this is the circle of [the summer standstill] and the [tropic] [?]...

(Continuation of *סימן מ* — the Circle of Cancer / the summer standstill, begun at the foot of the previous page.)

so it comes about at the true summer solstice (תקופת תמוז האמיתי — the qualifier is on the leaf), with its heat: at that season the day is longest for us of all the days of the year, [the night is shortest,] and the heat too then grows greater for us than in any other days of the year. The declination of the center of the sun from the equator at that time is, according to Ptolemy [בטולמיא"ס], 23°21′. The astronomers call this declination "the great declination," since no [solar] declination of this kind is found greater than it. This circle is also called "the reversing circle" (ההפוך), because from this point the sun begins to turn its face toward the south and to withdraw from the inhabited world day by day, and the days of winter — that is, the winter season — draw nearer to us, until it reaches the head of Capricorn, which is the utmost of its withdrawal from the inhabited world, as will be explained shortly.

From the principles we have set out it becomes clear to you that all who are more than 24 degrees from the equator [toward the north] — — such as we, the dwellers of the north: Canaan [כנען], the men of Eretz Yisrael [אנשי א"י], Babylon [בבל], Persia [פרס], Media [ומדי], Chaldea [כשדים], Aram [ארם], Egypt [מצרים], Spain [ספרד], France [צרפת], Ashkenaz [אשכנז], Greece [יון], Italy [ואטליא], and countless other lands — the sun never passes over the zenith (the crown of the head) of the inhabitants there, over all the choice, settled part of the world; rather the sun always passes to their south, because the sun never crosses beyond the Tropic of Cancer for all the days of the world.

[98] the clause names two seasons and one endpoint of each — the close of the one and the opening of the other. They are two distinct seasons in the rabbinic division, not synonyms, and the leaf treats them as consecutive; any rendering that gives only "the end of summer" or only "the beginning of summer" reports half the clause.

And just as this is the rule for the northern dwellers, so it is for the southern dwellers who are more than 24 degrees from the equator toward the south: the sun circles around to their north all the days of the world — as will be explained to you in siman 66 and in siman 75 (כמו שיתבאר לך בסי׳ ס״ו ובסי׳ ע״ה), God willing.

סימן מ״א — Explanation of the eighth circle, called the winter standstill (עמידת החורפי), or the circle of Capricorn (עגול גדי)

The eighth circle is called the circle of Capricorn [עגול גדי; also read עגול נריינם? — reading uncertain], and it is [also] called the circle of the winter standstill (עמידית החורפית). For when the sun reaches the point of the head of Capricorn, there it stands still and ceases to withdraw any farther, since the sun is then at the extreme of its distance from [the inhabited world] and can go no farther. At that moment is the end of autumn and the beginning of winter. On that day the sun makes one full circle [about the earth] by the diurnal motion, [and this] circle is the lowest, and the sun stands closest [to the horizon] toward the south of the year. This occurs at the winter solstice (תקופת טבת), the time at which the day becomes shortest for us and the night longest, and likewise the cold grows greatest. There the distance of the sun toward the south is 23°21′ [ך״ג מעלות כ״א — the degrees are set with the descender-form final kaf ך; the minutes sort is read נ from its letterform].

Know, too, that this circle is called "the reverse of the [summer] one" (היפך הקיץ), because from there the sun begins to turn its face back toward the north, to draw nearer to the inhabited world day by day; and the summer season likewise draws nearer to us day by day, until the sun reaches the head of Cancer — and so this matter recurs in a cycle continually, all the days of the world.

From the things we have mentioned it becomes clear to you that the difference between the extreme of [the sun's] withdrawal from the inhabited world and the extreme of its approach [to it] is 47°42′ [מ״ז מעלות מ״ב דקין = twice the obliquity]. You should also know that the distance between the two circles — between the Tropic of Cancer and the circle of Capricorn — since the sun is always confined moving between these two bounds [is 47°42′]; and this was the view of all the ancients [כל דעת הקדמונים], the [Greek: πλανώμενα? "wanderers"] planetary bounds [reading uncertain, ~two lines here are garbled], and it is enough to be brief about this. **

[Gloss, small type, largely illegible: "*עז … ע״ה … כמו … שם שום*" — a short marginal/footnote line above the next siman, mostly unreadable on the scan.] [?]

סימן מ״ב — Explanation of the ninth circle, called the northern circle (עגול הצפוני)

The ninth circle is called the northern circle, and it is traced around the pole of the ecliptic [קוטב של עגול המזלות]. How so? We have already explained above that the ecliptic is inclined to the equator by 23°21′ [כ״ג מעלות כ״א דקין — the minutes are read from the letterform on the leaf itself, not inferred from the received value of the obliquity]; accordingly, the axis of the ecliptic is likewise inclined by that same amount. Now since the ecliptic is carried around by the diurnal sphere, it follows that the axis of the ecliptic revolves and traces a full circle around the axis of the world; and this circle is called the northern circle, for no circle traced in the making of the celestial sphere lies nearer to the north pole than it does.

From the principles we have mentioned it follows that the distance of this whole circle from the north pole is also 23°21′ [ך״ג מעלות כ״א — the degrees again in the descender-form ך; the minutes sort is again read נ from its letterform], and that those who dwell beneath this circle are, by this reckoning, 66°9′ [ס״ו מעלות ט׳ דקין, so printed — recorded as ink, not as the derived complement 90° − 23°51′; the two agree, but the agreement is an observation and was not used to read any glyph] from the equator — and by that many degrees the north pole is raised for them above their horizon. For those dwelling beneath this circle at the summer solstice (תקופת תמוז), the day lasts 24 hours [כ״ד שעות], as will be explained further on, siman 143[?] [סי׳ קמ״ג — cross-reference number uncertain].

סימן מ״ג — Explanation of the tenth circle, called the southern circle (עגול הדרומי)

The tenth circle is called the southern circle, and its tracing is like [that of the ninth]: because the ecliptic sphere, through the diurnal sphere, causes the axis of the ecliptic to revolve around the axis of the world toward the south. The cause of this was already set out just above in [the discussion of] the ninth, northern circle, and that very same cause holds for the tenth, southern circle — for as is the case with the one, so is the case with the other; therefore it needs no separate explanation.

And behold, we have now traced out for you ten circles of the sphere, the ones most necessary for the science of the stars and the constellations, in constructing a sphere resembling [the heavens]. There are also many other traced circles besides these; for each and every day of the year [the sun traces] a distinct circle — these are called "the daily circles of the sun" (גלילי השמש), as [will be explained] further on in this gate, siman 132[?] [סי׳ קל״ב — number uncertain] — and likewise the path that each star and the fixed stars trace, making each day a circuit around the sphere of the world. Were all these to be

drawn as circles upon the sphere, [it would be crowded beyond use]; [therefore we drew only] these [ten], upon the sphere. [?]

סימן מ״ד — Explanation of the distances of the three circles — the equator (קו הישר), Cancer (סרטן), and the Northern circle — from one another

From the principles we have mentioned — that just as the ecliptic is distant from the equator, so [each corresponding circle is distant] — it likewise follows what the distance of the whole northern circle is from [the north pole], and likewise the distance of the Tropic of Cancer from the equator. And it becomes clear to us, without much reflection or extensive calculation, how great [each of these distances is]:

The distance between the Tropic of Cancer and the northern circle: the distance of Cancer from the equator, and likewise [the distance] of the northern circle from the north pole, and from the equator to the north pole in the sphere is, as already explained, 90 degrees. Now the two [component] distances we mentioned — namely the distance of the Tropic of Cancer from the equator, and the distance of the northern circle from the north pole — each of them is 23°21′ [כל אחד מהם ך״ג מעלות כ״א דקין — the words an earlier reading took for the numeral כ״א מהם are in fact **כל אחד מהם**, "each of them," not 21; the minutes sort is read **נ** from its letterform]; joined together they come to 47°42′. Subtract this from [90 degrees], and there remain 43°18′ [מ״ג מעלות י״ח דקין — so printed; the subtraction the sentence itself prescribes yields 42°18′] [recte: 42°18′], and that is the distance between the Tropic of Cancer and the northern circle, as follows by this reckoning. And from the equator up to the northern circle there are 66°20′[99], and this itself is [also] found [as the distance] from the north pole down to the Tropic of Cancer.

These, then, are the measures and distances that always obtain among the three circles — the equator, Cancer, and [Capricorn / the Southern] — and [so too] for the southern side; and remember these matters, for [we shall need them] in their place. ** [?]

סימן מ״ה — Explanation and construction of the meridian line (חצי יום) by another method, with its great usefulness

After we have explained the circles of the sphere in a general way, [we turn] further to explaining and constructing the meridian line (אופן חצי יום) by another

[99] this leaf sets three quantities its own text treats as one derivation, and they do not agree. The two obliquities are each 23°21′; their sum is printed 47°42′, where doubling gives 46°42′; the remainder from ninety is printed 43°18′, where the printed sum yields 42°18′; and the distance from the equator is printed 66°20′ here and 66°9′ earlier in the same stretch, where the figures above would give 66°39′. Every one is given as printed; no figure on this leaf has been adjusted to close a chain with any other.

method. For this instrument you are to make yourself, from wood or from brass [מנחושת?] or from some other [material], a hollow ring, like a signet-ring [כפי טבעת], whose hollow and thickness run along the diagonal of the sphere; and this will serve you as the meridian ring [אופן חצי יום], like the [earlier] arrangement of the meridian. Its hollow should be like [the section?] of a ring, and its thickness about a quarter of [a finger / הליפורין?] or less, of about this measure. On this ring you make two [markers / כוכבים? "studs"] opposite each other, such that a [thread/rod] may pass through the two holes; and within the two holes you set the two poles [קוטבי] of the [sphere], at the place of the two poles of the sphere, so that the ring and the sphere [turn together on] a single meridian ring. This you take within the ring of the [horizon-and-diagonal] frame [טבעת הכסא?], as explained in siman 35[?] [בסי׳ ל״ה]; and in it you make two slits [חרירין] opposite each other, [set] in the middle, and the [pointer / הצפון] of the frame at the middle of the [south]; and the [thickness of the] slits should be about a quarter of the thickness of the meridian ring. Within these two slits you fit [the meridian line], and you erect this ring so that the two poles [קוטבי] — the diameter of the [sphere?] — are the two points of the ring, standing true to the horizon, with the meridian ring standing upright and true, high [at the top] and low [at the bottom]: the upper semicircle rising toward the point of the zenith [נכח נקודת הקדקד], and the lower semicircle bending down toward the point [opposite it, the nadir], between [the pointers?]; [thus the sphere is set up] toward the [zenith] point, or the crown-point above. And this will give you [the meridian line] of the upper ring — the meridian ring — upon which, when the sun [transits] this line, it is the time of local noon [חצות היום], as [stated] in siman 35[?]; and [the point] of the lower [semicircle] will be for the midnight line, upon which, when the sun [is on it], it is the time of local midnight — in every place and at every time — as will be explained at the end of this gate, in siman [?] [בסי׳ ב״ל? — number illegible], God willing. ** [?]

[Rashi script / small-type note: "האופן חצי יום — of which we have also spoken; in it too will be marked … a [circle] upon the sphere, like the [inclined?] ring … [reading uncertain]."] [?]

(Continuation of *סימן מ״ה*, top of the next column.) …For the four quarters, and every fourth [division] — for its whole [circumference] is divided into 360 parts [reading of the fractional scheme uncertain], so that each quarter is 90 parts — and the tracing of the 90 [degrees] should be made [upon the ring]; this will be the meridian ring, which serves the whole surface of the sphere. The benefit of this is that by it we can know, at any point on the surface of the sphere, [the position of any marked object]; and the meridian line thus fixed [gives] the noon [transit]. [?]

סימן מ״ז — To construct, upon a globe resembling [the heavens], an arc — after measuring the distance [of the stars, הכוכבים]

Know that I have seen [in a certain place], as the astronomers [do]: on a [fine-graduated] quadrant [קשת רביעי — a quarter-circle] of a sphere, its rim is marked with ninety degrees; and to this we return [to draw] a circle [serving as] the meridian at the place opposite the point of the zenith at the horizon, [mounted] so as to move upon the axis around [the sphere], over the whole surface of the sphere. And the benefit of this construction is that by it we can know and find, upon the sphere, by inspection at first glance [בסקירה ראשונה], the points opposite the zenith; and also to know and to measure with it the distance of everything marked on the sphere — how far each is, whether from the horizon, or from the equator, or from [its own] place [i.e. its coordinates] — all ready and set out, without any labor or calculation whatsoever. Or else you raise the globe according to the height of the pole of the place whose position you wish to know; and then, in the turning of the model globe, you will see the very motions of the sphere of the heavens themselves. An example of the thing: suppose it is known to you — whether from those who report it, or by your own inspection, in the manner that will be explained to you further on in this gate — that the height of the pole in the city of Prague [פראג] is a little more than 50 degrees [נ׳ מעלות] above the horizon. Accordingly you raise and turn the meridian ring together with the axis higher and higher, until the fiftieth degree marked upon the meridian ring reaches the horizon there; and with the globe so set (the figures of the signs and the stars being marked upon it), you will see in their places the courses of all the stars of the heavens — how they rise upon the horizon from the eastern quarter, mounting higher and higher, and from there descend lower and lower until they set beneath it at the western quarter — through all the days of the year, and at every hour of the twenty-four hours of the day.

סימן מ״ז — We establish that the horizon line (קו האופק) and the meridian line (קו חצי היום) are shared by two people distant from one another

Know: for Reuben and Shimon, when they are at the utmost distance from one another, the horizon line, and likewise the meridian line, are both shared by the two of them. This is the case when Reuben dwells at the eastern edge [of the world] and Shimon dwells at the western edge — and so in any place in the world where two people stand with the body of the earth intervening between them, their zeniths directed opposite one another: the horizon line is shared by both, and so too the meridian line. This meridian line [is such that] when it is midday-transit [חצות יום] for Reuben, at that same line it is midnight [חצות לילה] for Shimon; and when it is midday-transit for Shimon, it is midnight for Reuben. So the matter goes, and this holds forever.

The horizon too is shared in this way, round about, by Levi, who stands upon the navel of the earth (ללוי העומד על טבור הארץ), and Yehudah, who stands directly over against him beneath the earth (ויהודה העומד נגדו ממש מתחת להארץ): both share a single horizon, except that the half which is above [the earth] for the one is the very same half that is [below] for the other, and the eastern horizon of the one is the very same as the western [horizon] of the other; and the moment of sunrise for the one is the moment of sunset for the other, and the moment of noon for the one is the moment of midnight for the other; and the [span of] day for the one is, from its beginning to its end, the very [night] for the other. For [when] the night of the west is the whole of Shabbos day at the eastern edge, and the whole of Shabbos eve [Friday night] at the eastern edge is the whole of Shabbos day at the western edge. (I wrote at the beginning [of this discussion] that each day begins at the eastern edge — at all events, [see] at the end of the third gate [בסוף שער השלישי].) From all the things mentioned it becomes clear to you [what follows] when Reuben dwells at the eastern edge and Shimon at the western edge, and Levi [upon] the navel of the earth (ולוי [על] טבור הארץ) and Yehuda directly over against him [?] beneath the earth (ממש מתחת להארץ [?] ויהודא מכנגדו), that […] the meridian [?] shared by Reuben and Shimon is a horizon shared also by Yehuda and Levi (הוא אופק משותף גם ליהודא׳ ולוי). And so the matter runs conversely: the horizon shared by […] — and this meridian circle, shared by Reuben and Shimon, and the horizon […] for Reuben and Shimon, is the meridian circle for Levi and Yehudah (הוא אופן חצי היום ללוי ויהודה). And set [?] these matters in your memory, for further on you will have need of them.

סימן מ״ח — Just as a person is distant from beneath the equator toward its north, so is the distance — or the height — of the axis (the pole) above his horizon

Know that the distance of the point opposite the crown of every person's head [the zenith] from the equator, toward the north, in every place, is always exactly equal to the distance — or the height — of the north pole above the horizon of his view. And [equal to] the height of the north pole [above] the horizon of his view is the distance of [that point's rays] from the equator. That is to say: whichever of these two you know, or is made known to you, the other [is thereby known] to you, without any need of calculation… [a general statement follows, the middle of which is degraded]. As many degrees as a person is distant from the equator toward the north upon the earth, so many degrees is the north pole raised and set for him above his horizon; and this is [a consequence of] the sphericity of the earth and of the sphericity of the ecliptic sphere, as will be explained further, God willing, in gate 3 [שער ג׳].

סימן מ״ט — All the stars near the north pole never set for us

From the principles we have mentioned it will become clear to you, [as one may verify] readily in the construction, that all the stars near the north pole (within [an arc equal to] the height of the pole above one's horizon, or within [the distance of] the points opposite the zenith from the equator) are always seen by us above the horizon and never set for us. And correspondingly, the same will hold for us with respect to the south pole: that all the stars near the south pole (within [an arc equal to] the [distance of one's] zenith-ray from the equator, or [equal to] the height of the pole above our horizon) are always hidden from us. All such matters are seen sensibly [בחוש] on the globe-instrument, when you tilt it to the height of the [pole/equator] line of your location and turn it about — [and then] it will become clear to you, [as one may verify] readily, that stars farther from the axis than [the pole's height], or [nearer] than the height of the axis above our horizon — behold, [such] a star [rises and sets]; while a star near the equator [remains above only briefly]; and a star far from the axis and near the equator, and toward the south, is the reverse of this. [?]

סימן נ — To find the meridian line of the south (קו אמצע הדרום), and to see sensibly the days of the four seasons (תקופות) of the year

Since the knowledge of the southern meridian line (that is, to know the line and the time of local noon at every place and at every time) is of great necessity for the studies and for many matters that lie before us, and many great things depend upon it… I have seen fit to instruct the students [and] to fill this [gap] for every place and every time.

Take yourself a board (דף) … and [level] its whole surface; and though [you already know] the place [and] rising of the sun, return it to your horizon without any inclination to the sides, and hold it fast so that it does not move, or shift, or tilt. Take a compass (מחוגה) and inscribe upon it one circle around the [center] point ה; and take a small, thin rod [עמוד קטן דק, a gnomon] whose length is less than half the diagonal of the circle, and fix it at the center of the circle, at the point ה. [At the top, from above,] …

Diagram. The shadow-circle of the gnomon construction of סימן נ. Its drawn lines are, exactly: a vertical diameter, a horizontal diameter (the two crossing at the centre), two further radii running from the centre to the rim — one to the upper left, one to the lower left — and one straight chord, parallel to the vertical diameter, joining the two rim-points where those radii land. The chord crosses the horizontal diameter, and it is at that crossing that ב stands. The chord and the two radii together enclose a triangle on the left-hand side of the disc.

Word-labels, all four in large bold display type outside the rim, one at each cardinal point:

- **מזרח** [East] — top
- **מערב** [West] — bottom

- **דרום** [South] — right, set vertically
- **צפון** [North] — left, set vertically

Letter census (closed). Seven single letters, an unbroken run **ה–א** plus **ז** and **ח** (no **ו**):

- **ה** — the centre point (foot of the gnomon), just right of the crossing
- **ז** — inside the rim at the top, right of the vertical diameter
- **ח** — inside the rim at the bottom, right of the vertical diameter
- **ד** — inside the rim at the right, above the horizontal diameter
- **ב** — at the crossing of the chord with the horizontal diameter
- **ג** — at the upper-left rim-point, where the upper radius meets the chord
- **א** — at the lower-left rim-point, where the lower radius meets the chord

ג and **א** are set in the same large display type as the cardinal words, which is why they read at a glance as parts of a word; both are single letters and both are unambiguous at 9×.

- [large bold letter(s) at the far outer-left of the rim — possibly a further cardinal word (דרום/צפון?) or point-letters; illegible] [?]

Draw a line from point **א** through [the center] to point **ב** — this is line **א־ב**; and mark the points on this circle [where the shadow-tip fell, forming] the end of the arc. Then divide [that arc] into two equal parts at the point [**נ** / the midpoint], and mark it, and [the bisecting line] will pass along the diagonal [ז־ג?], [which is] the meridian (חצי יום) for all the days of the year: whenever the gnomon's shadow reaches this line, it is the moment of local noon for you and for all who share the same longitude of the world, as [explained] above in siman 36 [ל״ו] and siman 45 [מ״ה]. And, more precisely, [for] those who lack [instruments] — where there is a deficiency or a defect — they make [the construction] in the manner described.

And to discern the days of the seasons (תקופות) of the year by means of this gnomon and board, there are two methods: one, to test with it only the days of the Nisan and Tishrei seasons [i.e. the equinoxes]; and by the second method, to test with it all the days of the four seasons. This is done thus: draw another diagonal, from the middle of the east to the middle of the west, passing through the center of the circle at point **ה** [reading of the intermediate point-letters uncertain] — this is the diagonal א־ה־ד[?], which is parallel to line ח־כ; and since line א־[ק]־ד[?] passes through the middle… [it marks] the true east-west; and by means of it, on the days of the equinoxes of Nisan and Tishrei, [the shadow will fall exactly along it]… In this way you can recognize the days of the two seasons of Nisan and Tishrei.

But to discern all the days of the four seasons of the year — [note that the noon shadow] changes its order [i.e. its length] each day: on the day of the summer solstice (תקופת תמוז) the shadow is [shortest], and it goes on lengthening until [the winter solstice of] Teves — and for all northern dwellers [it reaches] the utmost [length]…

(Continuation, top of the next column.) …the [winter] solstice of Teves: the shadow goes on lengthening day by day until [that day], and it grows

shorter again toward the seasons of Nisan and Tishrei, [the shadow falling] between the two extremes of the [solstices of] Tammuz and Teves. And if a person watches this shadow [and its] circuit at the four seasons — [the full course] of its day at its four measures: the extreme of length [at Teves] and the extreme of shortness [at Tammuz], and the two intermediate measures [at the equinoxes] — a person can know the days of the four seasons truly. But for exact reckoning of the hours and the [divisions], there are other methods and calculations, and this is not their place.

סימן נ״א — Constructing the first viewing instrument (כלי מחזה), called the "square instrument," and in the Latin tongue "quadrant" (קוואדראנ״ט)

Said the author [אמר הכותב]: [Greek/Latin term illegible — "טרס טופי הלום"?]. I saw fit, at the close of this gate, that it should serve to instruct and enlighten the students in measuring the height [altitude] of the sun, of the moon, and of the other stars, by means of a single instrument — the square instrument [כלי מרובע, i.e. the quadrant] — to know with it, in any place, how many degrees and minutes is the altitude of any star above the horizon, and likewise to know how many degrees and minutes is the height of the north pole above the horizon, in every place and at every time. We have already composed a separate treatise on this [subject], and its proper place would have been here; but only because I did not wish to burden the students, or to hold back the learners of the other gates that lie before you, I have assigned the matter of measuring the height of the stars and constellations — and likewise the measuring of the height of the north pole — to the end of this book, [in gate 11 (שער אחד עשר) / and gate references, the several numerals here being garbled] [?], the [gate] in which we have expanded the explanation with many examples, God willing. Yet since there is need of it for the third gate — together with the tenth gate that lies before you — we have great need of measuring the stars… for in truth many matters depend upon them. Therefore I saw fit to reveal to the students, even here, a little of the matter of this measuring, [if only] by a small and brief note. Attend and hear one of the methods of this measuring:

Make yourself, from wood or from metal, a board [דף] whose shape shall be, in general, a quarter-surface of the circle [i.e. a quadrant], which we mark in the figure before us א, ב, ג. Call the [right-angle] corner of this instrument — the point א — the center of the instrument, for a reason that will be explained at the head of gate 11 [שער י״א], God willing. Along the rim of the instrument, marked א, ב, ג [and] the arc ב, ד, the arc which is here [to be graduated]: divide this arc into ninety parts. (And this division, to enlighten the students by an easy and finished method, has already been explained above: first it is divided into three parts, and each of those into three parts, making nine parts; and each one of these is divided into two, so that now there are eighteen parts, each one of which stands for five degrees. Mark these below, along the arc of

the instrument — thus: 5, 10, 15, 20, and so on up to [90]. And the interval between mark and mark divide into fine lines, each of them ל״ה parts[100], so that their sum is ninety; and these are called degrees.) All this you shall make set right, according to its rule, and according to the figure [depicted]. This arc, upon which the numbers of the degrees are inscribed, is called "the arc of number" (קשת המספר), because [the degrees] are counted upon it. And from the [center, past] the numbers of the degrees, draw one plumb-thread (קו חוט) … [continues].

שער ב (Gate Two) — continued

סימן נ״א (Siman 51) — construction of the quadrant (continued)

for the way of the instrument is to draw the line ג-א [aleph–gimel], and the length of this line should be a little more than the length of the diagonal of the instrument; its designation in the figure is [[ה/ח]]״ד[101]. This line is called the plumb-line (קו המשקל), because upon it will hang a single weight of lead, to pull the hanging thread taut and straighten it downward. It is best to fasten it firmly to the corner and along the edge of the instrument's face, and at the corner [[נ/ג]]׳[[ה/ח]]׳] opposite it.

Beneath it [the top edge], mount two small, thin pieces like pinnules (ניפורין [pinnules/sighting-vanes]), or [make them] of hollowed metal, and make in each one a small hole, so arranged that the two holes lie on a single straight line, aligned one directly opposite the other, along the side of the instrument that the leaf names אל״ף גימ״ל[102]. The holes should sit on the very edge of the instrument, or a little above it. In this way you will have a good and straight [sight-line], and the two holes through which one sights are called the sighting-holes (חורי הקבבטה). From this moment the instrument stands before us, prepared according to its rule; and the student who works with it will understand it, as [indicated by] your sign.

Diagram. A quarter-circle (quadrant) instrument. The right-angle corner at the upper left is the apex/centre; two straight edges run from it — the horizontal top edge to the upper-right corner, and the vertical left edge down to the lower-left corner — and a graduated arc joins those two outer corners. Two pinnules (small raised sights) stand on the top edge. From the apex a diagonal

[100] the printed per-division value is the two sorts ל״ה, and the ink cannot decide between two constructions: as a letter-numeral ל״ה = 35, which the arithmetic cannot support (18 marks × 5 = 90, so each interval takes 5); or as preposition + numeral, ל + ה׳ = "into five parts", which it does. They differ only in how the mark between the two sorts is parsed: as printed it sits high and doubled, i.e. gershayim rather than a geresh following ה, which favours the first; the sense favours the second. Recorded as printed, unresolved.

[101] the siglum's second sort is ד; its first is ה or ח and is not א. Carried unresolved between ה and ח: neither witness can separate them here.

[102] the sighting edge is designated by the letter names spelled out in full, אל״ף גימ״ל, not the two sorts א״ג. The line so defined is קו ראות הכוכבים, the star-sighting line.

line runs across the field, crosses the graduation band and ends in a plumb-bob hanging outside the arc at the lower right (the plumb-line, קו המשקל).

Letter census (closed). Three single letters, one at each corner, and nothing else on the plate is a letter:

- **א** — upper-left corner: the apex / centre of the quadrant (the right angle)
- **ג** — upper-right corner: outer end of the top edge, one terminus of the arc
- **ב** — lower-left corner: outer end of the left edge, the other terminus of the arc

The graduation. The arc is a band carrying two concentric rows of small Hebrew letter-numerals, each numeral set radially (so they stand at every angle round the quarter-circle). At high magnification on witness B the glyphs are individually visible and belong to the tens series — **ל**, **ס**, **ע**, **פ**, **צ** are each identifiable at points along the band — but the run was not read cell by cell, and neither the step of the scale nor its direction is established here. No numeral is transcribed.

סימן נ״ב (Siman 52)

To find the altitude of the sun, and likewise the altitude of any other star — how far it is above the horizon.

Know that the astronomers give the name — for every place at which the sun is found, from the moment it rises in the east until it reaches the meridian (קו חצי יום) — of the altitude of the sun (גובה השמש); and likewise from the moment it descends from the meridian toward the west until it sets below the horizon, they call the place where it is found by the same name, the "altitude of the sun," meaning their height above the horizon, whether above the eastern horizon or above the western horizon. And as the rule is with the sun, so is the rule with every other star.

To find the altitude of the sun, or of any other star, take the aforementioned instrument in your hand by the corner [⟦ה/ח⟧׳⟦נ/ג⟧׳] of the instrument. Face the instrument toward the sky and aim it at the sun, [marking] at corner **ג**. Hold it close to one of the outer corners of your eyes, close the other eye, and look and sight along the edge of the instrument and through the [sight-]holes — by way of point **א** [דרך נקודת א׳]. Raise and lower the center of the instrument (which is point **א** [מרכז הכלי שהיא נקודה א׳]) up and down, until you see, through the two sighting-holes, the center of the moon or of any other star whose altitude you wish to know. When this has been established for you, look at that moment below, at the edge [of the arc], [to see] how many degrees the plumb-line cuts off — and that is the number of the altitude-degrees you sought.

As for measuring the sun: because it is possible for a person to look through the sighting-holes toward its full brightness [and be dazzled], know that in measuring the altitude of the sun you need not look with your eyes directly at the sun; rather, only raise and lower the center of the instrument until the sun casts [its ray] through the two sighting-holes, and then you will see below

how many degrees the plumb-line cuts on the arc of number — and that is the number of the sun's altitude above your horizon.

And know, dear reader, that all we have said in these two adjacent simanim we have made into simple, easy measurements for young students, without any complexity. The essential rules and principles of this measurement, together with its great usefulness, will be explained to you later, in gate eleven (**שער י"א**), where you will find the nature and structure of this instrument, and hear it set out more clearly and more fully, God willing.

סימן נ"ג (Siman 53)

To find how great is the altitude of the northern pole (**קוטב הצפוני**) above your horizon, and the place of its point in the eighth firmament.

When you wish to know how great is the altitude of the northern pole above your horizon, in any place, take at the beginning of the night one of the stars that do not set below your horizon (these are the stars near the northern pole, high enough above your horizon, as [explained] above in siman 49). Watch one of the stars when, at the beginning of the night, it is to the east of the meridian; afterward the star will circle round with the diurnal motion through the west and reach the meridian (as I already showed you, your sign, in siman 50 [?]) — for then the star is at its greatest altitude above the horizon. Measure with the quadrant instrument (**כלי הרובע**) how many degrees is its altitude above your horizon, and keep the number of degrees found in your measurement. Then, after twelve hours, when the star circles round again through the east to the meridian a second time — and this time it is at its lowest [culmination] — measure likewise how many degrees is its altitude above your horizon, and keep this number too in hand, a second time. The mean (**הממוצע**) between the number of degrees of the first observation and the number of degrees of the second is the number of degrees of the altitude of the pole (**ציר**) above your horizon.

For example: when the star was at the meridian at its greatest altitude, its altitude above your horizon was 80 [**פ'** = 80 [?]] degrees; and when it circles to the meridian a second time, at its lowest point, its altitude above your horizon is thirty degrees; and so the mean between the two numbers — [55°; value not clearly legible [?] — (80+30)/2 = 55] — is the degrees of the altitude sought. When this becomes known to you, you can also reckon upon the meridian the place of the point of the pole (**ציר**), similarly. And in gate twelve (**שער י"ב**) you will find three more correct and straightforward ways to count the altitude of the pole (**גובה הציר**).

[Foot of p. 45: the words **גובה הציר** appear at the page foot, with a further mark **ל"ה** [signature/gathering mark? — reading uncertain].]

סימן נ"ד (Siman 54)

To find the instant and time of midnight (**חצות לילה**), throughout all the days of the year.

We have already explained, as your sign [indicated], how to count the instant of midday (חצות יומם) [...]; and [now] to reckon the instant of midnight, which is of great [use] to us. Therefore know that the instant of midnight is the time at which the center of the sun reaches the meridian that is below the earth [the lower meridian]. Determine which degree of the zodiac (מזל) will stand opposite the center of the sun [...], take the degree diametrically opposite it, and observe the time of its arrival at the meridian — [that is] the time of midnight. For example: when the center of the sun is at the tenth degree [?] of Scorpio (עקרב), so that the sun [stands there] [...], then the [opposite] point on the western side of Scorpio which is below [...] the sun comes to the meridian [...], [and this is] the time of midnight [?]. Thus keep watch through the night: [when the point] the tenth degree above [?] the sign opposite it [reaches] the meridian above [...], that is the time of midnight.[103]

Another method for finding the time of midnight: by [observing] the end of the motion of any of the fixed stars — [from when] it rises upon the horizon until it reaches the meridian, that is [half] of its course; from the meridian [onward] until it sets below the horizon [...], and the time of midnight is [midway]. Watch one of the stars at the beginning of the night [when] it rises upon the horizon, and observe the time [of its arrival] at the meridian — that is the time of midnight. But this reckoning does not come out exactly except by reckoning in "crooked" (seasonal) hours or [equal] hours, whose nature will be explained to you later, in gate four, in siman 101 (בסימן ק"א). By equal hours this reckoning holds good only on the days of the two [equinoctial] seasons, Nisan and Tishrei, on which day and night are equal — and understand this well, forever.

[Colophon, centered] He is One, and there is no second · May He requite me with all good · And in the paths of righteousness may He guide me · At the conclusion of the Second Gate.

[103] the worked example names a zodiac sign in three places. As printed: the sun's place is המעלה העשירית ממזל עקרב, the tenth degree of Scorpio; the opposite point is המעלה עשירית ממזל שור נוכח לה, the tenth degree of Taurus; but the third slot — the degree the text says comes to the meridian, the operative midnight sighting — prints **ממזל עקרב**, Scorpio, again, not ממזל שור. That contradicts the method stated two lines earlier in the same siman (take the degree opposite the sun and watch when it reaches the meridian), so the leaf is internally inconsistent. Recorded as printed and not emended to Taurus.

השער השלישי (The Third Gate)

In it will be explained: the divisions of the earth, and how many parasangs (פרסאות) its measure; and an exposition of the seven climes (אוקלימים) and of the three parts of the ancient world; and the existence of the New World; and, in addition to this, four [further] parts of the world[104]; and the figure of the earth's form in its entirety — its paths, its landscapes, its regions — in all, from all its six extremities; and the reality of the longitudes and latitudes of the provinces (מדינות); and the boundaries of the four directions of the world, where they begin and where they end; together with an exposition of the thirty-two winds [compass-points] of the world, each of which is called by its own name; and a table (לוח) of the many places and provinces of the inhabited world; and of the length of days, how much each of them [runs] along the length of the world [longitude] and how much in their latitude — with many other matters besides.

Says the author: The third essay — [treating] the lowest foundation, [the earth], the lowest of the four elements (יסודות), which we have already begun in this our book. Accordingly, it was fitting for us to begin from below and ascend upward — unlike the order of others, whose "head reaches the heavens" [cf. Bereishis 28:12, Jacob's ladder], setting the heavens first; whereas at the beginning of our book [we treated] the description of the figure of the terrestrial globe with all its climes and its regions, and from it we ascend [...], to descend [again] from above to below. Therefore I arranged and set in order that which, in the description of the two gates that have passed [...], informing the students with a small, brief note — an opening and introduction concerning the spheres of the heavens (גלגלי שמים) and the stars — so that we should not [proceed further] before it be known to us [the nature of] the earth, and how many degrees or parasangs its measure, and its places and provinces, and — regarding the inhabitants of the world (יושבי חלד) — how many degrees they dwell along the length of the world between east and west, and how many degrees in the latitude of the world between [north] and south; for [none of this can be grasped] unless the little introduction from the science of astronomy (חכמת התכונה) be first known.

סימן נ"ה (Siman 55)

Proofs and evidences that the earth is spherical.

Know that the astronomers have ruled, concerning the form [of the earth], that it is spherical; and they did not reckon the great mountains and the deep

[104] four, cardinal, and added to the three parts of the ancient world — the arithmetic tension (three ancient parts plus a New World would ordinarily give one added) is the edition's, recorded rather than repaired

valleys found in the world, because their magnitude is not to be counted for anything against the great size and mass of the body of the terrestrial globe — just as, if you were to pierce a hole with a needle inside an apple, the pricking of the needle does not nullify the sphericity of the apple [או תנקוב במחט נקב תוך תפוח אחד, שנקודות המחט אינה מבטלת כדורית התפוח]. And although we find, in the words of a few sages, that they held the earth to be flat and not spherical, and bring a proof for this from what we observe — that the sun [appears whole] at its rising on the horizon, [and] likewise at its setting, so that the sun is cut off from the terrestrial globe on a straight line; whereas, were the earth spherical, it would be fitting that the figure of the sun's half should appear as an arc, in the manner of the shadowing of one sphere by another, as we see in the moon by the shining of the sun upon it, and as the moon appears at the time of its eclipse — [nevertheless] the science of astronomy has refuted this proof, and said: What we observe, that the [moon] appears in the figure of an arc — the sun too [would so appear] — is for this reason: that we are able to see both the moon and the sun on all sides of them, [over] the whole of their spherical [face]; [...] and likewise the sun in its [season], [when] it appears to us as an arc.

But this is only because the terrestrial globe is not seen by our eyes at a single glance — not even an eighth part of it — and therefore we cannot perceive by our sense [of sight] that the earth is spherical like a ball; rather, the earth appears to our eyes as though it were flat and not spherical, and for this reason [the horizon] cuts the sun, to our sight, on a straight line. And although it is established as certain that the earth is spherical, behold, this proof [of sphericity] is [grasped] by the intellect and not perceptible by the sense of sight. The essence of the matter [is that] the earth is round and spherical, as will be explained shortly with [several] proofs. Several proofs:

There is [reason] for you to know that the sphericity of the earth [is established] by the things we explained above at the head of the first gate, and it will be further explained to you later — that the earth together with the water, the two together, form one sphere; and the earth is exposed within the water over the surface of all its extremities, and over all of them the inhabited land spreads out, over the whole surface of the sphere all around — in such a way that even the surface of the terrestrial globe opposite the soles of our feet [the antipodes]: there too will be found habitation and people who walk there, and there are found great and mighty cities and many provinces full of human beings. And although most of the common folk of the earth deny the sphericity of the earth and refuse to believe [in the antipodes] —

> [Boxed note / mnemonic] — [saying:] How is it conceivable that [Reuven] and Shimon should stand on opposite sides [of the globe], this one above it and that one beneath it, and each of them stand upright, his head up and his feet down, as though each of them were hanging by the soles of the other's feet — and how does neither of them fall? And further, [that] the two [points] of the world-globe stand for us [like] the navel of the earth (טבור הארץ): Reuven at

the eastern extremity and Shimon at the western extremity, both upright — how do Reuven and Shimon not fall? Sign: Know that the sphericity of the earth is demonstrated by conclusive proofs,

and by a decisive proof that admits no [denial] — namely, that we observe of the whole [heaven] that, when in the north a southern star is hidden from us [and the reverse]; and so it is conversely. For when a man stands on the equator (קו השוה) he sees both poles (הצירים) level with his horizon; and when he moves away from the equator and ascends toward one of the poles [it rises], so that as [one goes] northward, for every 15 [ט״ו] parasangs the northern pole rises one degree — for every 15, 15 parasangs [one degree] — until he reaches the far north, where the pole stands at the very zenith of his head (קדקד ראשו), as will be further explained. From this the sphericity of the earth is proved by conclusive proofs, and likewise the sphericity of the sphere of the stars. [And I have set my mind] upon all the spheres round about, from north to south.

And the proof of the sphericity [of the earth] between east and west: this is [furnished] to us by the eclipse of the moon (לקוי לבנה). For every lunar eclipse occurs at one and the same instant in all the places of the world, for all the inhabitants of the earth. Now, when a lunar eclipse occurs, and two men are in two places — for instance, Reuven standing at the eastern extremity and Shimon standing at the navel of the earth (which is midway between the eastern extremity and the western extremity) — the time of the eclipse falls for Reuven at midnight and for Shimon at the beginning of the night, even though the eclipse is, for both of them and for the whole world, at one instant; [and thus at the time of the eclipse for Shimon it is several hours later].

And this is [proof of] the sphericity of the earth: for when it is the beginning of the night for one standing at the navel of the earth, at that very moment and instant it is midnight for those dwelling at the eastern extremity — since the sun precedes in its rising, and likewise in its setting, for those [to the east], and is later for those dwelling to the west. But had the earth been flat, the eclipse [would occur] in all places, for all the inhabitants of the earth, at one instant, and the easterner would not see the eclipse at a time earlier than the westerner. Since, then, the priority [in time] belongs to the easterner before the westerner, this is by reason of the sphericity of the earth. So it has been demonstrated to you, by the preceding proofs, that the earth is spherical in all its directions.

And you must know that we have no priority, nor any pretext, over the people whose feet are opposite the soles of our feet [our antipodes], to say that we are seated above upon the globe and they are seated below it — because every place where a man stands, there he is "above" upon the earth, and there is for him the high point of the globe; and in this respect all the places of the world are equal. There is here no ground for any man to claim priority over his fellow, to say that he alone walks upright (קוממיות) while all [the rest] walk on the sides.

סימן נ"ו (Siman 56)

That many people encircled and went around the whole globe of the world, and returned and came [back] to the place from which they had set out.

While we are still speaking of the sphericity of the earth, [I saw fit to bring before] the world an account of a deed that happened in the year 1521 by their reckoning [אלף תקכ"א למספרם], which was the year 5281 by Creation [ה' אלפים רפ"א; 5281 − 3760 = 1521]. There was a man whose name was Sebastián del Cano [בהסטיאנא"וס די"קאני — Juan Sebastián Elcano], a man of war, a commander of the army of the King of Spain, a great sage in the science of geography (גיאוגרפיה) — that is, in the measurement and knowledge of the places of the terrestrial globe. He set out from [מבי"ניאה] — [a place] which is in Spain — and went down to the sea,[105] and circled the whole western side of the continent of Africa; and from there he turned his face to the east, and went on traveling until he came to the lands of India (אינדיאה), which is the land of Hodu. There the people of that land attacked him, and his lieutenant was killed there, while he escaped in his ship together with four hundred men; and straightway the wind bore them along until he came to the far east and beyond it — at which place the soles of our feet [would be] opposite the feet of the people of his own country from which he had set out.

There he resolved in his heart not to [turn] his course westward, but only to see whether he could encircle the whole globe of the earth. Therefore he continued to sail on in his ship still further toward the east, and traveled on until he came near [the New World] (whose location will be explained later, in siman 73 [בסי' ע"ג]). He rounded it, keeping it to his left, and always kept his face toward the east; [he] did not turn his face westward until his return to his resting-place, to his great city Seville (סיבילייה — Sevilla), which is in Spain. And a tablet was made for him bearing the figure of a globe, on which was written (as though the globe were speaking to him): "You are the first who encircled me" [cf. the Elcano device, Primus circumdedisti me].

The author of Me'or Enayim [Azariah de' Rossi], in chapter 18 [פר"קיח; the chapter is 18 or 118 — see the note][106], also mentioned this briefly; and a deed just like this one itself — that a certain man from England [ענגעלאנד-מ = "from England" [?]], a captain, named Francisco Drake [פרנציסקי דרהיקו — Francis Drake], in the year 1576 [אלף תקע"ו] by their reckoning, which was the year 5337 [ה' אלפים של"ז] by Creation [5337 − 3760 = 1577].

---

[105] "Biscay" is an editorial identification; the leaf's form is not the received name.

[106] the chapter reference is printed as a single unbroken string, **פר"קיח**, carrying exactly one mark — a gershayim pair between the ר and the ק — and none inside קיח. Two parses of the same six sorts: פר"ק + יח = chapter 18, taking the gershayim as the abbreviation mark inside פרק, where it belongs; or פר" + קיח = chapter 118, taking it as a terminal abbreviation of פר'. Its position favours 18; 118 is not excluded. No parse yields a properly pointed number — both י"ח and קי"ח would carry a mark between י and ח, and the leaf prints none.

סימן נ"ז (Siman 57)

That the earth stands at the very center of the sphere of the zodiac (**גלגל המזלות**), like a point within the circle.

The earth stands within the very center of the sphere of the zodiac, even though [it is but a tiny point]. As for the poles of the world (קוטבי העולם) and the axes of the zodiac (**צירי המזלות**) — this was [demonstrated] above at more than 23 degrees (יותר מך"ג מעלות), [[one word unresolved]] ל"[ז/ו] — 36 or 37, not resolved. Therefore [know] that the earth stands at the center of the sphere of the zodiac, and its center is the center of the ninth sphere [...], the center of the sphere of the zodiac itself; for it has already been explained above [...] that all these three great circles [of the globe] all stand upon the center of the world.

Therefore know that its center — the earth — does not incline from the extremities by more than [a single point]: not to the east and not to the west, not to the [north] and not to the south, not up and not down. And the proof of this is: that in every place of the world where one stands, he sees half of the sphere of the zodiac in its fullness; whereas, had the earth inclined toward the extremities, the man standing upon it would not see [exactly] half of the heavens, and the one opposite him would see more than his half. [Since everyone sees exactly half,] this is clear testimony and evidence that the earth is at the center of the sphere of the zodiac. Amen.

סימן נ"ח (Siman 58)

That the terrestrial globe, by reason of its great smallness, has no proportion or measure — [being] as if imperceptible to the sight of our eyes against the vast breadth of the sphere of the zodiac.

From the principle we have stated, it necessarily follows that the whole terrestrial globe is reckoned as [nothing] against the vast breadth of the sphere of the stars. For [were] the body of the earth reckoned as having some [appreciable] measure, and should it enter our mind [that the earth had a size] in proportion to the sphere of the zodiac, then not all the inhabitants of the earth would be able to see, in every place, half of the heavens; for of necessity each of the inhabitants of the world, in every place, would see only less than half of the circle of the zodiac — as you will see in the figure below, in which the [outer] circle [הקטון [?] — "small"; but context requires the larger circle] represents the sphere of the zodiac, and the inner one the circle of [the earth],

Diagram. A large circle with a small circle inside it. The small circle is not centred: it sits right of centre and slightly above the middle, and it is printed as a broken arc — its outline fails to close on the lower left on both witnesses.

The straight lines are three, and they are not three parallel chords. Two are full chords running rim to rim, one above the small circle and one below it. The third — the middle line — runs from the left rim and stops inside the small circle; it does not reach the right rim on either witness. A short vertical stroke stands inside the small circle just below that line; it carries no letter.

Letter census (closed). Six single letters in two rows of three, each row set just clear of its chord; nothing else on the plate is a letter:

- Above the upper chord, right to left: ה (right), ד (centre), ו (left)
- Below the lower chord, right to left: ב (right), א (centre), ג (left)

the earth; and the line divides the circle of the zodiac into two equal halves, thus. One standing at point ד — wherever he be — sees only what is above this line, which is less than half of the circle. (For it is not fitting to say that one standing upon the surface of the earth at point ד would see the surface of the earth below this line, as one standing on a mountain sees from opposite the mountain and downward — that is impossible; for even at 15 [ט״ו] parasangs he would see only one degree [rise], out of the 340 degrees of the sphere [מש״ם מעלות הגלגל].) And because we always see, in every place, whole [complete] zodiacal signs, and because the horizon — the circle of vision from one's standing-place on the earth — is exactly as though we were standing at the very center of the terrestrial globe, upon its center at point א; and the line that issues to us [from] the center of the earth from above, reckoned from point א to point ד, which passes over the edge of the terrestrial globe — even though its measure is a line of [thousands of] parasangs [?] — for our position it is reckoned as nothing. And this line — that of the whole terrestrial globe in its entirety — is reckoned as merely a point within the [great] circle. And this is by reason of the great distance and remoteness of the sphere of the zodiac; for the length of the diameter (קוטר) of the circle that issues to us from the center of the earth appears to us, in proportion against the eighth sphere (גלגל השמיני), like a grain of mustard seed or like a hair [כגרגר החרדל או כחוט השערה] — for the investigators have posited that [each] of the fixed stars (כוכבי שבת), its body is many times greater than the body of the earth, even though it appears to us like the width of a dinar or a sela [שנדמה לנו כרוחב דינר או סלע].

Know that many of the sages have expounded and inquired into the vast breadth of the eighth sphere; but to this day, for all their great effort and inquiry, it has not become known to them as it ought, according to precise and correct reckoning. The sage [name unresolved on the leaf, which prints רשי[ש/ט]והחכ׳ סי; the first reading gave it as "R. Yitzchak Yisraeli" and supplied the title Yesod Olam, neither of which is printed here] wrote, in chapter 1 of the second treatise [as printed, בפרק א׳ וממאמר שני; the first reading gave "chapter 8 of the second"], that some of the sages posited in their researches that the length [of the circumference] of the world [the eighth sphere] is more than [what corresponds to] thirty mil [שלשים מילין] per day — thus far [the quotation] [ע״כ]; and this — how much would it be? — according to the circumference of the circle, a journey of 44,000 [מ״ד אלף] years, which are sixteen thousand times [times] a thousand and sixty thousand [שש עשרה אלף פעם פעם אלף וששים אלף] days, and its number, in mil, is 481 [תפ״א] thousand times a thousand, and eight hundred thousand [mil]; so that one finds that every star of the eighth sphere standing on the straight line [the equator] or near it revolves, by the revolution of the eighth sphere, in each and every hour, twenty thousand times a thousand

and seventy-five thousand [עשרים אלף פעם אלף וע"ה אלף] mil —[107] even though it appears to us [that its motion is like] the [distance] of the eye [i.e. barely perceptible], [as it were,] by the science of [reckoning]. And this reckoning is clear and easy for those who know the science of number and measure. The investigators went even further, and wrote more than double this figure; but I have not found among them one who proves his reckoning.

סימן נ"ט (Siman 59)

That every line of the heavenly circle above — they are all inscribed, conceptually [in the intellect], upon the terrestrial globe below.

Since the earth is spherical and stands at the very center of the ninth sphere, and also [at] the center of the sphere of the zodiac, as [stated] above, it follows from this that all the circles of the heavens above are engraved, conceptually [in the intellect], after the likeness of those [circles] which are in the spheres — circles just as there are upon the surface of the terrestrial globe below. And this [means]: that the equatorial circle (עגול משוה היום), which is like the middle of the heavens between the two poles (הצירים), inscribes and marks out for us a line...

each one at the center of the earth's globe, which revolves and is called by the same name as the circle that stands directly above it in the heavens. It too is like the circle of the equator (עגול משוה היום); and likewise the other circles of the earth that correspond to the circles of the heavens — such as the circle of the zodiac (עגול המזלות), the circles of Cancer and Capricorn [the tropics], the circles of the nadir[?] and of the meridian[?] — each and every one is called by its own name, by the name of its counterpart standing directly above it. And the benefit that comes to us from this is that, by means of a place's position, all the dwellers of the earth are made known to us: those who inhabit the world, under whatever circle or sign they dwell; and each and every place of all the world's inhabitants — how far it lies along the length of the world [longitude] and how far along its breadth [latitude]. By its sign we come to know the nature of each and every land as to cold and heat, as to the length or shortness of its days, as to the earliness or lateness and the [rising][?] of the sun for the world's inhabitants, and many other matters besides these.

סימן ס (§60)

That the earth's globe too is divided into 360 degrees in length [longitude] and also in breadth [latitude]; and at what place this reckoning begins.

According to what we have just explained — that all the circles of the heavens above are inscribed upon the surface of the earth's globe below — you should now understand the following. Just as the astronomers divided each of the

[107] "times" is set twice in the day-figure, where the two parallel constructions later in the passage set it once; as printed. The first three figures close with one another; the hourly figure does not, by any reading, and stands as it is.

great celestial circles above, [as measured] upon the center of the earth, into 360 degrees (as above in §36 [ל״ו]), so too they divided every line encircling the earth's globe and passing through its center into 360 degrees, and each degree into 60 minutes [דקים], along the equator[?], conceptually inscribed, as it were, upon the surface and center of the earth's globe below. This runs from west to east, and is what is called the "length of the world" [longitude], as will be explained; and it is divided into 360 degrees.

We must now determine where the point or place is that holds the privilege [משפט הבכורה] of being the starting point from which the counting of the 360 degrees of the world's longitude begins. Know, then, that because of the earth's sphericity, no beginning or end can be discerned upon it [naturally]; rather, by convention, one must select for oneself some known place or point upon which to agree, to set it as the head from which to begin the reckoning. Since the earth's globe faces the heavens[?] — as [Ptolemy][?] said in the treatise… the astronomers[?]… found that the length of the inhabited world, from the edge of the western Ocean [אוקינוס המערבי] to the shore of the eastern Ocean at the far end of the East, is 180 degrees, which is half the earth's globe (as will be explained shortly). Accordingly there are here two lines — the eastern edge and the western edge — that hold precedence over all other places of the world. And because these two mentioned places are two [candidates] from which to begin, the ancient sages nonetheless agreed to begin this reckoning from the edge of the western Ocean, since most of the lands adjacent to it are more inhabited than the lands at the eastern edge, and also because the ancients [Ptolemy?][?] were nearer to the shore of the western Ocean… The starting point[?] is the place of the [Fortunate Isles / a known headland][?], running along the coast of [Cape Verde?][?] and continuing along the coast of [Porto / the Portuguese coast][?]… by way of… [Portugal — פורטוגל]… [The specific coastal toponyms of the prime-meridian line are badly garbled in the print — [?].]

[before Ralbag[?]] it fills[?] Africa, and running southward to the south pole [קוטב הדרומי] (places that will be explained further on). Along it runs, as it were, in the dark, across the breadth of the world, from pole to pole. It is called the "boundary line" [קו הגבול] or the "western line," for it forms the boundary and terminus at the western extremity, from the midpoint of which the boundary line begins and the equator[?] line runs along the length of the world, upon which the 360 degrees are marked — that is, from this boundary line and the numbering of the 360 degrees. From this line the count issues at the western edge, running eastward to the end of the inhabited world at the shore of the eastern Ocean, which is 180 degrees, half the globe of the world… and this line continues onward from the western edge yet farther, beneath the earth relative to our position, until it circles back to the whole place from which it began to issue — which is another 180 degrees, so that together they make 360 degrees.

But you should know that the tradition of the sages who delved deeply and investigated the science of measurement [geodesy] moved the boundary fixed

by the earlier authorities somewhat farther, into the Ocean toward the west, [by] ten degrees [עשרה מעלות] according to the divisions of the equator line from which the numbering of the 360 degrees begins, and so forth, as will be explained further at the head of the section, God willing.

And you should further know that, just as there is a distinction between longitude and latitude of the firmament (as above, §45 [מ״ה]), so too there is this very same distinction upon the earth's globe. Namely, they divided the circle surrounding the earth's globe into four quarters, each quarter holding 90 degrees, which together add up to 360. This is in the manner explained above in §45, and it will be mentioned again below, God willing.

סימן ס״א (§61)

How the ancients knew, when they measured the line of the length [longitude] of the dry land, that it equals the line of half the earth's globe, which is 180 degrees.

We have already explained just above that the length of the inhabited world, from the edge of the shore of the western Ocean to the shore of the eastern Ocean, is half the earth's globe — 180 degrees, no more and no less. You may ask: from where did the ancients know this measure for their reckoning, that the [breadth of the] sea is neither less nor more? So know that the ancient sages appointed for themselves messengers — trustworthy, expert men who understood these matters — and at times they sent some of them to the far East and [some] to the far West, to the edge of the West, and instructed them to observe and note carefully, each in his place, the time of the moon's entering into eclipse on a given day. The western group observed and saw that the moon began to enter eclipse at the beginning of Friday night, for example, while the eastern group observed in their place… that at daybreak the moon was fully extinguished in its total eclipse. (It is already known that the moon's eclipse [is visible] to all the world in a single instant; nevertheless, between the vantage of the westerners and that of the easterners there was a difference of twelve hours [י״ב שעה].) From this they concluded that the inhabited world extends in length by half the world's globe, which is 180 degrees. For [with respect to] two men standing opposite one another, the earth's globe is interposed between them, so that the beginning of night for one is the beginning of day for the other, as explained above in Section 2, §46 [מ״ו]. But apart from this they found the like with respect to the parasangs, as will be explained further on in this Section, in simanim פ״ב ופ״ג (§§82–83), God willing.

סימן ס״ב (§62)

How many parasangs upon the earth's globe are to be reckoned against one part of the 360 parts of the sphere above.

Even though, according to what has been mentioned and explained above concerning the vast distance of the zodiac sphere relative to the dimension of

the earth's globe — [the earth being] like a mere point to a compass[?] — even were you to lay out thousands upon thousands [i.e. millions] of parasangs, they would not suffice, in the astronomers' reckoning, for even a single one of the 360 degrees of the sphere (as above, in the siman marked [כ״ק]) the investigators reached [a measure] in this matter regarding the breadth of the zodiac sphere; and even were its dimension a thousand-thousand times larger still, and were the world's [measure] such, this did not deprive them of, nor prevent them from, investigating and finding [how many] parasangs below upon the earth are to be reckoned against one part of the 360. And they gauged and found the truth of this matter: that against each and every degree of the sphere above there is reckoned below, upon the earth's globe, sixty Italian mil [ששים מילין (איטלי״קי)], which are fifteen parasangs [שהם ט״ו פרסאות].[108]

Upon the earth's globe the reckoning of fifteen parasangs [ט״ו] per one degree does not apply to them [i.e. to the latitude circles], unlike the… longitude lines that run from west to east, but only on the equator [קו השוה] alone and nothing else. For although, with respect to the reckoning of determining the longitudes of the countries, all the longitude lines are each counted as 360 degrees, the degrees [on the higher-latitude lines] are smaller — because the closer a longitude line lies to the axis [pole], the smaller becomes the measure of a parasang. This you can perceive by the senses: that the circle of Cancer [the summer tropic] is smaller than the equatorial circle, and the northern circle [ועגול הצפוני, the arctic circle] is smaller still than the circle of Cancer; so too the 360 parts of the line of the Cancer circle, and the parts of the line of the northern circle, are smaller than the 360 parts of the line of the equatorial circle.

סימן ס״ג (§63)

The measure of the line surrounding the earth's globe, and how many days and years a person needs in order to circle the globe.

From the general principle we have mentioned — that the whole earth's globe [is such that] each degree above corresponds to fifteen parasangs [ט״ו] below — it follows that all 360 parts of the sphere above are 360 times fifteen parasangs below, whose sum comes to five thousand four hundred parasangs [חמשת אלפים וארבע מאות — 5,400]. Accordingly, since by the nature of the people of our land an average man's journey is five parasangs per day, the time to travel around this encircling line, from end to end, would be a journey of one thousand and eighty days [אלף ושמונים יום — 1,080], which is three years less fifteen days [ט״ו יום]. And let not the sayings of our Sages of blessed memory trouble you [ואל יטרידך מאמרי רז״ל], whose plain sense is that the measure of the earth is a journey of five hundred years [ת״ק שנה] — for in matters of astronomy

[108] the mil figure is a number-word while the parasang figure beside it in the same clause is a numeral; both forms stand in one sentence. The unit is qualified "Italian", in parentheses, with the mark inside the word, as the leaf puts it. The equivalence is stated once only, at the first statement of the result; the parasang figure recurs four more times in this siman with no mil beside it.

and the measure of the earth, the words of the Sages are one matter and the words of the astronomers another, of which more will be said below, near the conclusion of the book, God willing.

Know too, and be assured, that according to the view of the author of Me'or Einayim [בעל המא״ר עיני׳ם]… the measure of the earth's globe is close to the aforementioned figure — as is the view of one who was… [when] Rava said, "The world is six thousand parasangs" [Aramaic: שיתא אלפי פרסי הוי עלמא] (Pesachim 94a); and in any case we know and have seen that Rava's tradition was… and is very close to the reckoning of the investigators. So too according to ch. 5 of the Laws of Oaths of the Rambam [בפ׳ ה׳ מהלכות שבועה להרמב״ם] of blessed memory (and his Introduction to Seder Zera'im [ובהקדמתו לסדר זרעים]), the measure of the earth's globe, its circumference, is twenty-four thousand mil [כ״ד אלפי׳ מיל], which is six thousand parasangs [שהם שית אלפי פרסי] — [agreeing] with Rava's tradition. See the book Me'or Einayim, ch. 28, fol. 102 [ועיין בספר מאור עינים פ׳ כ״ח דף ק״ב].[109]

סימן ס״ד (§64)

Refutation of the view of the ancients [printed **החקרמוני׳**, for **הקדמונים**][?] in what they said, that half the earth's globe is submerged in water.

[This siman refutes the claim] that half the earth's globe is exposed while half is sunk and submerged in water — as you find in the sage Ibn Ezra [רא״בע] and in Radak [ולר״דק] of blessed memory, in their comment on the verse "for He founded it upon the seas" [Tehillim, ch. 24 — as printed, תהלים כ״ד; the verse figure "2" was supplied by the first reading]; and likewise the view of the great astronomer R. Avraham bar Ḥiyya, author of Tzurat HaAretz; and so too you find in the sage R. [Isaac] Israeli, chapter one, treatise two, of his book Yesod Olam [as printed, ר׳ ישראלי כפ׳ ראשון מאמר שני מספרו יסוד העול׳ — the leaf does print the title here; the first reading gave "part one, treatise…"], and in many other places there in his book, where upon this premise he laid down many foundations and built many structures upon it, as will be explained further at the end of the sixth treatise, §160 [as printed, בסוף מאמר ששי בסי׳ ק״ס]; also from the words of the Moreh [the Guide], ch. 73, of part 1 [as printed, מדברי המורה פ׳ ע״ג מחלק א׳]; and see that this was his view, as the author of Me'or Enayim noted precisely upon it, in ch. 61 [as printed, בפ׳ ס״א] — [the view of] all the ancients, all of them.

In this matter they were, as it were, [mistaken and] in error. For, as of a little more than a hundred years ago [זה מעט יותר ממאה שנים] and up to now, seafarers — the expert envoys of France, Spain, and Portugal [פורטוגאל] — went down to explore the [Ocean-]sea, [a region] known to them only by chance and not

[109] the halakhic division named is Laws of Oaths, which is not where a reader expects a measurement of the earth. That is what both copies set, and it is not normalised. The division's name is carried over a line break, so a reader stopping at the line end sees a chapter number with no division attached. The thousands in the figure beside it are spelled out around a numeral, the same mixed setting as in the preceding siman.

by the fixed measures of every[?] region of the world's globe; and they found inhabitants — some of them upon dry land, some upon the islands of the sea, some in the upper part, some in the lower part directly beneath the soles of our feet — and this is the part [that is] the New World [החלק העולם החדש], which they call Naba Monde [נאבא מונדע], where a broad and open land is settled: a great region, close to two-thirds of the world in which we dwell [קרוב לב׳ שלישי העולם אשר אנחנו יושבים בהם], and all of it full of human beings, as will be explained shortly.[110] And even though we find in the fifth chapter of Pirkei d'Rabbi Eliezer the statement that the earth stands upon the depths like a ship sunk in the heart of the sea, and also in the chapter "Kol ha-Tzelamim" and in Bamidbar Rabbah [as printed, למים ובמדבר רבה[ג/צ]גם בפ׳ כל ה; the first reading gave this as an unnamed chapter of "[Bereishis] Rabbah[?]"] they said that the world is like a ball and like a bowl — and accordingly one said, by what appears [to be its plain sense], that the world's globe is submerged in water, as is the view of many of the sages: [Ibn Ezra — רחב״ע][?], Radak [R. David Kimchi], R. Avraham bar [Ḥiyya][?], and the aforementioned Israeli [Yitzchak Yisraeli] — nonetheless, the revealed, well-known experience, plain to the eyes, contradicts [this]. For "for He founded it upon the seas" is to be understood — [taking] "upon the seas" as "upon the rivers [He established it]" [as printed, מ׳על ימים׳ כמו על נהרות יכוננה[?] — the leaf continues the same verse (Tehillim 24:2); the first reading gave this as a quotation of "By the rivers of Babylon," Tehillim 137:1, which is not on the leaf, and the word בבל does not appear]. And as for the words of our Sages of blessed memory, there is no great cause to wonder, for in many places, in matters of astronomy and the measure of the earth, their words are sealed and obscure; and this matter he mentioned by way of example, and…, and at the conclusion of this our book it will be disclosed in a brief note in the aforementioned… — a great matter, to take to heart concerning things in the words of our Sages of blessed memory that are contrary to the astronomy revealed to our eyes, so as to reconcile them somewhat… lest they conflict with what is well established.

סימן ס״ה (§65)

Whether the earth stands upon the water, or the water stands upon the earth.

Since it has already been clarified that all the seas together with the dry land form one globe [ח״א — a single unit][?], there is room here to be in doubt and to ask: does the earth stand upon the water, or does the water stand upon the

[110] the comparison is expressly approximate — "close to two thirds" — and not to the known world in the abstract but to "the world in which we dwell", the leaf setting a plural suffix after a singular noun. Given as set. The vernacular name beside it is a rough transliteration of a Romance "new world", but not spelled as that phrase ordinarily is — the first word ends in an alef and the second in an ayin on both copies, and neither is regularised. The printer marks his other foreign word on the facing leaf with parentheses and an internal mark, and this one with neither. The Hebrew name beside it carries the definite article twice, which is not ordinary construct state; given as set.

earth, [the earth] covering it? At first inspection it appears that the water stands upon the earth; and in truth this is the essential point[?], because all the waters, by clear proofs, are the smallest fraction of a fraction [מיעוטא דמיעוטא] compared to the earth's globe. For if the whole [surface] were left as water, as though the waters hovered over and covered the entire earth's globe; and were one to posit further that in every single place throughout the whole world one would find the depths of the waters — the whole world would there be filled with depths of water to the measure of קלי parasangs, as above [שהעולם כולו ימלאו שם עומקי המים שעור קלי פרסה כנ״ל].[111]

and the thickness of the earth [to its center], according to the aforementioned reckoning, is close to nine hundred parasangs [בקרוב תשע מאות פרסה]; [in a treatise][?] it will be [shown] that the measure of the water against the thickness of the globe is a fraction of a fraction of it. Take an illustration of this: that the pulp of an apple [שיעור עצמות התפוח] holds about fifty times the measure of its thin peel [על א׳ חמשים — a ratio of one to fifty] — and all the more so for a large, broad globe (for the larger the globe, the smaller becomes the measure of its peel relative to its body!). All these things are easy for those versed in the science of measurement, and there is no need here to elaborate the explanation of their reckoning, for it is not fitting to intermingle the matters. From the aforementioned it would appear at first inspection that, on account of its great size, [the earth] is the essential thing and the water is negligible — canceled, as it were — so that it would appear fitting for us to say that the water stands upon the earth.

However, after deeper inspection the opposite appears to us, and we say that the earth stands upon [the waters]. For if the whole earth's globe were entirely dust within, or were solid[?] throughout, it would not be filled with water even to the part of the part of it, in proportion to the measure of the earth's globe [חלק החלק ממנו, as printed].[112] But according to reason it appears to us to be the opposite: that the whole interior of the earth's globe is filled with water. This is why there is no level place [מקום מישור] anywhere in the world where, digging fifty or a hundred cubits [תחפרון חמשים או מאה אמה], water is not found there — for the waters press and well up and gush from within all the soil of the ground. So too we find, and see daily, that places in the mountains split open [in earthquakes], and at times… water flows out and issues forth like…,

[111] the sentence that ought to carry the depth figure carries a three-letter form which is neither a number nor a Hebrew word — the mark in it is a yod, at the height of the certain yod on the same line, not the double mark that would make it a numeral. Both copies print it. Given as set, not repaired.

[112] this siman states the comparison three times and never as a fraction — twice in words with no figure, once giving the earth's thickness alone. The only ratio with a figure belongs to the apple simile, is introduced as an illustration, and is expressly a lower bound, since the parenthesis beside it says the larger the sphere the smaller its peel's share. Reporting one part in fifty as this book's water-to-earth ratio would publish as the book's arithmetic something the book declines to fix.

and rivers form that never existed before.[113] From all of this it appears, to a first view, and it is near to believe — and it is the judgment of nature — that the interior of the earth's globe is filled with water. Accordingly we would say that the majority is water and the water is primary, and the earth stands upon the water. And perhaps to this the Psalmist alluded in "[Who] spreads out the earth upon the waters" (Tehillim 136:6). Some support for this I found in the book Maaseh Hashem by the sage R. Eliezer Ashkenazi, in ch. 3 [בפ״ג] of his book, on the verse "Let there be a firmament in the midst [of the waters]" [Bereishis 1:6]: that before "Let there be a firmament," the earth was a solid mass, so that if a man were to bore down to its center he would find no water there; but when the Creator decreed "Let there be a firmament in the midst of the waters," behold, [the earth] filled with water, and so on — such that this is [the meaning of] "Let there be a firmament": that the whole earth is [made] like a mixture[?], so that a firmament be enclosed within the water. Thus far his words. And in my view, "[Who] spreads out the earth" is also called "heaven," as it says accordingly, "And God called the firmament heaven" [Bereishis 1:8]. One may also say that what accords with the words of our Sages of blessed memory in their saying, "Upon what does the earth stand? Upon the water," is that their words agree with what we have chosen, as above — until I hear what ha-Kuti will say [שאשמע מה ידברו הכותי — so printed; the closing idiom the sense calls for is רבותי, "my teachers", but the page prints הכותי, and it is left as it stands].

סימן ס״ו (§66)

Refutation of the view of the ancients who said that, opposite[?] the equator [קו הישר], there is no habitation because of the excessive heat, and near the northern circle there is no habitation [because of cold]; and an explanation of the seven climes [אקלימים / climata].

Know that the ancients — chief among them Ptolemy, head of the astronomers [בטולמיא״ס ראש התוכיים] — and those who walk in his footsteps judged that beneath the equator,[114] and on both its sides, north and south, along the full breadth of the zones of the zodiac — namely, the entire band that lies between the circles of Cancer and Capricorn (as will be explained at the head of Section 5, God willing, regarding the breadth of the band between the two circles, which holds close to 40[?] degrees [מ״ם — likely 47/48, uncertain], as has been explained) — it cannot be inhabited [because of heat].

…[uninhabited] by dwellers, because of the excessive heat… the [torrid] zone[?], which in the Latin tongue they call Torrida [ובלשון לט״ין קורין לה טורידי״א — Zona Torrida]…, the zones being scorched, as it were, in their view — that

[113] both numerals are written out as number-words, both governing one unit in the singular; a reader expecting this book's usual numeral style would report the figures absent. The verb carries a paragogic final nun on both copies, given as printed.

[114] two honorifics stand in this clause and are not the same phrase — the relative "at whose head he stands", of the ancients, and the title "head of the astronomers", attached to the name.

everything there is burned and dried up. And so wrote Radak[?] [תרד״ק][?]… Accordingly, the beginning of the boundary of the habitable band runs from the circle of Cancer northward. About 24 degrees [כ״ד מעל'] from the equator to the north, the whole tract which is [from] the [circle of] Cancer toward the [south?][?] — throughout the whole quadrant[?] — they reckoned, and the ancients named it, as uninhabited; except that the ancients set the beginning of the habitable band from the line of the Cancer circle, [and] a further ten degrees [עשר מעלות] more toward the north…, so that they excluded everything that [lies] within the zones of the zodiac up to [the point where] everything is scorched and burned at the season of the summer solstice [תקופת תמוז]. Likewise the ancients [held] that from the circle of Cancer northward, and below it down to the [arctic?] line, [the region] is found devoid of habitation because of the excessive cold. Accordingly, habitation, in the reckoning of the ancients, was only about a quarter of the globe.

[From] the 24th degree [הכ״ד] from the equator to the northern circle [עגול הצפוני], which is 43 degrees [מ״ג][115] — which, by the reckoning of fifteen parasangs [ט״ו] per one degree, comes to 645 parasangs [תרמ״ה] — this breadth alone the ancients' investigation reckoned [as habitable]. They divided this mentioned breadth into seven parts and called each part an aqlim [clime] — an Arabic word; in our tongue it is called nof [נוף], called after the biblical expression "the three seasons[?]" (Yehoshua[?]…, [and] "…the earth," Tehillim 48[?]), as Radak wrote…

And these are the seven mentioned climes, each of them [extending] from the western place to the eastern edge, according to the length of the upper globe; and they are 180 degrees in length. And for fuller clarification… — [here is] this figure:

Diagram. A circle drawn in cross-section, crossed by nine straight horizontal lines, counted by pixel profile down the vertical centre-line on witness N. Eight of them are packed into the upper half — the topmost just below the rim, the lowest of the eight about a fifth of the disc above the middle — and they bound seven bands between them. The ninth line lies below the middle of the disc and is printed in two segments with a gap at the centre. The lower half of the disc is otherwise empty.

Letter census (closed). Nine letters. All but one stand outside the rim; פ alone is inside.

- ב — outside, at the top of the circle
- ד — outside, at the bottom of the circle
- ז — outside at the right, level with the topmost of the eight lines
- [[ח]] — outside at the left, level with the same topmost line. A small glyph, blotted on N and not separately secured on B: a head with a tail, not resolved into a letterform. It is recorded as unread; the reading ח comes from the body prose (קו ז״ח), not from the plate.

[115] the two figures do not sum to the sixty-six or sixty-seven degrees the wording leads one to expect; both are given as set.

- **ה** — outside at the right, level with the lowest of the eight upper lines
- **ו** — outside at the left, level with that same line (a vertical stroke with a small head, clean at 15×)
- **א** — outside at the right, level with the ninth (lower, gapped) line
- **ג** — outside at the left, level with that same line
- **פ** — inside the disc, in the empty lower half, below the ninth line and near the centre

One further inscription, unread. Outside the rim on the right, at mid-height, a word of four or five glyphs is set rotated 90°. At 13× on N the letters resolve to shapes but not to a word: reading right to left, ⟦?⟧ ה ד ר ו with the first glyph a heavy compound form. It is left unread; no reconstruction is offered.

Because every clime nearer the north pole[?] [צד קוטב הצפוני] has its length-line shorter — as you will see in the figure, each one being shorter than the [preceding] line…, at any rate…, for the sake of knowing and determining, for all the places of the earth, how many degrees each lies along the length of the world [longitude] and how much along its breadth [latitude], they divided all the climes — whether long or short — each one [into 360?]; each of them being 180 degrees along its length, as will be further explained [in §69?]. And as for their names, I have already written just above that all seven together have a breadth of 43 degrees [מ״ג]. The ancients recorded some of the names of the countries in each and every clime, and also the length of the longest day in each of them; but we have no need of these in this our book, for it will suffice for [our purpose] the measure of the divisions of the length and breadth of the globe, as [explained]. The extent of our discussion at this point is [confined to] their boundaries. The ancients set the earlier [seven climes] for the inhabited region alone, and reckoned the rest as wilderness and desolation, as they said, that no man passed through them, and the foot of no beast trod them — neither on the southern side, because of the excessive heat, nor on the northern side, because of the excessive cold.

However, [thanks to] the sages, the vessels[?] of their investigations, particularly in recent times — from some years ago until now — it has become known to us from them that trade has already been borne widely over the face of the earth [חלד], and settlement has spread even beneath the full breadth of the zones of the zodiac. Even in our own time, ships set out year by year (from France [צרפת], from Spain, and from Portugal [פורטוגאל]), traveling by way of the Indies [אבדיא״ם — India?][?] (Calicut [לקלקוט])…, [to] the inhabited [lands] that lie toward the East; and along this route they encircle and go around the region of Africa [אפריקא], which is like a bent palm set within the sea, and they pass around it in such a shape…, and all return to their place like…, and go back and return to their land. They must pass beneath the full breadth of the zones of the zodiac four times in all, such that in this journey of theirs the sun stands overhead four times — and [settlement and habitation] are found there, [directly] beneath…, as though appearing face to face[?]. Concerning the route of this journey — as [also] the countries mentioned that they travel to

— likewise, year by year, they go by way of the west of the whole world…, and go to the New World [עולם החדש] and to the region of Peru [חלק פיר"ז], which lies beneath the full breadth of the zones of the zodiac, as will be explained further [in §75?]; and it has been disclosed to us [that there are] many settled countries — and habitable countries have been found beyond the arctic circle to within fifteen degrees of the north pole, so that "the later ones have crossed the line the first ones had bounded" [האחרונים עברו קו אשר גבלו הראשון].[116]

סימן ס"ז (§67)

The reason the ancients divided the inhabited world, and [assigned it] to seven climes.

Know that when the ancients divided the inhabited world into seven climes, their main intention was to know in which clime each and every country, city, and town lies, and also to know the measure of the longest day of each and every clime. But I do not know why they fixed specifically seven climes; for it would readily occur to us [lit. "fill our heart"] to fix more climes — and not seven alone, but seventy-seven too, would come out for us [אקלימים יותר ולא לבד שבעה אלא גם שבעים ושבעה יעלה בידינו] — since it is an easy matter to know, for each clime, or at each degree, the line of the locations of the countries…[117]

[116] the three country-names are set inside parentheses, as this printer marks foreign names elsewhere on the leaf.

[117] the three number-words in this sentence are set three different ways within four lines — one abbreviated with a single mark, one written out, one written out as two words — in a book that sets three numerals as gematria a few lines earlier on the facing column. "Seventy-seven" is rhetorical, an arbitrary larger number, and the leaf itself points past it to a division at every single degree.

שער ג [Gate 3] — continued

[Continuation of סימן ס״ז / §67 — the divisions of the inhabited world]

the countries and the cities, and likewise the length of the daytime in each and every place, as before — as [stated] in the sixth discourse, in §145 [בס׳ קמ״ה (?)]. For this reason we will not expand on an account of the seven climes, nor have we assigned them as markers for the locations of countries, since it suffices for us to know the measure of the line of longitude and the measure of the line of latitude of the terrestrial globe, and from these to know its settled regions — as all this will be explained further on.

You should also know that the ancient sages divided the whole aforementioned inhabited world — that is, the seven climes — into three parts. And after many years, up to the present, they went on adding to the regions of the world, addition after addition, until in our own times they have reckoned and divided the globe into eight parts. These are their names. The inhabited region of the seven aforementioned climes they divided into three parts, namely (Asia [אסיה (?)], Africa [אפריקא], Europe [אירופי]); the New World they divided into two parts, namely (America [אמריקו] and [פירוט][118]) — that makes five; further, they took in a great part and called it ([נאבת ניכיניאס])[119] — that makes six;

and to these they added and marked the Northern World and the Southern World — that makes eight. And now, to detail them for you:

סימן ס״ח [§68] — The construction of the figures of the entire terrestrial globe, the seas together with the dry land, in all eight aforementioned parts, in general outline

The author says: Before I speak of the particulars of the eight parts of the world — so that these matters not be to the students like a dream without an interpretation — I saw fit to sketch broadly the whole plan of the figures of the entire terrestrial globe [together with its seas (?)], in general. And because it is impossible to depict a globe upon a flat surface properly, the opinions of the researchers here have multiplied, and they have depicted it in various aspects and forms [שונות] and the like; these are [their several] ways of representing the terrestrial globe upon differing flat aspects. But to make it easier for the students, I chose one of them [and thereby] discharged the obligation of them all [i.e. it serves in place of all], as [being] clearer and easier to explain to

[118] Peru?

[119] Nova Guinea / New Guinea?

the students: to draw it upon this surface as two flat circles. It will appear to your eyes as though an apple — or the globe — were cut in two from top to bottom, that is, [drawing] from the northern pole down to the southern pole (an easy way), and likewise easily from west [to east], into two equal parts, [the marking running] up to 180 degrees [ק״פ = 180] for each. And it will seem to you as though the two halves of the globe, or of the apple, were drawn out and flattened until each is like a surface [that is not raised]; yet nonetheless picture in your mind that each of the two flat circles is like a bowl, or like half a sphere.

so that in these two circles the aforementioned places will lie near [to one another (?)]… only in two circles… [and I have marked it] with symbols [וסמנים (?)] and dots — and this is enough.

And this making of the maps [charts] according to [כתובנייס][120] is [called] "mapping the world," and in the Latin tongue mappa mundi [מחפת מונדי]. The making of the maps themselves I did not find transcribed within this book… (and whoever wishes to grasp the configuration of the world that [Ptolemy set down], let him look within a chart [קארט] on which it is depicted).

סימן ס״ט [§69] — An explanation of the two maps, with an account of some of their circles

The two maps are required… for the globe [and its eight parts], as will be explained. Now it has already been explained above, in chapter 29 [בפרק כ״ט], that all the circles of the heavens above are inscribed — intellectually — upon the face of the earth below. Therefore I saw fit to mark for you, upon this surface that stands in place of the terrestrial globe, the more necessary circles: [some] extending eastward, and [a line] drawn from north to south. And although the five lines mentioned are [drawn as] simple lines, nonetheless know that each and every line encircles [the whole globe]. …[the line] whose opposite is the Tropic of Cancer [עגול סרטן]… This line is divided and marked off every ten degrees [and numbered 10, 20…] [14 (?) — see note] until the completion of 340 degrees [ש״ם] [recte: ש״ס = 360], and it is called "the long line," as above in §60 [כנ״ל בסי׳ ס']. …And in each quarter are marked ninety degrees [צ' = 90], corresponding to what was explained to you above in §35 [בסי׳ ל״ה] concerning the lines called lines of latitude [קוי הרוחב], by which one measures and estimates, in each and every place, how many degrees it lies between north and south — which is reckoned as the latitude of the world.

And now, once the names and locations of the countries and cities are marked upon the globe, you will easily be able to see plainly with your own eyes, without error, this reckoning: to survey the many places, and the longitudes of a country — that is, how far each of them lies in the longitude of the world between east and west, and how far it lies in the latitude of the world from the equator [קו השוה] toward the northern side. For example, Jerusalem [ירושלים]:

[120] Ptolemaeus / Ptolemy?

you will find it in the latitude of the world, toward the northern pole, [at] 32 degrees [ל"ב = 32]…

ע' סי' [§70] — Depicting the terrestrial globe in another manner — for it more closely resembles the solid, rounded globe [כדור המעוקב / המעוקם (?)] — to complete [the matter]

[Regarding] this work, I saw fit to inform the reader that some of the geographers among the later, more recent sages [depict] the terrestrial globe in a manner different from the foregoing… And the depiction begins as though one cut the globe in two: it starts from opposite the northern pole and runs through the center of the globe along with the southern-pole axis… upon a sheet [drawn] in such a way that you fill in the two poles on two discs [לוחות]… [In] the flat-circle [method] the ancient sages already made use, since through it three parts of the circle are represented [as] before — from the western edge to the eastern edge, which are [so-and-so] degrees, as above, and no more are needed. …[In the alternative method] the globe is divided differently, and this is how it is done: picture it as though the globe were cut in two, in every figure, upon the line of the equator [קו השוה]… on the northern [disc] you will find the disc [drawn] with its pole at the center within the circle, and likewise you make the southern [disc]… [the part] that is beneath the earth… resembling the solid, rounded globe [כדור המעוקב (?)]… and the circle of the Tropic of Cancer [עגול סרטן], and likewise the other circles of longitude [עגולי האורך]… [each] at an equal distance from the northern pole, truly like the circles of the solid globe, indeed like a sphere — for so it is seen plainly, as will be explained.

סי' ע"א [§71] — That the ancients divided the inhabited world into three parts, namely Asia, Africa, and Europe

Know that the ancients already divided all the inhabitants of the northern [inhabited world] in its entirety — that is, the seven climes — reasonably and with good sense into three unequal parts. The largest part of all is called Asia [אסי"אה]; the second, smaller than it, is called Africa [אפרי"קא]; and the third, the smallest of all, is called Europe [אירו"פי]. Now I will set out for you their bounds and borders, one against another — where they begin and where they end — all by clear and known markers; and the aforementioned figure will show plainly all the markers I mention. I will begin with the part upon which we dwell.

The first part is called Europe, after a certain woman named [איפרופי (?)][121], daughter of the king of [פיניצ'אן][122], who reigned and was carried off across the whole land, until this whole part fell under her dominion, and she called it after

[121] Europa?
[122] Phoenicia?

her name [איפדופי / חרו״פי][123]. …As for its situation, bounds, and borders: know that its place is, as it were, on the northern and western side of the world's settled region, and it is encompassed and surrounded by seas on all sides — from the south, the west, and the north. For toward the south this part reaches the Great Sea called in their tongue [אמ״ריקי״ו דיטע״רא][124] (its meaning: "the sea in the middle of the world"), which is the Mediterranean Sea [ים התיכון], running from Spain [ספר״ד] and passing across the face of most of Spain, France [וצרפת], Italy [איטלי״א], and all the land of Greece [ארץ יון], reaching as far as the Holy Land [ארץ הקדושה]. The length of this sea is about six hundred parasangs [כמו שש מאות פרסה], and its breadth — though it now increases and now decreases — is about two hundred parasangs [כמו מאתי׳ פרסה]. This Great Sea divides the part of Europe from the part of Africa [אפרי״קא]. And the islands enclosed within the Great Sea… the ancient geographers reckoned and marked all the islands of this sea as belonging to the European part…

And to the north, this part stretches upward and upward until the northern circle [Arctic Circle], where the Northern Sea sets its bound. On the eastern side this part begins from the shore of the Western Ocean [ים אוקינוס המערבי = the Atlantic]; and by the two boundaries, the northern and the western, the geographers [assign] to it all the islands of the northern and western seas. …[As for] the first part, called [איד״על (?)], stretching from the south to the north and falling within the Northern Sea, called [סיביעק״ן (?)]; and the second, called [טאני״סן (?)], running from north to south…

The particular countries in the European part are, then, as follows [several names garbled]: the kingdom of Portugal [פורטג״אל], [that] of Spain [ספר״ד], [אספכל״ן (?)], Italy [איטלי״א], [פאלחקי״א (?)], [ליט״א][125], [מהסק״רי][126], [ליפלתב״ד (?)], [בהמיא״ת][127], Hungary [אונגריא״ה], Turkey [טורקי״אה], [מח״צין (?)], [דוכיס״ם][128], [קוקסטאנטי״נא][129], and every land of [טאראנל״יאה / ציונו׳דחל״י מצל״יא (?)], Romania [רומאני״א], the great rivers [נהרות (?)], [אבנלטיר״א][130], Scotland [שאטלנד], [אושקולי״אה (?)], the land of Denmark [לאנד דעני׳מרק], [אינ״ה / מיהרק״ו (?)], Sweden [סוויד״ן], [חרמידי״ן (?)] — together with the great islands within the aforementioned Great Sea [והאיים הגדולים שבתוך ים הגדול הנ״ל], which are Corsica [קורסי״קה], Sardinia [סירדי״ניה], Sicily [ציצילי״אה], [ליפ״רו][131], and Candia [קאנדי״אה], besides many other lands and islands.

As for the extent of this part: know that the measure of the line running from west to east across it, from one end to the other — from the great city of Lisbon [ליזבו״ן], in the kingdom of Portugal [פורטגא״ל], which sits on the

[123] Europa?
[124] mare mediterraneo?
[125] Lithuania?
[126] Muscovy?
[127] Bohemia?
[128] duchies?
[129] Constantinople?
[130] Angleterra / England?
[131] Cyprus?

shore of the Western Ocean, as far as Constantinople [קונסטאנטיכ"א (?)] — is about five hundred parasangs of ours [כמו חמש מאות פרסאות]; and likewise its measure from south to north runs from the islands of [גיגילי"אה] as far as Iceland [היסלנ"ד].[132]

This part, the part of Europe, though it was settled many years after the two parts Asia [אסי"ה] and Africa [אפריק"ה], as will be explained, is smaller than [Asia]. Nevertheless know that it is a well-established land, and there are no wildernesses in it save a very little — apart from [מאסקוו"א][133] and its surroundings — for otherwise no place would be found in it around which there is a day or two's journey uninhabited, since the whole part of Europe is settled with great and populous cities and with people dwelling [in them]. On this account there is no need to travel through it in deserts; [one travels] from nation to nation and from kingdom to another people, tranquil and secure. And the researchers wrote that the European part is more populous than the part of Africa. Now, in our own time, this part is called "the part of the Christians" [חלק הנוצרים (?)], since the [Christian] faith has spread throughout this whole part from end to end, except for Constantinople [קונסטנט' (?)]…

The second part is called Africa [אפרי"קא], and they say that it too is named after a woman [ע"ש אשה] — and likewise the name of the third part, Asia [אסיא"ה]. This is not the place to expand upon it… And this is not the Afrikí mentioned in the Talmud, in tractate Tamid [במס' תמיד] and in other places besides — except that the one is written with an aleph [באל"ף] and the other with a yod [ביו"ד].

The part of Africa, of which we spoke — here all the ancients and the moderns agree in making it the third of the inhabited world in the seven climes. This part is larger than the European part, nearly double, but smaller than the part of Asia. Its bounds and borders: it is set and surrounded by seas on its four sides, being round. On the northern side it stretches and presses along the whole face of the shore of the Great Sea [the Mediterranean], from its beginning to its end, from below the right of Spain [ימין ספר"ד] as far as the coast of [סקלוסס (?)]; for along the whole length of the Great Sea — which is the boundary of the European part, only [on its] south, as above — the Great Sea [is Africa's northern bound]. …On the west it is bounded by the western Ocean [ים אוקינוס המערבי]; and [where] the whole [southern] part tapers, being surrounded by sea on all sides, [it forms] a point — like the point of the aforementioned Great Sea… as far as the interior [חוף (?)]… On the south this part goes on lengthening and widening as far as the Southern Ocean [ים אוקינוס הדרומי], and on the east it widens onto the tongue of the Red Sea [לשון ים סוף]. In such fashion the whole part is ringed by sea on all four of its sides, save that at its north-eastern quarter there is found a small tract that the waters of the sea do not ring, but which is

[132] the leaf gives these two bounds in these forms only. The northern romanizes as Iceland; the southern is the same name the leaf prints in the island list just above, and is given no identification here.

[133] Moscovia / Muscovy?

joined to the part of Asia [חלק אסי"ה] — that is, the span from the shore of the tongue of the Red Sea to the shore of the Great Sea, the space between them being small, as you will see in [בצורית המ"פא][134]; and by report it is only about forty parasangs of ours [מ' פרסאו] — among us [אצלינו].

This part somewhat resembles a triangle [החלק הזה קצת דומה למשולש], because the measure of its breadth runs somewhat further toward the northern side, its breadth being about five hundred parasangs [ת"ק פרסאות], as above; and all that it runs and spreads along its length toward the south, its breadth goes on diminishing, until the edge of the part reaches the Ocean [ים אוקיינוס] that lies opposite the southern one, where it has no breadth at all, only a few miles [רק מילין מעט]. So that this whole part resembles a triangle, or a taper [דומה למשולש או למחדד].

And the names of the countries and the kingdoms, the great and the mighty and the well-established, within this part are many beyond number; and some of their particulars are: [מצרי"ם], [כו"ש], [ברברי"א], [עמי"דאה], [אבטיופ"יא], [מלכו"ת שב"א][135]

The third part is Asia [אסי"אה]. Its bounds and borders: on the eastern side it begins from the end of the Great Sea, [running] along the shore of the Holy Land [ארץ הקדוש'] and from the Red Sea [ים סוף], and likewise from the two rivers [איד"על] and [טאני"ס] mentioned above [הנ"ל][136] … This part [extends] on every side; its corner to the east reaches the end of all inhabited land — that is, to the shore of the Eastern Ocean [ים אוקינוס המזרחי]; toward the south, to the shore of the Southern Ocean [ים אוקינוס הדרומי]; and to the north, to the northern circle. This part is more than double the two aforementioned parts, Europe and Africa. And this part was settled first, [as Scripture indicates concerning] the dwelling of Noah, according to what [is said]… [and according to] the view of Targum Onkelos [תרגום אונקלוס] and the view of the researchers, [namely] the mountains of Ararat / Kardu [הרי קרד"ו], in the second part [of the region] within our borders, which in my opinion are in the territories of [ארמכיאלת][137]. In this part was the confusion of tongues, when they built the Tower of Babel [בחלק הזה היה בלבול הלשונות כאשר בנו מגדל בבל]; and here dwelt our forefathers Abraham, Isaac, and Jacob [אברהם יצחק ויעקב]; here [was given] our holy Torah; in this part stood our Holy Temple [בית מקדשינו]; and, as a general rule, most of the account of Creation, the deeds of the patriarchs, and the deeds of the Torah

[134] transcribed as printed — בצורית with a yod, המ"פא with gershayim; no identification is supplied. The published "as the figure shows" was our reading of these two words and is withdrawn

[135] on-page observation, flagged and not reconciled: כו"ש stands here in this African list, while כושים stands in the European gloss-series of §72 below (p. 56, right column, line 11). Both were adjudicated against same-page ש controls. Recorded as printed; nothing has been moved.

[136] the boundary pair already named earlier in this siman. This slot was published as "the Tigris [חדקל] and the Euphrates [פרת]"; neither Hebrew form is on the leaf, and the identification is withdrawn.

[137] Armenia?

and the Prophets — all were in this part, which is the part of Asia. Only the events of Egypt [מעשה מצרים] were in the part of Africa; and of the European part we find nothing [recorded] in all the books of antiquity, save that in the prophecy of Obadiah [נבואות עובדיה] he mentions Tzarfat and Sefarad, as he says, "and the exiles of this host of the Children of Israel who are among the Canaanites as far as Tzarfat, and the exile of Jerusalem which is in Sefarad" [Ovadiah 1:20] — and these are the lands of France [פרנצ״יא] and the lands of Spain [ספ״ניא], as Rashi [רש״י] and Radak [רד״ק], of blessed memory, explained there.

In this part are found great matters, long and broad beyond measure; and from this [comes] the knowledge of the names of the great and hidden kingdoms found in this part — [too many] for most of them to be numbered. I will mention only some of them, the largest: [ארמכיא״ס][138], [ריס כד״יס / בכ״ם?אר (?)], Persia [פרס = פר״ם], Media [ומד״י], [אחיכד״יאם (?)]; here is the great […(?)][139], [סינא (?)][140], [יחפין (?)] — all mighty and very great kingdoms, and many others besides.

סימן ע״ב [§72] — That the sons of Noah — Shem, Ham, and Yefet — divided the three parts of the world among themselves

Those who write on this science say that Noah divided the three parts of the world among his three sons, Shem, [Ham], and Yefet — for his sons, all together [received their portions]… the part of Asia [אסי״ה] fell to Shem, the part of Africa [אפרי״קא] to Ham [ח״ם], and the part of Europe [ארו״פא] to Yefet. In my opinion [these authors have] rightly said what they said, for when you examine the genealogy of the sons of Noah you will find great support and hint for their words, since according to the plain sense of the verses before us…

[The sons of] Yefet received by lot the part of Europe [נפל לגורל חלק ארופ״א] … the sons of Yefet [בני יפת][141]: "Gomer and Magog and Madai and Yavan and Tuval and Meshech and Tiras; and the sons of Gomer: Ashkenaz and Riphath and Togarmah" [Bereishis 10:2–3]. All these names are the names of the countries [of Europe]… known [in that] each and every one [land] is called, or its city [named], after him — as you will find in the Sefer Yosippon of ben Gurion [ספר יוסיפון בן גוריון], according to what they cite; and likewise Don Yitzchak Abarbanel [דון יצחק אברבנאל] explained it, [in his account of]

---

[138] Armenia?

[139] this slot was published as "Cathay"; no such name is on the leaf and the identification is withdrawn

[140] China?

[141] two words on this line are not read and have not been smoothed: (i) the line's opening word, sorts י־ל־פ־נ־ש + geresh — also the catchword at the foot of p. 55 left column, and that catchword is broken past recovery in both witnesses, its sorts eaten by the threshold in the bitonal copy and unrecoverable from the greyscale at that margin; (ii) a five-sort word immediately before בני יפת, resolved only as ש־[ת/מ]־[א/ה]־[כ/ג]־[ן/ל]. Neither construes, and neither is rendered.

the names of the sons of Noah, [saying] that today these are the names of the countries in the European part. Of Gomer and Magog, Yosippon and [רוך[א]ו] wrote [רוך[א]כתבו יוסיפון ו] that from them came forth [שמהם יצאו] [נוונטי״ם]; and [ונוט״י] …[142]; and Yavan [ויון] — the Greeks [היוונים]; and Tuval [ותובל] — they said that they are the province of [ספר״ד] [אמרו שהם מדינת ספר״ד][143]; and so wrote the author of the Yuchasin, folio 135 ([וכן כתב בעל יוחסין דף קל״ה])[144]; and Tiras — set here [ותירו״ס] — its Targum [תרגומ״ו] is [אשכנ״ז] and [אלימי״נאה], that is to say [ר״ל] [טייטש לנד][145]; [כושים] — [נופרי], which they call [שקורין] [ליפרין][146]; Togarmah [תוגרמה], [טורקיה][147]; Dodanim ['דודני], [דעני מר״ק][148] — all of which are in the European part [אשר כולם הם בחלק ארופ״י].[149]

And to the sons of Ham there fell by lot the part of Africa [ולבני חם נפל בגורלם חלק אפריק״א], …[150]: "and his sons: [כוש] and [מצרים], [פוט] and [וחוילה]," etc. [וגו'] [Bereishis 10:6]. And they are all of them ones that were called after their own names, and they need no explanation, for they are all known today in the part of Africa [וכולם הם שנקראו על שמם ואינם צריכים עי׳ כי כלם ידועים הם כיום בחלק אפריק״א].[151] And to the sons of Shem there fell by lot the part of Asia [ולבני שם נפל בגורלם חלק אסי״א], and he said: "the sons of Shem: Elam [עילם], Ashur [אשר]

---

[142] the word after יוסיפון reads sort-by-sort ך־א־ר־ו־ו; it does not construe and stands as printed. The leaf's claim here is an origin claim — "that from them came out …" — not a "which is" equivalence. The people-name is transcribed sort-by-sort, י־ו־ו־נ־ט־נ + gershayim + ם, and no identification is supplied; ונוט״י (ט־נ־ו־ + gershayim + י) is a second such people-name, and the two words following it are not construed and not rendered. The published "following the later Yosippon [כיוסיפון האחרון]" is not what the leaf sets and is withdrawn.

[143] the gloss is hedged and attributed by the leaf itself; the hedge is carried, not flattened into an equivalence

[144] the folio numeral reads קל״ה = 135, and the attribution stands in Hebrew-order parentheses attached to the Tuval gloss. This supersedes the unresolved "folio 13–" reading and the first reading's "139 [קל״ט]".

[145] the one unambiguous vernacular gloss in the run — ר״ל, "that is to say", followed by a two-word vernacular name set in Hebrew letters. The Alemania / Teutschland gloss belongs to Tiras, not to Ashkenaz; the earlier assignment to Ashkenaz is withdrawn.

[146] glossed twice over — a first equivalent, then the "called" formula; both transcribed as printed and no identification is supplied for either. ⚠ This name stands inside the European series, between the Tiras gloss and תוגרמה, in a paragraph closing אשר כולם הם בחלק ארופ״י. That is where the leaf sets it; recorded as printed and not moved. See also כו״ש in the African list of §71 above.

[147] a bare apposition on the leaf — no "which is" formula

[148] likewise printed, as a bare apposition

[149] what carries no gloss. In the roll-call above, ומשך and וריפת are bare, with no gloss anywhere in the run; אשכנז is bare where it stands among the sons of Gomer (it recurs below only as part of the Tiras gloss). The run supplies an equivalence for six items only — ויון, ותובל, ותירו״ס, כושים, תוגרמה, 'דודני. The published "[and Meshech] with [כוסים נופרי / 'ליפרי (?)]" attached a gloss to Meshech that the leaf does not give him, and is withdrawn.

[150] the word introducing the quotation is not read — אמר?ש — and is not smoothed

[151] every Hamite name here is bare — no gloss on any of them — and the leaf itself says why: they are already known today in the part called Africa. That is a positive statement on the page, not an omission, and the absence of glosses is not to be repaired.

[recte: אשור], and Aram [וארם]" [Bereishis 10:22][152] — names of various countries [שמות שונים מדינו'], which need no explanation, save [בי[ח]?ד][153]: for Elam the capital is the kingdom of Persia [כי עילם הבירה מלכו' פרסי], which is named in Daniel, chapter 8 (שנקראת בדניאל סי' ח'): "and I was in Shushan the capital, which is in the province of Elam" [ואני בשושן הבירה אשר בעילם המדינה][154]. And likewise Ashur [אשור], for the great city Nineveh [כי העיר גדולה נינוה], which is called at present [שנקראת וכעת] [מוסי'], has been from of old the head and the metropolis of the kings of Assyria [הוא מעולם ראש ומטרפולין למלכי אשור], as is mentioned in the book of Kings [II], chapter 19 [במלכים ב' סי' י״ט]. And also the five lands of Aram, which are [וגם חמשה ארצות ארמי שהם]: [ארם דמש״ק] • [אר״ם צובה] • [אר״ם נהר״ים] • [אר״ם בית רחוב] • [ארם מעכ״ה] •[155] — (… of whom [some] are mentioned in Scripture … [אשר מהם נזכר בקרא ודו ?ע״ה ?] … Aram son of Shem son of Noah [ארם בן שם בן נח])[156]. And they are all of them countries, marked out and known, in the part of Asia [וכולם הם מדינו' ורשומות נכב]ר/ד[א״סי בחלק ועדועים בחלק אסי״א].

סימן ע״ג [§73] — The discovery of a New World, called America, in the year 5252 [ה' אלף רנ״ב = 5252 AM; 5252 − 3760 = 1492 CE]

The writer says: Since… this that lies before us is [only] a few matters… [for the benefit of] one of our students, so that the readers — even those who go astray — [may profit by it], I saw fit to set down in it a little more [than the bare arrangement], in order to establish [the matter]… [and to make known to the reader] the parts and locations of the terrestrial globe upon which he dwells; and joined to this [is the fact] that [the study of] the parts and places of the terrestrial globe involves many devices and great and glorious wisdom, and [the earlier authorities] delved deeply into it, as will be explained to you further on.

[There was] a great philosopher, Christopher Columbus [קריס״טוף קאלומ״בי], among them, [who came] before Ferdinand [ורדינגו׳ם = Ferdinand] king of

---

[152] the leaf prints only these three names. ארפכשד and לוד are not on the page — the whole line was read at 350–594% on the bitonal witness and there is no ink for them; any edition carrying them is carrying names the leaf does not set. The second name is printed אשר, three sorts, with no vav: verified at 594%, with no vav-width channel between the ש and the ר. The printed form stands in the reading and the familiar אשור is carried in [recte:] only; the Assyria gloss below is attached to the form אשור, spelled with the vav, not to this one.

[153] the leaf reads אינם צריכי' פירוש — they do not need explanation; the published "need explanation" is withdrawn. The word following אך is not resolved and is not smoothed.

[154] a scriptural identification, not a modern name; the verse figure supplied by the first reading remains withdrawn.

[155] all five are bare on the leaf — not one carries a gloss — each separated from the next by the mid-height bullet the column uses for gloss-pairs. The printed count חמשה matches the five items exactly. The third is set ארם דמש״ק, with the ארם printed; the published bare "Damascus [דמ״שק]" is corrected.

[156] a scriptural-attestation parenthesis, not a gloss; two words inside it are not read and are not smoothed.

Spain [ספר״ד] and his wife Queen Isabella [איזכל = Isabella], and argued that — according to what the philosophers had already established — the earth is round [עגולה], and he judged and said that — because of the constant winds that blow past the province of Portugal [הרוחות התמידיות הנושבים אחר מדינת פורטו״גאל], since the Ocean [אוקינוס] runs from west to east [ממערב למזרח] — it follows necessarily [יחויב] that there is found on the western side [לצד מערב] yet another dry land ['עוד יבשה א'].[157] And King Ferdinand ['ורד] sent him — [just] as he was — with wise men whom he assigned to him; and they went down to sea. The sea over them was surging and stormy, and an east wind [רוח קדים] carried them onto a west-southwesterly course [דרך מערבית דרומית]; and they went sailing on until, after a few days, they came to the New World — though its magnitude was not known to them, for they reckoned it only as islands of the sea. And this was in the year 1492 [בשנת אלף תצ״ב למספרם] by their reckoning, which was the year 5252 since Creation [ה׳ אלפי׳ רנ״ב = 5252; 5252 − 3760 = 1492].

(After [these] things) — later, some years [afterward], in the year 1498 [בשנת אלף תצ״ח למספרם] by their reckoning, which was the year 5258 [שנת רנ״ח לפ״ק; 5258 − 3760 = 1498] — Ferdinand [ורדי׳נגום] king of Spain sent to the aforementioned lord, a second [time], a man of understanding and knowledge, a warrior from his youth, named Amerigo [אמיר״יקו][158], a man of [פול רע״נלי][159], who had already sailed with Columbus [קלו׳מכי = Columbus] as mentioned; and with him great ships, with men of valor and fierce, bitter-souled men, and their weapons of war. And they went down to sea and came to the New World a second time, and he sailed to America [אמיריק״ו], [journeying] into that land a distance of many days, and did there great and awesome deeds, and became a marvel and a byword in all the kingdoms of Europe [אר״ופי]. For this reason that whole land was called after his name, America [אמיריק״ו], to this day. For although Columbus [קלומב״י] preceded him, as mentioned, he nevertheless did not perform notable deeds as Amerigo did. And this part is the fourth part of the terrestrial globe.

(Further) — after all the aforementioned things, in the year 1518 ['בשנת אלף תקי״ח לנוצרי] to the Christians, which was the year 5278 [שנת רע״ח לפ״ק; 5278 − 3760 = 1518] — Carolus [קארלו״ס][160] king of Spain sent great ships, a great multitude[161], to the aforementioned land of America [אמריק״א], and they captured there a great part of [those lands], and named that country [סטטני״א (?)]… New Spain [ספר״ד חדשה][162]. And there was found a land [סתיה (?)] lying in the latitude of the world, beneath the Tropic of

[157] the inference on the leaf is drawn from wind and current, not from a voyage: nothing in it names a direction of sailing. What moves west-to-east is the ocean, driven by the constant winds past Portugal; the conclusion is that land lies to the west. The sailing direction is narrated separately four lines later — see the east wind below.

[158] Amerigo Vespucci?

[159] not identified — the letters give no reading; this slot was published as "Vespucci"

[160] Charles V?

[161] ספינות גדולות עם רב — no "four"/ארבע on the leaf

[162] Nueva España?

Cancer [עגול סרטן], near the equator [near 34 degrees — ל״ד = 34 (?)], and in the longitude of the world from the western edge [at] 280 degrees [ר״פ = 280 (?)], spreading and widening in every direction, as reported… about a hundred parsangs by a hundred parsangs, roughly. This country is a well-settled land, good and broad; and great wealth abounds there… among the sands on the banks of the rivers [נהרות (?)], fine pearls [מרגליות טובות] too are found there in abundance.

When Francisco [פרונטש״קו][163] king of France [מלך צרפת] heard of all the aforementioned things, he too sent his ships with men of valor to that land, and they too captured there a great part of the land [סתיא (?)], and named it [פרחב״ני][164], the new [land]. And this country lies in the latitude of the world about 50 degrees [נ' = 50] from the equator [קו השוה], and in longitude 250 degrees [ר״ן = 250]; and according to what is written, its [extent] and breadth is likewise reckoned as though it were a hundred by a hundred parsangs.

סימן ע״ד [§74] — The fifth part of the terrestrial globe — it too is in the New World — and that part is called Peru [פיר״ו = Peru]

Know that the New World which we mentioned, the researchers divided into two parts: the one [lying] to the north by itself, and the second to the south by itself. The northern part begins from its dividing boundary at the equator [מקו השוה] and onward toward the north, and the dwelling of [התורים (?)]…

שער ג (Gate 3) — continued

[continuation of] סימן ע״ד (§74) — Peru, the fifth part of the terrestrial globe

toward the northern pole, up to 64°30′. For most of the year those who venture there [?] cannot move any farther from the equator, even in summertime, because the dew that falls there grows cold and freezes, so that from the intense cold its appearance is like [?] silver, and like ice. [Several words here are hard to read: this part... to the side... there, or [?].] The second part inclines toward the south; this is its territory and its boundary. In terms of the latitude of the world, this part likewise begins at the tenth degree already mentioned, and extends southward beneath the equator and beyond it, toward the southern pole, about fifty degrees (a place [?] very close to the southern pole, as will be explained). In terms of the longitude of the world, this part begins on the western side at the 250th degree [ר״ן] and runs eastward to the 350th degree [ש״ן]. This second part is filled with land and provinces — a desirable land, good and broad, called Peru [פיר״ו], and it is after this province [of Peru? — of Sevilla?] [?] that the whole of this part is called Peru in general. [The two parts are] America [אמידק״ו [?] = America] and Peru, each on its own [?], [and

[163] Francis I?
[164] New France / France Nouvelle?

שער ג (Gate 3) — continued

each?] extends from the tenth degree from the equator toward the north, and the outermost [?]...

on the western side, from the 250th degree [ר״ן], and it extends toward the east [?]. [The text here describes the moderns dividing the New World into a northern part and this southern part.] The moderns added to the three parts of the world — that is, Africa [and Asia?] and Europe [וארופ״י] — and it was fitting for them to add [these New-World portions to the] books of the parts of the world.

סימן ע״ה (§75) — A brief note concerning the aforementioned Peru, which is the fifth part of the terrestrial globe, as above

The part [called] Peru, of which we spoke — most of its provinces lie beneath the belts of the zodiac, called in their tongue zona torrida [זו״ל טורי״ד — Latin zona torrida, "the torrid zone"], that is, the "scorched belts." We already explained above, in §66, that the ancients judged that beneath the whole expanse of the belts — even for about twenty degrees to either side of them — no inhabitants could dwell, on account of the great heat and the great dryness of the land, for (they said) no grass or herb would grow there, nor any other plant, since all would be dry and parched from the great heat. But all this is contradicted [by the moderns?] [?]: [the men?] who now [survey/write of?] that land have seen [?] it gathered toward the edge — a land populous and full of every good thing. And there is reason to wonder greatly at this: how is it possible to endure and stand against so great and abundant a heat beneath the belt of the zodiac?

Therefore know that the Holy One, blessed be He, in His abundant kindness, reversed nature for the sake of these provinces beneath the belts of the zodiac, for the benefit of those who dwell there. For all those who dwell there beneath the belt — to the very degree that the sun draws near, directly over the point of their heads — to that same degree the winds and the rains of water grow strong for them, and the air of that land is by its nature cold and moist; and around the hours of midday, both before it and after it, the heavens most often grow dark with clouds, so that the clouds form a barrier between them and the sun, to shield them from the sun's burning heat. All this is among the wonders of Him who fashioned all. In any case, know that the heat and the [warmth?] [?] that remains there, even on a cloudy day, is very great and powerful — [enough to tax] the endurance of our own frailty, as [reported by?] discerning men who travel there [?], [where] year by year, roughly one in twenty-six [כ״ו] [?] — so it is reported there — most of them fall sick and wrap themselves up [?] from the great heat, and many of them die there.

Know, too, that in the provinces of Peru there are found many rivers and springs of cold water, just as in our own provinces, and grass and herbs and fruits and every kind of produce — they thrive more than in these lands [of ours]. The inhabitants of that land are not black, like the Kushites and the inhabitants of Africa [אפרי״קא], who are equally deep [?] toward the south and likewise dwell beneath the belt of the zodiac or near it; for the inhabitants of

the part called Peru are not so darkened [?], as are the inhabitants of Africa. Within this part called Peru there is [?] a province called Basilias [ביסליא"ס — Brazil? [?]], [whose land is a scarcity of hands? / a land that draws in hands? [?]] at the tenth degree of latitude, extending [?] toward the southern pole; and in [terms of] the longitude of the world [it lies at] about the 340th degree [ש"מ]. The land is blessed and built up, full of every good thing; and there is great wealth of silver and gold there — especially gold [?], reddish-blue [?] in [its ores? [?]]. There no rain falls; it is like the land of Egypt, and they have no fixed season for sowing, but they sow and reap there all the days of the year.

סימן ע"ו (§76) — Some say that the provinces of Peru are Ophir, to which King Solomon, peace be upon him, sent his ships

Know that the scholars who investigate the earth wrote that the land of Ophir [אופיר], to which King Solomon, peace be upon him, sent his ships to bring [gold?] [?] — to bring from there gold, as in Kings I ch. 9 and ch. 10 and in Chronicles ch. 8 and ch. 9 [as printed, 'במלכים א' סי' ט' וסי' י' וכד"ה סי' ח' וסי' ט — the first reading carried the two Kings figures but left the Chronicles chapters as "[chapters [?]]"] — that this is the kingdom of the aforementioned Peru; and they call it S'firo and Ophiro [ספיר"ו וחופ"ירו — "Ophir"] [?]. [The researchers — Kepler? / Copernicus? [?] — say so], and their words seem very plausible. For undoubtedly there was a great distance that [Solomon's ships] needed to travel and return over a span of three years, as Scripture says. This span of time our own contemporaries in our lands would need in order to go and return from it; and there [in that land] much gold is found, [more than in?] [?] all others. For the reasons mentioned, it is plausible to believe that S'firo [ספיר"ו] is Ophir. And accordingly [?] this New World, of which we have spoken, was [not?] [?] [unknown] before — rather our sages [knew of it], for it was already known in the days of Solomon, peace be upon him... [and it was rediscovered] in the year [5]232 [?] [רל"ב — perhaps 5252 = 1492 CE, the year of Columbus; the letters as printed give 5232 = 1472 CE [?]] of the sixth millennium, [on the voyage?] to explore the sea, and it was revealed [anew]. Thus this part, Peru, [was discovered] a second time, and their words are true according to reason.

But my heart [inclines otherwise]: since the ships that [Solomon] built at Etzion-Gever [returned], as it is written in Kings and in Chronicles as above, it appears that the ships went from Etzion-Gever upon the Red Sea [ים סוף] southward until they reached the Southern Ocean [ים אוקינוס הדרומי], and from there [turned?] [?] westward until they came to the land of Peru. And according to the author of Me'or Enayim, in ch. 8 [?] of his book, his ships passed along the whole length of the Great Sea [the Mediterranean] up to the edge of the land of Spain [ספר"ד], and from there through the Western Ocean [ים אוקינוס המערבי], thus [reaching it]. But his words cannot be right, for — as is well known regarding the boundaries of the seas — he would [have to] concede and admit that the ships could not have come from Etzion-Gever upon the Red Sea [by such a route].

סימן ע"ז (§77) — Explanation of the sixth part of the terrestrial globe, called Guinea [גביניא"ה — Guinea [?]]

Know that twenty-[six? [?]] years after the discovery of the New World, [in the year?] [the fifth [?] millennium... 5]... — which for the Christians is the year [רע"ט [?] = 1279 of their reckoning? [?]] — the king of Portugal [פורטוגא"ל] sent [his emissary?] [and] Rodrigo [?] [ורדיגנג"ו [?]] Magellan [מנגליהנו"ם — Magellan [?]] to explore... ...to learn whether there is yet more inhabited land beyond this [New] World; for it [the New World] also extends there, tending toward the southwest. And in part [thirteen? [?]] [there is] another [region], as far as [?] the strait [מיצר [?]] of the sea that serves as a divider between the part of the New World called Peru and the southern part of the world (whose [nature] will be explained to you further on, and as you will see depicted in the map of the world). There the measure of length is about 100 [ק'] parsangs long, and its width is only 48 [מ"ח], and its distance from the equator toward the southern pole is 51 [נ"א [?]] degrees. (This sea — [that is, the strait] — they named after him, the Sea of Magellan [ים מגנליהמו"ם — the Strait of Magellan], and he passed through the strait in great peril because of the waves and the storms, and they entered into it; and it brought all of Peru to his right hand and their southern boundary to his left, and he kept sailing many days until he reached land — a great and broad expanse, apart from the islands of new Guinea [גיביניאיה — Guinea/New Guinea [?]] — and they made war [?] with the inhabitants of that land; and although Magellan [מחנגליהנו"ם] made peace [?]... [and was slain?] [?] in that war, nevertheless the scholars of Spain [ספרדי"ס] and the scholars of Portugal [פורט"ג] strengthened the [expedition's] force until the inhabitants of that land [were doubly subdued?] [?]...)

And for many years it was not known whether Guinea [גיביניא"ה] is a province in its own right, or whether it is joined to the southern world — until close to forty years after this. I have heard that in the year one thousand תקע"[ם/ס] (אלף תקע"[ם/ס]) of their reckoning, which is the year של"ח by the abbreviated era, there went out a certain Spaniard called Frants Draki [פרנ"ץ דראק"י], and he ranged [?] with his ships over the whole part of Guinea; and so did likewise [?] Tomos Kandis [טומוס קנדי"ס], a man of England [אנגלטיר"ה], in the year תק[פ/מ]"ח of the Christians, [which is] the year 5348 [ה"א שמ"ח]. And they found the measure [?] of the surfaces of this land to be near to the surface of the whole part of Europe [אורפ"י] in which we dwell. On account of this the sages of our generation resolved to count this land as a part of its own among the parts of the globe; and by this reckoning it is the sixth part of the parts of the globe of the world. Its place, in the latitude of this globe, is between the equator and the Tropic of Capricorn, and it is near to both of these two lines — the equator and the line of the Tropic of Capricorn — by about fifty degrees [כמו נ' מעלות] from each of them. And in longitude this part begins [?] toward the west at 182 [קפ"ב] and runs toward the east as far as [?] degrees נ/ן"ר], in such manner that [?] most of the inhabitants of Europe [רופ"י[י/ו]א] are nearer to the eastern side than to its western quarter.

סימן ע״ח (§78) — The seventh part of the terrestrial globe, which is the northern world

We already explained that the ancients judged that from the northern circle onward, up to its pole, no inhabitants dwell, on account of the great cold and [?]... [A large part of it] is filled with the waters of the seas; and also part of its surroundings, where there is a [newly-found?] [?] expanse, is [a marvel]. And the reason for this [is] the great distance of the sun [from there]... [therefore they said] they cannot stand there because of the cold and the great [?]. And I have already mentioned this too, amid the many [investigations of the] researchers [?]... that it is impossible [?] toward the northern side, as much as is possible [?]... [with variations] of degrees, [both] below and above, and so on [?]... [several words here are illegible]. ...beyond [that], as we said above. Moreover, since the surface of this part is great in its extent — for in its circumference it is more than 106 [ק״ו [?]] degrees, which amount, in square measure, to hundreds of parsangs of length — [the moderns filled it in?] with known provinces [added] to their number, [drawn] from the northern circle (if there are indeed inhabitants). And the researchers said that, because of its great size, it was fitting to make this great expanse a part in its own right [?] (§[63? [?]]).

[The area computation of the northern cap:] The surface of the northern [region] occupies [?] hundreds of parsangs by hundreds of parsangs [?]... Every degree of the northern circle, its distance from the axis is 23 [כ״ג [?]] degrees, 21 [כ״א] minutes [?]... the full measure of the diameter that each northern circle [subtends] contains [twice?] 53 [נ״ג [?]] degrees, 28 [כ״ח] minutes, which are about 47 [מ״ז] by 46 [מ״ו] degrees; and the circle around them, by their reckoning, [is] three times 46, which comes to 141 [קמ״א → margin: 141]. And the area of this circle is known to us from the product of half its diameter with half its circumference, as was explained [in §29 [?]]. For half its diameter is 23½ [כ״ג ומחצה] and half its circumference is 70 [ע׳ [?]]... and the half [?] comes out to 1668 [Arabic numeral in the source]... [we take] the square root of [that?] product, and it comes to 4-hundred by 4 [?]... and every degree contains 15 [ט״ו] parsangs, so as to total [several] hundreds by [several] hundreds of parsangs; and this computation is simple for those who know the science of surveying. (Thus far the reasoning.)

סימן ע״ט (§79) — The eighth part of the terrestrial globe, which is the southern world, the largest of all the other parts of the world

This part is, in size, larger than any single one of the [other] parts of the world; and its surface contains almost the surface of all three parts of the world [together] — that is, Africa and Europe [and Asia]. And it is possible [?] to come to this part by way of the dry land [from each?] of the [other] parts of the world... just as one may come by way of the dry land from each of the three parts of the world, for its expansion [?] — even from S'firo [ספיר״ו] [?] to America [אמידיק״א]. For this southern part has already been explored [?], and

Magellan [מרגנליהם [?]] — [at the end?] his instruments [?] — encircled the whole coastline of the southern world from all four directions of the world.

From [one] edge to the [other] edge, know that the whole southern circle, from edge to edge, begins from this part... at degrees 150 [ק״ן] and 140 [ק״ם [?]], along the length of the inhabited region; this part reaches nearly to all [?] the degrees up to the equator, and it approaches the great island [?] near it by about 100 [ק'] parsangs. And along [longitude] [[150/120]] [ק״[[ך/ן]][165] [to?] 200 [ר' [?]], this part likewise reaches to the Tropic of Capricorn [עגול גדי] and beyond it, until [it comes] near the great island [called] [?] Guinea [כוכ״א גיביניאס [?]], and so forth.

Behold, we have here set down for you, in general, [an account of] the [eight? seven? [?]] parts of the world; and the researchers wrote [and we have transcribed] what [they said]... [namely] that many great and very large voyages [were undertaken], and many kings sent [ships] to explore the sea; and they crossed and encircled all [eight [?]] parts of the world [סל״ל [?]], and surveyed the whole coastline of the Ocean [אוקינוס] from edge to edge, and did not [leave]... ...[so that] not even one truth [?] remained that they did not encompass (part by part). They already [reached?] the equator toward the northern side [?] — but that they did not encompass, because they cannot press farther in that direction, on account of the great cold, as above in §74. They also crossed and surveyed the seas back and forth. (And in every place where water was disclosed to them — as well as [lands] near the shore of the sea or far from it — they recorded them all in a book: thus its location, in both longitude and latitude of the globe.) Henceforth, then, it is impossible and unfeasible that one more part be found beyond the eight [שמנה] parts of the world already mentioned; though within the southern part of the world it is possible that there dwell peoples [?] and special [nations?] and countless provinces — for this land [?] has not [yet] been known or investigated as one through which any man has passed.

סימן פ' (§80) — Who told the geographers the locations of the world and the boundary of the seas?

And if you should ask and say: who is it that revealed this secret to us — [the disposition of] all the places of the world, both sea and dry land, and likewise the boundaries of the seas, their length and their breadth — and at what time was this achievement accomplished? Know that this matter was not made known to us by any one man, nor at any one time. For many great and wise, discerning sages, in earlier generations — this [being] before [our time by] some thousands of years [?] — all the men who labored in their wisdom over the science of

[165] not settled. The sort descends on both copies, so a final form is certain, but final nun (150) and final kaf (120) are not separated: against two certified same-line letters, one of each kind, it matches the nun on head-width and the kaf on head-shape — an abrupt bar, not tapering. Neither reading is excluded or asserted. Settling it needs a survey of the fount's own variation across certified instances on this leaf.

the stars, the ancients too strove to know the boundaries of the earth: such as Archimedes [ארקמי״ד — Archimedes [?]], and [Hipparchus? Abraham? [?]] [אברכו״ם], and Ptolemy [בטולמיי״ם], as is found written [at length?] in their books. And after them, the scholars added to inquire into this in every generation, until in our own time researchers such as those before us investigated and inquired into the boundaries of the dry land, together with the boundaries of the seas — great scholars, who labored over this all the days of their lives.

The chief investigations, great and wondrous, concerning the boundaries of the seas and the dry land [came] from the time the New World was discovered. [They were undertaken] by [?] great and mighty kings, as detailed — [at one time and another?] — and also the kings of France [צרפ״ת], Spain [ספר״ד] and Portugal [פורטגא״ל], who strove to know the settlements and the boundaries of the whole terrestrial globe, [and] brought it [to light] with markers [?], by means of [?] wise and discerning men who knew well the science of Geography [גיאוגרפי״א — Greek γεωγραφία], which is the science of measuring the earth combined with the science of the stars and the constellations. They provided them [with] provision — food and stipend and much reward and payment — and sent them, together with officers and many attendants, to all the directions of the inhabited world; and likewise they prepared for them many ships and sent in them, in the same way, wise men and men learned in science, to explore the sea, to encompass its whole shore from every corner, and to traverse it in its length and breadth — many kings [sending them] back and forth — to investigate all the islands, near and far.

And in every place they came, whether by sea or by dry land, they carried out the observations by means of the science of the stars, with the measuring instrument [כלי] in their hands, [determining] the longitude and latitude of that place, and they recorded it in a book. The sages have already set forth their words on this, and they wrote many further books — great and expansive matters — not only [concerning] the many locations of the whole globe of the world, but also the natural order and the configuration of every province under the heavens. And there is no room to elaborate here.

סימן פ״א (§81) — How and from where did the researchers come to know the latitude of provinces (between north and south) and their longitude (between east and west)?

Determining the measure of the latitude of provinces in every place of the world — whether at sea or on dry land — how far its distance [from the equator], how many [degrees] from the equator [קו] [it lies] [?] — this is a very easy matter, for even schoolchildren, in a short while, will grasp it... without any labor, [in contrast to] what [the ancients?] toiled and wearied over. And its usefulness has [in part] already been explained to you above, at the end of Gate 2, in §51 [סי׳ נ״א]. It will be explained to you still more fully [?] in the Gate of [the calendar / the year?] [?] — that is, [Gate 11? / §... [?]] — where the determination of [one's position?] directly against the axis will be explained

to you, by [several] methods, [namely] how far it [lies] from the equator, as above in §48 [סי׳ מ״ח].

Now as for knowing the longitudes of provinces, by the method by which the measure of the longitude of every settlement became known to them — as was explained above in §61 [סי׳ ס״א] — and likewise the sage Israeli wrote about this in his book Yesod Olam, ma'amar 86 or 87 [as printed, כתב החכם הישראלי בספרו יסוד עולם מאמר פ[ז/ו]״ — the leaf does print the title, so the first reading's query on it is removed; but the final letter of the ma'amar numeral is not resolved between ו (86) and ז (87), and the first reading's flat "87" overstates the leaf]: that the ancient sages, who sought to know how many degrees of altitude [a given] city [stands at?] [?], or how many degrees or miles [one] city [lies] from another city — they would station two observers, near and far, [as] discerning [men of] science [?], in [each of] the two places whose longitudinal distance apart they sought to know. And each of the observers fixed, with great precision, upon the very first moment when the moon entered into a certain known eclipse [לקות] — how many equinoctial hours and moments it was before or after midnight. And when all this was set down in writing, in detail, from each [observer], it was easy for the researchers to know the [difference?]... [and] this [difference], by that very [interval], is [proportional to] the distance of the cities one from another. That is: [if] one [degree? one hour?] appears in eclipse [?] to Reuben one hour before it appears to Shimon, it is known that the distance between them is 15 [ט״ו] degrees — for the [luminaries? [?]] dwell [travel] thus [around?] the globe of the world each day, that is, in 24 [כ״ד] hours, [each hour] the same [amount]. And it is already known that the degrees of the circle are 360 [printed ש״ס/ם] — the final letter is not discriminable at 4× from the final mem of הם on the same line; if ם, the leaf reads 340. Not emended.]; and when you divide this number by 24, [being] the hours of the day, there falls to each hour a revolution of 15 [ט״ו] degrees. So a difference of 2 hours will be [equivalent to] a distance of 30 degrees, and so on always, by this reckoning: every distance of 15 degrees causes a difference of 1 hour; up to 12 hours, when the difference between them is at its extreme — a distance of 100 [ק׳ — recte 180? [?]], which is 180 [ק״פ] degrees.

סימן פ״ב (§82) — To find the longitudes of provinces without eclipse observations

Know that the ancient sages learned the longitudes of provinces by means of two men who observed, with great precision, the moment [the moon reached] a certain [point] in its eclipse; [likewise] it was in their power to mark the moment [the moon reached] a certain line, or a portion of it. And [what] appeared [as] the same moment [?] to Reuben, one hour before Shimon, [means] — as is known — the distance between them is 15 [ט״ו] degrees. [This is] like the rule of those who observe the time of an eclipse of the moon. By this second method you can find the longitudes of every province, whether at

sea or on dry land, all the days of [your life?], and you need not wait and watch for the time of an eclipse.

And it is evident that the two aforementioned tests [?] — that is, [observing] the moon at the time of its eclipse, and [observing] the moon over against a certain [reference point] — both require that, when the two provinces or cities in which the observers [are stationed], both of them are seated upon the equator, or [both] are seated upon [the same] line or [the same] parallel [?]... [and] the difference [?] from west to east [?]... — [in that case] the distance [?] between them, in this manner and by this reckoning, [is as above]. But when the two of them are not upon [the same] line or [the same] parallel, or...

סימן פ"ג (§83) — To find the longitudes of sea islands, without eclipse observations and without two observers

In knowing the longitudes of the islands of the seas — or when the ship stands out at sea, far from the dry land [by many hundreds of parsangs?], in places where no observer-emissaries ever stood — [determining longitude] not at the time of a lunar eclipse and not at the time [the moon] is over against a certain [meridian], is a very difficult matter: how are we to know how many degrees [it stands from the edge?] of the world, from the [eastern?] edge to the west? Know that this matter can be known to us by means of newly-invented instruments. For this, you must first observe the time and moment [the moon reaches] the beginning of a certain sign, over against a certain [reference], by which [determination] you will be able to reckon out for yourself all the degrees [?]; and [thereby you find], [even without] two observers, the longitudes of provinces — and even the longitudes of the islands of the sea, or [the longitude] where the ship stands out in the midst of the sea, far [from any land]. This [depends] upon your knowledge of the [course] of the moon at a certain place, [set out] in the aforementioned [?] tables — in how many degrees [the moon] stands, [reckoned] against the signs of the zodiac, on every day of all the days of the year, at its rising and its setting, [and its position?] relative to the noon-line of that place — [as given] in the tables called in their tongue **ע"פ ימי רידי"ם**[166].

And these [tables were computed?] for every city and city, [for] the lands they [the astronomers] wrote of, [and made known] to the sages; and I say, for example, that once the aforementioned table has been fitted to the horizon of the city of Prague [**אל אופק העיר פראג**] — behold, when [the ship is] far out on the [high?] sea [?], and we seek there to know the measure of the longitude of that place, we observe on that night the revolution of the moon, as it rises and its center reaches... ...to the beginning of a certain sign. And I say, for example, that we observe upon it, at the beginning of the eve of the 15th of the month of Cheshvan, and we find its center to be against the head of the sign Taurus [**ראש מזל שור**]; and if the moon stood over a certain line [some hours?]

[166] the letters run together as ***עפימרידים***, i.e. ephemerides — a foreign word broken into pseudo-Hebrew words by the compositor. The mis-division is the finding; the identification is not resolved further here

earlier — this we determine by [computing] the aforementioned tables, which were fitted to the horizon of Prague [אשר נתקנו על אופק פראג], for example. For example, [suppose] we found that on the third day [?], when the moon's center reached the beginning of the sign Taurus, the moon had already descended from the noon-line by 1½ hours [שעה ומחצה]. We know from this that the difference in the day-arc between the two places is 1½ hours — the center of the moon in Prague [בפראג] preceding [it] over the [noon-]line [?]. And it is found, accordingly, that the city of Prague [שעיר פראג] inclines toward the eastern quarter [?] — [reckoned] by the moon's revolution through the diurnal motion, [which travels] in the time of 1½ hours some 22½ [כ"ב מעלו' ומחצ'] degrees, by the reckoning of 15 [ט"ו] degrees per hour — inasmuch as the place of Prague [שמקו' פראג], upon which the aforementioned tables were fitted, we already know to be distant from the western edge by 32 [ל"ב מעלות] degrees [the first reading additionally gave "and 12 [י"ב] minutes [?]" here; a second reading of the leaf gives l12 as ל"ב מעלות with no minutes term — both readings recorded, neither decided], so that the distance of the second place from the western edge is only 7½ [ז' מעלות ומחצה] degrees. (And all this [holds] when the place of Prague [מקום פראג] and the second place [both lie] upon one line [that runs] from west to east, as above.) But if the city of Prague [עיר פראג] be found at a latitude of 20 [כ'] degrees from the equator, and the latitude of the second [place] from the equator [be] thirty [שלשים] degrees, then you must equate the matter by the method that will be explained to you in Gate 2, in siman 132 (בשער השני בסי' קל"ב).

סימן פ"ד (§84) — To know the longitudes of provinces by the time of the moon's revolution, according to its own [proper] motion and the desired [motion], combined with the revolution of the daily sphere

Yet another way to find the places of the world by means of the motions of the world and [the daily] sphere, according to the time of the moon's revolution — [reckoned] by its proper motion and its desired motion — and according to the time of [its] revolution with the daily sphere. And I say, for example, to one who has understood [?]: [suppose] we are in a certain place among the places of the world whose longitude, from the western edge, we seek to know. We observe there the revolution of the moon; and [suppose that] on the eve of the ninth of the month of Kislev, for example, [we find] that it has descended in its proper motion — which is from west to east — to the beginning of the eighth degree of the sign Leo [מזל אריה]; and thereafter [?] we reckon thus [?] [by] the tables that were fitted to the horizon of [פרלגומננון [?]][167], according to the reckoning that on the aforementioned night, at [that] degree, the moon will enter the tenth degree of the sign Leo. (And it makes no [practical] difference whether the two aforementioned entries be from here or from there, and [whether] the eastern [point lies] to the noon-line thus, [or] somewhat to the west of the noon-line itself; for in every case [the method

[167]Prolegomena? — an editorial identification, not a reading; the printed letters stand as given

holds] for you — [namely] that at the moment and time of midnight, when the moon comes to the midnight-line, which, according to the two aforementioned entries, [its proper course?] shows it to have descended in its proper [motion], [it] precedes midnight in a certain [place] by [?] two [degrees] at the [given] place opposite.) And according to what we already know — that the moon's revolution, in its proper motion in its sphere, is about 22 [כ״ב] degrees in [24 hours? [?]], as will be explained further on in §157 [?] [סי׳ קנ״ז] — [it follows] that the moon's proper revolution over the two aforementioned degrees [takes] four [ד׳] hours. And we know from this that midnight in a certain [place] precedes midnight in the [reference] place, the difference between them being four [ד׳] hours, which, from the time...

שער ג (Gate 3)

סימן פ״ה (§85) — The boundaries of the four directions of the world: where they begin and where they end

[The opening of §85 continues from the foot of the preceding page, completing the discussion of §84 on finding a place's longitude from the motion of the moon; the daily circuit is described as nearly uniform, "close" at every hour.]

The author says: Since we have profited from the tables that give the longitude and latitude of the various regions, I saw fit in this Gate to treat the directions of the world and their great revolution — a matter of much benefit to those learned in the science, and in particular to seafarers, for plotting their course, and to the teacher of astronomy, for orienting himself and aiming toward a given place.

The world as a whole is divided, in accordance with what our Sages [?] have laid down. The lines that run [north–south] are called "latitude" (רוחב), and those that run [east–west] are called "longitude" (אורך); and the celestial sphere was fitted out with its four quarters accordingly. The ancients likewise reckoned only from these four quarters of longitude, [measuring] from every nation and tongue. The leaf cites **זכרי׳ סי׳ ק׳** — "Zechariah, chapter 100" — and, one line below, **בדניאל סי׳ ח׳** ("in Daniel, chapter 8") and **ובסי׳ י״ח** ("and in chapter 18"), where it says and his kingdom shall be set up [?] toward the four winds of heaven (מלכותו לארבע רוחות השמים [?]ותקן) — and we do not find in all of Scripture other than four winds. [The verse quoted is Zechariah 2:10. ק׳ is as printed and is not emended: Zechariah has fourteen chapters, so the citation is defective in the book itself.]

Each of the four quarters has its boundary where it begins and where it ends, measured from the western edge [the meridian of the Fortunate Isles]. [The eastern quarter runs] up to the sign of Cancer [מזל סרטן], and [the southern] to the sign of Capricorn [מזל גדי]. [The specific boundary values given here — on the order of 23°, 46°, and figures in the hundreds of parasangs — could not be read with confidence from the source: numeral: ?] The longitude of the north

[runs] to a total of some [numeral: ?] parasangs, and likewise the longitude of the west; so that these are the two [complementary] measures. [?]

[Several clauses of this dense passage, giving exact degree- and parasang-figures for where each quarter begins and ends, are too abraded/small to recover at the available resolution — flagged for a re-examination of the leaf. numeral: ?]

סימן פ״ו (§86) — That the ancients divided the [dividing-circle], that is the horizon, into twelve winds

Know that the ancient investigators divided the curvature — the [dividing-circle], that is the horizon — into twelve parts, splitting each of the four winds of the world into three equal parts. For example, the east wind they divided into three: the northern part they called [east], the part to its right they called southeast (מזרחית דרומית), and the [remaining] part they called northeast (מזרחית צפונית); and so, by the same rule, for the rest of the winds.

You should know, accordingly, that there is [a difference / no difference] [?] between "the east corner" (קרן מזרחית) and "the northeast," and so forth — for the word "corner" (קרן) carries a distinct sense: a city situated at point [א] lies in the [east] portion, while a city at point [ב] lies in the northeastern portion, the difference in longitude between them being [numeral: ?] degrees. And all of this is in accordance with the words of the Torah, as [set out] in this figure. [?] For in the city of [[בונשפט[?] — a place-name printed here and unresolved on both witnesses]]…

סימן פ״ז (§87) — That the moderns divided the terrestrial circle, that is the horizon, into thirty-two winds

Know that the scholars among the moderns — the geographers (מחקרי הארץ) — agreed to divide the horizon, this circle, [into finer parts] because of the great benefit [to navigation]. To sailors and [travelers] and directions in general they gave names. Upon the four winds of the world they added four more winds and called them — precisely in this order — north-east (צפונית מזרחית), north-west (צפונית מערבית), south-east (דרומית מזרחית), and south-west (דרומית מערבית); and not "east-north" (מזרחית צפונית) nor "east-south" (מזרחית דרומית), and likewise not "west-north" (מערבית צפונית) nor "west-south" (מערבית דרומית) — because the principal name is east and west, and so it stands last in the compound. These [eight] they called the "principals," or "mothers" (ראשונים / אבות), for a reason to be explained.

The moderns then saw fit to add to the eight winds just named still more, dividing the dividing-circle into thirty-two winds — assigning to each [principal] wind [additional subdivisions]. These further-added winds they called by compound names, and these are their names, as they named them: (א) east-northeast; (ב) east-southeast [and] east[-…]; (ג) west[-…]; (ד) and likewise the fourth, west-southwest; and so for the added winds toward [the poles]: (ה) north-northeast [and] north-northwest; and likewise toward the south (ו)

south-southeast; … (ח) south-southwest. [The enumerated compound-wind names (א)–(ח) are partly abraded; several individual readings are uncertain: numeral/label: ?][168]

It emerges that each wind spans eleven and one-quarter degrees — that is, 11°15′ — since a thirty-second part [ל״ב] of the surrounding circle of 360° is 11¼°. [From mid-east, a span of some 33°[?] …] [?]

[The moderns also employ the magnetic needle: an instrument that shows the hours "by the tongue of the needle" (מחט מגנעטיכא [magnetic]) together with the lodestone (אבן השואב) that draws iron (ברזל) to it, indicating the [meridian] line and the noon-line at every moment. [?]]

Diagram. A wind-rose (compass rose) in the left column. Construction, counted off the plate: one heavy outer rim circle and one lighter inner circle, enclosing an annulus; eight straight spokes cross the annulus from inner circle to rim (four cardinal, four intercardinal). Inside the inner circle stands a sixteen-point hatched star — eight long points on the spoke axes alternating with eight shorter points — around a small ringed central boss. The inner circle carries no text at all; every label sits in the annulus. To the left of the rose, outside it, stands a pennant on a knotted staff; a single letter **ב** stands beside the staff-foot, clear of the rose.

Closed census of the marks in the annulus — twelve text-marks and one isolated letter, all of them printed, none illegible as ink:

Four large labels set tangentially along the rim, one at each cardinal point (all four read):

- **רוח צפונית** ("north wind") — top
- **רוח מזרחית** ("east wind") — right
- **רוח דרומית** ("south wind") — bottom
- **רוח מערבית** ("west wind") — left

Four short words set just outside the inner circle, each straddling its own cardinal spoke (all four read):

- **צפון** ("north") — at the N spoke
- **מזרח** ("east") — at the E spoke, the spoke running between מז and רח
- **דרום** ("south") — at the S spoke
- **מערב** ("west") — at the W spoke

Eight further labels, one per sector, set radially in the annulus. These are the compound winds of §87, and they are not flat pairs of the type **מזרחית צפונית**: each is built with the preposition **־ל**, i.e. of the form «X-*ית* … **ל**Y-*ית*» ("westerly … toward the north"). Two were resolved by rotating the sector to upright:

- sector between the W and NW spokes: … **מערב**[[**ית**]] … **לצפונית** — read on B at 500%, rotated 112.5°
- sector adjacent to the N spoke on the east side: … **מזרח**[[**ית**]] … **לצפונית** — read on N at 600%, rotated 67.5°

[168] the section rules out the reverse compounds by name and then, further down, an enumerated list prints both orders.

The other six radial sector labels are of the same form and are printed and unabraded, but were not resolved word-by-word in this pass. They are a legibility-limited item only in the sense that each needs its own rotation; they are not worn.

⁂

סימן פ״ח (§88) — An alphabetical table, from which to know the location of many inhabited places, and also of some sea-islands: how much each of them is in the world's longitude and in its latitude

I saw fit, in concluding this Gate, to append the table of "[The Table of] the LORD" [?], arranged in alphabetical order, in which you will find many inhabited places, and also some of the islands of the sea — how much each of them stands in the world's longitude and in its latitude. Some [longitudes] are measured from the east; [the reference used here is Jerusalem, whose longitude is …] [numeral: ?]. Know that the longitude is reckoned from the west [the meridian of the Fortunate Isles], and the latitude from the equator [?]. And now, enter and study, [and] know from this table the locations of the places of the world.

Let me illustrate. Suppose you want to plot the city of Prague [פראג] at its proper location. Consult the table, and you will find Prague at a longitude of [numeral: ?] degrees and 38 minutes [ל״ח דקין], and at a latitude of [numeral: ?] degrees and 12 minutes [י״ב דקין]. You will find the same [?] on the chart [?] of whatever terrestrial globe you please: [?] by the graduations, to the equator [קו השוה], [numeral: ?] degrees; and for its latitude count off [numeral: ?] degrees. The place where the two meet — where these two lines cut one another, the line of [numeral: ?] and the line of [numeral: ?] — is the point of Prague. And from this…

[The column ends here mid-clause, at a rule; the gazetteer follows.]

The alphabetical gazetteer (§88). In the source, each entry runs right-to-left: place-name, then latitude (מעלות degrees, דקים minutes), then longitude (מעלות degrees, דקים minutes). The columns below preserve that logical order. Place-names (the argument column) are given in full, as printed and without

identification; the identifications the first reading supplied are collected in an editorial note beneath each block.[169]

אות א (Letter Aleph)

אות א [the letter Aleph — the name column]	רוחבי המדינות [the latitudes of the countries]	אורכי המדינות [the longitudes of the countries]
אלכסנדריאה	31°10′	[[ring]] ‖ ל (30)
אלקוירא	29°50′	טז (16) ‖ נין — three sorts, ן·י·נ; not a minutes value, as printed
אנטיוכא	38°35′	[[ring]]ב ‖ כה (25)
אנט ווארף	15°28′	20°15′
אקוילי	43°30′	—
אויקשפרג	47°42′	[[ring]]ב ‖ יח (18)
אורלינגעניץ	47°13′	19°—′
אולמא	48°26′	30°20′
אויטינגע	48°58′	28°50′
אינגלשטט	מ[[ring]] ‖ ו (6)[170]	36°—′
אויבען	47°10′	36°44′
אויך	—	—
אולמיץ / אולמיין	—	—
אמשטרדם	52°40′	27°34′
אנדרינופל	—	—
אוזן בריק	—	—
אוסטרא	—	—
אלוני ממרא	—	—
אים לנד	[[ring]]ו ‖ ט (9)	—

[169] How to read the coordinate cells. **31°10′** gives degrees and minutes as printed. An em-dash means no figure is printed there — **—** alone sets neither degrees nor minutes, **19°—′** sets degrees but not minutes. That is a statement about the page, not about legibility: an unreadable cell carries `[numeral: ?]` instead. Much of this table's coordinate field is simply blank — the place-names are set throughout, the figures beside them often never were. A cell given in Hebrew sorts reports the leaf's own form because it yields no value. [[ring]] — one sort standing for either of two letters. In this fount the ring used for ס and the ring used for word-final ם are the same shape, and the table supplies no instance of one to set against the other: counter, width, wall and base profile put them all in one population. The question is closed as unresolvable at this substrate, not left open. A search for a control across the name columns of later gazetteer leaves established that this fount's פ is also a closed ring, enclosing a range straddling that of its ס — so the argument that a ring inside a word cannot be a final mem and must be ס omits פ and ט and is invalid; a word-final ring can equally be a פ, proved on a word read whole. ס and פ separate at very high magnification by a feature of construction; ס against a final ם does not, a final mem carrying no such feature. The values differ — ס = 60, ם = 40 — and the table argues both ways: מ+ring parses only as מם, the letter-name of mem (= 40), matching this table's יוד = 10 and נון = 50, while ring+א and ring+ו parse only as סא = 61 and סו = 66. Choosing either breaks the other. The sort is written ⟦ring⟧ throughout and no value is computed from it.

[170] the degrees cell is not a well-formed value in the table's own system: both copies print the same closed sort, which also stands in the longitude-degrees cells of two resh-block rows. Recorded as printed; no value supplied.

אות א [the letter Aleph — the name column]	רוחבי המדינות [the latitudes of the countries]	אורכי המדינות [the longitudes of the countries]
אנדרך / אנדריך	50°25′	32°29′
אשקלון	32°27′	[[ring]]ז ‖ כ (20)

**

[Editorial identifications — NOT on the leaf. The leaf's ruled columns carry the place-name and the two numeric bands only; every identification below was supplied by the first reading and is not printed on the leaf. A *?* is that reading's own hedge, preserved. Rows: 1 ***אלכסנדריאה*** — Alexandria; 2 ***אלקוירא*** — al-Qāhira (Cairo); 3 ***אנטיוכא*** — Antioch; 4 ***אנט וארף*** — Antwerp; 5 ***אקוילי*** — Aquileia [?]; 6 ***אויקשפרג*** — Augsburg; 7 ***אורלינגענין*** — [Erlangen? / Nördlingen? ?]; 8 ***אולמא*** — Ulm; 9 ***אויטינגע*** — [Öttingen? ?]; 10 ***אינגלשטט*** — Ingolstadt; 11 ***אויבען*** — [Eupen? ?]; 12 ***אויך*** — [Aachen? ?]; 13 ***אולמיץ / אולמיין*** — Olmütz (Olomouc) [?]; 14 ***אמשטרדם*** — Amsterdam; 15 ***אנדרינופל*** — Adrianople (Edirne); 16 ***אוזן בריק*** — Osnabrück; 17 ***אוסטרא*** — [Ostrog? / Austria? ?]; 18 ***אלוני ממרא*** — Elonei Mamre (the Oaks of Mamre, by Hebron); 19 ***אים לנד*** — [Eyland / "island"? ?]; 21 ***אשקלון*** — Ashkelon.]

אות ב (Letter Bet)

[name]	[latitude]	[longitude]
בבל	לה (35) ‖ [[ring]]	פ (80) ‖ [[ring]]
בגדור	34°20′	85°6′
ביצלוני	41°35′	10°10′
בומבערגם	49°56′	30°45′
באזיל	47°41′	42°22′
בערלין	52°50′	33°30′
באנוניא	43°54′	33°5′
ברוקו לנדין	51°24′	20°16′ [?]
ברעסלא	51°10′	מ[[ring]] ‖ —
ברונשווייג	—	—
ברעמין	—	—
ברסק דליטא	51°10′	מח (48) ‖ מה (45)
בעלז	—	—[171]
בית לחם	31°50′	[[ring]]ה ‖ מח (48)
באר שבע	—	—
בוזק	—	—

**

[Editorial identifications — NOT on the leaf. The leaf's ruled columns carry the place-name and the two numeric bands only; every identification below was supplied by the first reading and is not printed on the leaf. A *?* is that reading's own hedge, preserved. No column header is transcribed for this leaf:

[171] the numeric cells of this row are empty on the leaf; nothing was printed in them.

was not reached on a second reading of the leaf, so the English column labels above are editorial. Rows: 1 *בבל* — Babylon (Bavel); 2 *בגדור* — Baghdad; 3 *ביצלוני* — Barcelona; 4 *בומבערגם* — Bamberg; 5 *באזיל* — Basel; 6 *בערלין* — Berlin; 7 *באנוניא* — Bologna (Bononia); 8 *ברוקו לנדין* — [London? / "Bruck–London" ?]; 9 *ברעסלא* — Breslau (Wrocław); 10 *ברונשווייג* — Braunschweig (Brunswick); 11 *ברעמין* — Bremen; 12 *ברסק דליטא* — Brisk d'Lita (Brest-Litovsk); 13 *בעלז* — Belz; 14 *בית לחם* — Bethlehem; 15 *באר שבע* — Beer Sheva; 16 *בוזק* — [Bozk? ?].]

אות ג (Letter Gimel)

[name]	[latitude]	[longitude]
גענובא / נענובא	43°50′	28°20′
געלדריא	52°20′[172]	16°4′
גראנטש / גראנטי	36°50′	8°34′
גערליץ	50°10′ [נון יוד][173]	33°45′ [לג מה]
גניוין	—	—
גרמיירא	—	—
גרעץ ששיר	—	—
גראן אונגריא	—	—
גרונרא / גרונדא	—	—
גבעין	—	—
גת	—	—
גראן לנד	[[two sorts that read as a word, not a numeral]]	—

**

[Editorial identifications — NOT on the leaf. The leaf's ruled columns carry the place-name and the two numeric bands only; every identification below was supplied by the first reading and is not printed on the leaf. A *?* is that reading's own hedge, preserved. No column header is transcribed for this leaf: was not reached on a second reading of the leaf, so the English column labels above are editorial. Rows: 1 *גענובא / נענובא* — Genova (Genoa); 2 *געלדריא* — [Gelderland? ?] (the name is read cold as *געלדריא* — a ד then a ר, the ד carrying the top-right overhang the neighbouring ר lacks; the first reading's *געלדריא* and its identifications are withdrawn); 3 *גראנטש / גראנטי* — [Granada? / Grantham? ?]; 4 *גערליץ* — Görlitz; 5 *גניוין* — [Gniezno? ?]; 7 *גרעץ ששיר* — [Graz? ?]; 8 *גראן אונגריא* — Gran (Esztergom), Hungary; 9 *גרונרא / גרונדא* — [Grodno? ?]; 10 *גבעין* — Gibeon (*גבעון*); 11 *גת* — Gath; 12 *גראן לנד* — Greenland ("Gran Land").]

אות ד (Letter Dalet)

[172] the minutes cell is set with a final form of the letter used as a numeral; recorded as printed.

[173] the table spells several of its numerals out as letter-names, which is the leaf's own defence against exactly the confusions that defeat a reader of the running prose.

[name]	[latitude]	[longitude]
דמשק	33°10′	[[ring]]ט ‖ יוד (10)
דאנציק	54°50′	25°2′
דרעזין	—	—
דערטמונר	—	—
דן היא לשם	—	—

**

[Editorial identifications — NOT on the leaf. The leaf's ruled columns carry the place-name and the two numeric bands only; every identification below was supplied by the first reading and is not printed on the leaf. A *?* is that reading's own hedge, preserved. No column header is transcribed for this leaf: was not reached on a second reading of the leaf, so the English column labels above are editorial. Rows: 1 ***דמשק*** — Damascus; 2 ***דאנציק*** — Danzig (Gdańsk); 3 ***דרעזין*** — Dresden; 4 ***דערטמונר*** — Dortmund; 5 ***דן היא לשם*** — Dan (which is Laish / Leshem).]

אות ה (Letter He)

[name]	[latitude]	[longitude]
המבורג	54°24′	30°15′
הלברשטט	52°11′	30°20′
הידל בורג	—	—
הנובר	—	—
הילרסים	—	—
האלי דוקסין	—	—
הילני אינזל	—	—
הר סיני	—	—
הר כרמל	—	—

**

[Editorial identifications — NOT on the leaf. The leaf's ruled columns carry the place-name and the two numeric bands only; every identification below was supplied by the first reading and is not printed on the leaf. A *?* is that reading's own hedge, preserved. No column header is transcribed for this leaf: was not reached on a second reading of the leaf, so the English column labels above are editorial. Rows: 1 ***המבורג*** — Hamburg; 2 ***הלברשטט*** — Halberstadt; 3 ***הידל בורג*** — Heidelberg; 4 ***הנובר*** — Hanover; 5 ***הילרסים*** — Hildesheim; 6 ***האלי דוקסין*** — Halle (in Saxony) [?]; 7 ***הילני אינזל*** — St. Helena Island ("Helena Insel"); 8 ***הר סיני*** — Mount Sinai; 9 ***הר כרמל*** — Mount Carmel.]

אות ו (Letter Vav)

[name]	[latitude]	[longitude]
ווינציאה	45°15′	33°30′
ודוני בעצן / ורוני בעצן	45°15′	31°15′
ויאונ׳ דצרפת	45°12′	21°25′[174]
וויטן בערג	51°50′	30°30′
ווילנא דליטא	55°—′	44°30′
ווירץ בורג	49°58′[175]	30°30′
ווירמיש	—	—
וויצענץ	—	—
וורשא דמזא	—	—
ווינא	—	—

⁂

[Editorial identifications — NOT on the leaf. The leaf's ruled columns carry the place-name and the two numeric bands only; every identification below was supplied by the first reading and is not printed on the leaf. A *?* is that reading's own hedge, preserved. No column header is transcribed for this leaf: was not reached on a second reading of the leaf, so the English column labels above are editorial. Rows: 1 *ווינציאה* — Venice (Venezia); 2 *ודוני בעצן / ורוני בעצן* — [Verona? ?]; 3 *ויאונ׳ דצרפת* — Lyon of France (Lyon); 4 *וויטן בערג* — Wittenberg; 5 *ווילנא דליטא* — Vilna of Lithuania (Vilnius); 6 *ווירץ בורג* — Würzburg (on a second reading of the leaf the name is two words, *ווירץ בורג*; the first reading's *ווירין בורג* is withdrawn); 7 *ווירמיש* — Worms (Wormaisa); 8 *וויצענץ* — Vicenza; 9 *וורשא דמזא* — Warsaw ("Warsha d'Mazovia"); 10 *ווינא* — Vienna.]

אות ז (Letter Zayin)

The heading **אות ז** appears at the foot of the left-hand block; no entries fall within this page. The table continues onto the following page.

___[176]

⁂

§88 (continued) — Gazetteer of places by the order of the alphabet

Table reads right-to-left in the source. Each entry: place-name | latitude (°,′) | longitude (°,′); the number-group adjacent to the name is latitude, the outer group longitude. The leaf rules three content columns and prints no column header — the English column labels below are editorial. Place-names are given

[174] the first sort's leg runs longer than others of its class in the same column because it is a final kaf used medially — this table's regular form for 20. The cell reads 21.

[175] the minutes figure of the latitude is the sort another copy's reading doubled into both degree cells; it stands once, in the minutes.

[176] How to read the coordinate cells. **41°10′** gives degrees and minutes as printed. An em-dash means no figure is printed there — **—** alone sets neither degrees nor minutes, **44°—′** sets degrees but not minutes. That is a statement about the page, not about legibility: an unreadable cell carries `[numeral: ?]`. A figure followed by `[?]` is a reading the leaf supports but does not settle.

as printed; identifications are collected in a marked editorial note beneath each block.

אות ז (Letter Zayin) — p. 65

Place	Latitude	Longitude
זלצבורג	—	—
זמשט דפולין	—	—
זיגעט	—	—
זונט [?]	—	—
מיגן [recte זיגן = Siegen?] [?]	—	—
זושט	—	—
זיף	—	—

[177]

[Editorial identifications — NOT on the leaf. The leaf's ruled columns carry the place-name and the two numeric bands only; every identification below was supplied by the first reading and is not printed on the leaf. A *?* is that reading's own hedge, preserved. Rows: ***זלצבורג*** — [Salzburg]; ***זמשט דפולין*** — [Zamość, Poland]; ***זיגעט*** — [Sighet? / Zieget] [?]; ***זושט*** — [Soest?] [?]; ***זיף*** — [Ziph (biblical; Yehoshua 15:24)].]

אות ח (Letter Chet) — p. 65

Place	Latitude	Longitude
חמת אנטוכיא	—	—
חברון	—	—
חורב	—	—

[Editorial identifications — NOT on the leaf. The leaf's ruled columns carry the place-name and the two numeric bands only; every identification below was supplied by the first reading and is not printed on the leaf. A *?* is that reading's own hedge, preserved. Rows: ***חמת אנטוכיא*** — [Hamath = Antioch ("Hamat of Antioch")]; ***חברון*** — [Hebron]; ***חורב*** — [Horeb (Mount)].]

אות ט (Letter Tet) — p. 65

Place	Latitude	Longitude
טלטול ספרד	41°10′	10°30′
טוני דמצרים	—	—

[177] the coordinates of this block were never set: the place-names are printed throughout and the ruled fields beside them stand empty. See the note at אות כ below, covering this block and the four that follow.

Place	Latitude	Longitude
טוני ברבריא'	—	—
טריר	—	—
טארין	—	—
טבירי'	—	—

**

[Editorial identifications — NOT on the leaf. The leaf's ruled columns carry the place-name and the two numeric bands only; every identification below was supplied by the first reading and is not printed on the leaf. A *?* is that reading's own hedge, preserved. Rows: *טלטול ספרד* — [Toledo, Spain]; *טוני דמצרים* — [Tunis of Egypt? / "borders of Egypt"] [?]; *טוני ברבריא'* — [Tunis of Barbary] [?]; *טריר* — [Trier]; *טארין* — [Turin] [?]; *טבירי'* — [Tiberias].]

אות י (Letter Yod) — p. 65

Place	Latitude	Longitude
ירושלים	32°15′	[[ring]]ו ‖ ך (20)
יענט	—	—
יערסלאוו	—	—
יובא אי	—	—
ירימו	—	—
יפו	—	—
יבנה	—	—

**

[Editorial identifications — NOT on the leaf. The leaf's ruled columns carry the place-name and the two numeric bands only; every identification below was supplied by the first reading and is not printed on the leaf. A *?* is that reading's own hedge, preserved. Rows: *ירושלים* — [Jerusalem]; *יענט* — [Ghent? / Jena?] [?]; *יערסלאוו* — [Jarosław / Yaroslav]; *יובא אי* — [island of Java? "Yuba island"] [?]; *ירימו* — [Jericho]; *יפו* — [Jaffa]; *יבנה* — [Yavneh].]

אות כ (Letter Kaf) — p. 65

Place	Latitude	Longitude
כרמל ראלי'	—	—
כרמל דנבות	—	—

**

[Editorial identifications — NOT on the leaf. The leaf's ruled columns carry the place-name and the two numeric bands only; every identification below was supplied by the first reading and is not printed on the leaf. A *?* is that reading's own hedge, preserved. Rows: *כרמל ראלי'* — [Mount Carmel

of Elijah — *כרמל דאלידהו*]; *כרמל דנבות* — [Carmel of Naboth (the vineyard of Naboth; Melachim I 21)].]

אות ל (Letter Lamed) — p. 65

Place	Latitude	Longitude
לונדן	50°30′	—
לויפק [?]	54°48′	—
לימן הצרפת	מה (45) ‖ מ[[ring]]	—
לוינעבורק	נון (50) [?] ‖ מח (48)	—
לייפצוג	51°24′	לד (34) ‖ ל (30)
לייזיבין [?]	מ[[ring]] ‖ מה (45)	4°56′
לינץ	—	—
לובלין	נ (50) ‖ נז (57)	מד (44) ‖ נו (56)
לעמבורג	50°30′	43°15′
לאדמער	—	—
לשם הוא דן	—	—

**

[Editorial identifications — NOT on the leaf. The leaf's ruled columns carry the place-name and the two numeric bands only; every identification below was supplied by the first reading and is not printed on the leaf. A *?* is that reading's own hedge, preserved. Rows: *לונדן* — [London]; *לימן הצרפת* — [Le Mans, France? / Limoges] [?]; *לוינעבורק* — [Lüneburg]; *לייפצוג* — [Leipzig]; *לינץ* — [Linz]; *לובלין* — [Lublin]; *לעמבורג* — [Lemberg / Lviv]; *לאדמער* — [Ladmir / Volodymyr (Lodomeria)]; *לשם הוא דן* — [Leshem, which is Dan (biblical; Yehoshua 19:47)].]

אות מ (Letter Mem) — p. 65

Place	Latitude	Longitude
מצרים [Egypt (Mitzrayim); printed מצדים]	24°50′	10°50′
מענץ	נון (50) ‖ מ[[ring]]	30°—′
מעביל [?]	51°14′	24°50′
מיידבורק	52°20′	34°30′
מאנטובא	44°30′	לב (32) ‖ מ[[ring]]
מרסלא צרפ'	43°6′	34°30′
מיודיקיא [?]	לד (34) ‖ מה (45)	יז (17) ‖ מח (48) [?]
מיילנד	44°36′	דח (28) ‖ ך (20)
מרפוק [?]	נא (51) ‖ —	30°10′
מוינכן	—	—
מגין [?]	נ (50) [?] ‖ ל (30)	ך[[ז/ו]] (26 or 27) ‖ ל (30)
מוינשטר	—	—
מינדין	—	—
מאנגאל [?]	—	—

**

[Editorial identifications — NOT on the leaf. The leaf's ruled columns carry the place-name and the two numeric bands only; every identification below was supplied by the first reading and is not printed on the leaf. A *?* is that reading's own hedge, preserved. Rows: *מענין* — [Mainz] [?]; *מיידבורק* — [Magdeburg]; *מאנטובא* — [Mantua]; *מרסלא צרפ'* — [Marseille, France] [?]; *מיילנד* — [Milan (Mailand)]; *מוינכן* — [Munich (München)]; *מוינשטר* — [Münster]; *מינדין* — [Minden].]

אות נ (Letter Nun) — pp. 65–66

Place	Latitude	Longitude
נרבונג דצרפ׳	33°10′	14°18′
ניאפלוס	41°10′	מ[[ring]] ‖ יוד (10)
ירן[[ג]]	—	—
נירן בורג	מט (49) ‖ לד (34) [?]	31°10′
נומברג דזאל	מט (49) ‖ ך (20)	32°10′
נבערן [?]	—	—
נייס	—	—
נורט הויזין	—	—
נורטט	—	—
נינוה	43°—′	פ (80) ‖ —
נור ווירן	[[ring]]ו ‖ ט (9)	—

178

**

**

[Editorial identifications — NOT on the leaf. The leaf's ruled columns carry the place-name and the two numeric bands only; every identification below was supplied by the first reading and is not printed on the leaf. A *?* is that reading's own hedge, preserved. Rows: *נרבונג דצרפ׳* — [Narbonne, France] [?]; *ניאפלוס* — [Naples]; *ירן[[ג]]* — no identification supplied; *נירן בורג* — [Nürnberg]; *נומברג דזאל* — [Naumburg?] [?]; *נייס* — [Neisse (Nysa)?] [?]; *נינוה* — [Nineveh].]

**179

אות ס (Letter Samekh) — p. 66

178 the third row of this block is not a row of the table but the catchword at the foot of p. 65, repeating the opening word of the row that follows. The leaf rules two rows under אות נ, not three, so the block has ten entries, not eleven. The row is left in place with its coordinate cells open: no coordinates are printed beside a catchword, so neither a figure nor a blank belongs there. Established on the ink of both copies — the mark sits below the last rule, set left of the name column's edge rather than aligned to it, and reproduces the next leaf's first word.

179 the catchword repeats the opening of the next leaf. It is the same mark that stands as the third row of the table above, which is why that row has no coordinates: it was never a row.

Place	Latitude	Longitude
סיבילאה	36°—′	ו (6) ‖ ל (30)
סירן גיאה	22°10′	31°10′
סלינעק [?]	—	—
סיני	—	—
סדום	—	—

**

[Editorial identifications — NOT on the leaf. The leaf's ruled columns carry the place-name and the two numeric bands only; every identification below was supplied by the first reading and is not printed on the leaf. A *?* is that reading's own hedge, preserved. Rows: ***סיבילאה*** — [Seville (Sevilla)]; ***סירן גיאה*** — [Syracuse? / Cyrene?] [?]; ***סיני*** — [Sinai (Mount)]; ***סדום*** — [Sodom].]

אות ע (Letter Ayin) — p. 66

Place	Latitude	Longitude
ערפורט	41°10′	30°30′
עסליקאן	48°35′	—
ע[[?]]לא דאונגרין	—	—
עמרן [?]	—	—
עציון גבר	—	—

180

**

**

[Editorial identifications — NOT on the leaf. The leaf's ruled columns carry the place-name and the two numeric bands only; every identification below was supplied by the first reading and is not printed on the leaf. A *?* is that reading's own hedge, preserved. Rows: ***ערפורט*** — [Erfurt]; ***עסליקאן*** — [Esslingen] [?]; ***ע[[?]]לא דאונגרין*** — [Erlau of Hungary = Eger] [?]; ***עציון גבר*** — [Etzion-Geber].]

אות פ (Letter Pe) — p. 66

Place	Latitude	Longitude
פראג	50°12′ [יב ‖ נון]	25°38′ [לח ‖ כה]
פ״פ דמיין	52°33′	לב (32) ‖ לד (34)
פ״פ דאדרה	52°33′	לב (32) ‖ לד (34)
פירדא	44°23′	לב (32) ‖ טו (15)
פאנצישטי [?]	35°10′	[[ring]] ‖ ך (20)

[180] the second sort of the third row is a single stroke that could be either of two letters; it is not resolved.

Place	Latitude	Longitude
פנום ראפרן [?]	34°48′	—
פרייבורק	50°58′	—
מייסן	—	—

181

** | פרייבורג | 48°13′ | — | — | — || [?] פרישן || — | — | — | פולרענץ || — | — | — | פאביאה | 44°20′ | — | — | — || — | — | — | פיטרקוב || —′42° | 52°45′ | [?] פוגוא || — | — | — | פאסא || — | — | — | 31°22′ || פארמה | 43°30′ | 32°10′ || פאריבה | [?] מה (45) ‖ נ (50) | 32°50′ || פאריש |
**

[Editorial identifications — NOT on the leaf. The leaf's ruled columns carry the place-name and the two numeric bands only; every identification below was supplied by the first reading and is not printed on the leaf. A *?* is that reading's own hedge, preserved. Rows: ***פראג*** — [Prague]; ***פ"פ דמיין*** — [Frankfurt am Main]; ***פ"פ דאדרה*** — [Frankfurt an der Oder]; ***פירדא*** — [Ferrara? / Fürth?] [?]; ***פרייבורק*** — [Freiburg]; ***מייסן*** — [Meissen]; ***פרייבורג*** — [Freiberg]; ***פולרענץ*** — [Florence (***פלורענץ***)?] [?]; ***פאביאה*** — [Pavia]; ***פארמה*** — [Parma]; ***פאריש*** — [Paris]; ***פאסא*** — [Passau? / Padua?] [?]; ***פישרקוב*** — [Piotrków].]

אות צ (Letter Tzadi) — p. 66

Place	Latitude	Longitude
צוען מצרים	29°50′	[[ring]]א ‖ נון (50)
צוריך שווייץ	—	—
צוויקא מייסן	—	—
צעמלאנובא [?]	—	—
צור	—	—
צדון	—	—
צפת	—	—
ציין	לב (32) ‖ ו (6)	—

**

[Editorial identifications — NOT on the leaf. The leaf's ruled columns carry the place-name and the two numeric bands only; every identification below was supplied by the first reading and is not printed on the leaf. A *?* is that reading's own hedge, preserved. Rows: ***צוען מצרים*** — [Zoan of Egypt (Tanis)]; ***צוריך שווייץ*** — [Zurich, Switzerland]; ***צוויקא מייסן*** — [Zwickau, Meissen] [?]; **צור**

[181] the two rows after Prague are identical in all four sub-cells — latitude 52°33′, longitude minutes 34′, longitude degrees לב = 32. They stand one row-pitch apart, so they are two distinct rows, not one counted twice. Recorded as printed. Neither row is to be "corrected" against the other, and neither was: each degrees cell was read on its own ink at 18×. ⚠ The earlier claim that only the longitude degrees differ and that both are illegible is withdrawn on both halves; the rows nonetheless remain two, and the instruction against reconciling them stands.

— [Tyre (Tzor)]; *צדון* — [Sidon (Tzidon)]; *צפת* — [Safed (Tzfat)]; *ציין* — [Zion? / Zeitz?] [?].]

אות ק (Letter Kuf) — pp. 66–67

Place	Latitude	Longitude
קראקובא	50°12′	לז (37) ‖ נון (50)
קרימונא	מד (44) ‖ [[ring]]	—
קליקוט	ה (5) ‖ יוד (10)	קיב (112) ‖ יוד (10)
קאנניאה	31°45′	54°10′
קרטגינא	31°50′	31°58′
קאשור דאונגרין	48°20′	מ[[ring]] ‖ לו (36)
קיריא	24°50′	[[ring]]א ‖ נון (50)
קלון ד׳רינוס	43°21′	26°10′
קונם טנשינא	43°5′	55°10′
קרטובא	לו (36) [?] ‖ נון (50)	8°4′
קורשיקעי	מ[[ring]] ‖ נון (50)	31°10′
[?] קאשטשן	46°30′	לו (36) ‖ מג (43)
[?] קאבלוצן	—	—
קאפין האגין	—	—
קמניץ פדולי	—	—
קיניגסבערג	—	—
[?] קופו אינס	38°—′	44°—′
[?] קריכן ד׳וישבתיג	—	—
[?] קרשברנע	—	—
קיובא	—	—
[?] קאבלא	—	—
קראקא	נ (50) ‖ יב (12)	מב (42) ‖ מ (40)

**

[Editorial identifications — NOT on the leaf. The leaf's ruled columns carry the place-name and the two numeric bands only; every identification below was supplied by the first reading and is not printed on the leaf. A *?* is that reading's own hedge, preserved. Rows: *קראקובא* — [Kraków]; *קרימונא* — [Cremona]; *קליקוט* — [Calicut]; *קאנניאה* — [Cana? / Kanya?] [?]; *קרטגינא* — [Cartagena / Carthage] [?]; *קאשור דאונגרין* — [Kaschau of Hungary = Košice] [?]; *קיריא* — [Cairo]; *קלון ד׳רינוס* — [Cologne on the Rhine (Köln)]; *קונם טנשינא* — [Constantinople? / Constantina] [?]; *קרטובא* — [Córdoba (Cordova)] [?]; *קורשיקעי* — [Corsica] [?]; *קאפין האגין* — [Copenhagen]; *קמניץ פדולי* — [Kamianets-Podilskyi]; *קיניגסבערג* — [Königsberg]; *קיובא* — [Kiev (Kiova)]; *קראקא* — [Kraków?] [?].]

אות ר (Letter Resh) — p. 67

Place	Latitude	Longitude
רומי	43°4′	מ[[ring]] ‖ ך (20)
רבינא אטלי׳	44°2′	מ[[ring]] ‖ ו (6) [?]

Place	Latitude	Longitude
ראסניק	51° 36′	32° 10′
רעביל	[[ring]]א ‖ —	44° —′
רין אויף לנד [?]	—	—
רעגנשבורג	—	—
רויטן בורג	—	—
ראב ד'אונגרי'	—	—
ריג	— ‖ [[ring]]א	44° —′
רעבל	—	—
רבת בני עמון	—	—

182

**

**

**

[Editorial identifications — NOT on the leaf. The leaf's ruled columns carry the place-name and the two numeric bands only; every identification below was supplied by the first reading and is not printed on the leaf. A *?* is that reading's own hedge, preserved. Rows: ***רומי*** — [Rome]; ***רבינא אטלי***′ — [Ravenna, Italy]; ***רעגנשבורג*** — [Regensburg]; ***רויטן בורג*** — [Rothenburg]; ***ראב ד'אונגרי***' — [Raab of Hungary = Győr]; ***ריג*** — [Riga]; ***רעבל*** — [Reval (Tallinn)]; ***רבת בני עמון*** — [Rabbath-Ammon].]

אות ש (Letter Shin) — p. 67

Place	Latitude	Longitude
שפייאר	מט (49) [?] ‖ ך (20)	24° 36′
שאקמיא [?]	נו (56) [?] ‖ יוד (10)	ך (20) ‖ יוד (10)
שטראם בורג	—	—
שטיילנבורג [?]	—	—
שדוויץ [?]	—	—
שושן הבירה	—	—
שבא	—	—
שכם	—	—
שילה	—	—
שווירידן [?]	[[ring]]ו ‖ ט (9)	—
שאלונקי	מ[[ring]] ‖ ב (2)	מט (49) ‖ נ (50)

**

[Editorial identifications — NOT on the leaf. The leaf's ruled columns carry the place-name and the two numeric bands only; every identification

[182] rows one and two both print מ followed by the closed ring in the longitude-degrees cell — a form that yields no value on either reading of that sort, and that recurs ten times across five leaves. Recorded as printed; no value supplied. Rows four and nine build the other recurring form, ring followed by א. See the [[ring]] note above.

below was supplied by the first reading and is not printed on the leaf. A *?* is that reading's own hedge, preserved. Rows: *שפייאר* — [Speyer]; *שטראם בורג* — [Strasbourg]; *שושן הבירה* — [Shushan the capital (Susa)]; *שבא* — [Sheba]; *שכם* — [Shechem (Nablus)]; *שילה* — [Shiloh]; *שאלונקי* — [Salonika (Thessaloniki)].]

1. The page range. This batch's gazetteer is on PDF pp. 65–67 only. p. 68 carries no table at all, and that is proved on both copies rather than assumed: a scan for long vertical runs on p. 68 returns only the page-edge and binding bands, and on the second witness's corresponding leaf it returns nothing whatever. p. 68 carries two columns of prose (§90, §91) and the square wind-rose. So the gazetteer occupies pp. 63–67 in all, and ends where the prose of §89 begins.

2. The column structure — the leaf rules FIVE columns, not three. Each coordinate field is divided into degrees and minutes sub-columns with no rule between them; the degrees sub-column is the right-hand one and is consistently the wider of the two. Measured per stack, e.g. on p. 65's left stack the latitude field's sub-columns run x 678–760 and 617–678 and the longitude field's x 510–592 and 441–510. The rendering here combines each field's two sub-columns into one cell; the page does not. The distinction is not cosmetic: a row whose degrees are printed and whose minutes are not is something the leaf actually says, and is written above as **44°—′**. Note also that the three leaves sit on different type-block positions — p. 65's table runs x 413–1895, p. 66's x 66–1512, p. 67's x 1237–1858 — so no crop or column boundary carries from one leaf to the next.

3. The stacks. p. 65 carries two table stacks side by side, p. 66 two, and p. 67 one — the last occupying only the right ~40% of its leaf, with the remaining ~60% given over to the prose of סימן פ״ט. Read right stack before left. The header band, אורכי over המדינות and רוחבי over המדינות set rotated and in two lines, is printed on both of p. 65's stacks and on neither of p. 66's or p. 67's — those simply continue the table, so their field assignment follows from position.

The **אות** sub-headings run unbroken in Hebrew alphabetical order, continuing p. 63's **אות א**: across p. 65 right, p. 65 left, p. 66 right, p. 66 left and p. 67 they run **ר ש | צ ק | ס ע פ | ל מ נ | ז ח ט י כ**. The sequence closes exactly, which is an independent check on the stack order. There is no **אות ת**; the table ends at **אות ש** and §89 begins in p. 67's left column.

The table spells some of its numerals as letter-names — **יוד** = 10 (certified eight times on p. 65 alone, and confirmed on the second witness, which renders its three sorts separately) and **נון** = 50 (certified six times, its last sort carrying a descender). Twice on p. 65 **נון** prints with its last two sorts fused into a single mass; counting components rather than sorts there would give **נך** = 70, an impossible minutes value. That convention is why several cells in this table can be given as figures at all.

⚠ p. 65's right-hand stack — **אות ז** through **אות כ** — is blank of coordinates except two rows, about 128 empty sub-cells beside a full column of names. See the note at **אות כ**.

No single alphabetical block is confined to one stack in the way the block headings above suggest:

- **אות נ** runs across the p. 65/p. 66 leaf turn and has TEN rows, not eleven. p. 65 carries two of them, p. 66's right stack the other eight. The mark at the foot of p. 65 that could be taken for an eleventh row is the leaf's catchword; see the note at that block.
- **אות פ** straddles BOTH of p. 66's stacks — eleven rows in the right-hand stack, where its heading stands, and seven more at the head of the left-hand stack, above the **אות צ** heading, every one of them **פ**-initial. Eighteen in all. The earlier structural record described p. 66's left stack as **ק·אות צ** only, which is why the top of that stack had been mis-attributed.
- **אות ק** runs across the p. 66/p. 67 leaf turn — sixteen rows on p. 66's left stack and seven on p. 67, above the **אות ר** heading. Not two, as the earlier reading of p. 67 supposed: its two unattributed coordinate bands there are the second and the seventh of those rows. On the leaf the block therefore has twenty-three rows against this table's twenty-two; the row absent here is the last on p. 66, and it is recorded at that block rather than supplied.
- p. 66 carries no catchword at the foot of either stack, established positively — the only marks below its last rule are one small blot at the rule itself and two page-edge runs, all far shorter than this leaf's type. So the p. 66 → p. 67 seam has no catchword link, unlike the p. 65 → p. 66 seam, and the block that crosses it had to be joined on its row lattice and its names instead.
- A correction for anyone re-cropping p. 67: that leaf's name field runs x 1621–1888, not 1590–1858 as the earlier geometry table gives. A crop taken to the old figure clips the first one or two sorts of every name on the leaf — and in a right-to-left script that is the line-initial side, so it returns fluent-looking fragments rather than an obvious failure. The corrected figure was measured on the column's ink profile, which is zero from x 1890 to the page edge.

**

סימן פ״ט (§89) — p. 67

§89. A resolution concerning what our Sages, of blessed memory, said: "Jerusalem is the center of the world."

Even though, on account of the sphericity of the Earth, one cannot posit in it any beginning or end, any up or down, any middle or antipode — since people stand and dwell upon all its various extremities, and in every place where a person stands, there he is upright [with the heavens above him] [remainder of clause uncertain] — nevertheless, we have already expanded above in siman 60 (למעלה בסי׳ ס׳) that the inhabited world extends from the shore of the Western Ocean to the shore of the Eastern Sea, a span of half the Earth's sphere, which

is 180 [ק״פ] degrees. The ancient sages set this down [in their works], and all the later ones likewise, [reckoning] the number of degrees and minutes of the Earth's sphere from the [western] shore [text partly illegible]. According to this premise, and with these supports, it is fitting and proper for us to call "the center of the world," or its "navel," that point which lies on the plane at an equal distance between the eastern edge and the western edge — each of them being ninety [תשעים, spelled out] degrees [away] — such that when the meridian line (the midday circle) running from the northern pole to [the southern pole] passes through that point and divides [the Earth's line] evenly into two parts, and the two [great] circles — namely [the equator] and the meridian — cross upon the aforementioned point crosswise, in warp and woof, extending to the edges of east and west and to the two poles of north and south, and dividing [the sphere] into four equal quarters: then that point alone would deserve to be called the center of the world, or the navel of the Earth. Concerning that place it is proper for us to say that it is set apart from all others, and that there is no other place [of] this measure. [...] And so we have here room to ask: what is this that our Sages said in the Yerushalmi, chapter [?] [[הוליאו[?] — an unresolved token, possibly a chapter name]] and so forth, and in Midrash Tanchuma, Parashas Kedoshim, and in the chapter Elu Hen ha-Nechnakin (ובפ׳ אלו הן הנחנקים), and in other places besides them — that Jerusalem is called the navel of the Earth, and its foundation-stone [?] the center of the world?

And is this not known to us also by demonstration? For in the alignment of Jerusalem, it sits at a longitude of the settlement of 66 [ס״ו] degrees, and at a latitude of the settlement of 32 [ל״ב] degrees,[183] as [explained] above [text partly illegible — a reference to the science of astronomy (תכונה) and mensuration, and measuring from the equator with a quadrant, "as explained above in Chapter [י׳ב]"]. And so those who teach wisdom and knowledge and understand every matter have repeated this reasoning a thousand times. This is the reason, and for this reason [the Sages] set Jerusalem as the center of the world.

Know that others besides them have already been troubled by this difficulty, and they treated it at length [...]. To resolve this doubt I shall tell [you] in a few words [what was said] above: it is known that the inhabitants of the world dwell in only about a quarter [of the globe], and the ancients already divided it well into seven [climates], as in §66[?]. Now behold, the Sages — natives of the city of Jerusalem — [held that] it sits among the climates, [dwelling] between the two [extremes]; for it is a mean between the cold and the heat, and therefore its climate is more temperate than the rest of the airs [regions] of the world.

**

(continued on p. 68, right column):...for on account of the predominance of the southern [heat] and the predominance of the cold opposite it in the

[183] this siman gives Jerusalem's longitude as sixty-six degrees; §§קנ״ב and קנ״ג, on two later leaves, both give it as a hundred and fifty. The book does not reconcile them, and neither figure is emended here.

north, the people [of those regions are darkened / of a different complexion] [text uncertain]. And I have already found in the words of the Sage (Rambam) [parenthetical gloss in source]: "[a wise man may be found] in the land of Kush..." [remainder uncertain]. [...] All these things the Sages intended in their saying "Jerusalem [is the center of] the world" — that is to say, the center [of the inhabited region]. The latitude of the settlement [...].

Know [דע — display initial] that [[פמנוכה[?] — an unresolved token standing immediately before the title; it may be a further title or a descriptor, and no name is supplied for it]] the author of Me'or Einayim (בעל מאור עינים) has already been roused to this, and others besides him, and they expanded upon their own concerns. For such indeed was their intent, since they compared it [the Land] to a navel, as they said in Midrash Tanchuma, [Parshas] Kedoshim [as printed, ובתנחומא פ' קדושים]: "Just as the navel is set in the middle of a person, so [the Land of Israel] is placed in the middle of the world" [...]. [Just as the navel] is set in the middle of one's body [...] [remainder partly illegible — cites "the LORD shall reign forever and ever" (Shemos 15:18 / Tehillim) as a sign of that which is without end]. [...] This is what the Sages [meant] in saying "Jerusalem [is] in the middle" — meaning the middle of the settlement, as above.

סימן צ (§90) — p. 68

§90. A resolution concerning the saying of our Sages, of blessed memory, that "the Land of Israel is higher than all lands."

There is also room to wonder at what the Sages said in the chapter "Asarah Yuchsin" [Kiddushin ch. 4] [regarding] the verse "And you shall arise and go up [to the place]" (Devarim 17:8) — from which [they derived] that the Temple is higher than all [of Eretz Yisrael], and that the Land of Israel is higher than all lands. [...] For it cannot be said that it is [physically] higher on the sphere, since for every person, in every place he sits, there he is level [and upright] [...] [reference to Beit She'an(?)]. If you were to go the way of the researchers [natural philosophers] to say [...] [text partly illegible].

(left column): [...The biblical idiom of "going up" and "coming down" — as in "and they brought up... the king of Babylon," and likewise in Yehoshua — refers not to physical elevation but to honor and rank.] For we already know that in all of it [Babylon] is a low[-lying] land [...], "excellent," and the like [text partly illegible], "as it is said" [...]; Scripture says "and they brought him up," "and they raised him up" — up to greatness and honor [...], for [Joshua and Israel] were there in the valley [i.e., a low place, yet spoken of as "going up"]. So too the Sages said "the Land of Israel is higher" — meaning in rank and honor, more than all lands.

סימן צא (§91) — p. 68

§91. The reason why the later ones objected [**טעם למה השיגו האחרונים**] to what the earlier ones received [by tradition] concerning the beginning of the 340 [**הש"ם**] [recte: **ש"ס** = 360] degrees for the sphere of the world.

We have already explained above [as in §(?)] that the later ones [said thus and so], and they relied on the science of mensuration; by this they attain the boundary [prime meridian] [...]. They drew, by the reasoning of their imagination, a line [...], and ten degrees further to the west; from there they began to count, and the beginning [of the count runs] from there [...] the [360] degrees of the Earth's sphere, which — being filled out as the sphere of the Earth — [runs] toward the north side [...]. [There are] two kinds of [islands(?)] [...] the aforementioned [...] the city of [Mainz(?)] [text uncertain]. No single line would fill the whole surface of the sphere [...] only the aforementioned line alone [...] the circles of the [Earth(?)] [...] the year [reckoning?] of the aforementioned boundary.

Know that close to three hundred years ago the masters of mensuration discovered — for the need and benefit of kings, and of the mariners who travel the sea-routes, and for the benefit of others besides them — an instrument that indicates the hours [**מורה שעות א'**; the **א'** read as the numeral "one"(?)] by the power of the magnet-stone [**אבן מאגנט"יש**]. But the character of this instrument, and its rule, and its making, are too much for [this place] to contain; it requires a book of its own, a very long and broad exposition, for which there is no room here — only in a small and brief note shall I mention [it], and so forth.

[Editorial note printed in the source, above the figure on p. 68:] "This figure belongs to §87, folio 30b, in Section 3" [***הציור זה שייך לסימן פ"ז דף ל' ע"ב בשער ג'***].

Diagrams

p. 67 carries no figure. The diagram marker `fig-p67-1` and its description have been deleted,.

Diagram. Construction, counted off the plate: a square frame; inside it a circle drawn as a heavy segmented band; sixteen straight spokes run from a small blank hub-circle at the centre out to that band, four of them continued past the band to the four corners of the square, so that each corner shows a crossing. The hub carries a single short diagonal stroke and no lettering.

Caption line printed above the square (verbatim, read on both witnesses): **'הציור זה שייך לסימן פ"ז דף ל' ע"ב בשער ג** — "This figure belongs to §87, folio 30b, in Section 3."

Closed census of the lettering — twelve direction-labels, set outside the square in four groups of three (each a two-line stack), plus two letters inside the frame. All twelve labels are printed and were read; none is abraded:

Above the square (reading right to left) — the east side:

- **מזרחית דרומית** ("east-southerly")
- **אמצע המזרח** ("mid-east")

- **מזרחית צפונית** ("east-northerly")

Below the square (right to left) — the west side:

- **מערבית דרומית** ("west-southerly")
- **אמצע המערב** ("mid-west")
- **מערבית צפונית** ("west-northerly")

Along the left edge (set vertically) — the north side:

- **צפונית מזרחית** ("north-easterly")
- **אמצע הצפון** ("mid-north")
- **צפונית מערבית** ("north-westerly")

Along the right edge (set vertically) — the south side:

- **דרומית מזרחית** ("south-easterly")
- **אמצע הדרום** ("mid-south")
- **דרומית מערבית** ("south-westerly")

Inside the frame, in the upper-left corner between the corner-crossing and the circle, two letters set at an angle: ⟦**ג/צ**⟧ above and **ה** below. They are the only marks inside the square besides the rulings; no point-letters are lettered on the spokes or on the hub.

**

השער הרביעי — The Fourth Gate

[Gate-opening rubric, spanning both columns, p. 69] In this gate will be explained the ordering of the units of time — namely years, months, days, weeks, and hours: around what center they revolve, from what source their measure is known, upon what secret they were founded, why the sages divided the measure of the day specifically into twenty-four hours, the reason the days of the week are seven, what pertains to the reckoning of equal (straight) hours and of oblique (crooked) hours, and other matters besides.

סימן צ״ב (Siman 92) — The units of time in general; there are five, beginning with the year and the month

Know that the units of time which reach the ear are, in the general sense [?], five in number: years, months, weeks, days, and hours. Why the year has such-and-such a measure, why the month is as it is, and likewise the reasons for the remaining units — you should understand that three of them, namely years, months, and days, are governed [ינטלו] by the revolutions of the spheres. Their measure is not directly known to us, nor can we perceive it by sense; no one truly knows it except through the revolutions of the spheres, as will be explained further on. The reckoning of weeks and hours, however, and the basis on which they were established, require much study and reflection, and many have grown weary [in the attempt]. [The three time-units] governed by the revolutions of the spheres are years [?], months [?], and days [?]; weeks and hours are of a lighter [conventional] kind, as will be clarified. First, the measure of the year and of the months:

The year is a period in which the sun revolves in its sphere beneath the circle of the zodiac from a [given] point back to that [same] point — that is, from the moment the sun begins to revolve from point A until it returns to that very same point from which it began — this is called a "year," as will be explained. If the reckoning of the "year" were applied [uniformly], then every sphere would have its own [year], for the time of each sphere's revolution is its "year." I say, by way of illustration: were it to enter our minds to count and reckon the units of time by the revolution of the sphere of Saturn [שבתאי], and were that sphere before our eyes to observe — its period of revolution being such-and-such — then, just as we now say that the sphere of [Mercury? — כירק, uncertain] revolves and renews itself some twelve or thirteen times within the [solar] year, so we would say that within a single "year" of Saturn the [inner] sphere revolves thirty times, and such-and-such a sphere so many times, and another sphere so many. Nevertheless, our holy Torah has already agreed to

count and reckon the great and long periods of time solely by the revolution of the sun in its sphere; to it belongs the right of the firstborn, that the revolution be named and reckoned by its revolution alone and by no other star. To this all the ancients and the moderns agreed: that from the time of the sun's departure from a known point opposite the sphere of the zodiac until it returns a second time to that very point — this is called a "year."

(Its measure of time is 365 days and close to a quarter [365¼], as will be explained further on, at the head of Gate 7, in §138. It serves us as a true guide for reckoning, by the time of its revolution, all the other spheres' revolutions in combination with all the other long cycles beneath the heavens — because it is more fitting and correct for us than any of the other spheres' revolutions: for it is in the annual cycle of the sun that the measure of the length [חורכי, uncertain] of the days and nights, the seasons of summer and winter, and the seasons of all the ripening [?] of fruits, all recur in their combination — these times that recur again and again.

And the time of the month is the period which the moon marks off in its revolution in its sphere, from the time of its molad [conjunction] until the time of the second molad that comes after it. This [?] is called a "month," and [?] [ופעה[?]] from the language of chiddush [renewal]; and it is not fitting to attribute it save specifically to the moon, which renews itself, and to nothing else — for the sun [?] has no "month" at all, and the moon has no "year" at all, as will be explained shortly. And the period between one molad and the next, our Sages of blessed memory [יגאו[?]] set its measure at 29 days, 12 hours, and 793 parts of the 1080 in an hour [כ״ט ימים י״ב שעות תשצ״ג חלקים מתתר״ף בשעה] — and this is the measure of the month of the moon. And although the moon circles its whole sphere in 24 days and eight hours [ואע״פי שהלבנה תסובב כל גלגלו בכ״ד יום ושמנה שעות], approximately, nevertheless there is no disagreement whatever between the two reckonings, as will be explained further on in §204 [בסי׳ ר״ד].

)

סימן צ״ג (Siman 93) — That the sun has no "month" at all, and the moon has no "year" at all

We are still speaking of the matter of the sun and of the renewal of the moon; it is fitting, before proceeding further, to clarify the three [units] called weeks, days, and hours, at the proper place. This is a matter for our sages — that the sun has no "month" and the moon has no "year" — for there is need and benefit in it for the students.

Know that the sun has no "month" at all, for renewal [chiddush] belongs specifically to the moon, as has been explained; and for this reason it is called chodesh [month], which is from the language of chiddush [renewal]. This applies [וליחנה?] only to the moon, which renews itself, as Rashi of blessed memory wrote in chapter 2 of [tractate] Rosh Hashanah[?], fol. 21a [as printed, בפ״ב דר״ה[?] דף כ״א ע״א, the citation breaking across the line end; the first

reading gave "chapter [22? — כ"ב]"]. And so too the sage Ralbag [Gersonides] wrote in his discussion "of the World" [בפ' העולם], and these are his words: nothing is renewed in accordance with its name except the renewal that gives power to the light of the moon; for this reason it is called chodesh — which is not the case with the revolution of the sun, in which nothing is renewed. And even though we find in the course of the sun four distinct motions, as will be explained further on in §214 [סי' רי"ד], nonetheless no trace or sign of the measure of a "month" is found in it: [the interval] we mark in it, from the time of its departure from a known point until it returns to that point a second time, is the sun's "year," not a "month." So too wrote the sage Ibn Ezra [כן כתוב החכם ראב"ע], and others [wrote likewise, that] this is called [a year? — text garbled: שנא ספרוגו …ואלתסטמפני] "a year" a second time, from the language of shanu ve-yishnu [Melachim ב', ch. 18 — as printed, מלשון שנו וישנו דמלכים ב' סי' י"ח, the reference breaking across the line end; the first reading transcribed the lemma as סנו וישגו and hedged the reference] — which is not the case [with a "month"] at all, as will be explained.

As for what people say, "the months of the sun" — R' David Abudarham [Abudarham] wrote that this is by way of borrowed usage: the term is borrowed from the course of the moon, for although the sun has no renewal at all, they nonetheless called a twelfth part of the year a "month." And the sage Ralbag wrote in his discussion "of the World" that, since the moon renews itself twelve times each year, they divided the year into twelve parts and called each part a "month," because [each] approximates the days of the lunar month — not because there is any [renewal] in the sun's revolution that divides those parts in actuality, nor because the moon renews itself within each such month, as [he] states elsewhere, [each part] being 1/12 of the year [?] —

the portion of the year [חלק השנה]; and likewise wrote the author of ha-M…im [בעל המ[?]ורים[?]] — epithet unresolved on both witnesses; deliberately not supplied], and so also wrote the sage R. Eliyah Mizrahi [ר' אליה מזרחי] in parashat Bereshit, on the verse "for days and for years" [as printed, בפ' בראשית בפסוק לימים ושנים — the leaf names the portion and the verse by catchphrase; the chapter-and-verse "Bereshis 1:14" was supplied by the first reading, which also gave the catchphrase as "for seasons and for years"], and the sage Israeli [החכם ישראלי] at the head of the fourth ma'amar.

And in truth we do not find in the whole Torah a month reckoned to the sun, but only the month of Aviv alone — for the ripening [הבשול, printed with a closed bowl: הבסול] and the aviv belong specifically to the sun. But this [?] is how Scripture is to be explained: "Keep the month of Aviv" means — keep the lunar month in which the aviv will fall; and this is "and you shall make the Passover offering."

And just as […] month at all, so too that term will not be found in the moon at all — because it never begins to renew in the place where it renewed in the preceding month, and it does not vary in its course so as to arrive, at the month's end, at the point from which it went out, as the sun does. For from

the time it renews until it renews a second time, it circles its whole orb, and there is added to this nearly one sign [ונוסף ע״ז קרוב למזל א'], as will be explained further on in §204 [בסי' ר״ד].

And the time of this circuit is called a "month." And even though we find in the moon's course seven [שבע] different motions, as will be explained further on in §201 [בסי' ר״א], nevertheless [?] there will not be found in any one of them a thing fit to be called a "year" — so that you should know that the word "year" applied to the moon's course, and the word "month" applied to the sun's course, are, in truth, both inadmissible.

And as for those who speak of a "lunar year": the reason already given nearby, at the phrase "months of number" [חדשי מספר], suffices for us — that is, that this too is by way of borrowed usage; or else because the moon, at the end of every twelve [י״ב] months, for the most part […] to renew in the same sign in which it was renewing at its beginning, they call twelve lunar months a "year," even though it does not renew in that same degree of the sign in which it already renewed in the year that passed. So wrote the sage R. Ibn Ezra [ר' אב״ע [?]] and the Rav [?] Mizrahi [רב המזרחי ו[ה/ס] — the article's bowl prints closed on both witnesses; וסרב is not a word and והרב fits, but the printed form is retained] in the places cited just above.

And now let us return to explaining the three times mentioned.

סימן צ״ד (Siman 94) — On their natural times, which are reckoned "from period to period" [the 24-hour natural day]

The natural days (that is, each day combined with its night), which are before us, [are what] is called a "natural day," as [explained] just above, in §160 [?]. [The days] are not [reckoned] by the revolution of the moon's sphere; rather, the natural days are governed by the motion of the daily sphere: from the moment the sun begins to circle the globe of the world by its daily motion, until it returns to that same place from which it began to circle — this period is called a "natural day." Thus we reckon the beginning of the day from one of the degrees [rising], with the four [additional] "moments" that were spelled out, as stated just below, in §105 [כדלפנים בסמוך בסי' ק״ה]. Behold, from one period to the next is [about] 24 [hours] of the units of time, until [the sun] returns to it a second time by the daily motion — [this] recurs, according to the sages, as a "natural day." [It is] a little more than the circuit of the daily sphere, close to one degree [more] [קרוב למעל' א'], as will be explained further on, at the end of this order, in §150 [בסוף זה הסדר בסי' קן — printed bare, with no mark].[184]

But bear in mind: these three units of time — years, months, and days — are governed by the revolutions of the spheres. Therefore, just as no human being has the power to lengthen or shorten the motion of the spheres, so too there is

[184] the same cross-reference is printed twice on this leaf, bare in the one place and marked in the other; and the surplus is stated two ways on the same leaf — as close to one degree here, and, in the next siman, as close to one part in three hundred and sixty of the sphere.

no room, no opening, and no possibility whatever to imagine lengthening or shortening these times. Hence one should not ask why the measure and time of the year is thus, why the measure of the month is thus, and the measure of the day thus. As for the reason for the numbers and times of the days of the week, and likewise the reason for the number of the hours of the day — that requires much study and reflection.

סימן צ״ה (Siman 95) — On the times of the day's hours, and on what their foundations were established

Know that the times and number of the hours, of which there are 24 in a day, constitute the fourth kind of time, added to the three kinds already mentioned. This kind of time we do not find anywhere in Scripture, nor can it be attributed to the motion of any sphere, as could the three chief kinds of time mentioned. Therefore know that the hours are conventional times, not times founded [in nature]; they are but parts of the day. The sages had the authority to divide the day as they saw fit, into many parts or few, more or fewer than 24; but they chose to divide it into 24 parts, for a reason to be explained shortly, and called each part an "hour." [This is] not because the sphere fixes [these] times of hours as it does one of the three natural time-units; rather, the sages did this as a [deliberate] act.

Know that the numbers of the days of the week and the numbers of the hours of the day — indeed, [also] the reckoning of the hours of the day — were a great and constant perplexity to us: why, and for what reason, did the ancients fix specifically the number of the days of the week at seven days, and the number of the hours of the day at 24 — when we would seem to have an opening to say that the hours of the day might have been fixed at more or fewer than 24; and still more of an opening to fix the days of the week at six days near it, since by [the criterion of divisibility] it would have been more fitting for the number to be divisible by half and by quarter — and [six] is also divisible by half and by third.

(Moreover, the number six is one the sages already treated, and they called it a "perfect number" [מספר שלם], since a wondrous property is found in it: all the divisors of this number add up to the number itself — namely its half, which is three; its third, which is two; and its sixth, which is one — which together sum to exactly the number itself. This is not so with the other numbers: no perfect number is found except among the units [6], among the tens [שמנה ועשרים — twenty-eight, spelled out in words], among the hundreds קצ״ו [recte: 496], and among the thousands [the figure is not resolved; no value is supplied]; and there

are no others [below ten thousand].[185] We have already given some explanation of this at the head of our book [§4:4? — נסי׳ ד׳ ד', reference uncertain].) The number seven, by contrast, admits of no divisor at all.

And beyond all doubt, the fixing of the number of the natural day's hours at 24, and of the days of the week at seven days, is not without a fitting reason in each case. What I have found concerning this — incline your ear and hear. You will grasp the reasons for the [number of] hours, their basis, and their placement; and by that means we will arrive also at the reason for the days of the week.

Know that the times and number of the hours, of which there are 24 in a day, are [something the astronomers established]. The astronomers agreed to divide each and every hour into 60 parts, called "minutes" [דקים] of the hour, or "seconds" [שניות]; each minute into 60 "thirds," and so on into fourths, fifths, sixths, and onward down to tenths. And there is surely no doubt that the fixing of the numbers — the natural day at 24 hours and the days of the week at seven days — is, in each case, not a conventional time without a fitting reason.

The astronomers reckon the times of the hours specifically by the revolution of the equator [המישור], because it always revolves at a uniform rate and over one uniform arc, which is not the case with the daily [zodiacal] sphere, which sometimes revolves 22 degrees [כ״ב] in an hour and sometimes 18 degrees [י״ח], as will be explained further on. And you should know: since they divided the day into 24 parts, [dividing] the 360 degrees of the sphere by 24 gives each hour 15 degrees [ט״ו], so that in each hour the equatorial sphere rotates about 15 degrees along the meridian above the horizon. We say "about," because the daily sphere revolves each day slightly more than one complete circuit — by close to one part in 360 of the sphere's parts [קרוב לחלק א׳ מש״ס חלקי הגלגל] — as [explained] further on, in §[[106/107]] [[בסי׳ ק״[[ו/ז]]][186]

סימן צ״ו (Siman 96) — The reason why the measure of the natural day [is divided] into 24 parts

As for the sages' having divided the measure of the natural day into 24 hours: the plain reason is that this number possesses [convenient] divisors — a half, a third, a quarter, a sixth, an eighth, and a twelfth [חצי שליש רביע ששית שמינית

[185] the printed figure in the hundreds is a hundred and ninety-six, not a perfect number; the series requires four hundred and ninety-six. The leaf's form is given as it stands, with the required value beside it. The member in the tens is spelled out in words where its neighbours are set as numerals. The thousands figure is not resolved on either copy — the sort that can be seen does not settle into a numeral.

[186] ⚠ the earlier reading "§150" is WITHDRAWN — excluded on the ink. The numeral's second sort sits flush on the line of writing, where the ק beside it in the same word descends clearly below it; a final nun, which 150 requires, descends. The value is 106 or 107, and the choice is not made: the mark merges into the sort's head on its right, and the line carries no instance of the alternative letter to measure against, so ז is unsupported, not excluded.

• וי״ב] — which is not the case with the other small numbers.[187] Beyond this, know that I have found another reason, fine and sweet to the palate. Since the ancient sages of inquiry, from earliest times, and those who grasped the ancient [traditions], apprehended for a firm and remembered [purpose] the mystery of the seven planets — **שצ״ם חנכ״ל** [the mnemonic: Shabtai (Saturn), Tzedeq (Jupiter), Ma'adim (Mars) / Chamah (Sun), Nogah (Venus), Kochav (Mercury), Levanah (Moon)] — each one of them "reigns," one after another, over one part [hour] of the 24 in a day. Thus they rule one after another and exchange their dominion each natural day among the 24 periods, in such a way that [the sequence] fills out the mnemonic-signs for the "heads of the nights" of the seven days of the week (כ״צנש חל״ם) and the mnemonic-signs for the "heads of the days" (חל״ם כצנ״ש), as will be explained shortly.[188] In this way [the sequence] recurs perpetually, world without end. All of this could not have worked out, nor could their reckoning have been made to fit, except by dividing the natural day into twenty-four parts.

סימן צ״ז (Siman 97) — The reason for the days of the week being seven days

And so, by this very reason, our holy Torah fixed for us — [Torah] given by the Blessed One — the measure of the days of the week at seven days: "Six days you shall labor, and the seventh day is a day of rest" [as printed, ששת ימים תעבוד׳ ויום השביעי שבתון — the leaf prints no reference, and its wording is that of Shemos 34:21 (שבתון), not the Decalogue's שבת לה׳ אלהיך; ed.: the first reading's "cf. Shemos 20:9–10" is an identification supplied to a wording the leaf does not carry]. For within this period of seven days, which is 168 [קס״ח] natural hours, the seven planets complete their perpetual cycle, each returning to the place of its rule that it held at the outset; seven times 24 [שבע פעמים ך״ד] amounts to 168 [עולה קס״ח], and they recur perpetually — [the mnemonic] כצנ״ש חל״ם for the "heads of the nights," and חל״ם כצנ״ש for the "heads of the days," through all the days of the world.

The ancients gave a mnemonic for this: (ח״ס כ״ל פ"), meaning "Kochav [Mercury] — night; Chamah [Sun] — day," that is: the first hour of the night of the first day — which is the eve of Shabbos [Friday night] — the rule of the sun begins; and this is [the sign], meaning "Chamah [rules the] day." In this fashion they recur perpetually, through all the days of the world.

And although we are not compelled to rely on the reasoning of the sages of inquiry rather than on the words of our holy Torah — nonetheless, I found

[187] the list has six members, the sixth set as a numeral where the other five are spelled-out ordinals, and a clause-closing point stands inside the list before it. There is no fifth part in the list and no gap in the setting where one could have stood.

[188] in the first of these two strings the mark stands after its opening sort rather than before its last, where the second string and the planet-mnemonic both place it. The strings are given as printed.

written in the book Mekor Chaim [of R' Shmuel Tzartza?], at the head of the portion of Bereishis [בריש פ' בראשית], quoting the sage Ibn Ezra [ראב״ע], and these are his words: "Know that Moshe, peace be upon him, gave the Torah not to the wise-hearted alone, but to every generation and age; and our sages relied on the words of Moshe, who provided many signs and wonders that he was the messenger of God, adding nothing and subtracting nothing — [so] the words of the men of inquiry were sufficient for us [only insofar as] their view accords with the words of Moshe, and one may rejoice in them" — end of quotation. How eloquent are the words of that sage, of blessed memory.

And it was from this same reason [mentioned] that all the nations of the uncircumcised, under all the heavens, though they have no share in our holy Torah, willed to fix the days of the week at seven days [?] —

[סימן צ״ז, continued — p. 71, left column]

— [seven days] equal and whole; [and though] the number of eight days [would have divided evenly, and] by appearances a more fitting cause [for a smaller count exists], for the reason I wrote just above [i.e. divisibility], nonetheless they too chose to count the days of the week as seven days, since this number [seven] admits of no division whatever — chiefly because of the choice of seven days to correspond to the seven planets, which recur perpetually every single week, world without end, as above.

סימן צ״ח (Siman 98) — A table for the rulership of the planets — of the seven planets — in every hour of all the days of the week

I saw fit, to satisfy the youths' desire to understand the matter, [to provide] a fixed table [לוח], from which the students may know — without any need for study or reflection at all — the rulership of each planet in every single hour of all the days of the week; and just as it operates in one week, so it operates in [every] week, and so it recurs perpetually through all the days of the world. The benefit of the thing is great; from it, too, many sayings of our Sages of blessed memory will become clear, as well as some of the reasons for words in the Torah. See the commentary of the sage Ibn Ezra [ראב״ע] on the verse "Remember the Shabbos day to sanctify it" [as printed, בפסוק זכור את יום השבת לקדשו — with יום, which the first reading dropped; ed.: Shemos 20:8, an identification not printed on the leaf], and also [the] Mekor Chaim on the verse "in righteousness shall you judge your fellow" [as printed, בפסוק בצדק תשפוט עמיתך; ed.: Vayikra 19:15, an identification not printed on the leaf]; and this is not the place to expand. (And see the table in my book Ma'or HaKatan [ועיין הלוח בספרי מאור הקטן — the author's own shorter work].)

Know that in matters such as these — that is, the reckoning of the hours by the seven planets — the sciences have already been employed from earliest times, and those who grasped the ancient [traditions], particularly the peoples of Ashkenaz [the Germans]. And it should be noted that the days of the week

are named in their language after the seven planets, each one after the star that rules the first hour of that day. How so? The first day — on which, in its first hour, the planet of the Sun rules — is called [זונטא״ג] Sonntag, meaning "Sun-day." The second day, named accordingly, is called [מונטא״ג] Montag, meaning "Moon-day." The [third] day is called [דינשטא״ג] Dienstag, meaning "day of service [?]," on which, on the third day, they used to worship the planet Mars [Ma'adim]. The fourth day is not named after a star, but [מיטוו״ך] Mittwoch, meaning "mid-week." The fifth day is called [דונרשטא״ג] Donnerstag, meaning "day of thunder," concerning the matter that the planet Jupiter [Tzedek], which rules at the start of the fifth day, governs thunder and lightning. The sixth day is called [פרייטא״ג] Freitag, meaning "day of weddings [?]," because the planet Venus [Nogah] governs love, joy, betrothals, and marriages. Shabbos day is called [זונאבנ״ט] Sonnabend, meaning "the eve of a day like the sun's" [פי׳ערב יום כחמה]; and in many places, especially in the provinces of Saxony [זקסין — Sachsen] and [[a second territorial name, unresolved: ר · ו · ק firm, then a small high י, then a letter with a straight stem descending well below the baseline, then a tall hooked ל, then a final glyph with a foot kicking down-left]], it is called [[a German day-name, unresolved: some six sorts, then a mark, then a final ס]], meaning "Saturn's day [Saturday]," because Saturn [Shabtai] was called Saturnus [סטיר״נא].[189]

סימן צ״ט (Siman 99) — That the time of each planet's rule, of the "wandering" [?] planets, is not only in the first hour of the day, but it rules a whole day

Know that in reckoning the rule of the wandering [?] planets, at first inspection there is great perplexity for us, because their daily rule is the same for all the inhabitants of the earth: for when the sun rises above the horizon for those at the eastern edge — by way of illustration, on the first day, in which the planet of the Sun rules, granting them the first hour — at that very time and moment [it is] the onset of night for those at the western edge, and even more [continues]. This perplexity — great and deep — [is resolved as follows]: [only] if we could pin down and specify [it would be difficult; but] this problem is explained further on, in the Eighth Section, §214 [בסי׳ ריי״ד / בשער השמיני].[190] As for us, we need [only] to know for which place this reckoning was founded, and each person would [otherwise] have needed to compute the natural hour [and] which hour it is at his own location. [But] know that I put the matter

[189] the leaf sets the Sonnabend gloss with a comparative particle — "the eve of a day like the sun's" rather than "the eve of the sun's day" — and sets the explanatory abbreviation closed up against the following word. The second territorial name and the German day-name beside it are not resolved on either copy: the readable letters do not close into a word, and no name is supplied.

[190] the gate is spelled out as a word and the siman set as a numeral; the reference breaks across the line end.

before Johannes Kepler [יוהנו"ם קעפפלירו"ס], according to the position of [his] place, and he answered me that for this reckoning we have no need to know for which place the reckoning was founded — because of what the astronomers said: that at the first hour one kind of the rule of the planet of the Sun [applies], meaning that the Sun does not rule in the first hour of that day alone, but its rule extends over that whole day, from its beginning to its end — only not over one [single] place; for as its revolution around the globe of the world, so is the measure of its rule, since at every place where it rises above the horizon, there, at that place, it rules for one hour, until the completion of the 24 hours in which it circles the whole globe of the world.

So, when the sun rises for those at the eastern edge — where it rules from the beginning of its rising until the completion of one hour over that place — and as it moves away from there, by way of illustration by just one degree [so that it is now] rising to the middle of the firmament [?] above the horizon, its rule [there] begins from its rising there until the completion of one hour; and such is its rule that whole day. Just as [this holds] for the Sun, so the same rule [holds] for the Moon, specially assigned to the second day [Monday], and likewise for all the rest of the seven wandering [?] planets: each of them rules 24 hours per day, one after another, over the circuit of the globe of the world.

And know [further — as Christianus (?), meaning] you should understand that the rule of the planets is not the same for all the inhabitants of the earth, but [only] for the climes that share the same longitude — that is, those whose dwelling-places [lie] along the same [meridian] line running from north to south, all of whom share one [and the same] meridian ["midday" line]. And yet know that even for people who share the same longitude, if they are far from one another [in latitude], the rule of the planets is likewise not the same for them, [this being] on account of the precedence of the sun's rising for the more northerly over the more southerly, as [explained] further on, in §132. This too is a deeply intricate matter — nonetheless, [resolved in its place]. Every place of the world begins each day to be called by its own [planet's] name, as [explained] just below [כל פנים בסמוך] in Gate 6 [?], §181 [בסי' קפ"א [?]שער הששי]; this too bears upon the reckoning. This too was the intent of this reckoning — the rule of the planets — and in its [proper] place it shall stand.

סימן ק' (Siman 100) — On the reckoning of the equal (straight) hours, [and] the equal ones apart from them

The equal (straight) hours require no lengthy explanation, since it has already been made clear that the sages divided the measure of the natural day into 24 hours, in each and every one of which the equatorial circle rotates 15 degrees — as these matters will be explained further on, in the Sixth Section, in simanim קמ"ב וקמ"ג (§§142–143). But the reckoning of the oblique (crooked) hours has a different law and rule, as will be explained shortly.

and it rises above the horizon, or [passes] beneath the horizon of the meridian, fifteen degrees [ט״ו מעלות]; and this reckoning is for us a founded foundation, that for every [?] fifteen degrees of the circle of right [the equator] you shall reckon one hour, at every time of the hour [?]. And accordingly the measures [[in the equal hour, always, in every place and at every time, and according to the reckoning of these]][[in the equal hours, always, in every place and at every time, according to the reckoning of these]] — in the equal hours it will be found, for the most part, that at times the numbers of the hours of the day exceed [יעדיפו לכו[?]] the numbers of the hours of the night, and at times the reverse of this, in the numbers of the hours…

(The two clauses set between [[ ]] are the printed dittography of A40/A41, given in the order the leaf prints them and in their two printed forms; nothing between them is editorial.)

You should know that the astronomers reckon [from] the beginning of their day until midnight always as 12 hours, and likewise from midnight until midday, again 12 hours. Upon this reckoning the ancients founded for themselves the hour-indicators [the striking clocks and bells — הפעמונים, שעות־המורה] that sound the hours: from midday until midnight, 12 hours, and from midnight until midday, likewise 12 hours. In particular, those who reckon the [calendar] intercalation — the inhabitants of [Rhineland? — רינו״ס], who reckon by the equal (straight) hours — must set the head of the day-count from the onset of the night, as will be explained. They also require [an explanation of] the 12 hours of day and 12 of night throughout all seasons of the year, as all the halachic authorities have written: they reckon in this manner, always beginning each night at [six? — משעה] hours after midday, and beginning the day at six hours after midnight, in all seasons of the year — summer and winter, [heat] and cold — whether [the day] is advanced or delayed, whether the daylight or the night is long, [of] the aforementioned periods. We have already given a fuller treatment of this in [my] Ma'or Katan [?], in the gate on [—], together with what we wrote about the great difference in this reckoning between the inhabitants of [—, R... (?)] and the inhabitants of [—, Fiess? (?)] and Poland [ופולין] [—]. [Text garbled at column foot.]

סי׳ ק״א (Siman 101) — On the reckoning of the oblique (crooked) hours, called ”temporal” [seasonal]; they are always 12 hours in the daylight and 12 hours in the darkness of night

Know that the reckoning of the oblique (crooked) hours is this: always, in every place and at every time, one divides the measure of each day — from the time of the sun's rising over the earth until [its setting] — into 12 parts, and likewise the night into 12 parts [reckoned by] the sun [passing] beneath the earth, again 12 parts — whether the day or night be long, or the day or night be short. The rule in all cases is the same. For example: at the summer solstice [tekufat Tammuz], for the inhabitants of the city of Prague [פראג], the [daylight] arc

rises above the horizon 240 degrees [ר״מ] of the equal circle, which is 16 equal hours [ט״ז], reckoning 15 degrees per hour [ט״ו] as above. But when we divide the aforementioned measure of the day into 12 parts, we must divide the 240 degrees into 12 parts, yielding long, oblique hours: each hour amounts to 20 degrees, which is one and a third equal hours. Thus each oblique hour is longer than an equal hour by a third of an equal hour. And likewise, in this manner, the day [יו׳ — the leaf's contraction for יום] of the Teves [winter] solstice, whose measure is for us eight hours [שמנה שעות] — dividing [it] into twelve hours, they will be short hours, since each hour comes to only two-thirds of an [equal] hour [שני שלישי השעה] of the equal hours. And it is found accordingly that, just as the measure of the daylight at the Tammuz solstice is double the measure of the day at the Teves solstice, so too the measure of the hours of daylight at the Tammuz solstice is double their measure against the measure of the hours of the day of the Teves solstice. And likewise the measure of each night is divided, each [night] into 12 [parts].

Even though the reckoning of these oblique hours is strange in the eyes of the young students, know that upon this reckoning all the sages agreed, ancient and modern alike, whether of the Children of Israel or of the nations of the world — both in the reckoning of the intercalation and in the other calculations. All of them agreed upon [this reckoning — continues in the next section].[191]

for the reckoning of the temporal hours, as will be explained further just below.

You should also know that — as I already explained above, in §34 — for people who dwell beneath the equator [קו השוה], the measure of day and of night is always equal for each of them, twelve hours each. Those people, therefore, have no difference at all between the equal (straight) hours and the temporal hours. Only those who are tilted [in latitude] and dwell off the equator have temporal hours [that differ]. Know, too, that every group [of inhabitants] has its own temporal hours: the hours of one place are neither identical nor equal in their measure to the hours of another place. For all who dwell along one straight line [meridian] running from east to west, there is no difference except in precedence — those to the east are earlier, those to the west later — as will be explained below, in §150 [?].

These hours of which we have spoken are called [?] "temporal hours" [שעות זמניות], that is, seasonal hours; for in every season, throughout all the days of the year, the measure of the hours changes in the world for all who dwell beneath [a given latitude]. Since a person dwelling in one place has the

[191] across the ten rubrics of these four leaves the abbreviation marks are applied to only three of the ten numerals, the rest being set bare. the tenth rubric alone opens with the abbreviated form of the word for "siman"; the other nine spell it in full. one rubric carries a full stop inside it. the numeral twenty-four in §96 is set with a final form of its first letter in a medial position. two words in the last of these rubrics are set in forms that differ from the ones the neighbouring rubric uses for the same words; they are given as printed and not normalised. One further rubric carries a word-space inside a single word.

measure of his hours changing each day according to the measure of the length of the days, the measure of one day's hours is never equal to the measure of the following days' hours throughout the whole year. It never happens that temporal hours coincide with the equal hours during the whole year except twice a year — namely, at the seasons of the equinoxes of Nisan and Tishrei, when day and night are equal for all the inhabitants of the world in every clime.

סימן ק״ב (§102) — On what basis the reckoning of the temporal hours was established

Know that for all the inhabitants of the world, in every clime, six signs of the zodiac are always [above the horizon] during the time of daylight and six signs during the night, neither more nor less [?], whether the day (or night) be long or the day (or night) short — and the seasons of Tammuz and Teves are equivalent in this regard, as will be explained to you further on, in §115 [?]. Know, then, that the scholars of this science agreed to reckon [?] in this configuration: since fifteen degrees [ט״ו מעלות] pass across the meridian for each equal (straight) hour, so they reckoned the motion of all six signs, which span 180 degrees [ק״פ מעלות], as making up the twelve [temporal] hours — so that the degrees are always divided fifteen to an hour [in ecliptic terms]. In this way, when the daytime is reckoned as twelve hours and the nighttime as twelve hours, at the two seasons [?]… the difference between the measure of day and of night is great; and correspondingly the difference in the temporal hours is called great. For in winter the degrees of the signs [rising] during an equal hour exceed the degrees of the signs [rising in a temporal hour], and in summer the matter is reversed. That is: at the season of the Teves [winter] solstice, which is the shortest day of the year, nonetheless, since only six signs — 180 degrees — ever rise above the horizon on that day, when we divide those 180 degrees by twelve, each temporal hour comes to fifteen degrees [ט״ו מעלות], which is one-twelfth [חלק אחד מי״ב] of the measure of daylight; for 180 degrees divided among twelve [hours gives fifteen each]… only two-thirds of a [short] hour [?]…

[Continuation of §102, top of the left column:] …[to complete the temporal hour] we need only twenty-two and a half degrees [ך״ב מעלות ומחצה] of the degrees of the signs; for when we divide the 180 degrees of the sphere by the number of the [equal] hours of that day — which are eight [שמנה שעות, i.e. the short winter day] — we obtain 22½ [כ״ב חלקים ומחצה] of the degrees of the signs rising at that moment during an equal hour. And on the day of the Tammuz [summer] solstice, which is the longest day of the year, nonetheless — since no more than six signs, which are 180 degrees, ever rise above the horizon — when we divide those by the number of that day's [equal] hours, which are sixteen [ששה עשר], you obtain 11¼ degrees [י״א מעלות ורביעית] of the degrees of the signs [per equal hour]. And as the rule is for the day of the Teves solstice,

so is the rule for the night of the Tammuz solstice; and as the rule is for the day of the Tammuz solstice, so is the rule for the night of the Teves solstice.

סימן קג (§103) — That the reckoning of the intercalation — the seasons [tekufot] and the conjunctions [molados] — was established according to the temporal hours

Although the reckoning of the temporal hours is what turns and recurs constantly for most of the world, so that [?] this reckoning is not [otherwise] grasped in every place — nonetheless, know that it was according to these temporal hours that our early sages of blessed memory established for us the whole reckoning of the seasons [tekufot] and the conjunctions [molados]. Likewise, all the other "hours" mentioned in the Mishnah are temporal hours, as several great authorities among them attested — such as Rambam of blessed memory, in the first chapter of [tractate] Berachos, and these are his words: "Know that all the hours mentioned throughout the Mishnah are the temporal hours; and the meaning of 'temporal' is the hours of which there are twelve by day and twelve by night." And what he said, "until [a certain number of] such hours are completed," means until the end of a quarter of the day, whether it be the day of the Tammuz solstice or the day of the Teves solstice — thus far the words of Rabbeinu Ovadiah of Bertinoro [ר׳ עובדיה ברטנורא], and he set down his words [likewise?]. The Israeli sage [Yitzchak Yisraeli] also wrote so in his book Yesod Olam, essay II, chapter 7, and again in essay IV; and Rabbi David Abudarham [ר׳ דוד אבודרהם] likewise wrote so at the head of his "Order of Intercalation"; and so, apparently, is also the view of the author of the Shem[?] [?] in the matter of §46 [?], and of the Tur, Orach Chaim, §428 [ת', recte תכ״ח?].

Know, then, from now on: when the reckoning yields for us that the Tammuz season falls — for example — at seven and a half hours [ז׳ שעות ומחצה] into a given night, know that those are seven and a half temporal hours, which, according to the reckoning of the equal hours, mean that this season falls for us, the inhabitants of Prague, at five hours [ה׳ שעות] into the night. Likewise, when the conjunction [molad] of the month of Teves, or its season, comes upon us — for example — at ten and a half hours [עשר שעות ומחצה] into the day, this conjunction or its season will be, by the reckoning of the equal hours, seven hours [ז׳ שעות] into the day; and from this [proceed] to the rest of the times in the manner of reckoning by temporal hours.

Know further that these temporal hours were called by the sages of the nations "the hours of the Jews" [שעות היהודים], since they were [in use] for the Jewish people when they dwelt on their own land; and to whoever writes [of them]. I have seen in books [?] narratives of events that occurred in Jerusalem during the time the Temple stood, in which many deeds at various times are reckoned as "at the close of the sixth hour" [being] the end of the day, or "at the close of the twelfth hour" [being] the end of the day — from which it apparently follows that in that period the Jews reckoned their hours by temporal hours,

for we say [?] that all those deeds were done specifically in the seasons of Nisan and Tishrei [when temporal and equal hours coincide].

I have further seen fit to inform the reader that these temporal hours are called, in accordance with [?] the hours of the seven planets [שבע המשרתים] — that is, the [planetary] hours of the seven planets [שבעה כוכבי לכת]. For just as the rule with the signs is that there are twelve temporal hours [rising] on the horizon in every time and place, so is the rule with the seven planets — because Ptolemy [שבטלמי?] and [Nasibutis?] [?], author of [?], hold that [the planets] are always beneath the revolution of the signs, as will be explained further on, at the beginning of the Fifth Section, in §108 [?]. Accordingly, just as there is a rule for the risings and settings of the signs, so there is a rule for the setting [and rising] of each one of the seven planets. The illustration of this: when, say, the star of Saturn [כוכב שבתאי] completes [its passage] beneath the head of the sign Cancer [ראש מזל סרטן], the rising and setting of that star follow the revolution of the daily sphere in the rising and setting of that sign itself. (However, I do not know why they were not called "the hours of the signs"; and the reason and benefit [of the term] "temporal hours" will be explained to you somewhat further on, in the Eighth Section, in §[?].) With the help of God.

סימן ק״ד (§104) — On the cause of night, and the shadow of the earth [ומצל הארץ]

The cause of night is already known even to those just weaned from the breast [עתיקי משדים; cf. Yeshayahu 28:9]: when the sun sets beneath the western horizon, its light is withheld from us, and the absence of light is the darkness, which is night. Yet even so, we still have something to say, and we shall speak here about [the light and its removal, which is] the cause of night. Know that after the sun has set, [it goes on illuminating around] the surface of the earth — which is entirely round, its base below, in the breadth of the sphere of the earth. And considering the ratio of the size of the globe of the [?]-mini [מיני…כדור ה — the tail of the word is clear, its head is not] — which is larger by one and three-eighths [פעם ושלשה שמינית], as will be explained further on in §233 [בסי׳ רל״ג] — to the smallness of the sphere of the earth, which is a [mere] point in relation to the heavens, behold, the shadow [of the earth] goes on [tapering] until it returns to a point [and the stars…] [text degraded]; … [that shadow] is so high and lofty that it is wondrous [?]; … and it enters within the sphere of Venus [ונכנס עד תוך גלגל נוגה] by several thousand miles [כמה אלפים מיל], and there, within that sphere, the shadow is entirely dissipated [יתבטל הצל לגמרי…ושם בגלגל]. … [And this shadow] is what is cast over us so that we abide [in it] at night; and by this shadow, [there is] no [surface?]… over the whole world; only [the sun] itself revolves around the sphere of the earth, together with the motion of the [daily sphere]. So, in accordance with the [motion of] the sun, so goes the revolution of the sphere, returning in cycle forever; … the points of the world [tevel] [remain?] fixed opposite the signs at

every moment; … the sun [?]. This matter shall be to you a reminder [when] you consider these things elsewhere. See further on, in the Ninth Section, §221 [בשער התשיעי בסי׳ רכ״א], and there you will find the figure of the sphere [ושם תמצא צורת הגלגל]. With the help of God.

סימן קה (§105) — The meaning of the word "day": the distinction between a working [artificial] day and a natural day, and from what time it begins

This matter we already explained in our book Ma'or HaKatan [בספרינו מאור הקטן], ק״ק [so printed]; nonetheless [I will explain it here again, for in this too there is benefit].[192]

Know that the word "day" [יום] is used in three senses [ג׳ מלתפני, so printed]. The first: it is said of the time during which the sun rules above the horizon — in the sense of the verse, "day and night shall not cease" [cf. Bereishis 8:22], "Yours is the day, Yours also the night" [לך יום חף לך לילה, so printed; recte: אף]. This span the scholars call the "working day" [יום מלאכה].[193] The second [sense of] the word "day" is said even of the night, as in "on the day [He] smote every firstborn" — for this was at night, as it says, "and it happened at midnight, and Hashem smote every firstborn" (Shemos 12:29); and likewise, "by day I cried out, [in] the night, before You" (Tehillim 88:2), whose meaning is [the whole span of] time. Specifically the time the sun is over the earth is called "day," as the sage Ibn Ezra [ראב״ע] explained on the verse "the pillar of cloud did not depart by day" (Shemos 13:22). The third [sense]: the word "day" is used for the time of the working day together with the night that precedes it, as in the verse "and it was evening and it was morning, day one" (Bereishis 1:5), whose meaning is that the evening together with the morning constitutes "day one." This span our scholars call the "natural [day]" [יום טבעי], and in the Latin tongue they call it "diem naturalem" [דיא״ם נאטוריא״לום]. Most [occurrences of "day"] mentioned in the Torah without mention of night mean the natural day.

The natural day has no fixed [obligatory] time set for its head and beginning — only four reference-times [ד׳ זמנים], of which four [?] are fit to be set as the head and beginning of the day. The first time is sunset, which is the end of the day that has passed and the beginning of the day to come; and this is [the beginning] according to the consensus of our Torah, as will be explained. The second time is [mid]night, and to this some of the scholars agreed, according

[192] the leaf prints a two-sort letter-numeral immediately after the title, both sorts descender-bearing ק, giving ק״ק — 100 and 100, which is not a well-formed number. It is given as printed; no value is supplied for it. No סי׳ is printed before it, so no siman is supplied either.

[193] the second proof-text carries a compositor error inside a scriptural quotation — the leaf sets חף where the verse (Tehillim 74:16) has אף. The printed form stands in the transcription, the expected form in [recte:], and the bracket is not emended to agree with the verse. The frame sentence is set ג׳ מלתפני, מלת run together with פני׳ — an apparent dittography of מלת from four words earlier; given as printed, the sense unaffected (פני׳ = פנים, "senses").

to the course of the stars. The third time is sunrise from the direction of the east; and accordingly the night that comes after it follows and extends after the day that has passed. This reasoning, too, is found in our holy Torah, regarding the beginning [of the day] — as with the eating of the flesh of the thanksgiving peace-offering [shelamei todah], of which it says, "on the day it is offered it shall be eaten" (Vayikra 7:15), and "you shall not leave any of it until morning" (Vayikra 22:30). The fourth time is the moment of midday [רגע חנות יומם], and to this most of the astronomers agreed, for a reason to be explained further on, in §134 [?]. … [Shabbos day, for instance, is reckoned to begin with part of the sixth day…] six equal hours earlier [שש שעות ישרות]; and the time [set] by the consensus of our Torah [differs from that of] the astronomers, who set the beginning [of the natural day] on Shabbos day at midday [בחצות יום שבת], so that there was a difference of י״ק hours between our reckoning and theirs [והיה ההבדל בין חשבונינו לחשבונם י״ק שעות]; [and one who does not distinguish this] has not spoken correctly.[194]

So you have four reference-times in the natural day, at each of which it would be fit to set as the head and beginning; nonetheless, know that our holy Torah agreed that the reckoning of the beginning of every day shall be specifically after sunset, which draws on the beginning of the night. The sage Ibn Ezra [רחב״ע, recte ראב״ע?] already wrote, in Parshas Yisro, on the verse "from the morning until the evening" (Shemos 18:13–14), that the true evening is at sunset. And all the astronomers admit that the day [runs] from sunrise until [this point].

Shabbos and the festivals, by Torah law, enter from when the sun sets; only the Sages added [some] of the profane to the holy: at the entry of Shabbos, [its onset] shall be before sunset, and at the exit of Shabbos, [its close] shall be after the stars come out. And the reason, as the sense of our Torah [conveys], is to begin every day after sunset — [as] the Israeli [Yitzchak Yisraeli] wrote in chapter 16 of the third essay [כתוב הישראלי בפ׳ י״ו ממאמר שלישי] [of Yesod Olam]. For [the festivals depend on] the new moon [chodesh la-levanah], and we compute to sanctify them by the sighting of the moon at its renewal; and where is the new moon first seen? Only at the beginning of the night. Therefore, by law, the days of the month begin at the beginning of the night; and since each of the festivals depends on the beginning of the month and its start — as it says, "in the first month, on the fourteenth day" etc., "on the fifteenth day of this month" etc. — therefore

[the beginning of] every festival will begin, by reckoning, [at night], and it too begins at night. For this reason Scripture bounds Yom Kippur at its beginning and its end, when it wrote [the command] and made it a paradigm [binyan av] for the other Shabbosos and festivals — to say, "from evening to

[194] the figure is a two-sort compound that is not a well-formed hour-figure; both copies print the same sorts, including the descending leg that excludes the reading eight. A second candidate for the closing sort is not excluded and no value is supplied. This earlier figure is spelled out in words, where the difference-figure four lines below is set as a numeral.

evening you shall keep your Shabbos" (Vayikra 23:32); and likewise you find [that] Scripture wrote, like us, "in the evening you shall eat matzos," with the day of the fourteenth [י״ד; יש?] of the month, in the evening (cf. Shemos 12:18).

סימן ק״ו (§106) — On how the time of the natural day exceeds the measure of the time of one revolution of the daily sphere

It is already explained above that from the revolution of the daily sphere the measure of day and of night comes about, whose number [appears] at first glance [to make] the measure of the natural day and the measure of the daily-sphere day one and the same time entirely. But know that, in essence, the matter is not so. For if the sun stood in one place, without moving from it, then the measure of the time of one revolution of the daily sphere would indeed — without any addition or subtraction at all — equal the measure of the natural day. But since the sun revolves each day nearly one degree of the 360 degrees of the sphere [קרוב מעלה א׳ מש״ס מעלות הגלגל], as will be explained further on, in §165 [בסי׳ קס״ה].[195] Blessed is He who nourishes me, sustains me, and satisfies me [ברוך זונני פרנסני ומשביעני] —

[Elaboration of the same, in the left column:] …And this revolution [is such that] the daily sphere revolves each day slightly more than one complete revolution, by nearly [one part?] of the parts of the sphere [?], and so the natural [day] exceeds the time of the daily rotation. For example: at Nisan [the spring equinox], the center of the sun rose together with the head of the sign Aries [ראש מזל טלה] on the horizon; so, when the head of Aries revolves the next day, at the setting of the daily sphere on the horizon a second time, the sun has [not yet] returned there — for the sun's [own] portion has already [moved on] during the [previous] revolution of the daily sphere, along its first course, by nearly one degree of the sphere's daily motion. Because of this, the sun does not rise on the horizon until the daily sphere revolves a further nearly one degree. It thus emerges, accordingly, that the daily sphere revolves, over a full day [מעת לעת] — that is, from the [true] east at the [start] of the day until the sunrise of the next day — one complete revolution plus, in addition to it, nearly one part of the 360 degrees of the sphere [קרוב לחלק א׳ מש״ס מעלות הגלגל]; and accordingly the measure of the natural day exceeds the time of one revolution of the daily sphere by about one part of 360 in an hour [חלק א׳ מש״ס בשעה בקרוב]. And it is "approximately," because the sun, in its own course, does not revolve a full degree each day, but only about fifty-nine minutes and eight seconds [נ״ט דקין ושמנה שניית], as is explained in §105

[195] the two forward references in this siman are printed with different numbers on one leaf, both introduced by the same word. Neither is emended, and the reference in the left column is inconsistent with the siman's own position without any correction being proposed for it.

[כמו שיתבאר לפנים בסי׳ ק״ה, so printed].[196] — who helped me to the completion of the Fourth Section [שעזרני בסיום שער הרביעי].

[196] this siman gives the sun's daily motion as fifty-nine minutes and eight seconds, the seconds spelled out in words. §128, on a later leaf, gives the same quantity as fifty-nine minutes and a figure that reads as a hundred seconds. The two places do not agree and neither is emended.

השער החמישי (The Fifth Section)

On the breadth of the belts of the zodiac and the shapes of the signs themselves; that they are reckoned in two ways; that the signs are reckoned according to four considerations [ד׳ בחינות], with an explanation of their ascensions [מצעדם]; (and that the degrees of the signs are reckoned according to four considerations); that six signs rise on the horizon and six set — that the signs, in rising on the horizon, are "girded" [in order], Taurus before Aries and Aries before Pisces; that over many years the position of the whole host of heaven changes for us; together with other matters particular to it.

סימן ק״ז (§107) — On the belts of the zodiac and their shapes, and why they were called by their known names

It is already explained, in the mathematical science [סלמודית], clearly and by demonstration, that most [geometric points] are of a fineness that has no measure at all: even thousands of thousands of points [נקודות] cannot combine to make a line. Likewise, in accordance with their great fineness, [a line] has no breadth at all: even thousands of thousands of lines cannot combine to make of them a surface. For points and lines are only markers of a boundary [and have no extension]. So you should know that in all the aforementioned circles of the sphere, none of them has any measure of breadth at all — not even as much as the point of a needle. Nonetheless, know that the astronomers gave the zodiac circle a breadth of twelve degrees [רוחב י״ב מעלות] in the sphere; and the later sages, who were more precise in their measurements, added to the first measure until they gave it a breadth of [?] degrees, for a reason that has been explained — [namely,] so as to encompass within a circle of such breadth [all that is needed]. They called it "the belts of the zodiac" [חגורות המזלות], and in the Latin tongue they call it "zodiacum" [ובלשון לטיי״ן קורין לו נודיאקו״ם, as printed]. The line at its middle, which divides its breadth into two, [with so many] degrees to each side, is the line of the zodiac circle itself [the ecliptic], whose path [runs through it].[197]

[This central line] has no breadth at all, like the other circles of the sphere; beneath this aforementioned line the sun always travels [מהלך השמש], and — to the ancients — [the sun] never departs from it, all the days of the world, for which reason it is called "the course" [מסלול]. This line is also called "the line [קו…]"; and in the Latin tongue [it is called] "linea ecliptica" [Latin: linea

[197] the name of the branch of learning at the head of this siman is set defectively — its opening sort is a closed form, so the word as printed is neither of the two names it stands between. The sense is not in doubt; the printed form is given as it stands.

ecliptica, "the ecliptic line"], because eclipses [קדרות] befall neither the sun nor the moon except when they are beneath this line — as will be explained further. And now hear the definitive rule and law of the belts and the circle of the zodiac and its working.

Know that the scholars of stars and signs divided the whole length around the belt of the zodiac into twelve large parts [לי״ב חלקים גדולים], each part comprising exactly thirty degrees [שלשים מעלות] — so that the sum of the degrees of all twelve amounts to 360 degrees [ש״ס]. These large parts they called "signs" [מזלות], and to each sign they gave a name according to the figure depicted there, [each] in its place. Their names are: (Aries [טלה], Taurus [שור], Gemini [תאומים], Cancer [סרטן], Leo [אריה], Virgo [בתולה], Libra [מאזנים], Scorpio [עקרב], Sagittarius [קשת], Capricorn [גדי], Aquarius [דלי], Pisces [דגים]); and a mnemonic for them is: **טש״ת סא״ב מע״ק נד״ד** [so printed at all four groups; the fourth group's first letter is a nun with a full left foot, not a gimel. The sense of the mnemonic calls for גד״ד — Gedi, Deli, Dagim — and the same נד״ד recurs at §142; the printed form is preserved and no compositor error is asserted].

And you should know that these figures mentioned are [merely conventional]: the sages did not fix them as shapes in the [heavens] themselves, but only as it arose in the mind of the ancients

[§107, continued — right column:] …to depict a shape for each and every sign, as [the students would see]; the ancients [did this] in order to [teach] them and to instruct the students, [saying]: this star [belongs] to this [sign], and this star to that [sign] — so as to mark and depict thereby the figures, [and to say,] "such-and-such a star is on the head of Aries [ראש מזל טלה], such-and-such a star hangs on its horn, this on its nose, this on its back," and so on; and so they did for all the figures — Taurus, Gemini, and the rest. Had it arisen in the mind of the ancients [otherwise], they would have named [them otherwise], as you [may] see in the nature of the compound stars of which we spoke above, in the First Section, in §56 [?נ״ו]: for the astronomers depicted [certain stars] as the figure of a Bear [דוב], whereas the common folk depict [them] as a Wagon [עגלה]. And so with the belts of the zodiac [and the rest], whose total is [140? ק״מ] [?] figures, [which] they now [use] to remember [the stars] by [?].

As for why the ancients chose to depict each of the twelve [signs] of the sphere in the figures of living creatures [בצורות בעלי חיים], and not [otherwise] — this is not without reason. Some say [יש אומרים] that each figure and sign indicates a specific action and property known to [each]: as Leo [אריה] and [Aries] indicate strength [גבורה], Virgo [בתולה] [indicates] satiety [שובע, i.e. harvest], Libra [מאזנים] justice [משפט], and so on; [Gemini indicates?] the heavens, and so the rest of the figures. For it is already known that every [herb below has a power set over it]; [the constellations were] given, from the days of creation, power and benefit for the array [of nature] — as our Sages of blessed memory hinted, saying, "There is no herb below that does not have a constellation [mazal] in

the firmament that strikes it and says to it, 'Grow'" [Bereishis Rabbah 10:6][198] — and [likewise] "as it says, 'Do you know the ordinances of heaven,' and so on" [Iyov 38:33] [as printed, שנאמר הידעת חקות שמים וגו']. So too, chapter "Ve-elu megalchin" [as printed, ובפ׳ אלו מגלחין — the leaf names the chapter only, not the tractate; the first reading supplied "Moed Katan"], [it is stated] according to their testimony of blessed memory [?] — concerning [the influence] and the decree of the stars.

סימן ק״ח (§108) — For what reason the astronomers gave the zodiac circle the aforementioned breadth

Know that the astronomers examined closely and found, in accordance with their observations, and said that the course of the sun in its sphere is always aimed, at its center, beneath the middle of the belt of the signs — that is, beneath the line that divides the breadth of the belt in two, which is the line of eclipses [קו הקדרות, the ecliptic] mentioned above. In their view the sun never departs from it, all the days of the world. The other planets [כוכבי לכת] revolve always close alongside this line, and not one of them goes far from it: according to the view of the earlier astronomers, six degrees at the most, and according to the view of the later ones, eight degrees [לפי דעת הראשונים לכל היותר שש מעלות ולדעת האחרוני׳ שמנה מעלות]. The demonstration for each and every one of the wandering stars, and the measures of their nearness to and distance from this line, will be explained to you further on, in the Eighth Section, §241 [בשער השמיני בסי׳ רמ״א], God willing.

And I, the writer, heard from the mouth of the eminent astronomer (Iohannes Keplerum) [יאהאני״ס קעפליר״ום — Johannes Kepler] that the utmost distance of the star Venus [נוגה] from the line of eclipses, toward the north and likewise toward the south, is three degrees [ג׳ מעלות]; … Jupiter [צדק [?]], toward the south, [?] degrees; … Mars [מאדים], its utmost distance toward the north, three degrees; … three and a half degrees [ג׳ מעלות ומחצה]; … and Mercury [וכוכב] goes off three degrees to each side, and the moon [ולבנה] five [?] degrees [ה׳ מעלות]. [The values for the intervening planets run into the binding gutter and are not committed; the two figures the report of Kepler turns on — 3° and 3½° — are printed and secure.]

in all, extending three degrees [ג׳ מעלות] to each side.

סימן ק״ט (§109) — That the ancients agreed, by reasoning and sound cause, to set the sign Aries as the head of the zodiac signs

Although the sphericity of the sphere admits in it no [beginning], and no [fixed] endpoint by first intuition — so that [it would be] fitting [to begin anywhere] — when the sages wished to establish and be precise about the

[198] the leaf's two chapter-name pointers here are illegible, and no tractate or chapter is supplied for them.

course of the sphere of the signs, they were obliged to choose for themselves a known point, upon which to agree, to set as the head from which to begin the reckoning. And since every part of the sphere of the signs is equal [to every other], [they had grounds to choose]. Yet they chose [a particular point] on account of several natural properties that exist [there] and that make it fitting to set as head and beginning: [namely, one] of [four?] points on the sphere, and they are — the head of the sign Aries [ראש מזל טלה] and [the points] paired opposite it [?], where day and night are equal in all climes [the equinox]; and it happens to them [?] at the time [of the equinox], balanced between heat and cold, and [likewise] the two points [of the solstices], the head of Cancer and the head of Capricorn [ראש סרטן וראש גדי] — [Cancer,] where, upon the sun's entering the head of Cancer, the summer reaches its fullness for us and the heat is at its strongest; and [Capricorn,] where, upon the sun's entering the head of Capricorn, the summer [i.e. daylight] is at its shortest for us and the cold reaches its completion, as all this was explained above, in the Second [?] Section. So you have four points, which have a status more distinguished than the other parts of the circle of the zodiac.

Indeed, [know] further that we [chose Aries] because, at the entry of the sun into [Aries], the time of the conjunction [?] [falls] between the lengthening of the days and their shortening [i.e. the equinox]; and this is so [?] — for most inhabitants of the world, and for those who dwell in the north, the [equinox] is the [balance] between cold and [heat], [always] equal, [the] mid-point between the two climes. In this regard, [the sign] and [the points] paired [with it] are equal. The astronomers therefore [chose the head of Aries]: for when [the sun] enters it, [it is] the moment [that] finishes the [?] — [the change] between cold and [warmth] — [the season] neither very cold nor [?]. At [the sun's rising into Aries], the living creatures and the plants [flourish], for the heaven [grants ease] and moisture; the warmth exceeds [the cold], and the heat over the cold; the [vital fluid, the blood,] begins to increase in the body of living creatures, [both] man [and beast]; [the plants] are saved and blossom — every herb and [growth] sprouts from the ground. The reverse of all this [comes] from the time of the sun's entering the sign [of Capricorn, in the] signs [of winter], at which begins the onset of the winter days, whose season is cold and dry and brings [everything] to decay, in every matter [that concerns] the sustenance of man [?]. Therefore they judged the sign Aries [to have] the status of the firstborn [משפט הבכורה], being the head and beginning of all the twelve [signs], each of thirty [?] degrees [כל י"ב מעלות; "the twelve," each 30°].

סימן ק"י (§110) — The figures on the sphere of the zodiac are reckoned in two ways [aspects]

Know that the figures on the [belt] of the sphere of the zodiac have two distinct considerations [שתי בחינות], according to what was mentioned at length in its place, [where] the astronomers agreed [to set?] the sign Aries as the head of

the signs, which is received [as the point?] from which they open [i.e. begin] the line of the signs and the line [of the ecliptic?]…

שער ה — The Fifth Gate (Sha'ar 5), continued

Running header on every page: *שער ה* (Sha'ar 5). The prose is set in two columns per page (read right column first, then left). The 1743 square type is heavily worn on these leaves; genuinely illegible words and numerals are flagged *[?]*.

[§110, conclusion — from PDF p. 77]

and so they divided the sphere of the signs into twelve parts, and each part is called a mazal (a sign). By this reckoning nothing changes: no sign ever departs from its allotted domain. Upon the sphere [of the constellations], however, there is a slow motion [precession], so that over the long course of time the figures shift away from the points at which they once stood, [drifting] from the equinoctial point [?]. The twelve signs, by contrast, are bound and joined fast to the equinoctial point [נקודת המשוה], fixed so that [that point] never separates and never [departs] — from the beginning of Aries [ראש טלה]; and the figures [of the constellations] remain bound [to the parchment globe], and by [precession the equinox] never breaks off entirely [?].

And the second consideration is according to the disposition of the signs themselves that are in the eighth sphere. And those signs are in motion, by reason of that slow motion — one degree in a hundred or in seventy years [התנועה כבדה כמו למאה או לשבעים שנה מעלה א׳]. And the law of this consideration is not as the law of the first consideration, for it alters the relation to the sphere of the equator and to the [other] spheres; and by this consideration the head of Aries and [the head of] Libra are not fixed at the two [equinoctial] points, but the point and the points of the head [of Aries] and of Libra are in motion — not merely away from the point of the equinox, but they move also a great distance from the place of the equinox. And by this second consideration these are the celestial [?] signs, the bearers of the figures visible to our eyes; and it is to these true, moving signs — so the Israeli says — that the star-diviners direct themselves [?], and [they observe?] the stars for the needs of their science […] the figures of the stars; whereas for the reckoning of the times [?] the sages reckon by the fixed signs.

And you should know that we too, the holy congregation of Israel, reckon in the reckoning of the intercalation — the molados and the tekufos [?] and the fixing of the festivals — upon the foundation of the first consideration. For example, the tekufah of Nisan, which is the New Moon of the Aviv: we

reckon it at the moment [?] … at the hour, by the head of Aries as marked in the sphere of the [?]. For were we to reckon the tekufah of Nisan, by way of illustration, by the sun's entry into the head of the sign Aries that bears the figure, then Pesach would sometimes fall in the middle of the summer, and also in the middle of the winter — because after many years all the host of heaven shifts [?], as will be explained shortly; and then there would not be fulfilled "Keep the month of the Aviv and make the Pesach offering," nor "and on the day of the first-fruits, when you bring a new meal-offering" etc., nor yet "the feast of ingathering at the turn of the year," and the other verses. And these [?] are why we look not to the reckoning of the intercalation [alone] but to the entry [of the sun] into the head of Aries as engraved [?] in the ninth, dividing sphere — for [that is the head of Aries] of the fixed signs, which never move.

And the difference found between the two considerations, with respect to the head of Aries that bears the figure and the head of Aries that is in the upper [?] sphere — know that this matter is not yet known to me with certainty, nor in its fullness. But according to what I have seen upon the corporeal globes made by the astronomers of our own time, and also according to what I have heard from writers and reporters [?]: the figure-bearing sign Aries has already slipped away from the equinoctial point in the upper sphere by more than one whole sign — that is, by thirty degrees [יותר ממזל א' שהוא שלשים מעלו] — and likewise all the other signs have slipped [?], each from its place, by more than a whole sign.

And you should know that I found in the words of the Israeli, in the second chapter of the second essay [בפ' שני מאמר שני], that in his time the head of the moving sign Aries was marked [?] on the sphere, as on the equator, exactly opposite the tenth degree of the fixed sign Aries — just as the head of the fixed sign Pisces was in his time marked opposite the tenth degree of the moving sign Pisces. And he wrote further there that [?] fifty [?] years [ש"ן] before his own time — according to what I have heard from the modern investigators in this present age, that the head of the sign [?] — you should know that the moving [head] and the head of the fixed sign Aries were marked, or aligned, one exactly opposite the other, standing joined upon the sphere of the equator; and likewise the sign Libra and all the other portions of the signs. And there was then, on this reckoning, no difference at all in the [?] places of the stars between the fixed signs and the moving ones — thus far his words.

And if the words of the sages of our own time are true, that a sign has already slipped by about thirty degrees [כמו ל' מעלות], then by the reckoning of the Rav, the Israeli, it is far-fetched: for from the Rav's time to our own is only about three hundred years [רק כמו שלש מאות שנה], and it is impossible, by that reckoning, that the signs should have slipped twenty degrees [עשרים מעלות] from his time until now.

סימן קיא (§111)

The constellations bearing figures in the eighth sphere are not equal to one another in their measure — neither in their length nor in their breadth.

The stars and the ancient constellations, which [the ancients] named — each according to the figure they agreed upon for it [?] — [the ancients] did not divide the constellations into equal portions, neither in their length nor [in their breadth]; for there are constellations that are compressed [יקדר] by their nature, such as Cancer, because its place [?]... and [some are] short, spanning [few] degrees of the twelve [signs]... while others [are long], spanning [more] of the twelve... spreading over into the portion of the sign before it and into the sign [after it].

Now know that not all the figures of the constellations are equal in their [extent]; rather, one of them inclines toward the north [like...] and one inclines toward the south, like Scorpio — all this [being depicted] as figures upon the globe that resembles the sphere of the heavens. And as to why [the ancients] did not divide them into equal portions: I do not know a sufficient reason [?]; only what has been mentioned, [namely] a tradition [handed down] to you [?] — "such a constellation abides thus, and opposite it such a constellation holds [thus]" [?] — and by these [figures] they gaze upon [the heavens] [reading uncertain].

סימן קיב (§112)

That all the stars of the firmament are divided among the twelve signs.

Since the circle of the signs — whose parts are 360 degrees [ש"ס] — [they reckon the stars] to it, and its breadth is twelve or sixteen degrees [וברוחב י"ב או ט"ז מעלות]...[199]

and they also divided it into twelve parts and called each part [a sign], so that the measure of each sign in length is thirty degrees, and in breadth twelve or sixteen degrees [וברוחב י"ב או ט"ז מעלות — the printed disjunction, matching §108's six or eight degrees to each side of the ecliptic]. [Ptolemy?] makes known that they wrote down for one consideration [?]: for its length 180 degrees and for its breadth thirty degrees. After they had divided the circle of the signs into twelve parts, the lines that [run] between each sign and the next are drawn from both sides — [north] and south — to the two poles of the circle [of the signs]. In this manner no star in the eighth firmament will [fall outside] one of the twelve signs; and it follows, by this consideration, that each sign [runs] from pole to pole 180 degrees, while its breadth, corresponding to a length of thirty degrees — thirty degrees [?] — [narrows], for the widths of those parts diminish and taper from both sides after their [maximum], until, on

[199] the breadth is given as a pair of alternatives in both places, never as a single figure; the second figure of the first occurrence is filled with ink on both copies and rests on the second occurrence, which is clean.

reaching the two poles from this side and that, they return to the [pole-]point and have no breadth at all.

סימן קיג (§113)

That the divisions of the sphere of the signs are reckoned according to seven considerations.

In sum: from the things we have mentioned it will be clear to you that the divisions of the sphere [of the signs] are reckoned according to seven considerations. (א) The degrees of the equator [קו המשוה], and likewise the degrees of the ecliptic [קו הלקות] or otherwise: the division of the 360 degrees of the sphere into twelve parts, which are the twelve signs, the length of each sign being thirty degrees. (ב) [The breadth...] [?]. (ג) [...] the twelve signs [?]. (ד) A breadth of thirty degrees [?]. (ה) Consider the lengths of the signs [?]... (ו) [consideration illegible — [?]].

And there is furthermore a seventh consideration [ועוד יש בחינה שביעית], added to the foregoing considerations — a new consideration, which I received from the scholar Kepler [אשר קבלתי מהחכם קעפלירו"ם — ס and final ם are inseparable in this fount, so the final sort is recorded as printed and left unresolved; Johannes Kepler]. Take an apple and cut it into twelve equal parts [קח לך תפוח א' ותחתוך אותו לי"ב חלקים שוים]; [in this way the divisions run through the whole depth of the sphere, and not along its surface alone] … and by this consideration are reckoned the comets [כוכבי דשביט], that is, the stars with tails [ר"ל כוכבי בזנבות], called cometa in the vernacular [קומ"ט"א בלע"ז].

סימן קיד (§114)

[Printed heading abbreviated; reads "*סי' קיד*"]

The six signs [that stand above the horizon]... are not found [equal, neither to the east] nor to the west, except for those who dwell beneath the equator [קו השוה].

We have already explained in the Second Gate, in §36 [בשער השני בסי' ל"ו], that for all the dwellers of the earth there is always visible half of the circle of the signs — that is, six signs visible [?] over against their horizon — and six signs sunk and hidden from their eyes beneath their horizon, at every hour of the time and in every place in the world. But you should know that a great and wonderful difference is found between those who dwell beneath the line of right [קו הישר — the equator, sphaera recta] and those who dwell beneath the oblique [המעותות — sphaera obliqua]. For all who dwell beneath the line of right have their meridian dividing [?] equally the signs visible to them above their horizon into two equal parts; and at those [times] of the world they will have three signs to the east of their meridian and three signs to its west. And when there is taken for them [?] — at one of the [seasons] — the head of the sign Aries upon [?] the eastern horizon, then the head of the sign Libra has set for them beneath the western horizon, and there stands accordingly the head of Cancer

upon their meridian above, and the head of the sign ♑di [מזל ♑ די] upon the meridian opposite the soles of the feet, beneath the earth. And likewise will the law be for the rest of the signs always: whenever one sign is taken for them and the second sign opposite it sets for them, then the beginning of the third sign, which has already risen before the visible ones [?], will always be for them in mid-heaven — that is, on the meridian above them; and the beginning of the third sign after the visible ones [?] will always be for them on the meridian beneath the earth. And this is the law of those who dwell in the land of the line of right, or [?] of those who dwell elsewhere on the days of the Nisan and Tishrei equinoxes [תקופת ניסן ותשרי].

However, those who dwell beneath the oblique [המעו[ת/ק]ות — the two witnesses do not agree on the fifth letter; unreconciled] have other laws and other rules in the matter of the division of the six signs. For according to the distances of the dwellers from the side of the line of right, so will the division be in the dividing of the [?] portions of the circle of the signs on the two sides of their meridian — that is, on the eastern side and on the western side; for [?] some of them, when two and a half of the signs are complete on the meridian's side toward the east, and two and a half of the signs toward the west. And so is the measure [?] of the thing in its reverse, all according to the time and according to the dwellers of the climes. Take an illustration of this kind for us, the dwellers of the city of Prague [עיר פרא״ג], where the elevation [?] of the north pole is about fifty degrees [חמשים, written out, not as gematria]; thus on the day…

> PRINTED DITTOGRAPHY at p. 78, left column, lines L16 and L18, shown twice as the forme prints it — both lines carry ותחלת מזל השלישי … הנגלים, they sit on non-overlapping line cores in both witnesses (with L17 between them), and their continuations differ (שכבר עלה לפני against שלאחר). The second reading transcribed both and refused to merge. Both stand in the restored paragraph above ("the beginning of the third sign, which has already risen before the visible ones … and the beginning of the third sign after the visible ones"). This is the compositor's text; showing it once would be a silent deletion.

סימן קטו (§115)

[Printed heading "*סי' קטו*"]

[That every sign draws out its rising over a set span of time — the division of the rising-time into hours and minutes.] (heading partly degraded)

From the moment each sign begins [to rise until it has risen] wholly [?]... by reason of the [governing] principle [?]... hours; and this matter needs no lengthy explanation [ודבר זה אינצריך ביאור רב]... that [the sphere] makes a complete revolution, from the one point to the same point again, within 24

hours [סבוב גמור מן הקלה אל הקלה בכדי ך״ד שעות][200], so that in its course it reaches every [meridian/point] [?]. ...so there comes to each sign two and a half hours [שתי שעו׳ ומחצ׳], since every sign covers thirty [שלשים] degrees; and there comes to each equinoctial hour [שעה ושעה ישרה] fifteen [ט״ו] degrees — approximately.) And he said "approximately" because [בקרוב) ואמר בקרוב מפני ש] the daily sphere completes its revolution before [the sun completes] its own circuit, as stated above in siman 106 [סי׳ ק״ו].[201]

סימן קטז (§116)

That every day six signs rise, and likewise in its night — whether the day or the night be long or short.

In all the climates [אקלימים] [six signs rise], and likewise six signs [set] during the night; in every climate, no fewer and no more [than six]. If the day be [short], then the night is long [?]... and so six signs rise in the span of six [hours] [?].

סימן קיז (§117)

Explanation of the ascensions of the signs [**מצעדי המזלות**] and their direct rising [**וישר**]: that there is a sign which rises slowly (at length) and a sign which rises quickly (in short span).

The divisions of the signs [as they cross] the horizon — the astronomers call them the ascensions of the signs [מצעדי המזלות] [and the "line of right" / right ascension], of which we shall speak [?]. Let it be known to the reader that the division of time into hours and minutes [corresponds to] what the sphere of right [גלגל הישר — the celestial equator] revolves over the horizon, or over the meridian [קו חצי היום]... [that is,] the daily rotation of the sphere, as was explained above in the fourth Gate, §100 [כמו שנתבאר למעלה בשע׳ הרביע׳ בסי׳ ק׳] — in such a way that you may know the time of the rising of the signs, namely, their ascensions.[202]

These too are reckoned by the revolution of the parts of the sphere of right [equator], which circles for the dwellers of the world at large [ליושבי חלד], at a

[200] the leaf sets the 24 with a final kaf — ך״ד, not כ״ד — the sort carrying a descender below the line of writing that the ד beside it does not. The value is 24 either way; the form is given as printed, this fount using final letterforms as live numerals.

[201] three figures — a sign rises in two and a half hours, a sign spans thirty degrees, an equinoctial hour carries fifteen degrees. Thirty degrees in two and a half hours is twelve an hour, not fifteen; and this siman's own printed heading says two hours, not two and a half. All three are given as set and not reconciled; the leaf itself qualifies the fifteen as approximate and appends a parenthesis explaining why.

[202] the back-reference names both a Gate and a siman — the Fourth Gate and siman 100 — and is printed split across a line break, … בשע׳ הרביע׳ ending one line and בסי׳ ק׳ opening the next; either half alone gives a wrong reference. All four elements are abbreviated with a geresh, and the bracket carries them as set.

measure and rate of about fifteen [ט״ו] degrees an hour; it hastens and does not tarry in its rising, [nor] in its setting.[203]

And now know: when we are exact concerning the ascensions of the signs — although they too, of themselves, revolve perpetually at one measure, and neither hasten nor tarry in their revolution from one time to another — nevertheless, because of their inclination from the line of right [the equator], we have found that they are appointed upon the horizon, for the dwellers of the inhabited earth [ליושבי תבל], in equal times, [in] differing parts — sometimes [[15]] [ט״[[ו/ז]]] degrees an hour, and sometimes more than this and sometimes less than this.[204] The matter, and its reason — hear it: Know that were the sphere of right [equator] standing directly [above], from the [meridian] — as [a straight line] [?] — from pole to pole... [it would rise evenly]; but [because the ecliptic is oblique,] the signs precede and lag, one relative to another, upon the poles and axis of the circle of the signs [ecliptic], which are inclined from the poles of the world — as stated above in siman 36 [סי׳ ל״ו] — because [the ecliptic] is [inclined] from the sphere of right [equator] and does not stand directly opposite it.[205]

[the signs] Gemini and Cancer, and likewise Sagittarius and Capricorn — since their standing [?]... [Aries and Pisces, near the equinox,] stand more evenly opposite the equator than all the other signs [?]; [for these] they call it "direct rising" [עלייה ישרה], yet even so their rising is a [slow] rising [?] — [only] slightly [faster] [?], because the circle of the equator stands [obliquely to] the globe. As for Sagittarius [and the others]... the four signs mentioned, [28?] [numeral [?]]... [standing] opposite the equator [?]... [at] the lower part of the globe, it follows from this that... its standing opposite [it] and the measure of its arc holds more [?]... [the ascension of] Sagittarius equals the length of the sign lying opposite it, measured from the arc of the [equator].

of the equator, more parts than what stands [?] at the lower parts. Therefore, in the motion of the diurnal sphere with respect to the two arcs, it revolves and rises above the horizon; and in one [א׳] and the same time there rise, of a portion of the equator, more parts than rise of a portion of the sign.

And since the times [?] of the hours are reckoned according to the revolution of the equator, as stated above [כנ״ל], it follows that the revolution of a portion of the sign — which is thirty [שלשים, spelled out] degrees — is delayed until there rise, of the equator, more than thirty degrees, since this one is longer than it.

---

[203] the two per-hour figures in this siman belong to two differently named classes of dwellers — those of חלד here, and those of תבל in the paragraph below.

[204] this second per-hour figure is set with a final form of its second letter, which is not a well-formed numeral. It is given as printed and no value is supplied for it.

[205] the second sort of this numeral is not determinable from either copy. It is given as a choice rather than resolved, and the same form is used at every occurrence of this numeral on these leaves.

It has thereby become clear to us that a portion of the aforementioned signs [המזלות הנזכרים] is delayed in its rising behind the portion of the right line [the equator] that faces it; the measure of the delay is about two [שתי] degrees and more — which, by the reckoning of a revolution of 15 [ט״ו] degrees per hour, means their rising is delayed by **חלק א׳ מט״ו** [= one part in fifteen] of an hour, approximately.

And the signs Taurus, Leo, Scorpio, Aquarius — since their standing is upon intermediate lines, so that they neither stand so obliquely, [ונסתיכם — six legible glyphs on both witnesses forming no construable word; syntax wants something like ואינם, which the ink does not support, so nothing is substituted] nor stand so directly opposite the right line — therefore they do not differ in their position opposite the portion [?] of the right line save by a very little, in that they are delayed in their rising; and because of this smallness they are counted in the class of crooked risings.

The sum that emerges from our aforementioned words [מדברינו הנז׳ [?]]: eight [שמנה, spelled out] signs — Aries, Taurus, Leo, Virgo, Libra, Scorpio, Aquarius, Pisces — since all of them incline toward the oblique, are in the class of crooked rising and setting; and the four other signs — Gemini, Cancer, Capricorn, Sagittarius — since they do not incline toward the oblique, are in the class of the right risings and settings.[206]

סימן קיח (§118)

Explanation that in [four] places the divisions of the signs vary [in relation to] the divisions of the equator [**קו הישר**].

Know that for those who dwell beneath the equator [קו הישר], the signs are made equal, day by day, with the divisions of the equator.[207] [At four places] the sphere of the signs [rises] in its equal place, day and night: these are the beginnings [ראשי] of the signs Aries and Libra [the equinoctial points], and the [two] places where the sun stands [at its turning], the beginnings of the signs Cancer and Capricorn [the solstitial points]. And what [one place] falls short, [the other] fills [?].[208]

[at the] returns of the signs Aries and [Libra?]... [these] signs, and their rising [takes] less than two hours [?]... and [Aries?] and Sagittarius are made equal; there [one] precedes [?]... more than [42?] hours [numeral [?]], and likewise the law is [as for...] [?]; [whereas] in Cancer and Capricorn the rising of the equator precedes [?]... and [Libra?] is made equal, [where] the [equator] lags [?].

---

[206] both lists are printed out of zodiacal order, and the four are set גדי תאומים סרטן גדי קשת — גדי before קשת. The order is retained as printed.

[207] this siman names those dwelling under the equinoctial line and gives no rate for them; the per-hour figures in the neighbourhood belong to other dwellers.

[208] what §118 enumerates is not a list of signs but four points — the two equinoctial and the two solstitial — matching its own rubric's ד׳ מקומות.

סימן קיט (§119)

The order of precedence and lag, according to the arrangement of the four quadrants of the sphere [**ארבע רביעי הגלגל**].

In the first quadrant, Aries [precedes]... Taurus lags [?]. In the second quadrant, Cancer lags [?]... In the third quadrant, [Libra]... [?]... In the fourth quadrant, Capricorn lags [with] Aquarius [?]. And just as [is] the rule in their rising, so [is] the rule in their [setting]: [what] lags in its rising [?] precedes... [what] lags in [setting] [?]. And [the reverse] holds in their rising upon the horizon [?], and [the reverse] in their setting upon [it] [?].

סימן ק״ך (§120) — The Ascension Table

[Printed heading appears abbreviated as "*ס״ק*"; by the running sequence §111–§119 it is §120. Numbering flagged in QA.]

A small table [showing] how many degrees and minutes — [and how many] hours and minutes — the rising of each sign [takes], whether direct [rising] or [oblique].

I saw fit to set before you a small table, in which you will find the direct ascensions and the oblique ones — how many degrees each sign precedes or lags, reckoning fifteen degrees to the hour [**לפי חשבון ט״ו מעלות לשעה**]. And I will explain one row of it to you, from which you may understand the remaining rows. Aries rises wholly in the time of the rising, from the right sphere [**מקו הישר**], of 27 degrees and 54 minutes [**ך״ז מעלות ונ״ד דקין**], and these rise in one hour and 51 minutes [**בשעה א׳ ונ״א דקין**]; and so the rest.

Table (§120)

The table has a right-hand label column giving the row names and twelve sign columns. In the markdown below the row-label is placed first (left) for rendering, and the twelve sign columns are given in logical order, Aries → Pisces.

The rows are: a header naming each sign, a header classification **ישרה / מעוות** (direct / oblique), **מעלות** (degrees of ascension), **דקין** (minutes), a ✻ separator row, **שעות** (hours of rising), **דקין** (minutes).

Each interior cell holds a two-letter gematria set as a vertical pair — tens above, units below. The three rows below are recovered from the ink of the leaf, and the recovery is corroborated by the arithmetic and by the position of the distinctive tall **ל** ascender, which appears at the four 32° columns and nowhere else.

(row)	ראש טלה [Aries]	ראש שור [Taurus]	ראש תאומים [Gemini]	ראש סרטן [Cancer]	ראש אריה [Leo]	ראש בתולה [Virgo]	ראש מאזנים [Libra]	ראש עקרב [Scorpio]	ראש קשת [Sagittarius]	ראש גדי [Capricorn]	ראש דלי [Aquarius]	ראש דגים [Pisces]
ישרה / מעוות	מעוות	מעוות	**ישרה**	**ישרה**	מעוות	מעוות	מעוות	מעוות	**ישרה**	**ישרה**	מעוות	מעוות

(row)	ראש טלה [Aries]	ראש שור [Taurus]	ראש תאומים [Gemini]	ראש סרטן [Cancer]	ראש אריה [Leo]	ראש בתולה [Virgo]	ראש מאזנים [Libra]	ראש עקרב [Scorpio]	ראש קשת [Sagittarius]	ראש גדי [Capricorn]	ראש דלי [Aquarius]	ראש דגים [Pisces]
מעלות (degrees)	כ״ז — 27	כ״ט — 29	ל״ב — 32	ל״ב — 32	כ״ט — 29	כ״ז — 27	כ״ז — 27	כ״ט — 29	ל״ב — 32	ל״ב — 32	כ״ט — 29	כ״ז — 27
דקין (minutes)	נ״ד — 54	נ״ד — 54	י״ב — 12	י״ב — 12	נ״ד — 54	נ״ד — 54	נ״ד — 54	נ״ד — 54	י״ב — 12	י״ב — 12	נ״ד — 54	נ״ד — 54
*	*	*	*	*	*	*	*	*	*	*	*	*
שעות (hours)	א — 1	א — 1	ב — 2	ב — 2	א — 1	א — 1	א — 1	א — 1	ב — 2	ב — 2	א — 1	א — 1
דקין (minutes)	נ״א — 51	נט — 59	ח — 8	ח — 8	נט — 59	נא — 51	נא — 51	[[broken sort]]ט — not resolved	ח — 8	ח — 8	נט — 59	נא — 51

שער ה — Fifth Section (continued)

סימן קכ״א — §121. The laws of precedence and lag in the ascensions of the signs, for those dwelling beneath the oblique [**ליושבי תחת המעוות**][209]

Know that everything we said above concerning the differences and distinctions found in the ascensions [מצעדי] of the signs applies specifically to those who dwell upon the equatorial line [קו הישר / the equator]. As for those who dwell [away from it], you should know this: the precedence and lag relative to the equator is only slight — the difference amounts to no more than about five degrees, so that the sign which is the most delayed of all [differs only a little]; the difference between them [is small]. But for the stars and signs [situated far] from the equator, the difference will be great and considerable, roughly in proportion [to the distance]; and it all depends on the amount of inclination [נטייה] from the equator: the farther they are from the equatorial line, the greater [the difference], as will be explained further on.

And know that as for the risings and settings [and ascensions] for us [in these latitudes]: the [six signs mnemonically marked] (ט״ט ת נד״ד [?] — the printed mnemonic is garbled; it denotes one half-group of six signs) rise quickly upon [the horizon], for all of them are swift in their rising and slow in their setting; whereas the [six signs marked] (סמ״כ מע״ק [?] — the other half-group, printed mnemonic garbled) [rise slowly], for all of them are slow in their rising and slow [in their setting]. And know that the stars outside the equator do not [rise and set] in the manner of the straight sphere [גלגל הישר] except in two places only [the two equinoctial points].

סימן קכ״ב — §122. A table [showing] how much the rising of the signs and their setting amount to, for us the inhabitants of the city of Prague

For the completeness of the work, I have thought fit to set before you a small table, constructed according to the elevation of our pole here in Prague, from which you may learn the rising and the setting of every sign — in degrees and minutes — how many parts each of them rises. Thus, according to the reckoning of the complete motions [תנועות שלמים] of the degrees upon the

[209] the heading is printed with the word for the oblique, not the word for the equator, and the same family of forms is printed in §101's heading two leaves earlier. An earlier reading emended it toward the expected term on grounds of sense; the printed form is restored.

straight sphere [גלגל הישר], [you may know] the risings and settings of each sign.

The meaning of this table is precisely the double [כפל] of the adjacent table above [i.e., the right-sphere ascensions]. For example, the sign Aries — as its column shows — its entire rising in time, reckoned from the equator [קו הישר], amounts to thirteen degrees and fifty-one minutes [י״ג מעלות ן״א דקין]; and they rise twenty-three minutes [כ״ג דקין] of an hour. All of this is written according to the elevation of the pole here in Prague, whose pole-elevation is fifty degrees and six minutes [נ׳ מעלות ו׳ דקין].[210] And from it one may verify, by the science of the sphere, [the corresponding values] for the [other] signs — for each and every place, according to the elevation of its pole.

עליית המזלות — Rising of the Signs [Table, for Prague]

Twelve sign-columns plus a row-label column; a ישרה / מעוות classification row and four data rows. On the leaf the signs run Aries at the far LEFT to Pisces at the far right, and the row-label stub stands at the left margin; the markdown below places the row label first and the twelve sign columns in logical order, Aries → Pisces.

(row)	טלה (Aries)	שור (Taurus)	תאומים (Gemini)	סרטן (Cancer)	אריה (Leo)	בתולה (Virgo)	מאזנים (Libra)	עקרב (Scorpio)	קשת (Sagittarius)	גדי (Capricorn)	דלי (Aquarius)	דגים (Pisces)
ישרה / מעוות	מעוות	מעוות	מעוות	ישרה	ישרה	ישרה	ישרה	ישרה	ישרה	מעוות	מעוות	מעוות
מעלות (degrees)	י״ג — 13	י״ג — 13	ך״ו — 26	ל״ו — 36	מ״ב — 42	מ״ב — 42	מ״ב — 42	מ״ב — 42	ל״ו — 36	[numeral: ?]	י״ו — 16	י״ב — 12
דקין (minutes)	ך״א — 21	ך״ה — 25	מ״ה — 45	ל״ד — 34	ך״ו — 26	ך״ו — 26	ך״ו — 26	ך״ג — 23	ל״ט — 39	מ״ה — 45	ב — 2	ך״א — 21
שעות (hours)	✻	א — 1	א — 1	ב — 2	ב — 2	ב — 2	ב — 2	ב — 2	ב — 2	[numeral: ?]	[numeral: ?]	׳ — 0
דקין (minutes)	נ״ג — 53	יו״ד — 10	מ״ג — 43	ל״א — 31	ל״ד — 34	נ״ן — 50	נ״ן — 50	מ״ט — 49	ל״א — 31	מ״ג — 43	יו״ד — 10	נ״ג — 53

ירידת המזלות — Setting of the Signs [Table, for Prague]

Same structure as the rising table (twelve sign-columns, a classification row, four data rows). The signs again run Aries at the far LEFT of the leaf to Pisces at the far right; the markdown gives them in logical order, Aries → Pisces.

[210] the minutes figure is set with a final form of its first letter, which is not a well-formed numeral; given as printed. The clause's two figures do not close against one another — the stated ascension is not the stated fraction of an hour on any reduction. Both are given as set.

(row)	טלה (Aries)	שור (Taurus)	תאומים (Gemini)	סרטן (Cancer)	אריה (Leo)	בתולה (Virgo)	מאזנים (Libra)	עקרב (Scorpio)	קשת (Sagittarius)	גדי (Capricorn)	דלי (Aquarius)	דגים (Pisces)
ישרה / מעוות	**ישרה**	**ישרה**	**ישרה**	מעוות	מעוות	מעוות	מעוות	מעוות	מעוות	**ישרה**	**ישרה**	**ישרה**
מעלות (degrees)	נו״ן — 50	מ״ה — 45	ל״א — 31	מ״ג — 43	יו״ד — 10	ג — 3	נ״ג — 53	יו״ד — 10	מ״ג — 43	ל״א — 31	מ״ט — 49	נו״ן — 50
דקין (band 2)	ב — 2	ג — 3	נ — 50	א — 1	א — 1	° — 0	° — 0	א — 1	א — 1	ב — 2	ב — 2	ב — 2
שעות (hours)	ד״ו — 26	ד״ג — 23	ל״ד — 34	ד — 20	ד״ה — 25	ד״א — 21	ד״ו — 26	ד״ה — 25	מ״ה — 45	ל״ד — 34	ד״ג — 23	ד״ו — 26
דקין (minutes)	מ״ב — 42	מ״ב — 42	ל״ו 36	ד״ו — 26	י״ו — 16	י״ג — 13	י״ג — 13	י״ו — 16	ד״ו — 26	ל״ו — 36	מ״ב — 42	מ״ב — 42

A small note [**הערה קטנה**]. Know that everything we have said above about the rising of the signs and their ascensions — what rises [in one place] — rises differently elsewhere, [each place] according to its inhabitants' clime. Therefore know that for all who dwell outside the seven climes [**שבעת האקלימים**], the opposite is found regarding the settings and risings of the signs. And it is exceedingly wondrous that there are countries where the circle of the signs [stands upright] to the horizon [?]... so that each day, in each of the twelve signs [is divided]; then signs rise for them above the horizon and set opposite them, as [we explained]. There are also countries where the signs [rise in reverse]: Taurus [rises] before Aries, and Aries before Pisces [?]; countries where signs [become visible] and remain above their horizon... [others that] set from them all the days of the world, while the other signs never rise for them at all. Choose for yourself these natural arrangements, in their order [?].

סימן קכ״ג — §123. Concerning some people, for whom each day the circle of the signs [lies aligned] to the horizon, so that each of the twelve signs appears to them with half of it above the horizon and half of it below the horizon

Those encamped on the side of the equator toward the northern pole [**קוטב הצפוני**] — sixty-six degrees [**ס״ו מעלות**, so printed] and nine minutes [**ט׳ דקין**] — are, accordingly [?], distant from the northern axis twenty-three degrees and twenty-one minutes [**כ״ג מעלות כ״א דקין**], as [at] [?] the start of the countries of Iceland [**איס״לאנד**]. Likewise the inhabitants of the far end of the countries of Sweden [**זוועדין**] and Norway [**ונורוועג״ן**], for whom...[211]

[211] the second name is printed with the gershayim standing inside the word, before its final nun — the convention for a foreign name, not a numeral. Both forms are given as the leaf sets them.

סימן קכ״ד — §124. When the axis is inclined [so the pole stands at the zenith]: for the heads of people dwelling beneath the northern [pole] circle — as [at] the equator [?] — [six] signs of the zodiac rise and six set from it at one and the same moment [**בשעה אחת**]

Know that when [the pole is at their zenith]... from the circle of their vision [ראייתם] they do not [reach] to the horizon; rather the horizon cuts [the sphere] as any two great circles [that bisect each other], [and] so all [the signs]... and it is found [ונמצא] that [the horizon] will run from the head of Capricorn [מראש גדי] to the end of Gemini [ועד סוף תאומים], and those nine signs all rise above the horizon at one and the same moment [ואותן תשעה מזלות כולם עולים על האופק בפעם אחת]. And the nine signs opposite them set at one and the same moment [שוקעים בפעם א'], which in the [southern] places are near, as [described] below; [beneath] the northern [circle], since the whole sign of Capricorn [כל מזל גדי בכללו] [is included]... more than half of them always [remain above the horizon], only [some] set from them; and the sign of Cancer [ומזל סרטן] conversely [בהפוכו], by their inclination all of them descend below to them [below] the horizon, while the other signs rise. In all these matters, things appear [tangibly] on the instrument of the globe or the armillary sphere [בכלי הכדור או הספיר״א], which cannot be depicted upon a [flat] surface.[212]

סימן קכ״ה — §125. We find three signs that remain always above the horizon, and three [always] below it, and six that rise and set alternately [**מתחלפים**]

The people who dwell over against the equator [קו הישר] and incline toward the northern side by seventy degrees — for whom, correspondingly, the pole is elevated seventy degrees [ונוטים לצד הצפוני שבעים מעלות אשר כמו כן מתרוממים להם הציר שבעים מעלות], as stated above in §48 [כנ״ל בסי׳ מ״ח], so that the pole stands no more than twenty degrees from the point of their zenith, as in the countries of Nron and the countries of Angl [(נרו״ן ומדינות מאנג״ל) כמו מדינות] — for such people three signs of the fixed signs always remain above their horizon: the sign Cancer and the two signs on either side of it, Gemini and Leo; and the three signs opposite these — Capricorn and the two signs on either side of it, Sagittarius and Aquarius — are hidden from them beneath the horizon forever.

[212] §124 prints six in its rubric and nine in its body, and both stand as printed. The rubric on p. 82 sets … משה המזלות עולים על האופק וששה שוקעים ממנו בשעה אחת, while the body at the head of p. 83 sets תשעה, nine, twice. Neither is emended; the disagreement is the finding. Further, the last body word of p. 82's left column, imaged as הנ[?]קדים, is not read: on both witnesses the sorts after הנ image as ד+ס/ק+פ and do not close into a word. The geometry wants הנחתכים, "that intersect" — as the rendering above glosses it — but that is a reading from sense, not from the page, and is reported unresolved rather than supplied.

And there remain six signs that both rise and set for them always, and in these are found things very strange and wonderful. For three signs — Pisces, Aries, Taurus — rise for them in the reverse of the usual order and manner: there Taurus rises first and Aries after it, while they set in their order, Pisces first; and the rising and setting of the corresponding southern signs is likewise reversed. The reason is their nearness to the pole and the inclination of the horizon-line for those dwellers, so that the signs stand obliquely upon their horizon. The southern signs nearer to them are found more sunken and distant from view, and others are hidden from them forever.

סי׳ קכ״ז — §126. For some, four signs remain above their horizon and four [below]; and for some, six [remain] above the horizon and six always below it

You should further know that in some places, for those distant from the equator by seventy degrees [המרחיקים מקו הישר ע׳ מעלות], we find four signs — Taurus, Gemini, Cancer, Leo — remaining above their horizon always, never setting from it; and the four signs opposite them — Scorpio, Sagittarius, Capricorn, Aquarius — hidden from them beneath the horizon always. Six signs remain above their horizon, namely (ט״ש כ״ב, so printed); and six signs, namely (מע״ק נד״ד, so printed — the same fourth group as the mnemonic at §107, printed with a nun), are hidden from them beneath the horizon forever. All of this you can see by the working of the globe; and this matter will be well explained to you further on in this Section, in simanim קמ״ה קמ״ז (printed §§145 and 147 = logically §§146 and 148).[213]

סי׳ קכ״ז — §127. Reckoning the rising of the signs upon the horizon: some of them an evening rising [עלייה ערבית / acronychal], and some of them a morning rising [עלייה בוקרית / cosmical]

Know that for every sign, and likewise for every star, there is found an [inclination] with respect to rising, [in] two aspects: the one is called an "evening rising" and the other is called a "morning rising." The evening rising is when the star or sign rises… at any horizon… just after the sun has already set [in] the west; this rising is called an "evening rising," and for it one needs no demonstrative reckoning whatever, for the matters [are visible] to the eyes just as [they are] in the world. The morning rising is when a sign or a single star [rises] together with [i.e., just before] the sun [comes up] upon the horizon; and this the eye cannot perceive properly, because of [the sun's light] — [it can be grasped] only by calculation and reasoning; therefore this rising is grasped

[213] §126 contains exactly one unambiguous degree-figure of the elevation class — ע׳ מעלות, seventy, stated as a distance מקו השוה, from the equator, the same quantity as the elevation of the pole. The two later letter-numeral clusters are unresolved: they answer to no latitude and no obvious quantity, no מעלות is printed beside either, and no value is supplied.

[only] intellectually. Therefore know the reckoning of the rising of the twelve signs [through the year]: Aries in Nisan, Taurus in Iyyar [Gemini in Sivan, and so on].

סי׳ קכ״ח — §128. On the rising of the twelve signs in [the course of] the year — and this is not by reason of the revolution of the sphere of the signs [but of the sun's own annual motion]

From the New Moon [ר״ח] of Nisan... [at] the true [tekufah], for on that day the head of the sign [Aries] rises upon the horizon first; and at the New Moon of Iyyar the head of the sign [Taurus] rises upon the horizon first; and so at the New Moon of Sivan the head of Gemini rises first, and at the New Moon of Tammuz Cancer [rises] first. And so are the rules of the rising of the signs at every New Moon until the end of the year — for at the New Moon of each month a [particular] sign rises, and at the next [New Moon] the head of [the following] sign [rises] upon the horizon [?] as at first; and thus the matter recurs perpetually.

And there is [reason] to inform you — lest, on account of this, you should think that the sphere of the signs circles the globe of the world once each year: the matter is not so. [The sun] by its own motion, according to the reckoning and precision of all the later [scholars], does not circle the globe of the world by itself except in about 24,000 years [רק כמו ך״ד אלף שנים], as will be explained to you shortly, at the end of this Section [כמו שיתבאר לך בסמוך בסוף זה השער]. The cause that produces the phenomenon of a [different] sign [rising] above the horizon each month is [the sun's own] motion — by its proper motion toward the east, [nearly one degree] each day — as will be explained shortly. For had the sun stood still in one place, then when Aries had risen upon the horizon first by [the diurnal] motion, on the morrow [the same point] would rise with the head of that sign and would not change its rising from its place. But because [each day the sun shifts], when Aries rises upon the horizon the sun is no longer found [there], for it has already moved by its own motion about [thirty degrees over the month] eastward, [now] with the head of Taurus; therefore [Aries] does not rise [with the sun] upon the horizon... [The sphere of the signs] is carried by the diurnal sphere [גלגל היומית]... degrees, [at] the point which is the end of Aries and the head of Taurus. And so at the New Moon of Sivan the sun rises upon the horizon with [the head of Gemini], and so its rule [holds] until the end of the year, and so it recurs perpetually. Here, then, is the reason that Taurus rises upon the horizon [in Iyyar] — [it is by] the completion of the sun's circuit, not [by] the [proper] actions [of the zodiac sphere].

Or [the matter] may be reckoned another way: when at the New Moon of Nisan the sun [rises] with the first degree of Aries upon the horizon, then on the morrow, on the second day, when the head of Aries rises upon the horizon, the sun is not found there with the head of the sign, for it has already [moved] by its own motion about one degree; therefore [the point] rises on the second

[day] upon the horizon with the second degree of Aries, and on the third [day] it rises upon the horizon with the third degree, [and so is] its rule from day to day until the completion of thirty days, when [the head of] Taurus [rises], as above.

And you should know that all we have said is approximate, for the sun does not circle a full degree each day, [nor] thirty full degrees in thirty days, because in a year, which is 365 days and a quarter, it circles 360 degrees [ש״ס מעלות], so that the reckoning does not reach a full degree each day, but only about 59 minutes and 100 seconds [נ״ט דקין ק׳ שניות], as will be explained in the [fourth?] Section, §165 [סי׳ קס״ה (ד׳)כמו שיתבאר בשער ה — the gate word is at the ink floor and is not committed; the siman is קס״ה, 165]. And in this there are yet further matters, in that the [stellar] reckoning is not exact [i.e., not in precise round terms], as will be explained.[214]

סימן קכ״ט — §129. The rising-degrees of the aforementioned signs [do not come out] exactly [the same] in every year, and are not equal for all the inhabitants of the world [יושבי חלד]

[The matter rests upon several] causes… [and depends on] the horizon [every 33 days?]… what we said, that at the New Moon of Nisan… the true [reckoning], the head [of Aries] rises… first. But know that there is no [single fixed] reckoning [that holds] in every year [?], for the sun does not [aim precisely] at the head of Aries at the beginning of the day, at the moment of its rising upon the horizon; this occurs only [when] the sun rises at the beginning of the night, or… between night [and day], sometimes by several hours [earlier or] later. And also know, O inhabitants of the world, that [this requires] the correct [value] to be known for [the latitude of] the country, for this reckoning was founded upon [certain] inhabitants… in the morning; for at the time it is day [for one place] it is night [for another], and for the inhabitants of the far west [it differs from] the inhabitants of the far east — [for them] the beginning of the sign's rising precedes that of the western dwellers by twelve full hours [י״ב שעות שלמות]… for when the sun circles half the globe of the world in thirteen hours [בי״ג שעות], according to the measure of the circuit of [[ט״ו/ז]] degrees an hour… we anticipate the head of Aries and the center of the sun by about one part [degree]… [and] the rising of the sign begins [there]. [There will be] a slight difference… [and] the [sun's setting] anticipates [for

[214] the seconds figure here reads as a hundred, which is not a possible number of seconds. §106, on an earlier leaf, gives the same quantity as fifty-nine minutes and eight seconds with the seconds spelled out. The two places disagree; both are given as printed and neither is emended. the quarter of the year is given as a word here and the thirty twice as words, while the two round figures beside them are set as numerals; the two systems alternate inside one sentence.

the northern dwellers over the southern dwellers], as will be explained below in §132 [קל״ב].[215]

סימן ק״ל — §130. On the period of the revolution of the sphere of the signs [the great precessional cycle]

Concerning [the period of] the revolution of the sphere of the signs there is confusion [קלקול], disputes and differing opinions among the sages [and] the ancients, and there is a great and considerable difference among them — [some holding] its revolution [to be longer than that of any other]. The reason for this is [that even] there [among them] there was disagreement... and from two kinds of reckoning... from [?] [49?] degrees... [?] [27?]... And our Sages of blessed memory already hinted at this in Pirkei d'Rabbi Eliezer, chapter 26, which the Yalkut brings in Parshas Bereishis, folio 23 [וכבר רמזו רז״ל בפד״ר פ׳ בראשית דף כ״ג(ה) פ׳ כ״ו מביאו הילקוט]... the ancients [held out] twenty-three [כ״ג] days in order to determine the tekufos and the signs. And I have found it written that the first scholars, who were from the days of Adam [אדם] and [from] ancient times, and long before אברכ״ם and וטלמיאו״ם, did not …

שער ה — Section Five (continued)

סימן ק״ל — §130 (conclusion): the great precessional cycle (continued from the preceding page)

this is what I have written concerning it, in view of the smallness and deficiency of its motion — a motion so slight that on these grounds some have judged, by their observations (even [?]), that this sphere has no motion of its own at all. Yet the renowned sages Euclid, Archimedes and Hipparchus [וחכמים המפורסמים אקלידו״ס ארקמידו״ס ואברכ״וס] did detect in it a motion of some kind, though they could not, by their own account, assign it a measure — a measure for the span of its revolution — until Ptolemy arose. Ptolemy, foremost of those who spoke with precision, likewise detected a motion in it; but it did not suffice him to determine exactly how great its motion is, so he made a rough, approximate estimate — though he himself knew that his estimate was not an exact and rigorous reckoning. He said that the motion of this sphere, from west toward east, is one degree in about a hundred years. By this reckoning this sphere would not complete its revolution, from point to point, until the passing of 36,000 [שש ושלשים אלף שנה — confirmed under magnification] years.

[215] this siman states the same half-globe interval as twelve full hours in one place and as thirteen hours four lines below, and both stand plainly on both copies. Neither is emended. the degrees-per-hour figure here is set with a final form of its second letter, as at §117; not a well-formed numeral, and given as printed. §129's numeral is set bare, with no abbreviation mark, where its six neighbours on the same three leaves all carry one; and the word introducing the rubric alternates between its full and its abbreviated form within a single leaf.

After Ptolemy — about [?] years later, in the year [?] of the fifth millennium — the sage al-Battani [אלבתאני] the Arab also examined all the reckonings of the ancients, [combined?] his own work with Ptolemy's, and made good their shortcomings with [fresh] observations, [finding] that this sphere shifts one and a half degrees every hundred years. By this reckoning the sphere of the signs completes its revolution [in about — cycle figure damaged, [?]; 360° ÷ 1.5° × 100 = 24,000] … down to this day.

And Maimonides [הרמב"ם], of blessed memory, wrote in chapter 3 [reference [?]] that the revolution of the sphere of the signs is one degree every seventy years; by his reckoning this sphere completes its revolution in 25,200 years [כ"ה אלפים ומאתים = 25,200; 70 × 360 = 25,200].[216]

And here is what I heard from the great and eminent sage of our own generation, [Tycho Brahe — טי"חא ברהא"סי], who said that he examined all the reckonings of the ancients with great and abundant precision, and found that the revolution of the sphere of the signs is, in every thirty years, 58 seconds — very nearly [בכל ל' שנה נ"ח שניים בקרוב]. By this reckoning it amounts, per hundred years, to 85 minutes, which are one degree and 25 minutes [למאה שנה פ"ה דקין שהם מעלה א' כ"ה דקין]; and by this reckoning this sphere completes a full revolution in about 25,411 years [סבוב שלם ככדי כ"ה אלפי' ותי"א שנה] — very nearly — which is close to the reckoning of Maimonides, of blessed memory.[217]

And now know: I heard from the words [?] of the sage Israeli [Yitzchak Yisraeli — הישראלי] a great and wondrous matter, [one] very hard [to grasp [?]], for in [his book?] he says that he [studied?] the books of the sages Ptolemy and al-Battani… and [others] examined [them] well… such as Abraham [?] who was in the city of Toledo [טוליט(ולה)]. And let us not say that the sphere of the signs never completes a full revolution like the other spheres for all the days of the world — rather [?]. It is only known that the sphere of the signs shifts eastward, and at another time westward; it is known that the sphere returns [?] to move… but not in its stars [?] westward — as he expounded at length there in his book, concluding that this is a sound reason and an exact configuration. [?] … and they said that this is the sphere of the signs with its stars, according to the opinion of [?].

Others held that this motion is not a simple advance at all, such as Abraham al-Zarqālī [כגון אברהם הזרק"אל], who was in the city of Toledo [שהיה בעיר טוליט(ולה)].

---

[216] the degree-word in this third entry is set with a final form of its last letter; and the sphere's degree-total is set in the same malformed way in two consecutive simanim, §129 and §130. Neither sort of the total carries an ascender, so neither is the letter the expected value would need. All given as printed.

[217] Tycho's rate as this leaf prints it — 58 seconds in thirty years — agrees with neither figure the same sentence goes on to give: eighty-five minutes a century, and a whole revolution in 25,411 years, both answer to about 51 seconds a year, some six hundred times the printed rate. Recorded as it stands; no value supplied to make the chain close.

And I inquired concerning the aforementioned motion of the sage Mulerus [מולירו"ס … דרשתי על התנועה הנזכרת מהחכם], head of the sages who sit before the Duke, the Markgraf of Brandenburg [ראש החכמים היושבים לפני דוכס מרק גרא"ב — the print carries both words, דוכס and מרק גרא"ב, and both are kept]. He answered that this whole motion is a slight one, called in their tongue motum trepidationis [ונקראת בלשונם מהטו"ם טריפידאציאנ"ם], that is, a motion of trembling and quaking, which in German they call die zitternde Bewegung [פי' תנועה של רתת ורעדה בל"א דיא ציט"ר גני בוועגונ"ג]; and in his view it revolves in seven thousand years [ולדעתו תסובב בשבעת אלפים שנה]; and there is no [further] motion or displacement [?] beyond the aforementioned, for the motion of the sphere of the signs is in every place [?] degrees [[?]], and it [holds fixed?] in its place…

[caveat, concluding §130 / §131:] …[Adjacent to this is] the opinion of some of the sages that the sphere of the signs at one time circles toward the east and at another time circles toward the west, so that it does not make a complete revolution like the other spheres for all the days of the world; for by [?] we do not find in their books… the motion of trembling and quaking… and after us [comes] the heavy motion of the sphere of the signs entirely — or it is necessary [?]… in the fullness of his words on this matter. Here we set it down: we do not know, and we cannot fully adjudicate this rule, for our intellect is too limited for it — and perhaps we have erred. In my opinion one should hold as [stated in] the Seventh Treatise [מאמר השביעי — i.e. Almagest, Book VII, on the fixed stars], [?], that this matter is exceedingly hard, and it is impossible for mortals to grasp it precisely except after many years.

סימן קל"א — §131: that after many years the positions of all the host of heaven will change for us

[Heading, p. 85, left column:] "I will make known in it that after many years the positions of all the host of heaven will change for us."

Know that, by the course of the sphere of the signs — the degrees of the figured constellations, which are the fixed signs [?] set in the firmament for the eye to see — after many years there will come about, for all the inhabitants of the world, a great and manifold change and alteration in their appearance and their aspect together with [?] the sphere [of the signs] and the other spheres, corresponding to [?] the inhabitants of the world, since their [reference] point in the figured [firmament], which we mentioned above in §27 [סי' כ"ז], is for them at present above the horizon [אופק], whereas after many years it will be at a point below the horizon; and when all twelve signs are for us southern, they will then be for us [northern? — כלטלפויי [?]]…

Thus, for example: at the time when the point of the head of Cancer [ראש סרטן] is at their zenith, the point of the head of Capricorn [ראש גדי] will then be opposite [at the nadir], and Aries [טלה], as a figure, will rise in the east [along with Libra? — כתשרי [?]] and Scales [Libra], with its accompaniment [?], and many other [changes] without number.

And to make it easier for the students to perceive all this with a little study and reflection, I offer an illustration and say: those whose place is at present situated under the circle of Cancer — which is 24 degrees from the equinoctial line [מקו יושר], in latitude, according to what I wrote above in §40 [סי' מ'] — the northern pole [הציר הצפוני] is raised for them above the horizon by likewise 24 degrees; and the star [?] that we marked above in Section One [at the point in] the sphere of the signs answering to the upper pole-point — the point that I called, above in Section One, in §26 [סי' כ"ו], the "quasi-pole-point," since in their day it functions in every respect like the upper pole-point itself — therefore, by Ptolemy's reckoning, that the sphere of the signs revolves one degree every hundred years, know now that when the sphere of the signs turns as a whole upon its axes [כדוריו [?]], by this reckoning, after [some] thousands of years [?]…

the corresponding point marked in the sphere of the signs [will shift] from its place, so that, just as it was for them above the horizon by about 24 degrees, it will incline either toward the east — and this will be [above?] the horizon; and likewise it will incline toward the south and toward the west, [?] the horizon — and whereas at this present time the circle of Cancer, which is their zenith-star, will then likewise, by the sage's reckoning [?], after [some] thousands of years, at the marked point, part from its place and greatly change its place, so that, just as at this time it was above the horizon by 24 degrees, it will [then] be below the horizon by 24 degrees; and the southern point of the southern pole, which is now for them 24 degrees below the horizon, will be for them [then] 24 degrees above the horizon. And [for] the aforementioned sages [places], as it is now the circle of Cancer that is their zenith-star, then it will be the circle of Capricorn opposite their zenith, and Aries as a figure will rise in the east [with Libra? — כתשרי [?]] and the Scales, and many, many other [changes] beyond number — all which matters you can see, as it were with the eye's own sight, when you look at the pole [?] upon the two poles of the signs over the horizon and turn the sphere until the point we marked is 24 degrees below the horizon; and, together with [?], by Ptolemy's reckoning as mentioned, after 9,000 [ט' אלפים] years [it will happen thus], and by al-Battani's [אלבתאי"נו] reckoning after…

[continues, p. 86, right column:] [The first line of this column is dense contracted prose and is not read; it carries no figure and no name.] …by Ptolemy's reckoning after 15,000 [י"ה אלפי'] years, and by al-Battani's [אלבתאי"נו] reckoning after 12,000 [י"ב אלפים] years, it will come to be [that the constellations reach the opposite horizon].[218]

From all the aforementioned matters one may say that, according to what we mentioned above in Section One, §11 [שער הראשון סי' י"א], that every [?]…

[218] the book gives the same authority two different intervals for the same event, three lines apart across the page turn — nine thousand years in the one place and fifteen thousand in the other. Both are given as printed. The first of the two places gives no figure for the second authority at all.

so too the heavy motion [carried] with the sphere of the signs [causes that], over the length of the ages, at the time of the winter solstice [תקופת טבת] [the sun] will draw near to us in the extreme of closeness, and the day will lengthen for us more than all the days of the year, and thus the heat will grow strong for us; while at the time of the summer solstice [תקופת תמוז] it will withdraw from us in the extreme of distance, and the day will shorten more than all the days of the year, and thus the cold will grow strong for us — [so that] cold and heat, summer and winter [will be reversed]. Nor does this contradict [our earlier account], since in the end these will [each] be fulfilled in their [proper] times and places; and at every time, likewise, you should know that, according to what we have made known above [it will be so].

With the help of the One who built the woman from the rib [Bereishis 2:22], we have completed five Sections.

השער הששי — THE SIXTH SECTION (שער ו)

In it will be explained the declination of the sun from the equator [קו השוה], and the [variations] and wondrous variations found in this; and the lengthening and shortening of the days, and the wondrous variations found in this among the inhabitants of the world; also to know the measure of the days throughout all the days of the year, in every place and at every time; and the precedence of the times of daylight for the easterners over the westerners, and for the northerners over the southerners, and other great and wondrous matters, and more besides.

סימן קל״ב — §132: on the sun's declination from the equator

[Heading, p. 86, right column — four printed lines:] "Siman 132. We will speak in it of the sun's declination from the equator [מנטיית השמש מקו׳ השוה], called in their language declinatione[s] [דיקלינצייאנו״ס]; and of the 182 [קפ״ב] circles which the sun makes, twice a year [פעמים בשנה]."[219]

We have already explained above, in Section One, §24 [שער הראשון סי׳ כ״ד], that every star makes in its course, each day, one revolution [כסיבת [?]] in the diurnal motion — a circle and an arc revolving about one [א׳] of the two [מב׳] poles of the world [קוטבי העולם]; which the sun too, as one of them, makes: one circle [עגול אחת — so printed, feminine with masculine עגול] every single day, from east to west, around the globe of the world.

Therefore know from now on that if the sun stood always in one place [במקו׳ א׳], like all the stars of the eighth firmament [רקיע השמיני], as we [?] — then the sun would be [?], revolving continually every day upon one circle

[219] the numeral קפ״ב = 182 in this rubric counts circles — ומקפ״ב עגולי׳ שעוש׳ השמ׳ — not occasions. No numeral stands in the "twice a year" clause at all: rubric line 4 is פעמים בשנה :, the "twice" carried by the plain word פעמים, with no geresh or gershayim on the line. A reading that reports the rubric as "182 times a year" is not what the leaf prints.

[עגול אחד] only; since they [?] like the movement of the clock [כמהלכ׳ הרלוגית], it would revolve opposite [the same point].[220]

[But the sun makes] the whole circle of the zodiac, beneath [תקת — so printed; [recte: תחת]] the line of the eclipses [קו הקדרות — the ecliptic], from west to east, once [פעם אחד] every year; and this comes, for each day, to close to one part [קרוב לחלק אחד — one degree]. Therefore, and because of this,[221]

[two printed lines here do not construe [?]][222]

Today it [rises] in the east from a known point [מנקודה ידוע], and makes one circle or circuit [גלילה אחת] around the globe of the world. Tomorrow we see it at [?] place[s], from another point, adjacent to the first point, close to one degree [אחרת סמוכה לנקודה הראשונה קרוב למעלה אחת]; and so is its way all the days: from day to day it exchanges its circuit for [?] — one circuit for a second circuit. And those circles, which are called [?], according to the astronomers [כפי התוכניו'],

the circuits of the sun [גלילי השמש]; and in the Latin tongue, [ובלשון לטיי״ן פאר][?]לו[?]א לע — the sorts of the loanword do not separate cleanly and it is not reconstructed]. And the numbers of the aforementioned circuits [ומספרי הגלילי' … הנזכרים] [?] are as the number of the days of the year — [given] to make known and to explain to his pupils the quality of the order of the circuits, made [?] up to [עד״ם [?] — so printed; it carries gershayim, but a bare final mem after עד yields no value that can be defended, and it may not be a numeral at all] the distance of the sign of Capricorn [מזל גדי], which is when [one line here does not construe [?] — the words legible in it are בהיותה שם ("when it is there"), היום ("the day"), כ׳כתכלי ("at the utmost") and a word in צרים-, evidently that the day is then at its shortest; the clause is not read].

And when it revolves round the circle of the zodiac, over against the way from Aries [טלה] as far as Cancer [סרטן], [?] it is at the utmost nearness [?] — and from its revolution, as its course, it is [?] — half a year, which is 182 days and a half [קפ״ב יום ומחצה], and a little more. And behold, in [?] the revolution

---

[220] three clusters in these two lines do not construe and are left unread. On the first line, a seven-sort word — כ ש [a fully closed bowl] ו נ י ת — and an eight-sort cluster ר כ [?] [?] ן ו נ ל, whose final nun stands mid-cluster, so the word-break is not where the spacing puts it. On the second, a two-sort word whose left sort is a bowl open on the right, matching no sort in this fount. Both witnesses print them alike, so none is a scan artefact. The sorts are legible; the strings are not, and naming them would be inventing letters.

[221] the middle sort of תקת carries a full descender, matching in form and length the ק of קו beside it and the ק of הקדרות three words later on the same line, where ח on this leaf has no descender at all; both witnesses print it so. The sense wants תחת, "beneath", but that is an emendation and is recorded as [recte:] rather than written into the transcription.

[222] what stands across these two lines is: אין ("there is not"), a three-sort word, a six-sort word (רגילין?), a four-sort word; then עולה ("rises"), יום ("day"), אשר ("which"), עולם; then, next line, a five-sort word, רק ("only"), a three-sort word, אשר אנו רואין אותה ("which we see it"), a word in מקום- ("place[s]"), בבקר ("in the morning"), and a final unread word. Without anything supplied, the sense is that the sun is not regularly in the same place and that what we see in the morning is at [changing] places. The sorts are legible and a second reading of the leaf agrees glyph for glyph, so this is not a scan limit.

of the diurnal motion the sun made, in the stated time, 182 [קפ״ב] circles; and this divides [?].

[It makes] the second circuit when it returns from the sign of Cancer [סרטן], by way of Libra [מאזנים], as far as Capricorn [גדי], [in] a year [ע[ל/ד] גדי [?]] in its course. Then it was making, a second time, 182 [קפ״ב] circles, and dividing [them] like the 182 [לקפ״ב] circles as at first — so that the number of its circuits is 182 [קפ״ב], and doubled [ומחלה [?]] twice [פעמיים]; and they are the number of the days of their year, which is 365 [שס״ה] circles and close to a quarter [[ת]וקרוב לרביעי] [more]. And as the rule is [?] with the sun, so is the rule with the moon; and likewise with the five wandering stars [מחמשה כוכבי הנבוכה], and likewise with the stars of the sphere of the eighth [heaven] ['גלגל הח] — as will be explained further on, with the help of Heaven [לפנים בס״ד].[223]

סימן קל״ג — §133: that most of the sun's circles are paired with one another

[Heading, p. 86, left column:] "We will announce and make known in it that most of the sun's circles are shared, one with another — they are one with the other [in pairs]."

Know that, of the sun's circles, not every single one is a circle by itself for one day alone; rather, most of the heads of the circles are shared by two days [?]… in each and every degree upon [the equator?].

[continues, p. 87, right column:] …upon two whole signs that share [the same] heads of the signs. These are five pairs, printed thus: Gemini with Leo [תאו״מים באר״ים]; Taurus with Virgo [שו״ר בבתו״לה]; Aries with Libra [ט״לה במאז״נים]; Pisces with Scorpio [דגי״ם בעקר״ב]; Aquarius with Sagittarius [ד״לי בק״שת]. Neither Cancer nor Capricorn stands in any of these five pairs. That is: the circle which the sun makes [in its day] at the head of the signs [?]… For example, the circle it makes at the head of the sign Gemini [בראש מזל תאומים] — that very same circle it also makes at the head of the sign Leo [בראש אריה], for the two are at equal distance [from the solstitial point], as with the rest. And there is no distinction between them at all, since both are [at the] same distance, only [that] the circle at the head of the signs [is] one, [and the corresponding one]… — this is the shared [pairing].

But the signs that share in their entirety [בכללם] — that is, one whole sign is paired with one [other] whole sign — these are they: Gemini with Cancer [תאומי״ם בסר״טן]; Taurus with Leo [שו״ר באר״יה]; Aries with Virgo [ט״לה בבתו״לה]; Libra with Pisces [מאזני״ם בד״גים]; Scorpio with Aquarius

[223] the displacement in this siman is stated twice, and both statements are angular — קרוב לחלק אחד, "close to one part," the sun's daily advance, and קרוב למעלה אחת, "close to one degree," the displacement between one sunrise and the next. In both the figure is spelled as a word (אחת / אחד) with no geresh and no gershayim, so no letter-numeral stands in either clause. No linear unit occurs anywhere in the siman — no מיל, פרסה, אמה or ריס. An earlier reading of "one part, 22" is withdrawn: 22 has no counterpart on the leaf.

[עקר״ב ב״דלי]; Sagittarius with Capricorn [קש״ת בג״די] — each one beside the other [?].[224]

Now the circle which the sun makes on its day at the head of the point [?]… is the circle which the sun makes at the end of the sign of Cancer [סוף מזל סרטן], and there is no interval [ריוח] between them at all; and the circle which it makes at the head of the second degree of the sign [?]; the circle which it makes at the head of the 29th degree [מעלה כ״ט] of the sign Cancer [?], and so on, [each answering to another] until each pair of them [is] one beside the other in the matter [?]. So too with the other shared circles. All this "sharing" is only [approximate], as will be explained; only at the outset of the circles [is it exact], as will be shown.

And now know: [the fact] that the sun makes each year, by [this] reckoning, only [182 — קפ״ב] circles [?] — that is, that the sun returns and rides [?] on each and every circle [?] — and know also that, in your reckoning, whether [the sun be] at the head or at the end of the two shared parts of the sphere of the signs [?] together — so too [with regard to] the days and nights of the two [?] — their measure [is] close, one to the next in reckoning, as will be explained further on.

סימן קל״ד — §134: on explaining that the sun's circles are not perfect circles

[Heading, p. 87, right column:] "We will explain in it that the sun's circles are not perfect circles."

Know that all the sun's circles mentioned are not perfect circles from point to point; for the end of each circle draws away from its own beginning [כי יתרחק כל עגול סופו מתחלתו], and in the oblique [direction] sometimes [by] close to one degree of the 360 degrees of the sphere [קרוב למעלה אחת מש״ס מעלות הגלגל][225], and sometimes by about half a degree — at one time adding, at another subtracting… as [the sun at] Aries [טלה] is [?] at the [end?] upon the horizon [?]… upon the horizon on the morrow, or [on] the day, its circling [is] a full circle — but because the sun goes [set?] in [its] spheres beneath the sphere of the signs, as [was said] above… therefore this circle is not a perfect one from line to line; rather each circle draws away from its neighbor a little, on the side, according to the obliquity by which the sun draws away in its course beneath the circle of the signs, by one day, from the equator, or draws near to it. And

[224] the same sign-name is set two different ways eleven lines apart in this siman, with a closed final sort in the first list and an open one in the second; both are given as printed. the abbreviation points in this siman mark nothing consistent — the same sign-names carry them in different places in the two lists. And the fifth pair of the second list is set with no separator before it and is split across the line end, where every other junction in both lists carries one.

[225] the degree-figure belongs to the clause about a circle drawing away from itself, its end from its beginning. The separate clause lower in this siman, in which each circle draws away from its fellow (רק כל גליל יתרחק מחבירו מעט), carries no degree-figure, and none is supplied for it.

picture to yourself the aforementioned circles as if you took a single thread [ותדמה לך הגלילים הנזכרים כאלו תקח חוט א'] and wound it round about [ותסבבנו], [seeing] that in all these circlings there is no perfect circle from a whole line — rather the end of each circle draws away [קופן מרלטיקו — a foreign term, garbled and not identified [?]], a little from the side.

סימן קל״ה — §135: on explaining that the shared circles are exact only at their beginning

[Heading, p. 87, left column, folio מג=43:] "We will explain in it that the sun's shared circles are not exact, in strict precision, except at their beginning."

Know that, according to what we already explained above — that the sun's circles are not perfect circles, but only a little [?], their end [differing] from their beginning — therefore know now that the sun's shared circles are not exact except at their beginning; for at their end the two circles separate and draw away, one from the other, by [about] the distance [covered] in one hour [?]. This is because the circle rising [?] at the head of the sign Aries [ראש מזל טלה], for example, circles upon the equator, and forthwith [its] power bends a little, curving slightly, and inclines toward the north; and after 24 hours [כ״ד שעות], like a full [solar] day, [that] circle [is complete] — (because the sign [?] inclines to the greater obliquity) — the end of the circle overshoots its beginning by more than one degree from the equator toward the north; while the circle preceding it at the head of [the corresponding sign], which is [now] on the equator, forthwith also bends a little, curving slightly, and inclines to its order, and after 24 hours, when its circle [is complete] for the day, its end overshoots its beginning by more than one degree from the equator toward the south — so that the difference between the two ends of the shared circles [amounts] to more than two full degrees. And by like comparison in the others, there is always some difference between the two shared circles — even between the circles of Gemini and Leo [גלגלי תאומים ואריה], and between the circles [at] the head-degrees of Gemini [?] and the end of the first degree of Cancer [סרטן], each of these beside the other.

From all the aforementioned matters there is explained to you the measure of the days at the two heads of the seasons — the tekufah of Nisan and the tekufah of Tishrei — [which] are equal, one to another, in their measure, in complete precision; for there is between them some difference [?], by which one exceeds the other, as will be explained to you further on, in §140 [סי׳ ק״מ]. And it remains for you to know that the 182 circles [שק״פב, so printed] which the sun makes from the head of Capricorn [מראש גדי] to the head of Cancer [עד ראש סרטן] are the same ones that pass, meet, and cut across [הם עוברים ופוגשים וחותכים] the 182 circles [הקפ״ב, so printed] which the sun makes from the head of Cancer to the

head of Capricorn [מראש סרטן עד ראש גדי].[226] For example, the circle which the sun makes at the head of the sign Aries [ראש מזל טלה] inclines toward the north; so too the circle which the sun makes, after half a year, at the end of the 29th degree [סוף מעלה כ״ט] of the sign Virgo [מזל בתולה] inclines toward the south — although, of necessity, its power inclines, and it uproots [i.e. supersedes] the circle of Aries and inclines it aside to [the other] side; and so it is with the others.

סימן קל״ו — §136: on explaining that the sun's circles are not equally near and far to one another — and needless to say [unequal in] their obliquity

[Heading, p. 87, left column:] "We will explain in it that the sun's circles mentioned are not near and far equally, one to another — and needless to say [not equal in] their obliquity."

Also know that the sun's circles mentioned are not near and far, one from another, by an equal amount or measure; for in every circle it draws near [to], [and draws] away from, its neighbor according to the amount of the obliquity, as was mentioned above in the Fifth Section — for at the place of Pisces and Aries [כי במקום דגים וטלה], and likewise at the place of Virgo [וכן במקום בתולה] — —

[continues, p. 88, right column:] …and Libra [ומאזנים], since they there incline to a greater obliquity [יען שהם נוטים לאלכסון יתירה], the circles will there be far apart, one from the other [יהיה שם הגלילי׳ רחקים זה מזה]; whereas at the place of Gemini and Cancer [ובמקום תאומים וסרטן], and likewise at the place of Capricorn and Sagittarius [וכן במקום גדי וקשת], the circles will be near and almost touch one another [יהיו הגלילים קרובים וכמעט נוגעים זה בזה];[227] and in all [these] the obliquities of the circles themselves [differ] — for all the circles [?], apart from the equatorial [day], whether [inclining] to the north or to the south, in every place, according to its nearness to one of the [two] poles, so [much] the smaller will its [circle] ever be, [reckoned] as a whole [?], from [?] the body [?], toward the equator [קו הישר [?]].

סימן קל״ז — §137: [that the day-arcs incline southward and the night-arcs northward, for northern dwellers]

[Heading, p. 88, right column, running header שער ו:] "Know that the semicircle of the equator [קו הישר] which is above our horizon, and likewise the rest of its circles, that is, the day-arcs [קשת הימים] which the sun makes by cause of the

[226] the edition sets the same figure twice, four lines apart, two different ways — שק״פב, gershayim after the ק, and הקפ״ב, gershayim in the normal place before the final sort. The value is 182 in both (ק=100, פ=80, ב=2). Both are given exactly as printed; neither is normalised to the other, and the divergence is a property of the setting, not of the reading.

[227] the sentence's predicate does not stand on p. 87 at all — the leaf breaks after וכן במקום בתולה, prints the catchword ומאזנים, and completes the sentence in the first three lines of p. 88's right column. A reader confined to p. 87 gets the regions with no predicate attached.

daily motion — all these, for us, most of the dwellers of the world who inhabit the north, incline from the climes above our horizon toward the south, and are for us as [?] quarantoi [קירנטוי [?]]. And the night-arcs [קשת הלילות] which are below our horizon all incline toward the north — even the night-arc of the winter solstice [ליל תקופת טבת], which is joined to the circle of Capricorn [עגול גדי], whose day-arc is at the extreme of distance from us toward the south — the arc which is beneath our horizon inclines, according to our standing [i.e. our latitude], toward the north; and the measure of the inclination is according to a person's distance from the equator toward the north: the more our northerly [distance] grows, the more the inclination grows for us; so that for those who dwell beneath the northern pole [ציר הצפוני], the equator is their horizon, and the circles gird it like a belt girding [the loins of] a man. All this you may see, as it were with the eye's own perception, plainly.

And [see] how sweetly the words of the sage Israeli agree [as printed, החכם הישראלי — the leaf gives the epithet only; the personal name "Yitzchak Yisraeli" is not printed], in chapter 12 of essay two of his book [as printed, כפ' י"ב מאמר שני מספרו — chapter and treatise are printed, but no book title is], in his explanation on this point of the dictum of our Sages at the head of the chapter Keitzad Mevarchin [as printed, ר"פ כיצד מברכין, the chapter title breaking across the line end — i.e. Berachos ch. 6] and in ch. 2 of Basra [as printed, בתרא — ובפ' ב' דבתרא without בבא], as they expounded: "[the sun] goes toward the south [by day] and circles toward the north [by night]," which, by the [?]… — the utmost of what is manifest and visible to our eyes. For just as the sun is ever found each day [rising?] in the east, making one circle, and part [?] upon the western horizon… it [screens/covers] all night opposite the [day-]circle. [?]… as a disciple [?]… [circles?] open [?]… and as its course by day, so is its course [by night]… and thus, on the northern side [beneath the pole], it has no motion or path [distinguishing] between day and night [?]… for it does not pass over the line of the circle of Cancer [קו עגול סרטן — the print carries both words], from world to world [מן העולם ועד עולם]… on account of which many have opened their mouths against the dictum of [our Sages, of blessed memory]; [but] according to this [account], that eighth [?] motion mentioned, of all the inhabitants of the world… that some climes have days [ever set] toward the south, and the [night-]arcs ever toward the north — [these people] examined the words of our Sages, of blessed memory, [and found them] in the fullest of exactness [כתכלית הצודק], and returned and interpreted them as [our Sages] of blessed memory [intended]. "How [pleasing are] the source of his words, [how sweet] to my palate" [Tehillim 119:103][228]

Incidentally [אגב], I saw fit to explain, in this place, what [we wrote above [?]]: [the verse] "[the wind] goes toward the south and circles toward the north" [Koheles 1:6]…

[228] the leaf carries the two halves of the allusion in the author's own words nineteen lines apart (R26 נמלצו, R41–42 מה מתוק דבריו מתוקים הם לחכי).

[continues, p. 88, left column:] …the plain sense of the verse is this: when the sun circles among the northern signs — for then it draws near to the inhabited world — it says "circles toward the north"; because in no verse [?] does [Scripture] impose upon us a circling in [only] a far-off place, for the encircler and the encircled are ever near, one to the other, as in "round about the Tabernacle" [סביב למשכן], "and you shall circle the city" [וסבותם את העיר], "and the border turned" [ונסב הגבול], and many like them [וכאלה רבים]. So too, when the sun circles among the southern signs — for then it withdraws from the inhabited world — [Scripture] says "goes toward the south"; for we find "sovereignty" [expressed] by way of a hint [רמז], as in "he walked in [embroidered work?]" [?].

סימן קל"ח — §138: on explaining that for those who dwell beneath the equator, the length of day and the length of night are always equal

[Heading, p. 88, left column:] "We will explain in it that, for those who dwell beneath the equator [קו השוה], the measure of the day and the measure of the night are always equal."

For all those who dwell beneath the equator, their horizon divides the equator — and likewise the circle of the signs [קו המזלות] — each of them into two equal parts: the part which is for them above their horizon is called the day-arc [קשת היום], and the part which is for them beneath their horizon is called the night-arc [קשת הלילה]. Accordingly, all the host of the stars — and the sun too, together with them all — when they circle the terrestrial globe by cause of the daily motion, the time of their circling above the horizon, each day, is found, for those dwelling beneath the equator, [to be] equal to the time of their concealment beneath the horizon, all the days of the world. And so the measure of the day and the measure of the night are always equal, each of them twelve hours [י"ב שעות] at every time; and [they know] no danger [?] of cold or heat, summer or winter; and one does not exceed the other — neither the day over the night, nor the night over the day — even in the days of the summer and winter solstices [תקופת תמוז וטבת]; and they have no variation, only the precedence of the tekufah for the people of the east and its delay for the people of the west.

And [for] those who dwell outside the equator, whether toward the north or toward the south — here too, day and night, joined together, are for them twenty-four hours [כ"ד שעות], just as for those dwelling on the equator, only that one exceeds the other: sometimes the measure of the day exceeds the night, and sometimes the reverse. And this variation comes from [the north?]… according to the inclination of the dwellers of a portion [of the earth] away from the equator toward one of the poles: so much do the days and nights lengthen and shorten for them; and the cause of the lengthening of the day and night for those who dwell beneath [any of] the degrees [of latitude] is entirely according to the time of the year, as will be explained shortly.

סימן קל״ט — §139: on explaining that, on the days of the two equinoxes, day and night are equal, also for most of the other inhabitants of the world

[Heading, p. 88, left column:] "We will explain in it that, on the days of the two tekufot, day and night are equal, also for most of the other inhabitants of the world."

Two days are found in the year which are excepted from the [general] rules mentioned, on which day and night are found equal for all the inhabitants of the world, in all the climes, just as for those dwelling on the equator [line]; for these are the two days of the tekufah of Nisan and the tekufah of Tishrei — the true equinoxes [as poles?], on which the sun enters the sign of Aries [טלה] and the Scales [Libra — מאזנים]. And the reason [is] that, on those two days as mentioned, the sun circles upon the equator [קו הישר]; and it has already been explained above, in the Second Section, §39 [שער השני סי׳ ל״ט], that all the great circles which pass through the center of the world are ever divided, each with the other, into two equal halves. It follows, by this, that the equator divides [?] every horizon [?] of the sphere of the world into two equal halves — since both of them are great circles; and close to this, likewise, that all… the signs which circle for them [by day], and likewise the sun which circles for them by night [when the sun…]

[§139, continued from the previous folio.] …so that the sun is always opposite one of them.) And since its revolution above the earth equals its revolution below the earth — exactly as is the case for those who dwell precisely beneath the equator — by all these considerations it works out eye to eye [i.e. exactly equal]. It thus appears that all the aforementioned inhabitants, in every place, have their day-arc equal to their night-arc [on those two days]. Were it not for these two mentioned days [the equinoxes], it would never be found that day and night are equal for the [world's] dwellers throughout all the days of the year; nor would any of the climes be found equal in this respect. Rather, in each of them one [arc] always has some excess over the other; and even [comparing the several regions], they are never found equal to one another in their measure in any place — except as stated above.

סימן ק״מ (§140)

Explaining that the measure of the daytime of the Nisan tekufah exceeds the measure of the daytime of the Tishrei tekufah.

Although in all the books I have found the measure of the [day of the] two tekufot, Nisan and Tishrei, [treated] as equal to one another — as [being the] mean [values] — because [at those points the sun] circles upon the circle of the equator, nevertheless I say that when one examines closely the revolutions of the two days of the two tekufot, it is found that the day of the Nisan tekufah exceeds the day of the Tishrei tekufah by a small amount. This is as was already explained above in §135 [קל״ה [?]]: that of the two signs Aries and Libra, [at

the one near apogee] the sun is more distant [from the earth]… [several words garbled: sense is that the difference plays out over the 24 hours]. Therefore know that the sun makes its circuit — its distance from the [quadrant/arc] ס [מרחק מחוג׳ ס, so printed] — from the head of Aries in the span of 24 hours [moving] like a thread [along the equator], and in the time it travels along its slanted path one degree toward the north, in that same time — within the revolution of 24 hours — the day-arc is lengthened for us over the night-arc by some small amount [שיעור מה [?]]; and [correspondingly, when it moves southward] the night-arc is lengthened for us over the day-arc, within that revolution of 24 hours, and the daytime is shortened for us by that measure.

סימן קמ״א (§141)

I inform herein that the natural [solar] days are not equal in their length.

We have already explained above [§? — reference garbled], and it will be further clarified below in §184 [קפ״ד], that the measure and span of the year, according to the view of the astronomers, is 400 [?] days, 5 hours, and 55 minutes [שס״[ם/ס] יום ה׳ שעות נ״ה דקין משמים בשעה בקרוב — the printed forms] [recte: 365 days — the emendation is the editor's; the leaf's own third letter is a closed bowl, and ה = 5 is excluded on it].[229] If you divide the 360 degrees of the heaven by the number of days of the solar [year], the mean daily motion comes out to about 0°59′8″ [נ״ט דקין ח׳ שלישיות] per day.

Know that this difference, for those who dwell beneath the equator, is a small and fine difference — so slight that it is scarcely perceptible and cannot be registered by [ordinary] sense, though reason and demonstration attest to it; whereas for those [who dwell] beneath [other latitudes] this difference is felt even by sense, as you will observe above in the previous section, in the table of the rising of the signs [and their setting]. This becomes clear when you combine the times of a sign's rising and setting: for the sign of Cancer, the measure of its two [risings/settings] is some five hours and 14 minutes in [equal] hours [ה׳ שעות וי״ד דקים [?]], the difference [between them being] about half an hour.

And there is yet a further point for you to know: the second, [more] necessary cause — namely, that the natural days differ slightly in their measure — is on account of the variation in the sun's own course, since [the sun] revolves [with non-uniform motion]. [Remainder of the paragraph continues onto p. 90; the sun's varying speed makes successive natural days unequal.]

[229] the leaf gives the astronomers' year a first figure of 400 (or 420 — the last letter is a closed bowl the ink will not resolve between final mem and samekh), which answers to no astronomical tradition and which the book contradicts wherever else it reckons the year. What it cannot be is 365: the letter carrying that value is open at the foot everywhere else on the same leaf and closed here, on both copies. Recorded as printed and corrected only in the note. The minutes beside it, 55, are secure and are the ordinary value.

סימן קמ״ב (§142)

We inform herein of the causes of the lengthening and shortening of the days for us, the dwellers of the north, throughout all the days of the year.

Know that for us, who are inclined away from the equator toward the north, our horizon divides all the [diurnal] circles that the sun traces by its daily motion into two unequal parts: the day-arc, which lies above the horizon, and the night-arc, which is beneath the horizon — but not into equal parts. As the sun's position recedes from the equator toward the south, the night-arc immediately begins to exceed the day-arc for us. From this it will become clear to you that all the circles the sun traces while in the northern signs (which are Aries [through Virgo]) yield a day-arc greater than the night-arc for us; while all the circles it traces in the southern signs (which are [Libra through Pisces]) yield a night-arc greater than the day-arc. And as a general rule: …it would not be found for us [that day equalled night] were the setting of this and the rising of [that separated] only by a revolution of 120° [ק״ך][230], [together with] 240° [ר״ם]… a revolution of [some] hours, reckoning 15° per hour [ט״ו/ט״ז [?]], and likewise always [dividing the arc by that rate]; so that at [the sun's] setting there is found a revolution of 240° [ר״ם] — a revolution of 16 hours. [At the Nisan tekufah the sun] turns its face toward the south [or toward the north], and the days go on drawing nearer and shortening, until the sun reaches the sign of Capricorn, which is the point most distant [from the north]; then the measure of the daytime is at its very shortest for us, because its day-arc is the smallest of all arcs, and its night-arc is the longest of all night-arcs.

[§142 continues on p. 90, closing with a self-note:] And I set this down as a marker, a reminder to myself, until I investigate it further — §142 [קמ״ב], [as noted] elsewhere [בפל' — abbreviation uncertain].

סימן קמ״ב (§142 — duplicate number as printed; logically §143)

[Explaining] that the measure of the days of Teves is not equal to the measure of the nights of Tammuz; and likewise that the days of Tammuz are not equal to the nights of Teves. [מדת ימי טבת אינם שוים למדת לילי תמוז וכן יומי תמוז אינם שוים ללילי טבת — corrected on the leaf. The rubric had been rendered with "Teves" in both slots, which compared Teves with Teves twice and made the second clause a restatement of the first. A cold probe, told that sense could not

[230] the earlier reading "150° [ק״ן]" is withdrawn, and with it the note that the arithmetic below required a different figure; the letter was settled on the leaf, not by the sum. Under magnification the sort does descend below the line of writing — as deep as the certified final nun at the other end of the same line — so the descent decides nothing; what separates the two letters is the head. This sort carries a wide horizontal top bar running well to the left of the stem, the stem dropping from the bar's right end, which is the construction of a final kaf, where the certified final nun beside it has a small rounded knob barely wider than its stem. Both copies show the bar. That the figure now closes with the surrounding reckoning is a consequence of the reading, not a reason for it.

help it here, established the discrimination by letter count: the two contested words are four-letter words opening ת-מ, standing in the same display block as two genuine three-letter טבתs for direct comparison. "Anyone reading טבת in either slot is reading three letters where four are printed." The body text three lines below spells both months out unambiguously and corroborates the cross-comparison. Residual: in the first of the two, the final pair is ז/ו vs ד/י — both on the do-not-resolve list — so תמיד is graphically admissible there; it is read תמוז from the parallel, and that much is inference, not ink.]

Many suppose that the measure of the daytime [at one tekufah] is always equal to the measure of the nights that fall at the [opposite] tekufah — that the daytime at the Tammuz tekufah [summer solstice] equals the nighttime at the [Teves tekufah, winter solstice]. But the matter is not so: for when one finds [the arcs of the] tekufot… [several words garbled]… the [day] is lengthened for us [beyond its counterpart by a small amount, on account of the eccentricity explained in §140].

סימן קמ״ג (§143 — printed קמ״ג; logically §144)

Explaining that for some people the measure of their daytime will be twenty-four hours.

Know that for those people who are inclined away from the equator by 66°9′ [ס״ו מעלות ט׳ דקין] toward the north — for whom the sun, on the day of the [Cancer] tekufah [summer solstice], does not set beneath the horizon at all — the measure of their day at that time will be like a full workday of twenty-four hours. Regarding this we must recall what was already stated above in [an earlier] section, in §[102 [?]]: that the northern circle [i.e. the Arctic Circle] merely marks the trace [drawn] about the axis of the world, standing off from it by 23°51′ [כ״ג מעלות נ״א דקין — the obliquity of the ecliptic]. It was also explained there, in §[?], that [when] the equator['s farthest point] is at the head of Cancer, which is inclined [to its maximum]… the sun [remains above the horizon the whole revolution].

סימן קמ״ד (§144 — printed קמ״ד; logically §145)

I inform [herein] that in some countries the measure of the day is one month, or two months and more; and likewise the measure of the night.

For those who dwell farther still beyond the northern [Arctic] circle, toward the axis of the world: in proportion as their dwelling approaches the northern axis, so much more of the arc about the point of the head of Cancer — together with the neighboring signs on its two sides — projects and remains above the horizon and never sets there. So long as the sun revolves along its path through the degrees of those signs that remain above their horizon, they have continuous daytime, and in that period they have no night at all. If the portion that remains [above the horizon] together with the head of Cancer, on its two sides, amounts to the measure of one sign, they will have one [month] whose

whole measure is daytime; and if that portion is the measure of two signs, they will have a daytime of two months [—] and so on, so that some will have a daytime of three months; and the reverse of this holds for them [in winter], when — with the arcs of Capricorn and Aquarius — they will have a night of three months.

The sun's [dwelling above the horizon] increases by about four degrees [in such regions] (as in the country [נו(ו)אן לנד] on the first reading; a second reading of the leaf, taken without sight of the first, gives גרתן at this locus — unidentified] and the country [מאסק(נ/ו)ל] on the first reading, the medial letter at the limit of the print; the second reading gives מחנ[ג/נ]ל — unidentified]).[231]

And I have seen, [recorded] in books, [an account] of a deed that took place in this matter about three years ago [כמו שלש שנה [?]], in the great city of Amsterdam [אמשטרדם], the chief metropolis in the land of Holland [האלנד]. A company of many men, among them great and renowned scholars, filled their hearts to go exploring and to survey the northern sea and the dwellers of the northern world. They fitted out for themselves a great and mighty ship, and gave it, moreover, [stout] heart and much spirit; and they went forth from the great city of Amsterdam and went down to the sea and sailed [northward] — which is along the length of the world, from [one] extreme… [reaching] ninety degrees [תשעים מעלות] in the longitude of the world, and being about 74° [ע״ד מעלות] from the equator — and there the sun set upon them beneath the horizon and could no longer [rise], [and their ship] froze in [the ice], and they dwelt there many days [before many men perished — sense of the abraded close].

סימן קמ״ה (§145 — printed קמ״ה; logically §146)

That in some places the measure of the daytime is four months, and likewise the measure of the night.

For those who dwell from there onward, toward the northern axis, a further [three degrees], being about 77° [שבעים ושבעה מעלות] from the equator: there [four] signs — which are [Aries through Cancer, or the like] — remain always above their horizon, and the four signs opposite to them are always hidden from them. The four signs that always remain above their horizon are Taurus, Gemini, Cancer, Leo [שו״ר תאומים סרטן ארי״ה], and the four opposite them that are always hidden beneath their horizon are Scorpio, Sagittarius, Capricorn, Aquarius [עקר״ב קש״ת גד״י ד״לי], in such a way that they have, over the whole year, four months of daytime and four months of night; and the four signs that rise and set for them always are Pisces and Aries, which rise for them [in reverse?] and set in order, and Virgo and Libra, which rise for them in order and set [in reverse?] — as you may see upon a table [?] laid out in the

[231] this passage opens with a paragraph-opening word in the larger sort and carries no rubric and no number of its own; it runs on inside the preceding siman. Its second word is set with a closed sort where the expected word has an open one, on both copies.

working of the globe, when you [study] it. [This holds] until the northern axis is elevated above the horizon seventy-six degrees [ע״ו מעלות].

And you, the reader, know full well that we have here some perplexity, and a great question in law [מבוכה ושאלה גדולה [כ/ב]דין]: namely, if it should happen that in one of the places mentioned Jews were to settle, or were to go there by ship — how, and for how long a span, are they to have the Sabbath day and the rest of the festivals? For it is not possible, and it will not enter our minds, that they should rest and keep Sabbath for two, three [שלשה] [שני [הנו?]], or four months. And one is driven [?] to say that from the days of their labour there shall come [?] to them the hour of the circuit of the daily sphere, and that the time of the seventh circuit shall come to them as the time of their Sabbath day.

סימן קמ״ו (§146 — printed קמ״ו; logically §147)

That the dwellers beneath the northern pole have a daytime measure of six months, and likewise a night measure [of six months].

For those who dwell beneath the northern axis — that is, where the axis itself would be [directly] at the point opposite the zenith over their head — [the pole is at their zenith]. On reflection, the circle of the equator [there] becomes the [horizon], and [the celestial equator lies along their horizon]; [the whole revolution] of the light of the signs about them resembles the turning of a millstone [i.e. the sun circles parallel to the horizon]. As was already explained, the equator divides the sphere of the zodiac into two halves… [each sign at its declination of up to 23°51′ rises above or sinks below]. So long as the sun is within the northern signs, they have the light of day; and this lasts half a year. And when the sun is within the southern signs [they have night] — for a natural day, always continuous, will be for these inhabitants the light of daytime for half a year, and the darkness of night [for the other half].

סימן קמ״ז (§147 — printed קמ״ז; logically §148)

To inquire and to know, by means of the globe [בכלי הכדור], the measure of the lengths of the days — [both the] long and the short — for all the days of the year, in every place and every time.

First you must know, for the day inquired about, the sun's place [in the zodiac] according to the [tabular] method [of the sphere of the signs] — for [only] the general [figure]… [Then find] the point of the meridian [nogah ha'ir] over the place for which you inquire, and reckon until [the ecliptic degree] reaches [the horizon]… Take the [ecliptic degree] rising on the eastern horizon and [the one setting on] the western horizon; the [arc] between them upon the equator is the day-arc. And by the same method [reckon] the night-arc: the [arc] between the two [ecliptic] points [below the horizon].

By way of a worked example: the city of Prague [פראג], where the pole rises above the horizon about [50°] — when the sun is at the [summer] tekufah in the sign of Cancer, [its day-arc comes out to] 240° [ר״ם]; therefore divide the

240° into the twelve [temporal] hours, and each temporal hour is 20 equatorial degrees [עשרים מעלות]; divide them by fifteen [ט״ו], the number of degrees to an hour, and there comes out for you the measure of its day there, ten equal hours [עשרה שעות ישרות].[232]

So by this rule you will find the day-length there to be fourteen hours [i.e. for Jerusalem at the summer tekufah, 14 hours]. And when the sun is at the beginning of the sign of Capricorn, and you elevate [the pole] in the usual way, the day-length here in Prague comes out to eight hours, and for Jerusalem, by the same rule, you will find its day-length to be ten hours. I have seen fit to give the students in this matter the reckoning, both in general and in detail. [Their guide is:] if the first point [of the ecliptic] that sets does so exactly at the western horizon before the [next] degree sets among the signs where the sun is, then the measure of the daytime, at the present inclination, is longer than the measure of [twelve] hours — that is, more than 12 hours — and this is while the sun is within the northern signs. [The reverse holds in the southern signs.]

[The passage continues with the detailed Jerusalem/Prague computation: the day-arc reckoned in degrees, divided by 15° per equal hour to yield the hours; e.g. a day-arc such that the daytime is 14¼ hours, and the corresponding latitude of Jerusalem taken as 32° [ל״ב מעלות [?]]. Several numerals in this stretch are abraded and are flagged.] …and thus for Jerusalem, [כו׳ — as printed; no value supplied].

סימן קמ״ח (§148 — printed קמ״ח; logically §149)

On the differences found among the inhabitants of the world in the beginning of each daytime, and [in] the moments and instants of midday — a general rule.

By reason of the sphericity of the earth, many differences and distinctions are found among the inhabitants of the world in the beginning of each daytime and the beginning of each nighttime, and likewise at the instants of the [moments] of midday: there is a precedence of the eastern [dwellers] over the western, and of the northern over the southern. These differences and distinctions are found in four respects, and these are they: (1) for [the dwellers] beneath the equator; (2) for those who share the [same] terrestrial latitude; (3) for those who share [the same longitude…]

(Continuation of *סימן קמ״ח* [§148 printed; logically §149], on the differences among the world's inhabitants in the moments at which day and night begin and at which midday and midnight fall — the fourth of its four respects.)

The fourth respect: those who share neither their longitude nor their latitude. From here on I shall treat them in order, in a compressed presentation. This

[232] the leaf prints ten hours for Prague's longest day in the same sentence in which it has just divided two hundred and forty degrees by fifteen. Its own figures elsewhere give Prague eight hours in winter and a four-hour surplus over the equinoctial day. Given as it stands; no value is supplied. the shortest day is spelled two different ways within the passage; and the difference for Jerusalem is stated only as an arc of thirty degrees, never in hours — the four-hour figure in this passage belongs to Prague.

subject touches on the small differences [among places], and I have alluded to it further — the Rav the Yisraeli [הרב הישראלי — the leaf names no work; Yesod Olam is an identification, not printed here], in chapter 15 of the second treatise [as printed, בפ׳ ט״ו ממאמר שני], in a passage where he unfolds something of this. Tabakiski [?] did not treat this matter at the length the subject deserves; therefore I do not presume to speak of it with precise exactitude, but only so far as my own eyes can see and as far as your understanding will reach — until you add further inquiry and expound the subject well.

סימן קמ״ט

[§149 printed; logically §150] — The rule of precedence and delay for those dwelling under the line of right position [i.e., on a single meridian / the celestial equator].

Concerning this matter we have already set out our words above in several places. Nevertheless, since this siman brings all four aspects together in due order, I saw fit to restate this rule here, for this is its proper place.

Know that for the dwellers under the equator — at the beginning of their day and night, at the moment of their midday, and at all the other hours of the day — precedence belongs to those to the east and delay to those to the west. The measure of that precedence and delay is proportional to the distance between them: for every 15° of separation, the easterners precede the westerners by one hour. Thus the difference between those at the far edge of the east and those at the navel of the earth [the mid-point] — a distance of 90°, a quarter of the globe — [is a set interval]; and when it is the start of day for the dwellers at the navel of the earth, it is already midday for those at the eastern edge and midnight for those at the western edge. The distance between the eastern-edge dwellers and the western-edge dwellers, being half the circumference of the globe — 180° — yields a difference of 12 hours between them. So the start of day for the one in the east is midnight for the one in the west, and the edge of day for the one is midnight for the other, and vice versa. In this way all of them always have their [alternating] days and nights.

סימן ק״נ

[§150 printed; logically §151] — Those who share the same latitude have the same length of day for all of them.

Places that share their latitude — that is, that lie at an equal distance from the line of right position [the equator] — even though they are far apart from one another to the east and to the west, have one and the same measure of day and night, exactly as it is for all who dwell under the equator, where a single rule holds for all its inhabitants. Even if one is distant from another by [several] parsangs [to the north — recte: to the east/west], there is no difference between them save the precedence of the easterners and the delay of the westerners, at

the rate of one hour for every 15° of the distance between them — just as it is for those who dwell under the equator.

סי׳ קנ״א

[§151 printed; logically §152] — Places that share the same longitude have the same moment of midday for all of them, but not the same beginning of day and night — except at the equinoxes of Nisan and Tishrei.

A line running straight from north to south [a meridian]... (and so too the antipodes, in latitude [?])... has already been explained above, in the Second Section, siman ל״ו [§36]: midday is shared by all of them on every day of the year, and the [same] fixed stars [culminate over them], and the moments of the equinoxes of Nisan and Tishrei [are common to them].

And likewise, from what has been explained — that the moment of midday is common to all [places on the meridian] at one and the same instant — at first glance it would appear, and it would seem to us, that the rule for the beginning of the day would be the same as for the midday line, since they are all fixed upon a single meridian running from north to south, whose whole length from its head to its end shares one [culminating point of] the east. But know that in truth the matter is not so, and it cannot be — for the sun does not rise and set for them all at once, with the [same] precedence and delay [that governs midday]. The sun does not rise for them all in a single instant, except on the days of Nisan and Tishrei [the equinoxes]. For all who dwell [along a meridian] incline toward one [pole], and in the summer the day-arc of the northerners is larger than the day-arc of the southerners. Necessarily, then, in summer the sun rises earlier for the northerners than for the southerners — by half the surplus arc added each day to the northerners over the southerners — and it likewise sets later over the northerners than over the southerners. Were we to say that it rose and set for them all at once, then day and night would be of equal measure for all of them — and that is an outright falsehood.

The precedence of the sun's rising for the northerners over the southerners is proportional to the [half of the] surplus day-arc that the northerners have over the southerners. Accordingly, to my mind, one must [know] the altitude of the pole [the latitude], that is, the distance from the equator, of each and every one of the aforementioned places, by the method explained just above. Now we have found that the distance of the city [רע״ב — a garbled proper name, not identified] from the equator is 61° [ס״א = 61; reading uncertain]; the distance of the city of Vilna from it [ממנה — the referent is left as the leaf gives it; taken strictly it measures from the first city, not the equator] is 55° [נ״ה = 55]; and the island of Corfu [is] 38° [ל״ח = 38] [?] from it. According to their distances — for the equator [is the reference from which] their pole-altitudes [are reckoned] — and when we compute, by their altitudes, the measure of their day by the method explained just above in siman קמ״ז [§147], we find that the length of the day at the summer solstice (תקופת תמוז) is: in the city [רע״ב] [about] 19 hours [?];

in the city of Vilna 19 hours [?]; and in [the region of] Corfu 16 hours [?] and a third of an hour [?]. [Reader's note: these three solstitial day-lengths and the three latitudes above are set in tiny, degraded type; the values are transcribed as read but several are internally inconsistent and are flagged uncertain.]

the [surplus] whose measure yields the surplus of the day-arc... two-thirds of an hour, and the surplus [of the westerners]... three hours... In the city [רפב״ל / רעב״ל on the first reading — not identified] [?], as [computed] by its altitude, [the day is] [x] hours... before [the moment reckoned for] Corfu... [ברסבורג — not identified] [?]... before Corfu... the city [פדגר — not identified] [?], [recorded here] as a memorandum for the matter, in a well-verified [?] compilation, with full exactitude.

סימן קנ״ב

[§152 printed; logically §153] — Places that share neither their longitude nor their latitude — how many rules and laws apply between them, one with another.

Places that share neither their longitude nor their latitude — [I shall now treat them] in order. The Chacham Yisraeli [חכם ישראלי — ed.: Yitzchak Yisraeli; identification, not printed on the leaf] discussed this matter in ma'amar 2, chapter 15 [as printed, במאמר ב׳ פ׳ ט״ו], though only a little, for [various reasons]; and other rules are hinted at, but they were not revealed to us — some of them remain obscure. [He wrote] that even if one [wished to specify] for each of them [its] constellation or its analogue, and if a man set his heart to detail every one of them as their rule requires, and to expand the discussion at length, this would not be to the students' liking, nor is there any great benefit in it for us. Also the Rav ⟦…⟧ [גם הרב ⟦…⟧][233] [?] says [as much] on this, [declining to elaborate] on these rules, because there is great [room for error] in them and one easily falls into mistakes; therefore I too have inclined away and passed over [the attempt] to enter deeply into them — let one consult them there in their [own] sources. Yet I shall go so far as to examine, to the best of my ability, and to state [the case] for places that share neither their longitude nor their latitude. For example, Jerusalem — which lies at longitude 66° [ס״ו][234] and latitude 32°

[233] the leaf prints גם הרב — "also the Rav" — as one three-letter word bounded by clean word gaps on both sides, then a word of five letters which is the name and does not resolve. There is no ר׳ abbreviation between הרב and that word: the gap carries no letter and no mark of any kind, so the "R'" formerly printed here was supplied and is withdrawn. Nothing is supplied in its place.

[234] the earlier reading "150° [ק״ן]" is withdrawn on both counts. Under magnification the second sort's foot sits flush against the line of writing, established from the other letters of the line, while this leaf's certified descenders fall well below it — so it is a ו, not a final nun. The first sort is a ס, not a ק: its counter is fully enclosed, where the leaf's certified ק has an open counter and a long leg below the line. One feature is left unexplained — a short spur below the first sort's bottom-left corner — and a later reader should test it against further instances of ס on this leaf.

[ל״ב]; and the city of Frankfurt [פראנקפורט], which lies at longitude 36° [ל״ו] and latitude 50° [נ']. The difference between the two of them in longitude is thirty degrees, and in latitude eighteen degrees [י״ח]. Now, according to their latitudinal position... the precedence belonging to the dwellers of Jerusalem over the dwellers of Frankfurt is two hours [שני שעות], by a reckoning of 15 degrees [ט״ו] to the hour — because the city of Frankfurt, inclining more to the north, has precedence over Jerusalem, since the difference in Jerusalem['s day-arc] is 14 hours [י״ד]... a difference of [x] hours, as above, by which they have precedence because of the surplus of the day-arc between them... [as stated] above.[235]

סימן קנ״ג

[§153 printed; logically §154] — That there are some western lands in which the sun rises before it rises in [the more] eastern ones.

From the matters we have mentioned it will become clear to you that there are some lands that are western and some that are eastern; and the sun rises upon them, [some] on known [days], not all at one instant, and it does not set upon them at one instant. And there are lands where the reverse holds — that is, [the sun] does not rise for them at one instant... it sets from over them [not] at one instant, [but] toward the [known] side... and, more remarkable than this, and a wonder: all of this concerns western lands in which, on known days, the sun rises earlier than it rises in the lands to their east. As an illustration: the city of Constantinople [קונסטאנטינ״א — Byzantium/Istanbul], for instance, lies at longitude 28° [כ״ח] and latitude 44° [מ״ד]; while Jerusalem, off to its east, lies at longitude 66° [ס״ו][236] and latitude 32° [ל״ב]. Now Jerusalem has precedence [in longitude] over Constantinople by 8 degrees [שמנה מעלות = 8]; and the city of Constantinople, by reason of its inclination toward the north, has precedence over Jerusalem by 12 degrees [י״ב]. And since Constantinople's inclination to the north is the greater, and it lies toward the west, its precedence over Jerusalem is greater than [Jerusalem's] precedence [over it]. It follows,

[235] the coordinates here do not close against the siman's own next sentence: the stated difference of two hours at fifteen degrees an hour makes the gap thirty degrees, where the difference of the two printed longitudes is a hundred and fourteen. The latitude pair closes exactly. Given as printed; none is emended. §89, on an earlier leaf, gives Jerusalem's longitude as sixty-six degrees. This siman and §קנ״ג both give it as a hundred and fifty. The book does not reconcile them.

[236] the earlier reading "150° [ק״ן]" is withdrawn. This is a separate setting from the figure in the preceding siman — it stands in the other column of the same leaf, in its own sentence — and was read on its own. Under magnification, against a baseline taken from the two nearest letters of the same line (the leaf is skewed, and a baseline across the whole column would have manufactured a descender), the last sort's foot is flush, and the first sort has the enclosed counter of a ס, not the open counter and long leg of this leaf's certified ק. A ם on the same line, same size and same fount, settles the spur on the first sort as belonging to the sort itself and not to a ק's leg.

then, that in Constantinople — which is west of Jerusalem — the sun will rise on a given day before it rises in Jerusalem.[237]

And now let us inquire, as befits so pleasing a precision, in the craft of the [celestial] globe... the longitudes of [these two] cities at the [summer] solstice in the two aforementioned places, by the method explained just above. We take the measure of the day-arc in Jerusalem as 14 hours [י״ד], and in Constantinople, less than that [פחות מזה]: fifteen hours [ט״ו]. Now had the two places lain on a single meridian, the rising of the sun in Constantinople would have been one hour [שעה אחת] earlier than in Jerusalem; but because they are close [in longitude] — Jerusalem having 8 degrees of easting over Constantinople, which 8 degrees amount to about half an hour [כחצי שעה] — the net remaining to us is half an hour, by which the rising of the sun in Constantinople (the western city) precedes its rising in Jerusalem (the eastern). So it appears to me, and the whole [reckoning] is in close approximation.[238]

סימן קנ״ד

[§154 printed; logically §155] — That the sages agreed to reckon the times of events by the moments of midday and midnight.

Yisraeli [הישראלי — ed.: Yitzchak Yisraeli; identification, not printed on the leaf] wrote, in chapter 66 [כתוב הישראלי בפ׳ ס״ו ממאמר שני — the numeral is a two-letter form opening with samekh; ס״ז = 67 cannot be strictly excluded] of [his] Book Two, that the sages of [reckoning] agreed to base the calculation of the differences of the times, and to relate the times of events and deeds, upon the moments of midday and midnight — [saying,] for instance, that on such a day an event occurred in the morning [reckoned as] so-and-so many equal hours before midnight, or so-and-so many equal hours before midday, [and so] throughout all the days of the year — [and this holds true] even for places that share neither their longitude nor their latitude. For example, between Jerusalem and Prague there is precedence and delay in the beginning of day and night, always by one fixed measure and reckoning: one hour for every 15 degrees. And there is no difference in this between the dwellers [on or off] the equator; rather it is always thus. But if they [chose to] relate events to the moment of sunrise or sunset, or [to] any [other] need — [given] the many rules and conditions that lie in astronomy — it would be a great and easy thing to fall into error. All this concerns those who dwell [in different latitudes] and

[237] the eight-degree precedence this siman states for Jerusalem does not agree with the difference of its own two printed longitudes, which is a hundred and twenty-two. Given as printed. §89, on an earlier leaf, gives Jerusalem's longitude as sixty-six degrees. This siman and §קנ״ב both give it as a hundred and fifty. The book does not reconcile them.

[238] the siman introduces Constantinople's day-arc as less than Jerusalem's and then prints a larger figure for it. Both are given as set. the eight degrees this siman states as Jerusalem's precedence do not agree with its own coordinates. the rubric of this siman is set across the column break, its first line closing the right column and its second opening the left; the text runs on without repetition.

share neither their longitude nor their latitude. But as for the shared latitude of two places [that dwell like those under the equator], there is no difference there between reckoning [an event] from midday or midnight and reckoning it from the moment of the sun's rising over the horizon or from the moment of its setting — because all the horizons of [places on] the equator are, throughout the world, [each] a midday-horizon [for others]. For example, the horizon of those at the navel of the earth is itself the midday-line [meridian] of those at the western edge, and likewise for those at the eastern edge; and so is the rule for all the horizons of the equator — they are all midday-horizons [for those who share latitude]. There is no difference in this reckoning as to whether the calculation is tied to the moments of midday or midnight, or to sunrise and sunset, for their rule in this is as the rule of all the dwellers of the equator, as we have said.

סימן קנ״ה

[§155 printed; logically §156] — The reason for the precision in knowing the aforementioned differences.

That which the sages of astronomy were so precise about — the knowledge of the differences of the times among the inhabitants of the world — was not merely to sharpen the students thereby, so that man's superiority over the beast might be [made manifest]... [but rather] for many matters, as will be explained. For us too, the House of Israel, there are things at stake in this — for instance, the matter of the seasons (tekufot) of the constellations. Suppose, for example, we need [to reckon] the Tekufah of Nisan, and it falls at the completion of Shabbos day [?]; since the tekufah occurs at one [and the same] moment for the whole world entire — how then can it be that at one and the same instant it is midday of Shabbos in every place on earth? [Rather,] we are, as it were, [only] a small share [of the world] at the hour of the tekufah, [and] we must know for which place on earth the reckoning of the tekufot was established. And it is, as stated, that its foundation was fixed upon the horizon of Jerusalem, where the tekufah falls at midday of Shabbos. If so, we must calculate what time this is here in the city of Prague; and we find, by the reckoning, that at that moment it is two hours before [midday] for us, and in the far west it is about 4 hours and two fifths of an hour [ד׳ שעות וב׳ חומש שעה] before [midday]. We derive great benefit in this matter from the reckoning of the tekufot as regards the intercalations (ibburim / evronot), and in the reckoning of the molads (conjunctions), of which we shall yet speak further on, in the Eighth Section.

Another illustration of the usefulness of knowing the differences of the times: it is already well known that lunar eclipses have [great value] for recognizing [longitudes] — [there are] many great benefits in [this], for knowing the boundaries of the earth, for knowing the times, for knowing the moments of

the molads, and [for knowing] the courses of the [planets, the] "kings" among the stars.

Take this example. Suppose it is known that the moon entered its eclipse here in the city of Frankfurt [פראנק'] one hour after midnight; and since Jerusalem is eastward, further east than the city of Frankfurt by thirty-three degrees [שלשים ושלשה מעלות], as above — at the time of the beginning of the eclipse it was in Jerusalem three hours [שלשה שעות] after midnight, approximately. And [for a place] drawn eastward, further east than the city of Frankfurt by about fifty degrees [חמשי' מעלו'], which amount to three hours and a third of an hour [ג' שעות ושליש שעה], we must therefore conclude that at the moment of that eclipse it was there four hours and a third of an hour [ד' שעות ושליש שעה] after midnight. And those at the eastern edge, who are distant from Frankfurt by 144 degrees [קמ״ד], had the moment of the eclipse at nine hours and three fifths of an hour [ט' שעות ג' חומשי שעה] after midnight — so that by their reckoning they did not see that eclipse at all, since the hour was daytime for them, and the eclipse-hour just given is not reckoned for them. And for those who dwell at the western edge, distant from the city of Frankfurt by 33 degrees [ל״ג מעלו'], the moment of the eclipse falls one hour and two fifths of an hour before midnight. And so you will find in every case of this kind.[239]

Here is a second illustration, set down for students for the benefit of knowing the differences of the times. A son is born to a certain king at the western edge, at midnight on the eve of Shabbos; and the astronomers in Jerusalem wish to compute [his nativity] by their own method, their reckoning following the moment of the birth — for what can be known to them from the moment he came out of his mother's womb [several words here do not resolve] [?]. It is therefore impossible to say that the hour of the king's son's birth was midnight of Shabbos eve in every place in the world; and so one must know at what hour it stood in Jerusalem when it was plain midnight [at the western edge]. Now since Jerusalem is seated 66 degrees [ס״ו מעלות] from the western edge, we know that the very moment which is the onset of Shabbos night at the western edge is, at that same instant, in Jerusalem four hours and two fifths of an hour before midnight — or one hour and three fifths of an hour after the onset of Shabbos night.

סימן קנ״ו

[§156 printed; logically §157] — On the variation of summer and winter, and that those dwelling on the line of right position [the equator] have two summers and two winters.

In the [matter of the] seasons of summer and winter we find variation and difference between every place and every place among the inhabitants of the

[239] three of the four legs of this example close exactly at fifteen degrees an hour; the chain from Frankfurt's one hour to Jerusalem's three does not, across the same thirty-three degrees. Recorded as printed.

world. For all who dwell between north and south, [in the register] of the lengths of the days, there will be found variation and difference between each and every one of those who dwell between north and south, according to their nearness to and distance from the equator, as above. Just so will be found among them variation and difference in the season of summer and of winter, according to their nearness to and distance from the equator. Let us begin with an account of the occurrence of summer and winter for those who dwell under the line of right position — the middle [line] between north and south, which is the equator.

Know that all who dwell under the equator have two summers and two winters in each and every year. The two summers occur when the sun is at the head of the constellation Aries (Taleh) and at [the head of] Libra (Moznayim) — for then [it passes over their zenith]... [these are their two] seasons, each of which [brings its own summer].

the sun passes over their zenith (קדקד), and then, in each of these two times, they have the utmost heat, with the mid-point [of temperateness] between them. And the two winters are when the sun is at the head of the constellation Cancer (Sartan) and [likewise] at the head of Capricorn (Gedi); for at these two [times] the sun stands opposite the point of their zenith at its utmost distance, and this [gives] them, at each of these two places, [the depth of winter] — the first [winter] at the summer solstice (Tekufat Tammuz), and its middle [phase]... and the two winters at the utmost distance, like the cold [of...].

סימן קנ"ז

[§157 printed; logically §158] — Those dwelling to the side of the line of right position also have four turnings and four shadows.

between the tropic of Cancer (עגול סרטן) and [the equator] — those who dwell between the tropic of Cancer and [the tropic of Cancer... i.e., within the tropics] have four turnings [of the sun], two summers, two winters, and four shadows, just as those who dwell under the equator have; except that the times of the turnings and of the [two] winters are not at one distance, one measure, and one time [as they are on the equator], and in this they differ from them. For example: those who dwell in the middle, between the [equator] and the tropic of Cancer — when the sun is at the middle of Iyar [אייר — the leaf prints the month, where the sequence wants a zodiac sign; carried as printed], which is the midpoint between Aries and Cancer, it will be above their zenith, and this will be like half [of their first summer]... [and so] they will have their first summer, and [again the like] when the sun reaches the constellation Cancer at the summer solstice (תקופת תמוז) [two words follow here which do not resolve on either copy and are not supplied]... and it will return and rise opposite the point of their zenith a second time, and this will be about the middle of the month of Av [אב], which is for them the middle of their second summer. And there will not be between the two midsummers more than about three

months [שלשה חדשים]; and from the time of the second summer until the time of the first summer comes round again, nine months [תשעה חדשים] are filled out. The times of the winters, too, are not at equal intervals... because the first winter... they had, from midsummer to midwinter, no more than about a month and a half [חודש ומחצי]; and the second winter, which is the time of the sun's being at the beginning of the sign Capricorn, about the New Moon of Teves [בר״ח טבת], is distant from the time of their summer by four months and a half [ארבע חדשים ומחצה]. And likewise there is found a great and considerable difference between the cold they feel when the sun is at the head of Cancer, near to the line opposite their head by about twelve degrees [שנים עשר מעלות], and its being in Capricorn, distant from the line opposite their head by about thirty-seven degrees [שבשלשים [[ה/ע]] — the third sort images between the two letters; on the second reading the phrase is not a number at all].[240]

סימן קנ״ח

[§158 printed; logically §159] — The nature of the summer and winter sun for those dwelling under the tropic of Cancer and beyond it.

For those dwelling under the tropic of Cancer, the sun passes over the point of their zenith once a year, and then (their day-measure is 24 hours, as stated in siman מ' [§40] ['מדת היומם כ״ד שעות כמ״ש סי' מ]); so it is, as above, for all who dwell [there], [where] days and nights are equal for each and every one who is in the middle [of that circle]. And likewise under the tropic of Capricorn (עגול גדי), in the reverse [season]. And in the middle [the equator], by day one will have no shadow at all, because all shadows stand upright and erect in a straight line... [and there is] only one summer and one winter. Just so will it be for all who dwell from the tropic of Cancer onward toward the north: the sun will not reach the point of their zenith [nor go] onward toward the north, as [stated] above, in siman ט' [§9 — 'כנ״ל כסי' ט; a single narrow letter with apostrophe, not a mem].

סימן קנ״ט

[§159 printed; logically §160] — Why at midday [it is] hotter than in the evening; why in the evening it is hotter than in the morning; and why it is colder in the season of winter than in the season of summer.

It is already known that the sun of the day [heats] by reason of the flashing of the sun's rays, on account of which it is called in Scripture chamah ["the hot one"] — as [the matter of] warmth [was explained] above, at the head of the First Section. (And according to the view of the philosophers, who said that in the celestial spheres there is neither cold nor heat, neither moist nor dry — let their opinion stand in its place.) For the sun's heat is felt on account of [several] causes. The first: that throughout the whole time the sun is above the

[240] every count in this siman is of months or of degrees, and all of them are spelled out; nothing in it is counted in days.

horizon — which is the time of daytime — it is hotter for us than the time it is beneath the horizon. The second: that in proportion as the sun draws near to the northern pole, so the heat grows stronger for us who dwell in the north; and, correspondingly, in proportion as it draws away from us toward the south, so the cold grows stronger for us. We also know of the great heat found among those who dwell [near the sun] and incline toward the sun — such as Egypt [מצרי"ם] [or] Barbary [ברברי"א] — not to mention the dwellers of the land of Cush [ארץ כו"ש] (Ethiopia) and the dwellers of the land under the equator.[241]

And likewise we know [by report] concerning those who are far from the sun the great cold and the extreme [chill] that reaches those who dwell under the northern circle [the Arctic]...

[The siman continues into the following pages.]

(Continuation of *סימן קנ"ט* / §159 — printed §159, logical §160 — begun in the previous pages: why the sun's heat varies by time of day and season.)

and the changes and moistening that come from it.

Now, since there is no doubt that by its nature the action of the sun in itself is always uniform, we have cause to wonder — for according to appearances its action seems to us to vary; yet it is the reverse that is the natural truth. For it is already known that the sun makes, each and every day, by the revolution of the diurnal sphere [בסבת גלגל היומי], a half-circle [חצי עגול] around half the ball of the earth [סביב חצי כדור הארץ] — this half-circle being called the "day-arc" [קשת היום], as explained above. And since this day-arc stands at an almost equal distance from us, from the ball of the earth,[242]

from the moment the sun rises above the horizon until it sets from us, people are right to ask why the sun heats us more at midday than it heats us in the morning and the evening.

(2) And further: according to appearances, the opposite ought to hold for us, since — by its northward inclination, as will be explained better below — the sun is nearer to us in the morning and the evening, when it fills out the daytime hours.

(3) And further: why does it heat us more in the evening than it heats us in the morning?

(4) And further: why is it hotter after noon [אחר חצות יומם] than before, at the fore-part of the day?

(5) And further: why, when the sun is in the signs Cancer–Leo–Virgo [סא"ב = סרטן, אריה, בתולה], is it hotter than when it is in the signs Aries–Taurus–Gemini [טש"ת = טלה, שור, תאומים], even though in both its distance from the inhabitants of the world is equal, and day and night too are equal within the two mentioned periods?

(6) And further: since in winter — in particular at the winter solstice [תקופת טבת] — the sun is closer to the ball of the earth than at all the other

[241] the third land is named with an internal mark, as the edition marks foreign names.

[242] the leaf makes the arc a half-circle drawn around half the globe and then adds that it stands at an almost equal distance from the earth; both statements are in one sentence.

times and seasons of the year (as will be explained ahead in the Seventh Section, siman קע״ז [§177 — כמו שיתבאר לפנים בשער השביעי בסי׳ קע״ז; the final letter carries a broad head with a centred stem]), it would therefore be fitting that at the winter solstice, when it is near the ball of the earth, the air should be hotter than at the summer solstice [תקופת תמוז], when it is far from it. [Yet the reverse is the case.]

Answer. To resolve these questions, you must know the following.

First, that wind — that is, air — is by nature very cold; and were it not that the sun warms it against its coldness, who could endure? No creature, neither man nor beast, could stand before the frost and the great chill [הצינה].

Likewise, you must know that the cold and the warmth [הקרירות והחמימות] we feel depend on the sun's nearness to, or distance from, the point opposite the crown of our head [the zenith] — not on its nearness to, or distance from, the ball of the earth.[243]

You should also know that the essential action of the sun's heat issues from the body of the sun itself, at its center.

Now that I have alerted you to these three known principles, we come to resolve the questions. Know, then, that when the sun pours its influence upon us onto the earth along a straight, perpendicular line — from directly above, straight down, as when it is near the zenith — it heats the air more than when it is far off and inclined away from the ball of the earth. For then the sun's rays go forth with power and strike the ball of the earth with great force; and when the ray rebounds from the ball of the earth upward, the air is heated for us by day with extra heat. It is not so when the sun rises and sets, for then it shines upon us from the side, along a slanting line, and there is not in it that force just mentioned.

The sages already illustrated this with an analogy and a parable: a stone thrown straight down [כאבן הנזרק ממעלה למטה], along a perpendicular, falls with great force and even rebounds and springs back upward toward the one who threw it; but when one throws it [slantwise], it does not fall with such force, nor does it rebound, but only skips and moves away from its thrower.

And now know that after the air has been chilled all night, in the morning, when the sun rises above the horizon and shines upon us from the side at a slant, it does not yet have force enough to heat the air that is above the horizon; in a moment it only warms it little by little, and the heat keeps increasing until noon, for then, on every side and in every place, the full force of maximum heat is present. Then, as the sun travels on and shines from the side at a slant, it lacks the force to heat as it did [at the day's height]. For this reason the air is hotter after noon than before, and in the evening more than in the morning.

From the reasons mentioned, you now understand why, when the sun is in the signs Cancer–Leo–Virgo [סק״ב = סא״ב], it is hotter than when it is in the signs Aries–Taurus–Gemini [טש״ת = טט״ת] — even though in both cases its distance

[243] one word stands between "and its distance" and the negation which does not resolve on either copy; three sorts that make no word. It does not touch the negation.

from the inhabitants of the world is equal, and the times are equal. It is because, over the span of its travel through the three signs Aries–Taurus–Gemini, the sun has already warmed the air; so that over the span of its travel through the three following signs — Cancer–Leo–Virgo — it adds still more heat. This is like a furnace [מדורה?] kept burning from the morning until noon, which grows hotter still as more heat is added to it after noon.

סימן ק״ס — §160

(Printed *ק״ס* = 160; logical count §161.)[244]

סימן ק״ס. That the cause of day and night, summer and winter, and the rest of the seasons of the year — all of them, too — lies in the two motions, the voluntary and the necessary [forced].

Even though the cause of day and night, summer and winter, and the other seasons of the year has already been explained to you in an earlier section, with reasons as needed, you should nonetheless know that the Israeli sage [החכם הישראלי — ed.: R. Yitzchak Yisraeli, author of Yesod Olam; identification, not printed on the leaf] wrote, in chapter 8 of the second treatise [בפ״ח ממאמר השני], that all the variations of day and night, summer and winter — in general and in particular — are due to the two motions, the voluntary and the necessary: the one being the voluntary [eastward] motion, from west toward east, and the second the western [diurnal, forced] motion... [and he explains that everything of the necessary motion belongs to the star/sphere that turns [הנוקב?] from east toward west]. And I say:[245]

(§160 continues on the next page.)

Now I say: were the reverting cause — the one that [revolves eastward, אחור?] — [reading uncertain] and that turns from east toward west [to exist alone], upon the foundation that the daily [motion] alone gave from among the instruments of motion toward the east, then the sphere of the stars would give us, all the days of our existence, only rest and stillness. The stars of the eighth firmament that face our horizon would be visible, and all the stars beneath our horizon hidden, all the days of our existence; and there would be no change in the nature of the stars, but it would simply revolve, each and every day, upon a single circle, all the days [of the world]. No part of them would draw near opposite the zenith, nor recede from it, and there would be no reason nor occasion for any change of its season, no alternation of summer and winter; the days would not vary [in length] in one place, and there would be no difference for cold or [heat?], no renewal nor any other of the works of Creation.

And conversely, were the western sphere-motion — turning from the west — to incline alone in the eastward revolution by means of the daily sphere, then the reckoning of days would be entirely void, and there would be no

[244] the rubric spells one word plene where the body spells it defectively two lines later.

[245] no book title is attached to the sage at this citation; the title is supplied editorially. It is printed with his name at the corresponding citation in the following siman.

light revolving [in alternation] because of darkness. On this account the sun would forever face us [at] the western horizon [reading uncertain], its light and heat spreading over it and never setting... and thus [in every place the portions of daytime and of night would be] uniform, and likewise for the other planets, each of which would have its [fixed] portion... [and its time] of setting beneath the horizon of each observer... nor would there be any occasion [for change]... nor any alternation of the divisions [of time]. Thus ends [the matter of] summer and winter.

סי׳ קס״א — §161

(Printed *קס״א* = 161; logical count §162.)

סי׳ קס״א. From which place each and every day begins to be called by its name.

A wondrous question — great, pleasant, exceedingly long and broad, deeper than the sea: to know from which place in the world each and every day begins [reading uncertain] to be called first by its name, and which place in the world is the one where the naming of each day ends, as in the natural days. Great ones of the world were roused to this — Rav Chisda the dayan and astronomer [רב חסדא הדייק והתוכן]; R. Avraham bar Ḥiyya; the great Rav, R. Yitzchak bar Baruch; R. Yehuda HaLevi, author of the Sefer HaKuzari; R. Zerachiah, author of the [Sefer] HaMaʾor; and [others,] may they be blessed. On this matter the great [האלטיגנון?, name garbled] already wrote... and R. Yitzchak Yisraeli, in chapter 16 of the Second Essay [בפ׳ י״ו ממאמר שני] of his book Yesod Olam, expanded at length upon it — several large pages, written [on both] their sides. He wrote that in these matters the earlier authors wrote according to the opinion of most people, and that the authors [themselves] strayed from the path of reason in what their spirit sought, and their reach fell short of bringing the judgment to light. And I have seen, in [various] books, in this passage, the substance of the aforementioned question... together with other hidden confusions, branching and cascading [one from another]... [so that] my soul became entangled... Nevertheless — the Rav, R. Yisraeli, set all the doubts and perplexities as a single question [העמיד כל הספקות והמבוכות בשאלה אחת], but I, the author, saw fit to divide them into four questions [אך אני המחבר ראיתי לחלקם לארבע שאל׳].

(§161 continues.)

[the circle is] held around point ט׳, which is the center of the earth — the circle אב״גד (see the circle here [עיין העגול כאן]) — and this will be the line encircling the ball of the earth, aligned beneath the equinoctial line [קו׳ השו].[246]

[the sun stands] at the western edge, and it delays yet further the onset of Shabbos night for him. And it is a plain matter that six hours later [דבר פשוט

[246] the text directs the reader to a circle "here", naming its four points, and no figure of any kind is printed on this leaf, in either column, on either copy. The only circle so lettered in this stretch stands three leaves further on.

הוא שלאחר שש שעות — the figure is spelled out as a word, not set as a numeral] the onset of Shabbos night will be for the one seated opposite the navel of the earth [its center] — which is the navel of the sea, as above — that navel being two hundred and seventy degrees [ר״ע מעלות] removed from the western edge; so that, accordingly, their [respective onsets] are [staggered]. And [again,] six hours later the onset of Shabbos night will be for Shimon, who dwells at the [eastern?] edge. (And thus, according to this, following the view of the author of the Maʾor and the author of the Kuzari mentioned above, the dwellers at the navel of the earth are earlier — when the holy Shabbos begins for them — than the dwellers at the western edge by six hours, given that the distance between them is only ninety degrees, which the sun traverses in six hours.)

And it would appear to us, by this reckoning, that after [a further span of] hours it would again become the onset of Shabbos night for Levi, who dwells at the navel of the earth — a second time. But this is a manifest falsehood: for how could it be that a sunset [the onset of Shabbos night] occurs at a certain place, and immediately, after twenty-four [כ״ד = 24] hours, at that very same place it should be the onset of Shabbos night a second time? This is vanity and vexation of spirit. We are therefore compelled to say that there is a place where each day begins to be called by its name, and a place in the world where that day comes to its end there — only, we do not know which is their location.

The [second] question. How many hours does the name "Shabbos" — or the name of any other of the days of the week — remain [in force] there, according to human reckoning, for all the inhabitants of the world who dwell along a single line [meridian] that runs from the west to the east, encircling the whole ball of the world? To explain, to make understood, and to give insight — for students — let us first speak of the semicircle-line of the ball of the earth, which runs from the eastern edge (where the head and the beginning of the numbering of the world's [degrees] is) to the [western] edge, completing one hundred and eighty [ק״פ = 180] degrees. And now let us make a supposition and say, by way of example, that Shabbos night has begun — the moment of the sun's setting on Shabbos [eve] — at the utterly eastern edge, and that it is [the moment of] the sun's standing opposite the navel of the earth... [and so on] as far as the eastern edge, so that they complete 180 degrees [שהם ישלימו ק״פ מעלות]: thirty-six hours [שלשים ושש שעות] have passed between the two moments — this for the inhabited half of the globe.

And now the question re-opens: how many hours does the name of the Shabbos day remain there [ומעתה השאלה כמה שעות ישאר שם של יום השבת] for those who dwell around the whole globe of the world? [Taking] three quarters of the globe [שלשה רביע הכדור], that is eighteen hours [י״ח שעות], the answer is forty-two hours [ארבעים ושתי שעות] — re-derived thus: Shabbos is 24 hours [שבת כ״ד שעות]; add them to the 18 hours just mentioned, and they come to forty-two [תחברם אל י״ח שעות הנזכרים יעלו ארבעים ושנים].

The third question. Behold: when the center of the sun stands, at the ending of Friday's daytime, above the zenith of Reuben at the western edge, and we

posit that it is then the moment of Friday's sunset for Levi who dwells upon the navel of the earth — and for Levi it is at that same moment the onset of Shabbos night (though it is not known to us whether the naming of the Shabbath day begins there, for it is possible that, some hours earlier, the onset of Shabbos night was already [reached]

(§161, third question, continues.)

at the eastern edge). And since Shabbos night begins for Levi at the navel of the earth, it necessarily follows that for Shimon, who dwells at the eastern edge, at this same moment it is midnight; and... [for the one] who dwells opposite the soles of [Levi's] feet [his antipode]...

Diagram. Construction, counted off the plate: one plain circle, crossed by a full horizontal diameter and a full vertical diameter. Nothing else is drawn — no second circle, no graduated rim, no radii besides the two diameters.

Closed census of the marks — eight text-items, four inside the circle and four outside; no isolated letters anywhere on the figure:

Inside the circle, one word on each half-axis:

- horizontal diameter, right of centre: **שמעון** [Shimon]
- horizontal diameter, left of centre: **ראובן** [Reuben]
- vertical diameter, above centre: **לוי** [Levi]
- vertical diameter, below centre: **יהודא** [Yehuda] — with a final alef; **לוי** and **יהודא** are the two set turned 90°

Outside the circle:

- top: **ערב** (”evening”)
- bottom: **בקר** (”morning”)
- along the right side, set vertically: **התחלת לילה** ⟦…⟧ (”the beginning of the night of …”) — התחלת לילה read on both witnesses; the word or words that follow are not settled
- along the left side, set vertically: ⟦…⟧ **התחלת היום** (”… the beginning of the day”) — התחלת היום read on B; the first word of the phrase is not settled

**

(The figure stands at the top of the right column of this leaf; the circle discussed in the following siman sits in the left column of the next, so the two are far apart in reading order despite similar band positions.)[247]

Opposite the navel of the earth [i.e., for its antipodal dweller] there is for him [half an hour?] [reading uncertain]... the beginning of morning... It has not been made clear to us whether [that moment] is morning for them — whether it is morning there — as it is [morning] for those opposite whom the naming of each and every day begins... at their place [at] the navel of the earth. Hence, [some] hours after the moment of the onset of Shabbos night for Levi, who dwells opposite the navel of the earth (for whom, accordingly, it is morning

[247]this leaf carries no siman rubric in either column; the whole of it falls inside the siman whose rubric stands two leaves earlier, and this figure belongs to that siman. The circle on the next leaf belongs to the siman after it.

when, at the sun's rising after it, the name "Friday" [יום הששי] is called)... And the same law itself [applies] when the naming of each day begins at the edge [where] it is likewise the "morning" mentioned — the morning of Friday... the days whose naming begins, each by its name, as "evening" opposite the navel [of the earth]. It follows from this that the onset of Shabbos night for Levi, who dwells upon the navel [of the earth], is twelve [י"ב = 12] hours after the onset of Shabbos night for the dwellers [at the antipode]. Accordingly, then, the aforementioned "morning" touches upon the morning of [Friday]...

The fourth question — and it is deeper, more perplexing, and more wondrous than all the other questions mentioned above. For it, let us posit a single point [reading uncertain — להרא"ש ולהריא"ף?] on the circumference-line of the ball of the earth — any point at all, since it makes no [practical] difference in the matter, for [all] points of the [earth's] sphere are equal in this regard... [taking a point on] the eastern [semicircle], and let us imagine as though there, for certain, the naming [of the day] begins...

Shabbos day. And it is already clear that it is a plain matter that, after six hours [שלאחר שש שעות — spelled out], the sun will set for Levi who dwells upon the navel of the earth; and after a further six hours the sun will set for Reuben who dwells at the western edge [שלאחר שש שעות תשקע החמה לראובן] — and that too is, for him, the onset of Shabbos day. Now let us ask about Yehuda [יהודא], who dwells opposite the navel of the earth [at its antipode]: when will the onset of Shabbos day be for him? It is a plain matter that after six hours Shabbos night begins for Yehuda [דבר פשוט הוא שלאחר שש שעות תחל' ליל שבת ליהוד']. Behold, at the [start of the] season it appears that his Shabbos begins some hours after the onset of Reuben's Shabbos — namely, seventeen [י"ז?, ~17] hours after the naming of the Shabbos day began at the place of Shimon, who dwells at the eastern edge, as stated... And now let us ask about Yissachar, who dwells between Yehuda and Shimon at point ט [ומעתה נשאל על ט' יששכר השוכן בין יהודה ושמעון בנקודת ט']: what is his case, and his brothers' — as far as point ח and as far as point ד [עד נקודה ח' ועד נקודת ד']? (*ט*, *ח* and ד here are point-designations in the argument, not hour-counts.)

And behold, the Rav Yisraeli [הרב ישראלי — ed.: R. Isaac Israeli; identification, not printed here] has already testified concerning the words of the two mighty ones [שני האדירים] — R. Yehuda HaLevi and the Ba'al ha-Maʾor [בעל המאור [?] — ed.: R. Zerachiah; the personal name is not printed here] — regarding what they established as a foundation: that the beginning of each and every day, to be called by its name, is first at Jerusalem — that is, at the navel of the earth. And he answered them with decisive replies, difficulties, and great and awesome [objections], such as we raised above in this siman. He, of blessed memory, labored over it in his give-and-take [as one who] plumbs the mighty waters, and he held that all the doubts and confusions mentioned — which testify against the sages — [rest] entirely, according to their premises, all of them...

[Sixth Section — conclusion of Siman 161 (printed קס״א; logical §162): the great date-line question]

and all of them [the doubts] are thereby settled and resolved. This he wrote, of blessed memory; and he added that the beginning of each day's being called by its name lies at the [eastern edge], the place "like the east" — just as Rav Chisda the dayan held, and R' Avraham bar [?] the astronomer, and R' Yitzchak bar Baruch. The Rav [Yitzchak Yisraeli], of blessed memory, wrote, and they concurred, sealed and concluded, that the place said to be "like the east" is specifically where the naming of each day begins — not any other place; and likewise the place "like the west" is specifically where the naming of each day is completed. His reasoning was that he held half the earth's sphere to be submerged in water — the view of our Sages of blessed memory [רז״ל] and of nearly all the ancient sages — so that the last quarter of the sphere is the portion sunk beneath the water, and we need not concern ourselves with any inhabitants there nor with what they might call the day in question. On his premise, all the said perplexities are settled and nothing remains difficult.[248]

But we have already shown above, in the First Section and again in the Third Section, at §84 [אך אנחנו כבר גלינו למעלה בשער הראשון גם בשער השלישי בס׳ פ״ד], that the premise the ancients held — that half the earth's sphere is submerged in water — has already been overthrown. For all of them, whether of the children of Israel or of the nations, we found alike to have erred in this inadvertently. It has already become known to us — not by riddle but plainly — that [inhabited lands?] [?] encircle the whole globe of the world at every hour, literally: as the upper portion is to us, so is the lower portion beneath the soles of our feet — and this is the antipodal world (הקדם) mentioned above. This is especially so at the end of the fourth quarter of the earth's globe, where all the said doubts and perplexities are compounded, as explained — in a land of broad expanse, which is the land now called by the [name] of the New [World] [?], [an expanse?] like the ocean sea, close to the eastern edge, about [ ] degrees [numeral left blank in source]; and it is [מחזס — a form of five sorts that does not resolve on either copy] larger and broader than the European part on which we dwell. Accordingly, R' Yitzchak Yisraeli's answer is thereby uprooted and has no foundation at all — notwithstanding that all the perplexities which he, of blessed memory, with the abundance of his sharpness and acumen, marshalled against the two sages [the Kuzari and the Baal HaMa'or]: even so, the difficulty and the doubts remain in their place. In sum, in these four adjacent questions our hand has

[248] the premise is stated in this book in order to be rejected, both here and where it is attached to the Israeli sage three leaves earlier; the cross-references given for the refutation are to the First Gate and to the Third Gate.

failed and our understanding fallen short; we have only gone astray in them, our lips [sealed] [?].[249]

Know too, dear reader, that I laid these questions and the said perplexities before great masters of enigma and learned investigators who sit before our lord the Emperor Rudolf [Rudolf II], may his glory be exalted — men wise and profound, keen of mind, whose understanding is beyond searching out. To one of them who [pondered?] [?] the said questions I put them for some days; and they were not ashamed to say that they had no correct and sufficient answer [ולא בושו לאמר שאין בפיהם מענה נכונה ומספקת].

סימן קס״ב [printed; logical §163] — One who circles the earth's sphere, and sometimes loses one day of the days of the week and sometimes gains one day

One who travels around the whole earth's sphere from east to west loses one day of the days of the week; and one who circles from west to east gains one day of the days of the week. There is no difference whether he circles the whole globe of the world — were it possible — in four days, or in four hundred years, or in any other span of time: for practical benefit he will always, in the course of his circuit, gain one day of the days of the week. To make this comprehensible, and to give understanding of it even to young students, let us illustrate the matter briefly and lucidly, as though it were possible for a person to travel here around the whole globe of the world in four days; and we divide the round board ABGD which is in the figure [ונחלק לוח עגול ה׳בג״ד שבצורה — printed as a centred line immediately above the woodcut].

Diagram. Construction, counted off the plate: one circle, quartered by a vertical and a horizontal diameter. Nothing else is drawn — no inner circle, no further radii, no rim marks.

Closed census of the marks: four letters, and nothing else. All four stand outside the circle, each just beyond the end of its diameter:

- **א** — above the top of the vertical diameter; set upright
- **ג** — below the foot of the vertical diameter; set upright
- **ב** — beyond the left end of the horizontal diameter; set rotated 90°
- **ד** — beyond the right end of the horizontal diameter; set rotated 90°

There are no other ink-marks inside or around the figure; the only excluded specks are scattered paper flecks well outside the block, an order of magnitude smaller than the letters. The traveler's positions are read round the circle **א → ב → ג → ד → א**, which is the order the text below the figure walks: **… מנקודת א׳ … עד נקודת ב׳ … עד נקודת ג … עד נקודת ד׳ … עד נקודת א׳.**

[249] the parentheses are set and the space between them is blank on both copies; the degree figure was never supplied, or was left out in the setting. It is given as a blank and is not filled. the comparison with the European part is unquantified; the blank figure two clauses earlier belongs to the distance from the eastern edge, not to this comparison.

**250

Let this line that encircles the earth's sphere stand for the horizon-line of the day [?]. Suppose, by way of illustration, that Reuben sets out at dawn from point א on the sphere: from above, the sun rises upon his horizon, and by the coming of that first day he reaches evening at point ד of the sphere, and there he lodges. This is according to the rule laid down: [it is set] beneath his horizon from point ג. On the morrow, the second day, when the sphere has turned round for him from point א upon his horizon from one [day's] time to the next — and by [the reckoning of] Reuben's arrival [?] up to the second sunrise on day two — in truth, from the morning of day one from point א to the [morning] of day two at point ב there are thirty hours [שלשים שעות]. For had Reuben remained standing in his place at point א, he would have had from the rising of the sun over his horizon to its setting a span of 12 [י״ב] hours; whereas because Reuben [traveled] up to point ב, the span of his sun's being over his horizon from point ד to its setting at point ג was eighteen hours [שמנה עשר שעות] — so that the measure of his natural day was thirty hours [יהיה מדת יום הטבעי שלשים שעות], and likewise his day's span in going from point ב to point ג was eighteen hours [י״ח שעות]. Correspondingly, so it would be for one who circles from point ג to point ד, and so on [?]. And so these four natural days come to כך hours [הרי לארבעת ימים הטבעיים הללו יגיעו כך שעות] [recte: ק״ך = 120].[251]

The reverse of this occurs when a person circles from the [west toward the east] [?]: [he will find] one day fewer [?]. Shimon sets out from his point, so that the sun comes to him on [the first day] [?], and it is [at point ב] toward the east; the sun meets him, and he circles until he comes to point ד, where he lodges; and on the morrow, day two, the sun is upon his horizon at point ג. Thus we see that he circled from one time to the next, from the morning of day one to the morning of day two, [and] he circles only 18 [י״ח] hours — because his circuit [runs against] [?] the [sun's] circuit; for it [amounts to] only [ ] of a quarter of the sphere, which is an arc of [ ] [?]. On this reckoning Shimon circles [ ] from one time to the next, likewise 28 [כ״ח] hours; and so the law holds for each of them [?].[252]

The sum of all this comes to 72 [ע״ב] hours — which for this circuit amounts, over all, to four days, all of them [reckoned] from one time to the next — but

[250] this figure stands inside the siman whose rubric heads the right column of the same leaf; the circle on the leaf before it belongs to the preceding siman, whose rubric stands two leaves further back, since that leaf carries no rubric of its own.

[251] the figure for the four days' hours is set as two letters with no abbreviation mark resolvable on either copy, so it is not a well-formed numeral. The same sentence's five natural days, and four days of thirty hours, both require one hundred and twenty. What is printed is given as printed and is not emended.

[252] the figure printed here is twenty-eight, and agrees with nothing around it: this traveller's circuit is given as eighteen hours in the clause above and as eighteen again a few words later, and his total of seventy-two is four times eighteen. The printed sort is a full-height kaf, distinct from the half-height yod of every eighteen on these leaves. Given as set; not emended.

for the whole world, and before them, they are five natural days [הם ארבעת ימים כולם מעת לעת אך לכל העולם ולפניהם הם חמשה ימים טבעיים]. In sum, then, [when Reuben, Shimon, and Levi stand at one place and time]: Reuben will go and circle toward the west [כלפי מערב], Shimon toward the east [כלפי מזרח], and Levi will not stir from his place; and the two circlers will return and meet [again] at point ג on [day?] [?]. For Levi, who stayed in his place, it will be day three [Tuesday] as [ordinary] [?]; for Reuben it will be the seventh day (Shabbos); and for Shimon it will be the fourth day of the week. And it is found that the total between Reuben and Shimon is two days.[253]

[253]in the worked example on the preceding leaf the traveller's direction is given by his destination — "toward the evening side" — and not by a compass phrase; the compass phrases stand only on this leaf.

השער השביעי [The Seventh Section]

Here too will be explained the matters of the sun's course: how long the measure of its year is; how many spheres are found in its orb, and how many its circles; that the sun has four motions; where the mean and the true position of the sun in the zodiac lie; that it revolves an equal course in varying times; and other particulars besides.

סימן קע״א [as printed; recte קס״ג by the sequence — logical §164] — Explanation of what is found in the sun, and likewise in the other wandering stars [כוכבי לכת]: changes and many varying matters[254]

Know that the ancient sages, in the abundance of their wisdom and the [profundity?] of their speculation and inquiry, filled [their books] with, and observed in, the sun — and likewise in the other six wandering stars [כוכבי לכת] — many variations:

- (א) that all seven confounded stars [כוכבי נבוכה], though they complete their [mean] courses from west to east [ ] [?], [carry within them] [?] the [motion of the outer sphere?];
- (ב) that all seven confounded stars [כוכבי נבוכה] sometimes rise and recede from the earth [from the center of the earth], and sometimes draw near it — the difference between their descent and their ascent amounting to [ ] thousands of parsa'ot;
- (ג) that the elevation of the planet itself, at its apogee, is not always in one place, for it too shifts from its place over the course of the years, in its own time;
- (ד) that equal motions are found in them in varying times, and varying motions [in equal times];
- (ה) that [in one place a planet appears to advance and in another to retreat — retrograde motion] [?];

[254] the rubric under the Seventh Gate's banner is printed with the number 171, where the sequence requires 163. Every neighbouring rubric on the surrounding leaves carries a different sort in that position, and the same 171 is printed again four leaves further on for a different siman. Given as printed; the siman is identified by its place in the sequence. the siman uses two terms for the planets and explains the second — "wandering stars" in its rubric and at the head of its body, and "confounded stars" throughout the numbered list, the latter glossed from the image of one straying and confounded in the land: אשר מפני כל תועה ונבוך בארץ … [one further word, unread] אלו השנוים נקראו נבוכים. at the foot of the leaf the summary clause reads נקראו נבוכים — the same word the siman's numbered list uses, not כוכבים. The word that follows it stands unread: four letters are clear on the leaf and do not assemble into any word, and nothing has been supplied in its place.

- (ו) that sometimes they are seen [to stand still], their going ceasing, advancing neither forward nor back — to return afterward [to advance] [?];
- (ז) that it appears to us of a certain planet [the sun?] that one day it rises for us on the eastern horizon in the morning as [one hour] [?] [ ], more or less, and another day as [ ], [reaching?] the western horizon after sunset — all of these — on account of all these variations — were called confounded [נקראו נבוכים] [ ] [?], and [each has its] [?] correct and settled [account].

[Note, below the section banner:] Above — as in the First [Section] — from these variations the ancient sages decreed that each of the seven planets must, by its nature, have a distinct ground [surface] or sphere of its own. As will now be explained to you in this Section, [we treat] all the said variations found in the sun, together with the other matters you require; but the said variations found in the other planets — their reasons and causes will be explained further on, in dedicated sections, God willing.

We begin with the configuration of the sun's sphere, though it is the fourth sphere by the nature of the planets; for it is nonetheless fitting to give it precedence, since knowing the courses of the other planets depends on the sun's course, and we cannot arrive at their motions and configuration unless we first know the sun's course and configuration. The sages already likened the sun, being in the fourth, middle sphere, to a king whose ministers circle about him, at whose command they journey and at whose command they encamp. And according to the view of the great investigator Tycho Brahe [טיכ״א דה ברא״ה], the center of the sun is the center about which the five confounded stars [חמש׳ כוכבי נבוכה] [revolve] [Tychonic system].

And [pleasant?] are the words of the Israeli in what he said upon the verse "and they shall be for signs" [והיו לאותות] — its meaning is "for markers" [פירושו לסימנים] — like a man by his standard, by signs; for were it not for them we should not recognise the parts of the firmament nor know the constellations, and equally, were it not for the constellations, we should not know the precision of the sun's course, as will be explained further on in §182 [בסי׳ קפ״ב].[255]

סימן קס״ד [printed; logical §165] — The definition of the solar year, and likewise the measure of its time

In knowing the measure of the solar year we have a matter of great length [and difficulty], for by it we fix the intercalary day of our years [ ] [?].

[255] the verse is quoted here as "and they shall be for signs" only; "and for seasons" is not set. One authority alone is cited, with no book title attached to him here — contrast the citation four leaves earlier, where he is named in full with his book. The supporting analogy is scriptural, not authorial.

Definition of the year: it is when the center of the sun now stands in its sphere opposite a known point [of the zodiac] — for example, opposite the head of the constellation Aries, or opposite some other first point — and revolves from there past all twelve constellations of the firmament, according to its own [proper] motion, and immediately returns a second time opposite the very same point from which it set out [?]. This is the correct definition of the year. And the measure of the span of the said [motion] — that is, the time [from the point back] to the point — [is what must be determined].

There is a dispute in this among the sages of the science of astronomy [?]; and it is already well known that a great difference exists between the reckoning of Shmuel [ריקנא״ט?] and the reckoning of R' Ada bar Ahava. For according to Shmuel the solar year is reckoned at 365 [שס״ה] days and a quarter, which are six hours [beyond the 365]; while according to R' Ada bar Ahava it is reckoned at 365 [שס״ה] days, 5 [ה'] hours, 997 [the leaf prints תתקצ״ז — the fourth letter is **צ**, not the **נ** formerly transcribed here; the final letter does not fully discriminate **ז** from **ו**, so 996 is not excluded] chalakim, and [43 as printed — מ״ג; recte מ״ח = 48, the received figure] regaim. [Over time?] this [difference has accumulated], so that in our day the difference between the time of tekufat Shmuel and the time of tekufat R' Ada is more than ten days. We have already expanded the explanation of it in our own book Maor HaKatan [בספרינו מאור הקטן], in its Gate of the [**החדוש**] [?], and here is not the place to elaborate.[256]

As for the difference found in this reckoning — between the sages of Chazal and the sages of ancient days down to the present — the is too short to contain the writing of it. But know in general that the astronomers, the sages of ancient days and the sages of our forebears — among them the ḥarṭumim of Egypt [חרטומי מצרים], and among them the sages of Greece [חכמי יון] who are in the city of the sages [שבעיר החכמים]… …[with] instruments and their imperfection — they already labored much over it with speculations and inquiry [?], [that]

[256] the gate's name is legible but its sense is not certain — whether it names the new moon or renewal is not determinable from the ink. the two numerals in R' Ada's year — the chalakim and the regaim — have been checked against the manuscript from which this edition was set. Regaim: that manuscript reads **מ״ח** = 48 where this edition prints **מ״ג** = 43 — a divergence of a single stroke (the left leg of the **ח**), the form a compositor's error takes; since the manuscript is the copytext, the printed 43 would be an error of the press, not a variant reading. The printed figure is kept and 48 is not adopted: 48 is also the received traditional value for R' Ada's year, which is the kind of agreement this edition treats as a reason for caution rather than confidence, and the reading awaits a further witness. Chalakim: the manuscript does not settle the value. It shows four separable letters followed by a long terminal stroke that may be a flourish or a fifth letter; the last certain letter is a **צ** in form. Every reading so far proposed has five letters, so the manuscript agrees with none of them on the count, and no value can be established from it. Its numeral does carry a doubled abbreviation mark, but it stands past the final letter, not between the last two as this edition sets it — and as the same scribe sets the mark on **שס״ה** on the very same line. The mark this edition prints is therefore still not a transcription of the copytext: not because the copytext lacks a mark, but because the mark stands elsewhere. Since this press sets such marks irregularly, the position is itself evidence and has not been normalized.

the composite reckoning not be diminished, for it is a great, lofty, and deep reckoning. A deep, prepared foundation is needed to stand upon in order to learn the measure of the solar year: one must examine and be exact in all four motions found in the sun, as will be explained shortly, in Siman [ק״ע = 170?] [?]. For all this a great examination and a very deep reckoning are required; and required for it, too, are many years and days — not merely a few [ ], but even thousands of years. The ancient sages already investigated this matter, in their speculation, with great precision, and agreed that the measure of the year is 365 [שס״ה] days and a quarter, a little less [?] — [as?] the fourth-part day, and there enters [into it a small excess] [?], being exact in all the composite [reckoning], as in Ptolemy's [reckoning] [?].

And [Ptolemy] wrote that the measure of the year is 365 days and a quarter, less one three-hundredth part of a natural day [שס״ה יום ורביעי פחות חלק אחד משלש מאות מיום טבעי] — which is, in fractions, two parts of twenty-five in an hour [והם בתשבורות ב׳ חלקים מכ״ה בשעה]; so that by this reckoning the measure of the year is 365 [שס״ה] days, 5 [ה׳] hours, 25 [כ״ה] minutes of the sixty in an hour [דקין מששים בשעה].[257]

And now I disclose to the reader's ear that I heard from the mouth of the great investigator — of whom the sages who examine the heavens testify that since the days of Ptolemy [בטולמיא״וס] no investigator so great has been found, namely [התכסטי״אן ברהא״י] — that after he had been exact in all the ancient reckonings he found, upon his own examination, that the measure of the year's time is less than Ptolemy's [בטולמיא״וס] reckoning, and that the precise measure of the year is 365 [שס״ה] days, 5 [ה׳] hours, 49 [מ״ט] minutes, very nearly [בקרוב מאוד]. And so too I heard from the wondrous sage who was a student-colleague [חבר־תלמיד] of Tycho Brahe [טיח״א ברהא״י], and who also sat after him at the head of the sages before our lord the Emperor Rudolf [רודו״לפוס], may his glory be exalted — that he agrees with the reckoning just given; and it is less than R' Adda's reckoning by close to six minutes [והוא פחות מחשבון ר׳ אדא קרוב לשש דקין].[258]

[257] the leaf states the derivation in two mutually agreeing forms and then prints a figure neither yields: a three-hundredth of a day is two twenty-fifths of an hour, i.e. 4 minutes 48 seconds, so the remainder should be 5 hours 55 minutes. The same twenty-five is set a few lines earlier in the conversion of R. Adda's figure, where the arithmetic likewise wants fifty-five. The print is consistent with itself and is given as it stands; no corrected figure is written into the transcription.

[258] the confirming sage is not named in this siman; he is described only as a student-colleague who succeeded the investigator at the head of the sages before the Emperor. Any identification of him is editorial. the investigator's surname is set three different ways within two leaves, and a fourth form of the same name stands two hundred pages earlier; see the note at §16. Recorded as they stand and not harmonised. The first element of the form at the head of this passage does not construe and is not normalised.

סימן קס״ה [printed; logical §166] — To know how much the sun moves in one day against the horizon of the zodiac

To know, according to the reckoning above, how many parts [or fractions] the sun revolves against the sphere of the zodiac in one day: know that, [given] [?] the measure of the year [ ]. This is an easy thing for those versed in the science of number, to calculate how much of the sphere's circuit falls to each day of all the days of the year: one divides [?] the 360 [ש״ם as transcribed = 340; recte ש״ס = 360 — ם/ס do not discriminate at this substrate] degrees of the sphere by the number and time [of the year] [?], and [the quotient] is the measure of each day of the year's days [?]. Our procedure follows the way of the masters of number, and we say: if 365 [שס״ה] days, 5 [ה'] [hours...] [ ] — we require, for the sphere's 360 [ש״ם as transcribed = 340; recte ש״ס = 360 — ם/ס do not discriminate at this substrate] degrees, [to find] how much of the sphere reaches [in] one day; and you complete it duly, by the way of the masters of number, and there comes out for you a mean motion for one day of 59 [נ״ט] dakim, 8 [ח'] shniyim, 46 [מ״ו] shlishiyim, 13 [י״ג] revi'iyim, 12 [י״ב] chamishiyim, 31 [ל״א] shishiyim — by a great approximation [בקירוב גדול].[259]

[Cross-references, in the right column :] And see the book Yesod Olam, Ma'amar 3, chapter 20, and the book Tzuros ha-Aretz, gate [?], perek [?] [ועיין בספר יסוד עולם מאמר ג׳ פרק כ׳ ובספר צורות הארץ שער [?] פרק [?]].

סימן קס״ו [printed; logical §167] — That the length of the year is reckoned by the revolution of the sphere of the fixed constellations, and not by the [visible] figured constellations; and whether the measure of the year stands at one measure

Ptolemy, chief of the astronomers, wrote that the length of the measure [of the year] is reckoned by the revolution of the sphere of the fixed constellations [the sphere of the fixed stars] — [and not by] the [visible figures]. [ ] [?] in the [reckoning] as [the curvature?] of the upper sphere, the portion [ ] [?] (as above in the Fifth Section). And so is the view and consensus of all the sages, ancient and later, whether of the children of Israel or of the nations: that the length of the year — the tekufot and the reckonings — is [measured by] the circuit of the sun's center [ ] back to [its] point, according to [ ] against the true, figured constellations, [as above] in the Fifth Section; their reckoning is not according to the [visible] sphere, for the [figured constellations], from point to point, as the circles of the figures, [give a value] exceeding a year [?].

For it has already been [set down] earlier, at the end of the Fifth Section, that according to Ptolemy the sphere of the [fixed] constellations revolves

[259] five of the six places are the received values for this quantity; the third is not, and is given as printed. No degrees place is set at all — the figure opens at the minutes. The fifth place is set twice, once at the foot of one leaf without its unit and once at the head of the next with it: a leaf-turn repetition, not a seventh place.

one degree in [a hundred] [?] years [precession of one degree per century]. Accordingly, when the sun's center goes out from a point — for instance, from the [resting place] of the head of Aries — and returns opposite it to the point [ ] in the sphere [ ] [?], [and] we reckon for it from the appearance of the point of the head of Aries [as a] star [?], [that is] not [truly a full return]: for it has already circled [ ] [?] as the [motion] of all the [zodiac], one part out of a hundred above one [degree], which is not [ ] [?]. In the Gemara it is written [ ] [?] [holding the tropical year] to one measure, close [ ] [?] — as above. And the sage "Israeli" [R' Yitzchak Yisraeli] wrote [ ] [?] in his third essay, that [ ]. The later [astronomers] hastened, in this matter, against Ptolemy, and demonstrated and proved that [ ] [?] — [namely that the tropical year?] does not stand at [a single fixed] measure [?]: it [changes] by a very fine amount, imperceptible, not discernible for even a moment, [only] after some [hundreds] of years [?]. This is on account of one of the two causes — by reason of the motion of trembling and quaking [תנועת הרתת ורעדה] — trepidation, as we wrote at §130 [סי׳ ק״ל]; and the second, that the [point] [?], against the [constellations], in most of the [breaking?] [?], [likewise now shifts] from its place, as will [be explained] further on in this Section, at §179 [בסימן קע״ט]. By reason of these two causes, the measure of the tropical year does not [strictly] stand at one single measure; and they are [ ] [?] — deep, intricate, and most wondrous matters.

But according to what we have received from the astronomers of our own time, they took no account of these two causes at all — for it has already been [shown] above, at the siman בסי׳ ק״[?][[the numeral's second letter is unread; it is not ל, so this is not §130], that the "trembling" (trepidation) motion is, in my view, not [among] [?] the motions of Ptolemy or of al-Battani [אלבתיאנו] at all. And also to note: the majority [treating] of the sun did not concern themselves with this matter, but rather their consensus, like that of the rest, [holds to] the tropical year.[260]

סימן קס״ז [printed; logical §168] — That the sun's sphere has [several] spheres that revolve around the earth's sphere

Know that the sages [who follow], for the most part, those who speak of astronomy [ ] [?] — following Ptolemy [בטולמי] — [teach], in the greater part of what they say, [that the variations] found in the courses of the planets [are as] mentioned just above. [Ptolemy] investigated and set in order, with the abundance of his wisdom, the keenness of his intellect, and the reach of his inquiry, to find the cause — in which [ ] to establish, to understand and to

[260] three of this leaf's cross-references to other simanim have been read on the leaf. Two are settled — §130 and §179 — and the third is not: its number begins with the letter for one hundred and the letter after it cannot be made out, so the reference is given as far as the leaf carries it. It is not §130: the letter standing there does not rise above the line of writing, where the confirmed §130 elsewhere on this leaf rises well clear of it. No replacement value has been supplied. A fourth cross-reference higher in the same column has been located but not examined.

settle what we [wrote] [?] — the wondrous and intricate [phenomena]. In any case, on this account [they hold] that each sphere among the spheres of the planets [is embedded] within another sphere that surrounds and covers it over its entire surface — over its convex side (its outer face) and over its concave side — in such a way that the thickness of each [portion] lies between two kinds of spheres, the one inner and the other outer. I shall now choose out for you their precise [account], with the sun's sphere, which is the one we are dealing with; and from it you will then understand the greater part of the surface [structure] of the paired spheres.

The inner sphere [of the sun's sphere]: the body of the sun is fixed in it like a pearl set within the ring [כמרגלית השקועה תוך הטבעת]; and in this sphere its center is displaced [eccentric], for its center [does not coincide] with the earth [ ]. Likewise, the center of the zodiac sphere is not the center of this inner sun-sphere; only this inner sun-sphere is the one whose center is displaced. Therefore its center is equal neither to the earth's center nor above the zodiac, but is always closer to one of the extremities than to the other. As for the upper sphere, which is written [set] within the inner sphere [?], its center is the center of the earth, the same as the center of the zodiac itself; therefore it is at an equal distance, throughout the circuit of its concave face, from the earth's globe, and likewise, on its convex face, it is at an equal distance from the zodiac sphere. And the line that revolves upon its middle [runs] directly beneath the middle line [ ] literally beneath [ ] a star which is within it — this line, too, [tracks] directly beneath the middle line that is in the sphere [ ] [?].

The concentric sphere ("the resembling sphere," גלגל הדומה): because it resembles the circle of the zodiac itself in every respect — resembling it as regards its center [ ] [?]. [Its] center resembles the center of the zodiac, and it also resembles [the zodiac] as regards its [equal] division [?], being equal on every side throughout its circuit; and the earth's globe, like the zodiac sphere, is likewise equal throughout its circuit, [at] an equal distance from the concave face of the zodiac sphere.

סי׳ קס״ח [printed; logical §169] — Concerning the two spheres of the sun mentioned, described as three spheres[261]

Know that the eccentric sphere of the sun is placed within [the belly of] the concentric ("resembling") sphere, evenly, like [ ] a case (tik) [?] for the eccentric sphere; and the concentric sphere in its entirety encloses the eccentric sphere from above and also from below (as above), in such a way that the surrounding sphere — which is the eccentric one [?] — divides and splits the thickness of the concentric sphere into two separate spheres. Although in truth both are one sphere, yet so that the matter may be better explained to students, we imagine them as though they were entirely separate; and it is accordingly called three spheres in the sun's sphere, all of which encompass the earth's globe on every

[261] two of the three rubrics on this leaf are set in full and the third abbreviated.

side. But in truth all are as one [ ] [?] (as above) — only that for [our] part they are divided into three spheres, as you will see in the figure.

To make it clear to students, the [astronomers] separated [it] [ ] [?] and drew it upon a surface: the concentric ("resembling") sphere in its entirety, which is the outer sphere [הגלגל החיצון] — the largest of all — and its [globe] [ ]; the inner [sphere], which is the smallest of all — the sages made it [with] [ ] [?] surrounding [drawings]; and point **א** in the figure is [ ] [?] the center for both — [as regards] the concave face [?] of the great [sphere] and the concave face of the small one. And the great sphere, on its convex side, which is the [middle] line [ ] [?], its curvature [belongs] to the small [sphere] [?] — [ ], which, by its convexity, [ ] [?]…

שער ז — Seventh Section (on the Sun), continued

[Continuation of סימן קס"ח — §168 as printed / logical §169]

with the sphere of Mars [המאדים, with the article], which is near it above; and the small sphere touches, with its concave face — which lies opposite the inner face — the sphere of Venus [נוגה] near it [below [?] — the printed text reads "above" a second time, but the sense requires "below"]. The middle sphere is the eccentric [גלגל היוצא מרכז]; the sages call it [כרתו [?]], and so point **ב** in the figure is its center, both for its concave side and for its convex side. The same holds for the two circles, inner and outer, that together make up the "resembling sphere" [גלגל הדומה] — the ones drawn in black in the figure: point **ב** is likewise [their eccentric center on one face], while point **א** is the shared center for the concave faces of both the great and the small [black] spheres. …the resembling sphere at point **ז** ['גלגל הדומה בנקודת ז], [which is?] the figure where the whole of its thickness is of… [ש[?כ] של העוביו כל שם אשר צורה]…

Diagram. Construction, counted off the plate: four circles, nested but not concentric. Outermost is a large disc filled with heavy hatching. Set into it, displaced markedly up and to the left of the disc's own centre, is a white ring bounded by two thin circles; within that ring is a second band of hatching; and within that a small white core disc. The displacement is the figure's whole content — the white circle is the eccentric — and it is plainly visible: the hatched body is much thicker at the bottom-right than at the top-left.

Closed census of the marks: two letters, and nothing else inside the figure. Both stand in the small white core disc, one above the other, both set rotated 90°:

- **ב** — upper
- **א** — lower

There is no third letter, no point on any rim, and no lettering in the hatched bands; the only other marks within the block are the printer's hatching itself.

Caption, printed in two lines beneath the woodcut (verbatim): "**הוא מרכז לשניהם שניהם מגבילים את עגול הלבן היוצא / מרכזו** :" — "It is the centre for both

of them; both of them bound the white eccentric circle, whose centre is [displaced]."

**

And these three spheres — each one is nested within the form of its neighbor: the great black sphere against its convexity, which is its outer circle, has its center at the point that is the center of the world [point **א**]; while against its concavity, its inner circle, [its center is point **ב**]. So too each of the black spheres has two centers, as depicted.

סימן קס"ט [§169 as printed / logical §170] — The form and structure of the fourth firmament, which is the sphere of the sun: how its thickness divides into three spheres

And you, O reader, I have already stirred you above in the First Section [to take an illustration from a single sphere]. So here too, know that the three spheres depicted in your diagrams are all complete spheres [כדורים שלימים] that surround the sphere of the earth on every side throughout the whole of its rotations.

סימן ק"ע [§170 as printed / logical §171] — That the middle [sphere], the white eccentric, and the sun itself, both touch the spheres of Mars [נוגעין בגלגלי מאדים]

The white circle in the figure is the eccentric [היוצא מרכז]; [within it is depicted] the body of the sun, which is fixed inside its sphere. Likewise the other planets [כוכבי לכת] have three spheres of their own, just as the sun does. Therefore know: when the sun is at its apogee [גובה רומה] and Mars is at its perigee [שפל רומו], the two bodies — Mars and the sun — draw close and touch [כדבקים ונושקים] one another in the heavens; and likewise, when the sun is at its perigee and Venus [נוגה] is at its apogee, the two bodies — the sun and Venus — touch and kiss. This corresponds to that. And so the sun itself does on reaching the two points — that is, at the point of the apogee [בנקודת גובה הרום] it meets and touches the sphere of Mars above it [גלגל מאדים ממעל לה], and at the point of its perigee [ובנקודת שיפולו], which in the figure is point **ח** [נקודת ח'], it meets and touches the sphere of Venus below it [גלגל נוגה מלמטה לה].[262]

[262] the rubric names only the upper of the two spheres; both are named in the body, each with its own point, and each contact is stated twice — once of the white middle circle and once of the sun.

סימן קע״א [§171 as printed / logical §172] — Explanation of the sun's path-line [קו מסלול], which is the girdle of its revolution, always, and never departs from it[263]

In the middle of the deferent [גלגל הנושא], whose sphere is depicted [in the figure], is drawn a single circular line whose center is [the center of] the sun; and it is engraved [חוקקת] and traced… and this is a line lying at the middle [of the thickness] from the figure, as [explained] above in §[ק״ו — 106 [?]]. And this line is called the sun's path-line [מסלול החמה], since upon it the sun's center revolves, always beneath the ecliptic line [קו הקדרות], and this motion is called the mean motion [מהלך המצע], the even one, as will be explained. By it the sun completes its circuit against all twelve constellations in a full year, and by its revolution are settled all the seasons of the year — cold and heat, summer and winter. Recall all this, for you will need it later.

סימן קע״ב [§172 as printed / logical §173] — Five circular lines [חמשה עגולים קויית] are found in the whole figure of the sun's sphere described above, and the eccentric center engraves a circular line about the center of the world[264]

From the principles we have stated you will see that in the three spheres of the sun mentioned there are five circular lines [חמשה עגולות קויית], and they are these: • the outer circle of the sun's sphere — the largest; • the inner circle — the smallest; • [the two circles bounding] the eccentric sphere; and • the path-circle [עגול המסלול]. For as already explained, the center [of the black] spheres in the figure is point **א**, and the center of the eccentric sphere is point **ב**. Hence you will see [that] the body of the sun, by the [uppermost] sphere, revolves — its center [being] point **ב** — [and] makes a circle about the center of the world, which is [marked] in the figure at point **א**, engraving [a line] over its whole revolution.

סימן קע״ג [§173 as printed / logical §174] — How great are the dimensions of the thickness of the deferent [גלגל הנושא]

The thickness of the deferent that carries the sun is about [numeral: ?]… the center of the sun's deferent from its own center… twice; and the astronomers said that it is about the measure of the diameter [קוטר]… and it is one-fifth [חמזת — read חמישית [?]] plus [a fraction] of the measure of the diameter, as will be explained further on in the Eighth Section, in §רל״ט [239]. For we have already written above that the line encircling the sphere of the earth is sixty

[263] this same siman number is printed a second time in this book, four leaves earlier, for the first siman of this Gate, where the sequence requires a different number. Both are given as printed.

[264] the word qualifying "circles" in this rubric and in its body is set the same way in both — קויית — and does not construe; given as printed and not normalised. the three are called "spheres" here, where the siman four rubrics earlier calls them "globes"; the terms are given as each place sets them.

thousand four hundred parasangs [ס' אלפים וארבע מאות פרסה], and there comes to the diameter of the earth, by simple reckoning, eighteen hundred parasangs [שמנה עשר מאות פרסה]; and when this number is multiplied by five and a half [ע"י חמשה ומחצה], their number rises to nine thousand eight hundred and fifty parasangs [תשעת אלפים ותת"ן פרסאות]. This is the measure of the thickness of the deferent that carries the sun, as [will be explained] further on in §[קע"ק — 176/179? [?]]; there it will be explained to you how far the sun's sphere is displaced from the center of the world. And see the Ikkarim, Ma'amar 4, chapter 2 [as printed, ועיין בעקרים מאמר ד' פ"ב; the leaf writes only בעקרים — "of R. Yosef Albo" is an identification, not printed on the leaf].[265]

סימן קע"ד [§174 as printed / logical §175] — The reason why the three spheres of the sun were made to differ, each one distinct from its fellow

What the astronomers needed, in their conception, was to draw on paper three spheres… each of them differing [in thickness at its four quarters] from its fellows; and it did not suffice them [to draw them] one within another, equal to one another, as was drawn above [in the figure], but [they had to draw them] one within another — because the center of the sun's sphere is eccentric… from the earth, as will be explained. Already the investigators [have shown, by demonstration], that there is no sphere [that leaves a void] within another sphere… and for this reason they were compelled to draw [it thus]; for the eccentric sphere that goes out [from center] between two other spheres — one above it and one below it — [must fill the gaps]: the sphere above it fills the void [רקות — read ריקות] with its convexity, and [the sphere] below fills [the void] with its concavity, so that no void remains; and no sphere enters within the hollow of its fellow. [Thus] the deferent [כדור הנושא] always keeps its center within the "resembling sphere" [גלגל הדומה], and the [resembling] sphere as a whole always keeps its center [at] Saturn [סארן — read the world-center [?]], its center coinciding [with the world-center].

סימן קע"ה [§175 as printed / logical §176] — Explanation of the saying of our Sages, of blessed memory, that the sun and moon are set in the second firmament [ברקיע השני]

Our Sages of blessed memory said in Bereishis Rabbah [רז"ל אמרו בבראשי' רבה שיכן הם נתונים חמה ולבנה ברקיע השני]: the sun and moon are set in the second firmament. (The underlying dictum is the baraita of Chagigah 12b, where the second heaven, rakia, is the one "in which the sun, moon, stars and constellations are set"; but the page names Bereishis Rabbah.) They do not mean by this that

[265] the thousands figure of the thickness is set with a final form of its last letter used as a medial numeral; given as printed. §178, on the following leaf, gives this same quantity as nine thousand nine hundred, where this siman gives nine thousand eight hundred and fifty. Both copies agree with each other at both places, so the disagreement is between the two places in the book, not between the copies. Neither is emended, and the chain does not close from its own three figures.

both of them [are literally there]; nor do they mean that the "second firmament" is [reckoned] upon the sphere of Mercury [כוכב], which is second from above… the fine [sphere] which is second from above… — this distinction is [not] clear; rather it appears that they mean each one [is set] in the second [sphere] of its sphere-system… namely the deferent, the eccentric [היוצא מרכז]. The words of our Sages, of blessed memory, [are] not [to be taken] but as [pointing to] what is well known and visible to us, to our eyes.

סימן קע"ו [§176 as printed / logical §177] — That the two [black] spheres of the sun mentioned above each have two centers

Know that the "resembling sphere" [גלגל הדומה] as a whole, as depicted by the two black spheres in the figure, on account of the variation of its thickness in the world [is drawn] so that each of them has two centers. The great black sphere, against its convexity — which is its inner [read outer [?]] circle — its center is [as it were] the center of the world [in the figure, point **א**]; and against its concavity — which is its inner circle, [the line] which itself likewise borders and touches the deferent — its center is displaced from the center of the world, and this is point **ב** in the figure. So too the small black sphere before it in the figure likewise has two centers, except that its arrangement is reversed: its line of convexity — which likewise borders and touches the deferent — has its center displaced from the center of the world; and its line of concavity is the reverse, [facing] toward the sphere of the earth, the center of the world. So that point **א** is the center for the inner circle of the small black sphere and also the center for the outer circle of the great black sphere; while point **ב** is the center for the outer circle of the small sphere and also for the inner circle of the great sphere.

סימן קע"ז [§177 as printed / logical §178] — That the middle sphere of the sun's sphere is absolutely eccentric, and by its revolution alone the length of the year is reckoned

Now the third sphere of the sun's sphere is the middle one, depicted in white, which is the deferent of the sun. It is absolutely eccentric with respect to its two circles, the convex and the concave, for both of them are [distinct] from the two spheres mentioned above and below it. For this reason it is self-evident, without need of elaboration, that point **ב** is the center both of its convexity and of its concavity; and likewise it is the center for the mechanism of the path-line. By the revolution of this middle sphere alone is the year reckoned, for it alone — and nothing else — carries the sun around the sphere of the world in its complete circuit of [כשס"ה — 365 [?]] days. And [reckon] as a fourth [point] that it is not so with the "resembling sphere" as a whole: for both its outer and inner spheres [do not] make any motion at all, except that in some thousands of years they complete two kinds of motion: the first is the motion of the eighth sphere [גלגל השמיני], one degree in [ע' — 70 [?]] years, as [explained] in §רי"ד [214] and §ק"ע [170]; and the second motion [shifts] the height of the apogee eastward, as will be explained shortly.

סימן קע"ח [§178 as printed / logical §179] — That the sun draws near to, and recedes from, the sphere and center of the earth

Know that the astronomers filled [their study] with contemplation and saw that the sun draws near to and recedes from the center of the earth from time to time by several thousand parsa. The cause of this is the eccentricity — the displacement of the center of the sun's sphere [also] above the center of the world [סארן — read the world-center [?]]; and this is the cause and reason that the deferent, keeping fixed the center of the sun, [carries it] little by little and distances it from the earth up to its apogee [גובה רומו], which is point ג [נקודת ג׳ — the sort is not decisively controlled] in the figure; and [there] it touches [ולסס ה׳ א'? [?]] the sphere of Mars [מאדים] at point ו [נקודת ו׳; as marked ו, ז, ח], at its farthest distance from the earth. This occurs at the true summer solstice [בתקופת תמוז האמיתי], when the sun reaches the [head of the constellation… — continues on next page].[266]

[Continuation of סימן קע"ח, §178] …to the beginning of [the constellation Cancer] [לתחלת מזל סרטן], drawing it little by little until it reaches its low point [נקודה שפילה], which is point ד [נקודת ד׳] in the figure; and there it is also nearest to the sphere of Venus [נוגה] below it, and there it is at its closest to the earth — and this happens at the true winter solstice [בעת תקופת טבת האמיתי], when the sun reaches the head of the constellation Capricorn [לראש מזל גדי]. And by the difference [ההבדל] between the far distance and the near — [some numeral of] years, according to the [structure] of the eccentric sphere — as already explained just above, that the thickness of the eccentric sphere is nine thousand nine hundred [ט׳ אלף בתת"ק] parasangs, and so forth[267] — from this it is clear to you why the sun, in the near season, [is closer]: its circuit is by so much shorter to the center of the earth, and in the season of its distancing its circuit is by so much longer from the center of the earth. And the sage of Israel [חכם ישראל] wrote, in Treatise III, ch. 4 [מאמר ג׳ פ"ד — of Yesod Olam, Yitzchak Yisraeli [?]] : that the [Creator] made this so [רביעי — a fourth reason [?]] in order that the heat should not grow too strong when the sun [is near], nor the cold too fierce in the rainy [winter] days. But know that this reasoning holds only according to [the view of] the author [of Yesod Olam [?]], who found the [revolutions of the spheres] moving beneath the girdles of the constellations; whereas I have already written on this at length, more clearly, in the Third Section [שער שלישי], §[numeral: ?].

---

[266] the apogee is given two different point-letters in consecutive clauses — one for the point of the figure, one for the place where the sphere of Mars is touched — and the two signs are entered differently, the one at the head of its sign and the other at its beginning, though the word governing the first is not certainly read. Given as set.

[267] §173, on the preceding leaf, gives this same quantity as nine thousand eight hundred and fifty, where this siman gives nine thousand nine hundred. Both copies agree with each other at both places, so the disagreement is between the two places in the book and not between the copies. Neither is emended.

סימן קע"ט [§179 as printed / logical §180] — That the "resembling sphere" as a whole — that is, the two black spheres in the figure — according to the opinion of Ptolemy [בטולמיאו"ס], has a motion of its own, and it shifts the height of the apogee [רום גובה] that is in its place

Know that the "resembling sphere" as a whole — the two black spheres in the figure — according to the opinion of Ptolemy has no motion at all of its own, except what results by way of the motion of the uppermost sphere [גלגל העליון]. For in his time [Ptolemy's] the height of the sun's apogee was at point **ג** in the figure, [where] the head [apogee] of the sun was fixed as a nail within the frame [tik], in the [middle of the] constellation Gemini [מזל תאומים]; and it was reckoned that there was and would be the seat of its motion for all the days of the world. But the later astronomers found in this "resembling sphere" a heavy [slow] motion, by which the two [black] spheres [displace] and turn the middle sphere — the eccentric — necessarily eastward, with great slowness [וכמתון רב], in such a way that this heavy motion shifts most of the [apogee's] displacement eastward in our own times. And this is [the doctrine] that in [numeral: ?] years [כ' חלקים ופ"ם ?[?]] the height of the sun stands against the ninth degree [המעלה התשיעית] of the constellation Cancer [מזל סרטן].[268] Reckon for yourself the span from that time [Ptolemy's] until our own — some close to 1,500 years [קרוב לאלף ות"ק שנה] — [in which] the height of the apogee has shifted close to five degrees [קרוב לחמשה מעלות];[269] and by proportion, for every thirty thousand years [לשלשים אלף שנה] the height of the apogee would move through the constellation Capricorn [מזל גדי] at the winter solstice, and so forth. To this the sage [Isaac] Israeli [ישראלי] testifies: he wrote in Treatise III, ch. [[?]] [Yesod Olam; as printed, במאמר ג' פ"[[ר/ד]][270], that the height of the sun shifts a degree in 280 years [ר"פ שנה], and accordingly the full circuit is not completed until after [כלסיסות"ת — numeral uncertain [?]] years. And it appears that there is an error there [ונראה שיש שם טעות]; see there — [a further reference, ע"ש [[…]]ק"[[?]] סי' י"ב, whose middle name does not resolve][271] [?] — §12. And in the book **נורות הארץ** [ובספר נורות הארץ], folio 15 [דף ט"ו], he wrote that the

[268] the ordinal and the sign are both given in words here.

[269] the figure is spelled out in words and carries no abbreviation mark; there is no numeral here to have been misread.

[270] the chapter reference is פ + a double mark + exactly one further letter, then a word gap. The earlier reading פ' ר… mis-parsed it twice: the mark is a gershayim, not a geresh after פ, and there is no continuation after the single letter. That letter does not settle between ד and ר, so no chapter number is supplied and the former "ch. 4" is withdrawn.

[271] the name is six letters, the mark set between the fifth and the sixth. The fifth is a ק beyond dispute — it descends well below the line of writing. The sixth does not read, and is not the ס the earlier reading gave: there is no right-side stroke reaching the line of writing, which both a ס and a ה would require. The ק"ס ending is struck rather than carried forward. The first four letters do not read either, and no name is supplied.

height of the sun's apogee, according to the opinion of Ptolemy, was five and a half degrees of the constellation Gemini [חמס מעלו' וחצי ממזל תאומי'ן].[272]

סימן ק"פ [§180 as printed / logical §181] — That the center of the eccentric sphere itself also shifts from its place

Know that when the height of the sun's apogee shifts from its place, likewise the center of the eccentric sphere itself also shifts from its [place]. For since the displacement of the whole sphere-body cannot [occur otherwise] — for if that were so, it [would collide] within the bounds of the sphere of Mars — rather it only [performs] the revolution of its center forever; and for this reason its center too shifts from its place, and it describes an arc about the center of the world, as [if it were] a circle of its revolution in respect of the diurnal aspect [הבחינה היומית], and so forth. [As for the] astronomers before us, [they said]: the center of the sun, by the diurnal motion, revolves [from] east [to west; and the sun, by the shifting of the sphere as a whole, moves from east to west], as [stated] above.

סי' קפ"א [§181 as printed / logical §182] — That the sphere of the sun has four motions[273]

From the principles we stated above it will become clear to you that four kinds of motion are found for the sun: (1) their fourth [read: the] motion [is] the [mean motion], from west to east [ממערב למזרח] each day, about 59 minutes and 80 seconds [נ"ט דקין פ' שניות] approximately, [completing its circuit] in [כשס"ה — 365 [?]] days approximately; (2) the fourth, in a day [numeral: ?]…; [another] motion which is caused by the higher motion around the whole world each day, one degree in [about a third — כשלישית [?]], carrying with it all the fixed stars, together with the motion of the sphere [numeral: ?]…; the [third] motion, [which brings] the sun's apogee forward one degree in seventy years [ע' — 70 [?]], as in §[קע"ד? [?]]; and the fourth motion — a heavy [slow] one — of the sun by the "resembling sphere," as explained above. And I have already chosen [to explain that] whoever wishes to arrive at the exact measure of the [length of the] year must [give it care]; and to be precise about all the [approaches of] the planets' motions requires study and reckoning… deep and profound, over many days and great toil, to reach [certainty]. Nevertheless I will [give] you enough to know the [approach of] the motions mentioned and found… just so, when [the star Mercury? כוכב כוכה [?]] and [Jupiter?] add… the fifth [motion] carrying [them] on the epicyclic sphere [גלגל ההקפה], as will be explained further on in the Fifth Section, §ר"ם [240] and §נ"ד [54 [?]].[274]

[272] the title's opening sort is a nun on both copies, so the work named here is not the one an earlier reading identified. The form is given as printed and no work is identified from it.

[273] the rubric's numeral carries a single mark, not the doubled one; given as printed.

[274] the seconds figure of the first motion reads as eighty, which is not a possible number of seconds; given as printed.

סימן קפ״ב [§182 as printed / logical §183] — Marking the mean place of the sun in its zodiac sign, and which is its true place from which to begin, and the difference between them, [in each of] the two places

Know that when the sun comes… [so that] we may have a [means] to recognize its place and the time of its revolution to more than [מע״פ — read מעל[?]] the minutes of the [numeral: ?] constellations through which the sun, whose center revolves always, passes beneath… the line of its [orbit], which is [reckoned] in the minutes of the line [and] thereby we know [its place]… we mark in [the figure of] the firmament its circuit; and [as for its] years, which we cannot recognize except by the mean motion of the sun as above — [there] it appears [numeral: ?], and so we cannot recognize the [true] course of the sun except by the minutes of the circle… in the way that each of the two [places] declares the other. And this: when [we are exact] in [computing] the sun's course beneath the girdle of the constellations… its course and its place in the firmament in two respects, [which] the astronomers named for it: the "mean course" [מהלך האמצעי] and the "second" [and the sphere… its true course and place in the constellations. And in order to explain [it] to the students… [continues on next page].

[Continuation of סימן קפ״ב, §182] …to the students, by the easier and simpler method [I saw fit] to open — [we set] two fixed circles: the great circle, whose center is point א [which is the center] of the constellations, whose center is the center of the earth; and the small circle, whose [center] is point ב, which is [as an illustration] of the eccentric sphere of the sun, as was explained just above in §קע״ח [178]. And now [reckon] the matter accordingly, up to [the point where] the sun's center stands at point ז on the eccentric [המסלול]; and likewise [draw a line] from the center of the earth from point ח through the place of the sun's center to point ו.

Diagram. Construction, counted off the plate: three circles. A large heavy outer circle; a second heavy circle inside it, displaced markedly up and to the left so that the two nearly touch at the upper left and are widest apart at the lower right (the eccentric); and, at that upper-left crowding, a tiny circle quartered by two crossing chords. Four straight lines run out from the tiny circle's neighbourhood — one horizontally to the right, one down and to the right, one up and to the left, one down and to the left and out past the rim.

Closed census of the lettering — four sorts and one small ancillary mark; nothing else:

- ב — well to the right of the tiny circle, at the end of the horizontal line; the largest and clearest sort on the figure
- א — below and right of the tiny circle, at the end of the descending line
- [[ה/ח]] — above and left of the tiny circle, outside the inner circle. Three strokes (top bar, left downstroke, right downstroke); it is not ד, which in this fount has a single downstroke
- ט — below and left of the tiny circle

- a small mark between [[ה/ח]] and the tiny circle — a head with a short stem, most likely ז, but not separable at this size from a geresh over a stroke: [[ז/ ׳]]

[Census taken on B (*Hebrewbooks_org_20763.pdf* p. 107, 2346×3313 bitonal, crops at 270% and 580%).]

Up to point ח, which is on the ecliptic of the constellations — and there will be a line [in the constellations]. Point ח is called the place [of the sun] in the constellations, that is, the true place; and the mean place… the true place… there is no [course of] the sun [along] one straight line, for it may [advance and lag]… so [that its] true place… [may differ] from its mean place by more or less. This [difference] arises [according to its position], from point ח… draw upon it a line to point ח… and [the sun] will be at point ח, the place… [right angles], properly and truly (neither [more] nor [less], and one is not to be over-precise) between the line of the diurnal aspect of the eccentric [היוצא] sphere… and the center of the earth toward the [places]… at the time it is at one line from the center… [when] the sun's center [is at] point ז… and if it be drawn at the time it is at another line [from] the center… up to the constellations at point ט, and this is the course [reckoned] by the minutes of the line כ״ט [numeral uncertain [?]] and so [too]…

Diagram. Construction, counted off the plate: two circles — a large heavy outer circle, and a second heavy circle inside it displaced up and to the left (the same eccentric construction as the small figure on this leaf, drawn large). Across them run one vertical line, from the top of the outer circle down to its foot, and one long straight line from the lower left up to the upper right, projecting past the rim at both ends. Two further short lines run from the left-hand crossing inward — one down-and-right, one up-and-right.

Closed census of the lettering — eleven sorts, positions given as they stand on the page:

- ד — at the head of the vertical line, just inside the outer circle
- ז — upper right, outside the outer circle, beside the crossing of the long line with the rim
- [[ר/ז]] — further right, outside the rim, at the projecting right end of the long line
- ח — inside the figure, upper right, below that crossing
- ב — at the crossing of the vertical line with the long line
- א — immediately below ב, at the end of the short down-and-right line
- מ — left of centre, at a crossing on the long line (medial mem: the counter is notched, not a closed final ם)
- ט — lower left, where the outer circle meets a line
- [[ח/ה]] — upper left, outside the outer circle, at the projecting left end of the long line
- ט — lower centre, just right of the vertical line where the inner circle crosses it
- ה — at the foot of the vertical line, with a right-angle mark

[Census taken on B (*Hebrewbooks_org_20763.pdf* p. 107, 2346×3313 bitonal; whole figure at 200%, label clusters at 290–480%).]

And the small circles [in the figure] point to [ולעגולים הקטנים רמז] the sun's path-line [מסלול החמה], the eccentric, and its center; and point ב in the diagonal [ד'? — numeral uncertain [?]] is called the line of the mean [motion], passing over [between] the two centers, and… point ז [is] the head [apogee] of the sun, and point ט [is] its low point [perigee, שפלה]. And thus, when the sun's center reaches point ז, there will be no difference [חילוף] at all between the mean place of the sun and [its] true place; and the rule likewise [holds] when [the sun's center] reaches point ט, its low point.

And now know: when the sun, in its course, [passes] from the [apogee toward the] west, in every reckoning and computation, from the apogee down to the perigee, the true course precedes [יקדים] the mean course, and it is called [in the constellations…]; so that the true [course] is "more" [advanced] than the mean course from point ז [the apogee] down to the perigee, [by an arc] on the eccentric [numeral: ?] and [by] a mean [arc]… of the constellations. And the rule likewise [holds] for the [second half]: from the perigee up to [the apogee], the true course precedes the mean by [numeral: ?]; and thus, in the [other] places, from perigee up to [apogee] at point ט, [there is a lag]. As for the constellations [between] — and so forth — up to point ח [on the eccentric] the [true precedes the mean], and [the difference] extends [numeral: ?]; and the true course precedes the mean by an arc of [ל״ד — 34 [?]], and so [too] the [second half], and thus at other places the [reckoning] shifts, up to a course of [כ״ד — 24 [?]] on the eccentric, at point ט [נס' — §60 [?]].

סימן קפ״ד

(Siman 184 as printed; logically §185)

That the sun completes an equal course in two different periods of time, or two different courses in two equal periods of time.

From all that has been said, it has become clear to us that the sun revolves against the sphere of the zodiac, in two equal periods of time, along two courses that are not equal — even though the cause driving the sun [שסבות החמה הממללת [?]] is always uniform, moving in one and the same manner, and there is no doubt or hesitation about this among the sages: the sun never hastens and never lags in its motion from one occasion to the next, throughout all the days of the world. Nevertheless we find that the sun traverses, against the zodiac, two [unequal] distances [שני מרחקים [?]] in differing times: against some of the zodiacal signs it revolves swiftly, and against others it revolves slowly. This variation is caused by the center of the sun's sphere, which lies outside the center of the world; and our reckoning of distance — from the earth to the sun, and from the sun to the zodiac — is not measured from the center of the sun's own sphere, but from the center of the world. Therefore it appears to us, and we imagine, as if the sun itself moves through its sphere with this variation —

which is in truth not so; rather the variation arises from the distance between the two centers.

For example: when we divide one of two circles into two equal parts, that smaller [circle] will divide the larger circle into two parts that are not equal, as you will see in the figure on the following page. [In that figure] the [outer] circle is the sphere of the zodiac, and its center is the point ס [?]; the inner circle, marked ו-ט-ח-י [?], is the sun's deferent, and its center is the point [ו/ט? — uncertain]. When a line כ-ו ט-ח [?] is drawn, as in the figure, it divides the zodiacal circle — from the head of Aries at the beginning of Libra — into two equal parts; yet it divides the deferent by way of it into two parts that are not equal. Hence, when the sun revolves —

— [when] the center of the sun [revolves] in the inner sphere [whose apogee is] toward the point of the sign [מזלו' — Aries?] up to Libra... [text partly garbled]...so that it does not revolve [across more than] the face of the zodiacal circle. In any case the sun in its sphere revolves in a time that is more than half of its circle, as is seen in the figure at the arc ט-ח-ו [?] — for the deferent is somewhat larger [along the arc] ו-ח-ט, and likewise the time of this revolution is more than half a year; therefore its motion along the arc [near] ט-ח-י-ד [?] is called the motion of [the ascending? מהלך הסימן]. And when it revolves from the region of Cancer... to the arc ו-ז-ט [?] — there too it revolves against complete zodiacal signs — yet in its sphere it revolves in this time less than half of its circle; and therefore, because the time of this revolution is less than half a year, [that motion] is called [מסלכ' בקצת ט״ז — uncertain]. So you have it: even though the sun revolves in its deferent with a course that is always uniform, still, against the circle of the zodiac it revolves with equal courses in unequal times.[275]

סימן קפ״ה

(Siman 185 as printed; logically §186)

That the four seasons of the year, [reckoned] according to the true motion of the sun, are not equal to one another.

From the principles already mentioned it will become clear to you that, according to the true motion of the sun against the zodiac, the four seasons [תקופות] of the year are not equal to one another in measure, nor even close [to equal]. This is so when we divide the circle [of the zodiac] by two lines crossing crosswise — by way of a line [א-ט? י-ט?] and a line [ד-נ?] — into four parts, as issues [from the figure]. The lines divide the sun's deferent into four unequal parts. For the season of Nisan [spring], which lies at [the beginning] of

[275] this siman compares two arcs of the sun's own path and names no zodiacal sign; the ranking of the four seasonal arcs belongs to the siman that follows it alone. the lettered arc-labels of this siman are at the limit of both copies and are deliberately not read from the diagram. the two rubrics on this leaf are pointed differently — the first with a doubled mark, the second with a single one — in the same fount at the same size, and both copies show the same asymmetry. And one of them sets two words closed up with no space between them.

Aries... in the fourth quadrant of the zodiacal circle, [runs] from the beginning of the circle of Aries to the end of Gemini.

[Figure follows — see below. The discussion of the four seasons continues in the text beneath the figure on the next page.]

Diagram. Construction, counted off the plate: a large double-ring wheel filling the leaf — an outer circle and an inner circle, the inner one displaced slightly up-and-right so that the annulus between them is widest at the lower left. Across the inner circle run one vertical line (top to bottom of the outer circle) and one horizontal line (left to right), crossing near the inner circle's centre. Between the two circles is a broad band carrying a continuous inscription, which includes the zodiac names and, over part of its course, runs in two concentric lines.

Closed census of the point-letters — five, all within the inner circle, on the two crossing lines:

- **ה** — at the intersection of the two lines
- **ח** — top of the vertical line
- **ט** — left end of the horizontal line
- **ז** — right end of the horizontal line
- **א** — foot of the vertical line

Outside the outer circle, on the two axes:

- top: **צפון** (”North”), with a separate small sort beside it: **[[ע/ט]]**
- bottom: **רום[[ז/ד]]** (”South”), with a separate small **ק** beside it. The first sort's stem sits inboard of the right end of its top bar — unlike the **ר** next to it, whose stem is flush right — which is why an earlier reading recorded it as **ז**. At 400% on B it will not separate from a **ד** with a worn left overhang. Recorded as a glyph; no compositor error is asserted.
- right: a two-line block, the outer line **מזרח** (”East”); the inner line is not settled
- left: a matching two-line block, not transcribed in this pass

Rim-band inscription — read with confidence on B, and recorded here as far as this pass took it: **תאומים** (Gemini) · **סרטן** (Cancer) · **ואריה** (and Leo) on the upper arc; **גדי** (Capricorn) and **קשת** (Sagittarius) on the lower arc, just inside the rim above **[[ז/ד]]רום**; and, running through the band, the words **החמה**, **וסובבת** and **המזלות**. The remaining words of the inscription are printed clearly and were simply not transcribed here — the band needs a systematic sector-by-sector rotation, which this census did not undertake.

**

[Beneath the figure, the discussion of Siman 185 continues:]

We divide, then, the four quadrants of the deferent [into their true lengths]; and thus, as they pass, the time of one revolution [through one quadrant] will run longer than the time in which [the sun] revolves through one of the [other] quadrants of the deferent. The sages labored [to establish] the measure of the time [of each]:

- Tekufat Nisan (spring — Aries to the end of Gemini): according to the reckoning of al-Farghani [לפי חשבון (האלפרגני)], 94½ days approximately [צ״ד יום ומחצי בקרוב]. (The name is set in round brackets on the page as a source-tag.)
- Tekufat Tammuz (summer — the arc from the beginning of Cancer to the end of Virgo): [Hebrew: **נ״ב** = 52½ days as printed; the arithmetic of the total (below) requires **צ״ב** = 92½ days — flagged, not emended].
- Tekufat Tishrei (autumn — the arc from the head of Libra): 89⅛ days [פ״ט יום ושמינית] — the smallest of all [היותר קטן מכולם].
- Tekufat Teves (winter — from the head of Capricorn to the end of Pisces): 90⅛ days [תשעים יום ושמינית — the figure is spelled out as a word]. (No superlative is attached to this season on the page.)

Do not let it trouble you that we reckoned all the seasons as always equal [in the older civil reckoning]; that [equal reckoning] is not [the truth], but only because the calculation of the seasons — and likewise the other reckonings of the intercalation — was founded for us by Chazal according to the mean motion, and not according to [the sun's] true place, as will be explained further on, in Siman **ר״כ** [220]. And when we divide the [total] measure of the revolution by the four seasons of the year, each quarter yields a tekufah of [—] **א׳ יום ו׳ שעות** — 91 days and 6 hours, the leading glyph of the day-figure standing at the foot of the column and not resolving [see Siman 187 for the mean quarter as given there].

סימן קפ״ו

(Siman 186 as printed; logically §187)

[Continued from the foot of the figure page:]...hours and a half. And the ancients recorded [a rule?] for this [וזכ׳ נחמו [?] הקדמונים]... [garbled]...forever it will never [יוק? — illegible].

That, for the same reasons already mentioned, the measure of the natural days [too] varies.

We have already explained above that, in the revolution of the sphere of the zodiac, some [portions] rise along a long [arc] and some rise along a short [arc], as was mentioned [regarding right ascension]. In the same way there is a difference in the measure of the natural days [הימים הטבעיים], as was noted for you — this matter [was treated] above, in Siman **קמ״א** [141? — printed **קמ״א**]. Know, therefore, from now on, that [besides] the cause of the difference in the rising-times of the zodiacal signs, there is yet another cause [that makes] the natural days perpetually vary — such that it cannot happen that in the whole year two days are found whose length is equal; and this [doubles the effect]. This is [also] the cause of the inclination of the sun's deferent from the [circle of the] zodiac: for since part of the [sun's] quadrant on the deferent adjacent [to a given point] varies [in relation to the arc beneath it], so too this rule will be found in each and every part [of the deferent], and in [the arc] beneath each

and every sign — so that sometimes the sun appears as though it hurries beyond its due course — the mean uniform course it keeps each and every day, which is 59 minutes 8 seconds approximately [מכדי מהלכה שהאמצעי השוה בכל יום ויום שהוא נ״ט דקין ח׳ שניות בקרוב]; and at another time it appears to tarry, less than its mean course. As will be shown in the [science of] astronomy [בתכונה], when the sun [traverses] the signs [where] its motion is slow — as in Siman **קפ״ד** [184] — then each day it moves with the smaller motion; and likewise, when it stands in the [six] signs of its larger motion, it too each day moves with its larger motion. And when the sun rises and falls [ascends and descends] toward the apogee and away from the apogee [נוכח רומה], it is [nearer/farther] each day against the zodiac — [more or less] than the mean course before us; and when it revolves from the point opposite the apogee up to the apogee, its course each day is added to the course of the [preceding day]... [some clauses garbled].

From all this it is seen that we do not find, in the whole year, two natural days equal in their length; rather this too [holds] doubly, and there will always be found more or less in the measure of each day compared with the measure of its fellow. But know that this difference between the natural days is a small, subtle, minute thing — so that the eye has almost no power to sense it directly; only the intellect testifies to us [of it].

סימן קפ״ז

(Siman 187 as printed; logically §188)

An explanation of the difference in time between the true tekufah and the mean tekufah.

The difference in time found between the two tekufot — the mean and the true — I have found [מצאתי [?]]... and a discrepancy of calculations [וקלקול חשבונות], for according to —

[The technical discussion continues in the left column, whose sense follows directly from "for according to…". The gate's colophon is not here: it is a single display line running the full width of the foot of the leaf, read right-to-left across both columns — see the close of the siman below.]

— what Rambam [Maimonides], of blessed memory, wrote in chapter 10 [כפ״י] of Hilchot Kiddush HaChodesh: the difference between them is about two days. And so wrote the Israeli [הישראלי — ed.: Yitzchak Yisraeli; the title Yesod Olam is an identification, not printed on the leaf], in the third treatise [מאמר ג׳], chapter 6, which we mentioned — [regarding] the reckoning of the true tekufat Tishrei, [which comes] after [the mean by] two degrees, a little less [?]. [Likewise for the other tekufot:] the sun moves [at differing rates]... and so too the true tekufat Nisan is prior to [/ later than] the mean — as when the sun is at its apogee at [/near] the point ה [?] and its rising... And in the tekufot of Teves [and the rest], the variation between the mean and the true is recognizable, because [the sun's] places are as computed as we mentioned; and [this is treated] above, in Siman [a numbered reference is printed here, ם״קם,

but the two gematria letters do not discriminate] [?], [concerning] how the center of the deferent passes [relative to] the center of the eccentric.

This is the view of Rambam, of blessed memory, and of the Rav, the Israeli, in the places cited. And here I have found in one place, from the sage the Israeli, [something] that implies otherwise: for in the third treatise, chapter 3, he wrote (that Ptolemy) [כתב (שבטולמיאוס)] found, in the sphere whose center is the sun, [that] the fourth part of the zodiacal sphere, from the head of Aries to the end of Gemini, is 94½ days [the leaf prints ל"ד יום ומחצה = 34½; recte צ"ד = 94½ — see the note below], which is more than a quarter of a year; and from the head of the sign Libra to the end of the sign Sagittarius, a full 88 days and about three hours [מלא פ"ח יו' וכמו ג' שעות], which is less than a quarter of the year. According to this, the difference found between the two tekufot is six days and nine hours [ששה ימים ט' שעות].

And in the books I copied out from al-Farghani [ובספרי העתקתי (מאלפורגאני) מצאתי — the name stands in round brackets, the compositor's convention on this leaf for a source-tag] I found:

- From tekufat Nisan to tekufat Tammuz (spring): [**ל"ד** = 34½ days as printed; requires **צ"ד** = 94½ — flagged] [and a half].
- From tekufat Tammuz to tekufat Tishrei (summer): [**נ"ב** = 52½ days as printed; requires **צ"ב** = 92½ — flagged] [and a half].
- From tekufat Tishrei to tekufat Teves (autumn): 88⅛ days [פ"ח יום ושמינית].
- From tekufat Teves to tekufat Nisan (winter): [**צ'** = 90⅛ days] [and an eighth].
- Sum of all: 365¼ days [שס"ה יום ורביעי].

And since the time of one [mean] tekufah, according to the reckoning of the mean motion, is [**ל"א** = 31 days 6½ hours as printed; the mean quarter of 365¼ requires **צ"א** = 91 days 7½ hours — compositor error, flagged], as [given] near the end of Siman קפ"[[?]] [סוף סימן קפ"[[?]]][276] — then, according to the reckoning of [Ptolemy, בטולמיאו"ס] and al-Farghani, [comparing the true seasons] with their [mean] words:

- Tekufat Nisan, [**צ"ד** =] 94½ days, exceeds the mean tekufah by 3 days, 4½ hours.
- Tekufat Tammuz, which by al-Farghani's reckoning is 92½ days [שמדתו **לפי חשבון אלפורגאני צ"ב יום וחצי** — printed **צ"ב** here], exceeds the days of the mean tekufah by 1 [or 5?] day, 4½ hours.
- Tekufat Tishrei, which by his reckoning is 88⅛ days, falls short of the days of the mean tekufah by 3 days, 4½ hours [**האמצעית ג' יום ד' שעות ומחצה**].

[276] the reference is three letters. The first is a ק and the second a פ, both read on the leaf under magnification; the mark between the second and third is a double mark, not a single. The third letter does not read, and no value is supplied — the "185" formerly printed here is withdrawn.

• Tekufat Teves, which by his reckoning is 50⅛ days as printed [נ׳ יום ושמינית] [recte: 90⅛], falls short of the mean by 1 day, 4½ hours [יום א׳ ד׳ שעות ומחצה].

Blessed be my God, my Redeemer, and my Savior, who has helped me complete the Seventh Section. [שעזרני בסיום שער השביעי • ברוך אלי וגואלי ומושיעי: — one display line running the full width of the foot of the leaf, read right-to-left across both columns; the same convention marks the other gate-ends.]

השער השמיני

The Eighth Section

Herein will be explained the structure of the spheres of the moon, together with an account of its inclined sphere and the time of the revolution of each of the seven planets [וזמן סיבובו כל אחד משבע כוכבי לכת]; and an account of the epicycle sphere and the time of its revolution [וביאו׳ גלגל הקפה וזמן סבובו]; and the variation in the moon between its mean and its true place; the definition of the molad [conjunction] and its causes; the many variations found in the moon throughout the days of the month; the mean and the true [reckoning] and the difference between them; [the moon's] nearness to and distance from the terrestrial globe, and a proof of the voluntary motion; the objectors on this [point], and the other topics and fundamental matters proper to it.[277]

סימן קפ״ח

(Siman 188 as printed; logically §189)

An explanation of the sphere of the moon and the structure of its spheres.

Know that the early sages determined [an account] of the thickness of the sphere of the moon [as they did] for all the other spheres of the [seven] planets: each and every one of them divides into four faces, or spheres [מתחלק לד׳ פנים או כדורים], that encompass the terrestrial globe, three of which are [the principal ones]... And they determined it like the three spheres [/globes] of the sun's sphere; their properties too, and the laws and rules of the three spheres, are as mentioned above in the adjacent Gate, in Siman 178 [קע״ח] and Siman 179 [קע״ט] [הנזכרים למעלה בשער הסמוך בסי׳ קע״ח וקע״ט — two consecutive numerals;[278]]. But the lowest sphere [הכדור השפל] is as depicted below... [it lies within] the belly of the "resembling" [concentric] sphere [גלגל הדומה]; and [it is] a covering/shell [?] revolving...

and [as for] the inclination of the line of the zodiac [relative to] the straight [reference] line, as [explained] nearby — [being] the inclined manner in which no star [/planet] whatever is found [except upon it]... beneath this inclined orb they added one further orb, and they called it the bearing orb, or the carrying orb [וקראוהו אופן הסובל או אופן הנושא], for it bears and carries upon it the star of the moon [כוכב לבנה] — a star among the planets... and this is the [manner belonging to] the fourth sphere of the whole sphere of the moon. And the orb

[277] the second item of this preamble is set with a singular possessive followed immediately by a plural, and is given as printed.

[278] the medial letter of each is an ע, read on the leaf under magnification against a certified ע and a certified צ standing in the same line. The previously carried non-consecutive pair קס״ט / קס״א stays refuted.

of the point-opposite-the-apogee is, according to the view of some [sages], [the orb] out of whose center [the motion] issues; and according to this we need to divide the thickness of the "resembling" sphere into two spheres, in order to fill out [its geometry] — by its convexity and its concavity, as [explained] above in Siman קע״ד [174]. [The "resembling" sphere] resembles [an empty] vessel [כוזא? — uncertain], and it does not suffice them that the inclined sphere [alone should exist] in the world... [there must also be] the deferent sphere [גלגל הנושא], since the "resembling" sphere and the inclined sphere are two [separate spheres]... [carrying] the head of the dragon and its tail [את ראש התנין וזנבו — the lunar nodes] from east to west around the [terrestrial] globe, as will be explained.

But here there are some sages who wrote that one cannot [dispense with]... in the sphere of the moon [with] the eccentric sphere [גלגל היוצא מרכזו], for it is impossible for us to derive [account for] all the motions of [the moon] without positing an eccentric sphere; and [this is part of] the intention of the view of the Israeli in the third treatise [מ״ג], chapter 8 [פ״ח], since in all the variations he relied [upon it]... as [mentioned] above at the head of the Seventh Section, in Siman קס״ג [163], to settle the variations in the moon by means of its epicycle sphere [גלגל הקפה], as will be explained further on, in Siman [[?]] ['כמו שיתבאר לפנים בסי [[?]]' — the reference is a forward one, לפנים, "further on";[279]]. Therefore they said that the deferent sphere of the moon is not eccentric at all [ע״כ אמרו שגלגל הנושא של לבנה איננו יוצא מרכז בכלל]; and that its center is the center of the zodiac itself. And according to [this]... the difference between the center of the "resembling" sphere and [the deferent] — for they revolve about [it]... its center ח' [ר״ל? — uncertain]. According to this, too, we shall not need to divide the thickness of the "resembling" sphere into two spheres, for the [single] "resembling" sphere ח' [?] suffices us; since, according to this, the "resembling" sphere is uniform on all its sides and is not [subdivided] as [the sphere] of the sun is [subdivided]. For we have no need to fill out empty [volumes], as [we do] not [with] the sphere of the sun. According to this, too, the [deferent] sphere is, in its entirety, [contiguous/inclusive of] the [sphere] beneath it, along its paths [מסילותיו], in a manner that there is no difference at all between the "resembling" sphere and the deferent sphere — only that the deferent sphere [is inclined] from the "resembling" sphere toward the north and toward the south, as will be explained... And it appears to us that we are not compelled to assign to the "resembling" sphere any [perceptible thickness];

— it suffices us [to imagine] a thickness like the peel of an onion or an apple [בקליפת הבצל או תפוח], along the lines of what we explained above in Siman ק״י [110] regarding the fixed [stars] set in the [eighth] sphere. We have set it [so thin] only for the purpose of explanation and of depicting it to students — (so it seems to me) — while the thickness of the [empty] "vessel"-sphere is such that [the star? / the moon] issues from its center [as] one [does] not [assign]

[279] the numeral is a single letter followed by a geresh — one sort, not a two- or three-letter gematria — and that letter does not read on the best available copy. No value is supplied. The ר׳ = 200 formerly carried here is withdrawn.

a thickness... as long as its thickness is like the length of the line [אלכם? — uncertain] and this [is] the [point] whose measure will be explained further on. According to what follows, you also have to know [about] the inclination of the deferent sphere from the [concentric] sphere... [garbled]...for it [the node?] always remains beneath the line of the [ecliptic/nodes, קו הקדרים], as [explained] above, at the head of the Fifth Section, in Siman **ק״ו** [106], and in the Seventh Section, in Siman **קע״א** [171] [**כנ״ל בראש שער החמישי בסי׳ ק״ו ובשער שביעי בסי׳ קע״א**: — a final **א** with crossed diagonals, not a **ח**, read independently on both scans].[280]

סימן קפ״ט

(Siman 189 as printed; logically §190)

That the deferent sphere of the moon is inclined from the "resembling" [concentric] sphere toward the north side and toward the south side.

The early sages marveled, in their contemplation, that the bending sphere [גלגל הכופף? — the inclined/deferent sphere] of the moon — and likewise all the [other] spheres of the five [/seven] planets, each and every one of them — is inclined below and opposite the axis of the mean [motion], [away from] the line of the zodiac [/the ecliptic axis, קו הקדרים]: from one side its inclination is directed toward the north, and from the other side its inclination is directed toward the south. Because of this they called it "the inclined sphere" [גלגל הנוטה]. And this matter of the inclination is [analogous]: it is like the inclination of the circle of the zodiac upon the equinoctial circle [עגול הישר], as [explained] above in Siman ⟦ל״ו/ז⟧[281] [?]; just so is the inclination of the deferent sphere from the "resembling" sphere — except that there is a difference between the two inclinations, [in details] which will be explained shortly, as [treated] above in Siman **ל״ט** [39 — printed and not in dispute]. These two spheres — the "resembling" [concentric] one and the inclined [deferent] one — pass through the point-opposite [the apogee] upon the globe, and [both pass] over the center of the earth equally; they are of the length of [equal] diameters, and each turns the other into two equal parts.

---

[280] these two facing simanim take opposite positions on whether the carrying orb and the inclining orb are the same body — the first expressly denies it, the second says the carrying orb is called the inclining orb for that very reason — and a third passage says there is no difference between the carrying orb and the concentric one at all. The book does not reconcile them. the print alternates two different words for the same orbs throughout these two simanim with no visible rule.

[281] three elements — a **ל**, a double mark, and one further letter: two letters only. There is no **ק** sort in the token, so a four-element form such as **קל״א** is excluded outright. The second letter is neither **א** nor **ה** — a plain vertical stem stands there, and both of those require ink where the leaf carries none — so the live alternatives are **ו** and **ז**, and the leaf does not decide between them.

Know that the inclination of the inclined orb from the orb concentric with the "resembling" [sphere] cannot properly be depicted on a [flat] surface... [but it can be rendered approximately] as in this figure:

Diagram. Construction, counted off the plate: two circles of nearly equal size, one displaced up-and-left of the other, so that they cross at two points — one at the left and one at the right. Near the middle stand two dots, one above the other (a centre to each circle). Nothing else is drawn: no diameters, no radii, no rim marks.

Closed census of the marks — two letters inside and two words outside; nothing more:

- **ב** — inside, immediately right of the left-hand intersection
- **א** — inside, immediately left of the right-hand intersection
- exterior left, set vertically: **צפון** ("North")
- exterior right, set vertically: **מערב** ("West")

**

שער ח — Eighth Section (the Moon)

[סימן קפ"ט continued — printed §189 / logical §190]

(Continuation of §189, begun on the previous page; catchword there was **לף**.)

✻ But in truth the drawn figure of the sphere is not really like a circle, because the two spheres — the "resembling" (concentric) sphere and the inclined sphere — are, as it were, pictured as if each had its own separate center, whereas in reality this is not so: the two of them have only a single, shared center. For just as the ecliptic circle of the zodiac and the circle of the equator [lit. the "straight" line] are inclined one from the other yet share one center — as [explained] above in §36 and §39 [כב"ל כסי' ל"ו ול"ט] — so too the two circles, the resembling and the inclined, have a single center, something that cannot properly be represented in a drawing, since it is impossible to depict it upon a flat surface as it truly is. And it has been explained already that, just as the sun is sometimes to the north of the inclined line, sometimes to its south, and sometimes on the equinoctial line itself, so too the moon; and likewise the five wandering stars [planets] are found sometimes to the south of the resembling sphere, sometimes to its north, and sometimes upon the [line of the] resembling sphere itself, [which is] the line of the nodes [קו הקדרות].

✻ And from all that has been said it becomes clear to you that, at the point of the inclination of the inclined sphere away from the resembling sphere, they meet and cut one another: half of the inclined sphere [lies] to the north side of the resembling sphere, and its other half [is set] to the south side. The two points of their meeting — the one toward the [east?] and the other toward the west — are the points called the Head of the Dragon and [its Tail]. The eastern node, from which the moon enters toward the north of the resembling sphere, is the point called the Head of the Dragon [ראש התנין]; and the western node, from which the moon enters toward the south of the resembling sphere, is [the

point] called the Tail of the Dragon [זנב התנין]. When the moon travels upon one of these two points, it stands directly upon [the line of] the zodiac itself; and as it goes out from those two points, or [moves away] from them, it grows more distant from the resembling sphere and adds [to its distance] until the utmost limit of the inclined [sphere's] inclination from the resembling sphere. At that point [of maximum inclination] it departs from either of them by five degrees [ה׳ מעלות] of inclination, whether in its inclination to the north or in its inclination to the south. The diameter [or: axis], namely the line that goes out from the point of the Head of the Dragon through the center to [the Tail] and passes over its axis, is the Dragon itself, which is called in our tongue aqalaton [עקלתון — "the twisting serpent," cf. Yeshayahu 27:1] as stated in Yeshayahu, chapter 27. [Several numeric details in this passage are abraded: [?].]

✻ And it has been said above that this [maximum] distance [i.e. latitude] rises up degree by degree until it reaches [the pole/limit of] the uppermost sphere [?]; and it is explained just below that the two inclinations are reckoned by [the great circles] that pass over the poles of the zodiac. The half of the sphere that lies above compels [drives] the Dragon [?] more than the [lower] half beneath it, like [the] track [?]. The [details on the] paths [?] of the Head of the Dragon and its Tail will be explained to you shortly, and also further on in Section [16 / the Seventh(?)], in §[50 / ?]. [Numerals here uncertain: [?].]

וכתב [And R. Yisraeli wrote]: R. Yisraeli[282] wrote in Maamar [3?] [במאמר ג'?], chapter [8? / 5?], that there is a great difference between the poles [lit. "lights"] of the resembling sphere and [likewise] between the poles of the inclined sphere: the poles of the resembling sphere are aligned [directly] opposite the poles of the zodiac in general, whereas this is not so for the poles of the [inclined] sphere, which are not aligned opposite the poles of the zodiac but are distant [from them], and this by five degrees [ה׳ מעלות] of the divisions of the sphere [?] and of [the line of] the nodes [הקדרות]. [Maamar/chapter numbers [?].]

סימן ק״צ — printed §190 (logical §191)

That three differences are found between the inclination of the sphere of the zodiac and the inclination of the inclined sphere.

We have already explained that, in the manner of the inclination of the zodiac-sphere from the [sphere of the] equator, so likewise is the matter of the inclination of the inclined sphere from the resembling sphere: one part [half] of the inclined [sphere] turns and inclines to the north side of the resembling sphere, and its second half turns and inclines to the south side of the resembling sphere. Likewise you should know that between the two inclinations three differences are found:

[282] R. Isaac Israeli, author of Yesod Olam — identification; neither the personal name nor the title is printed here

[First] — that the inclination in the zodiac is close to twenty-four degrees [כ״ד מעלות ≈ 24°], whereas here, in the moon, the inclination from the resembling sphere is at most five degrees [ה׳ מעלות = 5°], as will be explained shortly.

Second — [it concerns how] the [latitude of the] zodiacal inclination [is reckoned]: it is reckoned according to the manner [of the great circle] of the [solstitial?] colure, [and by] the other circles [drawn] and mentioned [as passing] over the face [surface] of the world [sphere], in order to know how great its distance is at each [point] from the equator, and the elevation [?] of the sphere. But the [amount of the] inclination of the inclined sphere from the [equator / zodiac] is not reckoned according to the manner [of the circles] of the solstitial colure [?], nor according to [circles through] the poles of the two [ends of] the world; rather it is reckoned by [the great circles] that pass over the poles of the zodiac, to know at every place and section how great is the distance of each arc of inclination from [the line of] the zodiac. This is the [latitude in] "breadth of the firmament" [רוחב הרקיע], as will be explained. And the third difference — that the two points of meeting of the resembling sphere with the inclined sphere are moving, and they shift westward within the zodiac, by the [motion of the] Dragon-sphere, by more than [several] parts each day, as will be explained shortly. [Interior numerals of the second/third difference are abraded: [?].]

סימן קצ״א — printed §191 (logical §192)

On the motions of the Head of the Dragon and its Tail.

The two points at which the resembling sphere [lit. "the deferent-manner"] meets the inclined sphere — which are called the Head of the Dragon and its Tail, as mentioned just above — have, both of these points, a special motion of their own [that carries them] from east to west, each day by more than three minutes [יתר משלשה דקים]. Their motion, too, comes from the [Dragon-]sphere, which revolves about the center of the world upon [the axis of] the poles of the zodiac and sweeps from east to west; and therefore the motion of the zodiac-sphere drives the spheres within it and turns them all in a general [westward] way. The two points [move] like [along] the Dragon [כתלי סוד התנין (?)], that is, by a retrograde motion of their own, sweeping against the whole zodiac in about [כ״מ?] years [full cycle uncertain: [?]], their motion being three minutes and eighteen seconds [שלשה דקים וי״ח שנית ≈ 3′ 18″] per day approximately [the seconds-value [?]; standard value ≈ 3′ 11″]. And the beginning of the reckoning [of their position] they set from the constellation Aries [מזל טלה]; and see [the] Sefer Yesod Olam [in Maamar (?), chapter (?)]. [Chapter reference [?].]

סימן קצ״ב — printed §192 (logical §193)

That the moon's position in the zodiac is reckoned both in the length of the firmament [longitude] and also in the breadth of the firmament [latitude].

We have already explained above, regarding all the stars, and likewise all the [circuits/revolutions] of the heavens, that when we speak of [and inquire into] their distances — how many degrees they are from east to west — this is called the "length of the world" [longitude], or the "great length." But "breadth" [latitude] is [the term] for [it] when we inquire about [and seek to know] the moon, or any other star, [to know] how far it is from the equator or from the pole [line] of the zodiac, whether toward the north or the south [side]; and all of this is called the "breadth of the firmament," or the "breadth of the world," [or] the [breadth] of the sphere. Now you must know that the moon's position in the zodiac [is reckoned] under two considerations. The first consideration is a reckoning proper [of longitude], of [its] position [and] the [amount of the] equation [?] [of longitude], whether by advance [קדימה] or by delay [איחור], all reckoned [along] the firmament, and the beginning of this is from a reckoning [starting] at the head of the zodiac. And under the [second] consideration there is no reckoning in the "breadth of the firmament," for the course of the sun has no latitude, since [the sun] does not stir nor depart from beneath the line of the nodes [קו הקדרות], as [explained] above in §187 [סי׳ קפ״ז]. But under the second consideration — [that of latitude] — the moon's position is [also] reckoned [along] the firmament. And the matter of the moon's [descent/motion] in the breadth of the firmament, [which arises] because of the inclination of the inclined sphere from the resembling sphere: [the moon] runs its course and grows distant from the resembling sphere according to the degree of the departure of the [inclined] sphere from it — that is, the small [line/arc] between the center of the moon (which stands upon the [inclined sphere]) and the point opposite it on the resembling sphere; this [breadth] is called the "breadth of the firmament." And it has already [been noted] from this, above, that this distance [latitude] rises degree upon degree until it reaches [the limit of] the uppermost sphere [?]. And it is explained below that the two inclinations are reckoned by [the great circles] that pass over the poles of the zodiac. Therefore know that the distance of the moon's standing-point upon one of the lines [circles] of the zodiac, toward the [zodiac's pole], whether to the north side or to the south side, is what is called the "breadth of the firmament." And under both of these considerations there will be found, in each of them, a discrepancy [חילוף] [between] the moon's mean position in the zodiac and its true position, as will be explained further on in §108 [בסי׳ ק״ח].[283]

סימן קצ״ג — printed §193 (logical §194)

How great is the amount of the inclination of the moon's deferent [bearing-sphere] from the resembling sphere.

We have already explained above that the moon's deferent [bearing-sphere] inclines and turns away from the resembling sphere on both its sides, up to a limit: for just as the sun is sometimes upon the equinoctial line [קו היושר] itself,

[283] introduced with the book's word for a forward reference, but pointing backward, to a siman eighty-four places earlier. Given as printed.

sometimes to its north, and sometimes to its south, so too is the case with the moon, [which departs from the line up to five degrees]. This [inclination] is called by the philosophers [astronomers] "inclination" [declination]; and it is important to know the utmost limit of the moon's inclination beneath the line of the nodes [קו הקדרות], to test and verify [it, as done by] the earlier and later [astronomers]; and it will be explained to you [how great it is, namely five degrees]. [Some clauses here [?].]

[Observational demonstration:] By an instrument [כלי] one takes [a measurement] upon the position of the moon when it is at the utmost limit of its elevation, [sighting] it above our horizon [at some measured altitude]. [Worked example, computed for] the city of Prague [כמשל כזה פה עיר פראג]: it has already been explained to us that the pole stands elevated above our horizon by about fifty degrees [שגובה הציר לנו ממעל לאופקינו חמשים מעלו' בקרוב — the figure spelled out as a word], and we shall not be exact here about the minutes [ולא נקפיד במקום זה על הדקין]; and likewise we are distant from the equator by fifty degrees [וכמו כן נתרחקנו מקו השוה ג״כ חמשי' מעלות]. According to this, the equinoctial line rises above our southern horizon forty degrees [אשר לפי זה הקו השיווי יתרומם לנו ממעל לאופקינו הדרומיים ארבעים מעלות]; and it has been explained that the utmost distance of the [ecliptic of the] zodiac from the equinoctial line is about twenty-four degrees [וכבר מבואר שתכלית רחוק קו המזלות מקו הישר כמו כ״ד מעלו']. Therefore the utmost elevation of the zodiac above our southern horizon is sixty-four degrees [א״כ תכלית גובה קו המזלות מאופק הדרומי לנו הוי ס״ד מעלות]. And so, when we investigate, at the aforementioned time [the summer solstice, תקופת תמוז], by means of one of the instruments — a [sighting-]compass [כלי מחוגה] — the position of the moon when it is at the utmost limit of its elevation, [sighting] it above our horizon at sixty-nine degrees ['ממעל לאופקינו ס״ט מעלו], then its inclination — from the line beneath the line of the nodes, toward the north side, [reckoned] near to directly opposite the zenith of our heads — you will find to be five degrees [חמשה מעלות … הרי נטייתו]. And so too you can investigate this at the time of the summer solstice [תקופת תמוז], and [again] at about half a [lunar] month [later?], when [the moon] is [at the utmost limit] of its elevation, that it [exceeds] what the sun [reaches] by more than [that amount] because of its inclination from the [resembling sphere]; and [thus the moon's maximum latitude comes to] five degrees each day [?] at the summer solstice; and so on. And the earlier [astronomers] were exact about the inclination of the [other] five wandering stars, each upon the surface of its own sphere; and this is [a matter for] a chapter in itself, [to know] how great is [each planet's latitude]. [The whole chain — 50° pole altitude, 50° from the equator, 40° equinoctial altitude, 24° obliquity, 64°, 69°, 5° — is printed continuously at the head of this column and is read off the ink, not reconstructed from the geometry; the arithmetic merely agrees.][284]

[284] the figures of this worked example alternate between words and numerals inside one argument.

סימן קצ״ד — printed §194 (logical §195)

Explanation of the matter of the epicycle sphere [**גלגל הקפה**] that belongs to the moon and to the other five wandering stars.

Know that the ancients, of blessed memory, in their study assigned to the moon — and likewise to the other five wandering stars — a further small sphere [כדור קטן], small in its magnitude, which does not [itself] surround the globe of the earth as the zodiac[-spheres] do; this sphere too, of itself, does not encompass the globe of the earth at all. And as to this sphere and its standing, know that, just as within the thickness of the epicycle sphere its center is set [and] above [it] the moon's epicycle is embedded within it, and the [deferent] carries it about the globe of the earth in general — as [explained] above in §164 [סי׳ קס״ד] — [so it is] within the [thickness/hollow] of the moon['s deferent]; and likewise for the [epicycle-]spheres of the other wandering stars. [The epicycle] is called, in the Latin tongue, ciclus [**ציקלוס** — Latin cyclus, from Greek κύκλος, "circle"]. This epicycle sphere is embedded within the thickness and the bulk of the inclined sphere, like a "drawn stone" [aspiration-stone? loadstone?] embedded within a ring in every manner, and [in] the manner and form of the sun, which is embedded and fixed within the deferent [bearing-sphere], as [explained] above. There is, however, a great difference between them: for the body of the sun's globe is fixed within its deferent like a nail in a wagon, and it has, of itself, no motion at all in the world — only that the deferent carries it about the globe of the world. But this epicycle sphere is not at rest and still in its place, for it revolves continually in its place within the hollow, or thickness, of the deferent, as if it were a stone [rolling] within a ring; and the moon, and likewise each of the other five wandering stars, is embedded within [its epicycle] like [a nail in a wagon / a stone] set within its epicycle, and the epicycle sphere revolves the star in its place.

(This section continues in the right column of the next page.)

[The moon returns upon its epicycle in one period, and revolves about the earth by its deferent in another:] the [anomalistic] return of the star in its epicycle-period [is]: Saturn [שבת״אי] in a year and thirteen days [בשנה וי״ג יום]; Jupiter [צדק] in a year and thirteen days [בשנה וי״ג יום]; the moon [הירח] in twenty-seven days and thirteen hours [בכ״ז יום וי״ג שעות'], as will be explained further on.[285]

And under this [aspect], the epicycle sphere does not carry the globe [of the earth] around all the days of the world; rather it revolves forever in its own place, in one place, within the thickness of the deferent — and this is its southern [own?] motion. But [as for] the great [deferent] sphere in which the epicycle is embedded, [that great sphere] carries the epicycle, together with its star, in its course as mentioned, around the globe of the earth. And know that the diameter of the epicycle sphere is, according to the reckoning of

[285] the rubric promises the moon and the five wandering stars; the list stops after three bodies, the first two carrying the identical figure. Both given as printed.

the astronomers, about the [thickness] of the deferent [bearing-sphere]. And you should know that the matter of the epicycle sphere the ancients filled out [ascribed] specifically in the case of the wandering stars, which is not so for the star of the sun; for all the discrepancies found in [the sun] can all be settled by [the] "eccentric" sphere [**גלגל יוצא מרכז**], as was explained above in its place, in the Seventh Section. But the [remaining] five stars — a star whose position [suffers] most of the discrepancies found [in it] — [require] more [than that]: what an eccentric produces is not sufficient for them, [and so] an "out-of-center" [device] is [added] to settle all the discrepancies that are found in them, as [more will be added] until the reader [continues on], [by] the mechanism of the epicycle sphere.

סימן קצ"ה — printed §195 (logical §196)

The figure of the epicycle sphere; and that its star, too, touches [is contiguous with] the sphere above it and the sphere below it.

I have seen fit to set before you the figure of the epicycle sphere, together with the figure of its sphere in which it is embedded, and [of] the [deferent] that carries it about the globe of the earth, together with its form and its track — for the epicycle is embedded, and its star is embedded within it, and it carries [the star] about, as [explained] above [[?]]. And [know that] the epicycle sphere is [itself] embedded within the thickness of the [inclined/bearing] sphere. When the center of the epicycle stands upon a [given] point [of the deferent], the star, [riding] upon the track [circumference] of the center of the epicycle sphere, will be there [at the corresponding point]; and it will be at that time between the utmost nearness [perigee] and the utmost distance [apogee], as will be [more fully] explained, together with the measure of the [near and far distances], and its [construction], [which] will be explained to you further on at the end of the Section, §[16 / 56 — [?]].

Diagram. Construction, counted off the plate: three concentric heavy circles — an outer circle, a second just inside it (the narrow band between them carries nothing), and a third further in. The band between the second and third circles carries the inscription **מסלול גלגל הקפה**, set along its lower-left arc. Within the third circle stand four further circles: a large one occupying the centre-right; a medium one overlapping it at the upper left; a second medium one overlapping it at the lower right; and a small circle sitting on the third circle's rim at the extreme upper left. No straight lines are drawn on this figure.

Closed census of the lettering — seven sorts, plus the ring inscription and the words below the block:

- [[**ז/ק**]] — extreme upper left, beside the small rim-circle
- **ט** — upper middle, above the upper-left circle
- **ה** — inside the upper-left circle
- [[**פ/ג**]] — left, in the inscription band above **מסלול**
- [[**ט/פ**]] — inside the large central circle
- **ד** — right, between the central circle and the third ring

• [[**ט/פ**]] — inside the lower-right circle

Inscription along the band: **מסלול גלגל הקפה** ("the track of the epicycle sphere"). Below the block, outside the outer circle: **מזרח** ("East"), and, set apart from it, a small **ע**.

**

סי׳ קצו — printed §196 (logical §197)

The moon's motion in its epicycle is the reverse of the motion of the other epicycles, and is called "the moon's motion in reverse" [**מהלך הירח בהילוך הפוך**].

Know that the epicycle sphere, as it revolves within the thickness of the moon's inclined sphere, [moves in] a motion whose direction is the reverse of the motion of the epicycle sphere of the five wandering stars. For [in the case] of each of the five: because [each of] the five revolves [its epicycle] to the side and in latitude, [carried] by [the deferent] sphere itself, according to its revolution — everything [going] from west to east, that is, when the star of the wandering stars [is at] the elevation [apogee] of its epicycle, then the epicycle sphere carries it eastward; from there [the star] descends westward until it [comes round], and it returns to the elevation of its [apogee]. But the moon's epicycle — its revolution is not so, for it revolves from east to west. An illustration of this: when the moon stands at the elevation [apogee] of its epicycle, at point ה [he] of its [epicyclic] circle, as above, and the center of its epicycle rests upon point ב [bet] — after five days [**חמשה ימים**], by the motion of the epicycle sphere, [the epicycle-center] has been carried by the deferent eastward and rests, at its center, upon point מ [mem] of the [deferent] circle, as above. And in these same days, the center of the moon has been carried from the top [apogee] of its epicycle westward, until it rests at point ז [zayin] of its epicycle. It is found, then, that when the moon [rides] the top [apogee] of its epicycle, [the epicycle] carries it westward, and from there it descends toward the east and returns to the north; and this motion is called "the moon's motion in reverse" [**מהלך הירח בהילוכו**], [arising] from the revolution of this epicycle sphere within the hollow of the deferent — that is, the [moon's] own [proper] revolution — until [the moon] returns [to complete its circuit].

[Its periods:] The [anomalistic] period, which comes out by a reckoning close to the "anomaly" [**לנמנוס** — Greek/Lat. anomalia], is twenty-[seven] days and thirteen hours [**כ״ז(?) י״ג** ≈ $27^{d}\ 13^{h}$; the day-count glyph reads **כ״ז/כ״ו** — [?]], its daily motion being thirteen degrees and three minutes [**י״ג מעלות ג׳ דקין** ≈ 13° 3′] approximately. But the revolution [of the epicycle] about the globe of the world by means of the deferent [i.e. the sidereal period] is twenty-seven days, six hours, and forty-three minutes [**כ״ז יום ו׳ שעות מ״ג דקין** ≈ $27^{d}\ 6^{h}\ 43^{m}$; the hour-glyph reads **ז׳/ו׳** — standard value ≈ $27^{d}\ 7^{h}\ 43^{m}$ — [?]], its daily motion being thirteen degrees [and some] minutes approximately [**י״ג** (**מעלות**) — [?]]. And the [synodic] period between [one] conjunction [molad] and the [next] conjunction is twenty-nine days, twelve hours, and 793 parts

[29 = כ״ט יום י״ב שעות תת״נג חלקים ^{d} 12^{h} 793 chalakim], the two [figures] being [apparently] contradictory [reckonings], yet they are one, for the whole comes out to one [and the same] reckoning, as will be explained to you further on in §204 [סי׳ ר״ד].

סימן קצ״ז — printed §197 (logical §198)

On the spheres of the moon and the orbs of the other wandering stars.

Know that in the heavens [where] the sun [gives light to the day?] [[?]], [the sun] as it were "leaps" and folds over from this orb [גליל] to that orb, [passing over the surface(s) of] seven [orbs? — number [?]], meeting [with them] each [year], as was explained above at the head of the Second Section, as in §123 [סי׳ קכ״ג — [?]]. So too the moon, which gives light to the night and [moves along?] leaping from orb to orb, and [passing over] about [פ״ז? ≈ 87 — number uncertain [?]] orbs each month, twice[?]; and these are called "the orbs of the moon." These orbs are wider [more spread apart], each from the next, than the orbs of the sun; for [whereas] beneath the seven [orbs] the sphere revolves the moon in twenty-seven days and eight hours [ה׳ שעות/'כ״ז יום וח ≈ 27^{d} 8^{h} — [?]]. And as the case is with this sphere, so is the case with each of the other five wandering stars, [each of] which performs [its share of] the [daily] southern [westward] motion upon the surface of its own particular orb, each day by [כ״ח? / a certain amount [?]]; and the width [spacing] of the orbs, too, is according to [the star's] period. [Thus] every single star, and [each] of the fixed [orb-]stars [כוכבי גלגל?], has this way with it. Because of this [manner of] motion of such a sphere, there is no latitude in it, and no one perceives in them any "leaping" from orb to orb — neither by this one[?] nor by that one — except when they [amount] to the seven[?]. [The heavens, though many, do not lack.] [This whole passage is numerically dense and heavily abraded; most interior figures are [?].]

הערה — Remark. At first glance it appears that one who wishes to be exact in the matters of the moon's orbs would find in them a reckoning greater [and more involved] — more complex and larger — than [the reckoning] of the sun's orbs. And this is [because] the [moon's motion is not] only [in longitude, whereas the sun moves] only in the length of the firmament [longitude], as [explained] above in §[160 / ?] [?]; but the moon travels [both] in the length of the firmament [longitude] and in the [breadth of the firmament — latitude], as we [have] explained. [Moreover, the moon's compounded motions are] larger [and more numerous] because of [[?]] that its [return] on its epicycle — [together with] the [motions] that the [orbs] produce by means of the revolution of the deferent — [comes to some number of orbs]. In [the days? — פל״ך ימים [?]], twice in [each lunar] month, as above; and by its epicycle the moon makes twenty-two [כ״ב = 22 [?]] particular orbs, [tracing out] the width [surface] of its epicycle. And furthermore, the moon revolves in its epicycle sometimes from east to west, and sometimes from west to east, as [explained just above]; so that, since the discrepancies of the [various] spheres are [many], the exactitude

[required] is great and abundant, and there are many rules and determinations required for this. And see further on in §207 [סי׳ ר״ז].[286]

סימן קצ״ח — printed §198 (logical §199)

On the discrepancy found in the moon between its mean position in the zodiac and its true position.

We have already explained above, at the head of the Seventh Section, in §163 [סי׳ קס״ג], and also in §182 [סי׳ קפ״ב], that there is no sign or better mark by which to know from it the measure of the time of the sun's course, according to its motion against the divisions of the zodiac [than the equation of center]. And just as this rule holds for the sun, so is the rule for the moon. The discrepancy found in the sun between its mean position and its true position in the zodiac — [existing] in the manner in which other discrepancies are found — is likewise found, so too, in the moon, [but] there more compounded, and [involving] more [rules] and determinations. And this is for two reasons. The first: that all the discrepancies found in the sun are caused by the eccentric sphere [גלגל היוצא מרכז], whereas [all] the discrepancies found in the moon are caused by the epicycle sphere [גלגל הקפה], as will be explained just below. And the second reason: that in the sun's course a discrepancy is found only in the length of the firmament [longitude], whereas in the moon its discrepancy is found [both] in the length [and the breadth] of the firmament [longitude and latitude].

And know [that] we come now to the explanation of the discrepancy between the moon's true position and its mean [position], and we shall come further to [treat] of the matters of longitude and latitude, in addition to what we explained above [in §138? — [?]]. Know as a general [rule] that the line that goes out from the center of the earth and passes through the center of the epicycle sphere, and the line that goes out from the center of the earth and passes through the center of the moon itself [up] to the firmament, [define the moon's positions]: [the second gives] the moon's true position in the breadth [/length] of the firmament; and the distance from the head of the zodiac to the [mean] position — as explained — is what is called the moon's mean position in the length of the firmament [mean longitude]; and likewise, the distance from the head of the zodiac to the true position is what is called the moon's true position in the length of the firmament [true longitude]. And the distance of the moon's center from [the apogee] of its epicycle — [measured] from the point of the top [apogee] — is called the "[argument] of the moon" [מכ״ת הירח (?)], and in the Latin tongue it is called [apogeum / perigeum — *פיניגיאום*, garbled] [?]. An illustration of this: I say that the moon goes out at point [ב]...

Diagram. Construction, counted off the plate: three concentric heavy circles, forming two empty bands — the bands carry no lettering and no inscription of any kind. Within the innermost circle stand three further circles: a large one at the centre, one overlapping it above and slightly left, one overlapping it

[286] the closing reference's numeral is not settled between two adjacent values.

below and slightly right. Two straight lines issue from the centre of the large central circle, diverge slightly, and run down to the lower right, crossing all three rings and projecting past the outermost one.

Closed census of the lettering — six sorts, and nothing else on the block:

- **ע** — top, in the band between the outermost and second circles, above the upper circle
- **ב** — inside the upper circle
- **ה** — inside the large central circle, at the point from which the two lines issue
- **מ** — inside the lower circle
- **ד** — right, where the upper line crosses the outermost ring
- **[[כ/ב]]** — lower right, outside the outermost ring, at the projecting end of the lower line

**

[Text continues around and below the figure:]...[the moon] which is [set] in its epicycle, and the center of the epicycle [rests] upon point ב [bet] of the track [deferent]; and after a known [number of] days, the center of the epicycle sphere will have moved [and] rests at point מ [mem] of the [deferent] circle, and in the time [of] those days the moon's center [has moved] from the top [apogee] of its epicycle, by its aforementioned motion, westward, until it rests upon point ז [zayin] of its epicycle; and [thus] the whole [figure of] the moon [describes] arc [[?]]. And now, likewise, from the center of the earth, from point ה [he] of the circle, [draw] two lines: the one [extending] to the center of the epicycle sphere, which is point ע [ayin], and stretch it upward to the firmament, and bring it to point ד [dalet] — and this is called the moon's mean position in the length of the firmament [mean longitude]; and the second line is drawn [extended] to the center of the moon, which is point ז [zayin], and from it upward to the firmament, [going down/along] to point ל [lamed(?)] [?] — and this is called the moon's true position in the length of the firmament [true longitude]. And thus [we have] here the moon's true position. It is now good and useful to investigate the moon's mean position in the length of the firmament by means of an instrument, a quadrant [כלי רבע קשת], [in] §[159 — קנ"ט? / [?]].

(Section §198 continues on the following page.)

Siman 199 [קצ"ט] — The difference between the true molad and the mean molad

Know that, just as there is a difference and discrepancy in the moon between its true position [in longitude] and its mean position, so too there is a discrepancy and difference of this kind in the molad (conjunction). Ptolemy already reckoned, regarding the molad, that there is a true molad and there is a mean molad. The mean is the precise, computed one, and it is [defined by the moon's being] aligned opposite the sun; this is the moment of the sacred molad according to the truth. Yet by the exact reckoning, as the astronomers compute it, the

intervals from one molad to the next are not equal on a single uniform basis, for one finds in them advance and delay [precedence and lag]. It is of this true motion that Chazal spoke [as I explained above]: sometimes it comes "at length" and sometimes "in brief," as will be explained further. …as it was at point **ה** or **ו** in the figure [כמו שהיה בנקודת ה' או ו' שבצורה]; and [if] its centre — all three of them — [lie] on line **א**'[**ע/ט**]"[**כ/ב**] [כ/ב]"[ע/ט] 'ויהיו או מרכזו שלשתן על קו א]…. And sometimes the moment of the mean molad falls before the true one; and this is when the place of the moon itself, in longitude along the firmament, is from the apogee [?] toward the place of [?]… [ולפעמי' יפול רגע מולד האמצעי קודם האמיתי וזה כשיהיה מקום הירח עצמו באורך הרקיע מגובהי למקום מר…].

[Short line standing alone on p. 117: **של** — two letters, ink ≈¼ of a full measure at B y2986–3033.]

The mean molad is reckoned when the epicycle's center is aligned against the center of the sun; that is when it is called the molad. For the mean [molad] we do not insist on [pinning down] the moon's own actual place; we merely imagine, as it were, that the moon at that moment was at the apogee [rum ha-hakafah] or at the perigee [shifulo of its epicycle] — [so that] the mean and the true molad [coincide] at one and the same instant, as will be explained shortly. And by the approximate rule, the moon at that moment is neither exactly at the apogee nor at the perigee of its epicycle, in such a way that it is not aligned against the sun; hence it is not a molad in truth. In every case, only when the epicycle's center is [aligned] against the sun is a molad reckoned and is called the token of the molad. [It is called] "mean" because it is the mean [midpoint], the molad falling between two extremes — between the extreme of the moon's greatest distance and the extreme of its nearest approach along its course — as will be explained further on, in Siman 212 [**רי"ב**]. And by this mean reckoning, the time between one molad and the next comes out uniform forever, for it never lags and never hastens, never advances and never delays from one occasion to another; because whatever is deficient or in excess in this molad-reckoning relative to the true molad-reckoning is thereby [balanced], and it is made up or paid off in another month.

Siman 200 [ר׳] — Every variation found in the sun on account of the eccentric sphere is all found in the moon on account of the epicycle

After the matters of the epicycle and the matters of the two luminaries' motions — in their true and their mean positions — have been explained to you, you should know [per the figure of the sphere; see the diagram below]. [Just as the sun's variation arises] from [the position of] its center, so likewise in the moon, according to the structure of this epicycle. Now, in the sun it has already been made clear that sometimes no discrepancy at all is found between its mean position and its true position; sometimes the true position precedes the mean; and sometimes the reverse. And so [it is with the moon]. The variations [themselves are as follows]:

- (א) [When there is no discrepancy at all — when the moon's center in its epicycle stands at the apogee or perigee.] [?]
- (ב) Whenever the moon's center [in] its epicycle is at [the apogee], the true moon [is aligned with the mean] [?].
- (ג) And whenever the moon's center is [reversed], at [the perigee], as mentioned [?].
- (ד) When the moon's center [reaches] the line [drawn from] the center of the earth [through] the center of the epicycle [?].
- (ה) According as the moon's center is farther [eastward], up to the deferent-path of the [epicycle] center [?].
- (ו) When the moon is [farther] [?].

It is on account of this [pattern] that the ancient sages said the moon has no eccentric sphere [gilgal yotze merkaz]. But I inform you, so that you should know, that the moderns [ha-acharonim] investigated closely and found in the moon yet other matters and variations. I heard from a sage [i.e., learned report] that the sage קפלי״וס [Kepler] [held] that for the moon['s sphere] [there is]… for the moon's sphere one eccentric sphere, and besides that — for the epicycle sphere — there is yet a second small sphere in its likeness. And now you have [the model with] two [nested] spheres of revolution [?].

And these are they: (1) the sphere ha-domeh [the like/resembling sphere]; (2) the sphere ha-noteh [the inclined sphere]… [ואלו הן א׳ גלגל הדומה ב׳ גלגל הנוטה] … four spheres [ד׳ גלגלים].

Siman 201 [ר״א] — That the moon's spheres have six motions

From all the matters mentioned it is clarified to you that the moon's sphere has six motions, even [reckoning it] as [nested] uniformly with an inclined orb, whose motion follows its natural southern course from west to east:

1. The daily [diurnal] compulsory motion.
2. [A second daily / longitudinal motion] [?].
3. The slow [heavy] motion [of the nodes], [?] over a year.
4. The motion of the epicycle, as in Siman 151 [קנ״א].
5. [The motion connected with] the [Dragon's] head and tail, as in Siman 158 [קנ״ח].

And in addition to these, there is found for the moon's own body yet a seventh motion — intricate and complex — by which it traces an oval by itself, as will be explained in Siman 206 [ר״ו]. As for the number of circles that must be drawn for the moon's spheres, they properly are five standing circles, as are found in the sun's sphere — as was explained above in the Second Section, in Siman 27 [כ״ז] and Siman 152 [קנ״ב] — and in addition to these: the circle of the star-sphere, the circle of the epicycle, and the circle of the path of the moon's [own] body.

Siman 202 [ר״ב] — That the reckonings of the seasons and the conjunctions were established for us by Chazal according to the mean motion

Know that, according to what has already been explained — that the true motions of the two luminaries, the sun and the moon, [vary] — so too the times of the seasons [tekufot] and likewise the times of the conjunctions [moladot] are not uniform; rather there are in them advance and delay that differ in several respects: according to the differing [motions] in their courses and also in their latitudes, according to the changing position of the sun among the constellations, and according to the changing position of the moon among the constellations. Concerning such matters — and others weightier and more intricate still — was the great secret over which many labored in their calculations back when they used to sanctify [the new month] on the basis of eyewitness sighting; and they scrutinized and investigated these things in nature: [inquiring] whether the sighting [inclined] toward this side of the [zodiacal] wisdom or beyond it, to its north or to its south, how much it was inclined and how broad it was — as [the Sages] laid down in the second chapter of [Rosh Hashanah]. All these inquiries were according to the true reckoning, as Rambam wrote, of blessed memory, in chapter 1 of Hilchot Kiddush HaChodesh, and Rabbeinu the Israeli in Ma'amar 3, chapter 11 [הרמב״ם ז״ל בפ״א מה״ל ק״ה ורבי׳ הישראלי בפי״א מאמ׳ ג׳].

These are weighty, deep, and hidden matters, requiring an exceedingly precise and profound calculation. Therefore, near the end of the era of the Sages of the Mishnah, when the [Roman] government decreed to slay [the Sanhedrin / abolish ordination], and it was no longer possible on account of the [decrees] to keep [a standing court] fixed in the Land of Israel, the Sages of Israel and Hillel the Nasi, his descendant, founded and instituted [the rule] to rely [on calculation] — for the intercalation of years and the fixing of the festivals — according to the [fixed] reckoning, and not [to be dependent] on witnesses nor on messengers. And this was in the year [c. 290 — reads ר״ן / ר״ץ; ?] after the destruction of the Temple, [namely] 4118 to Creation [ד׳ אלפים וקי״ח ליצירה; the final letter reads ח (=118 → 4118 AM); the traditional date of the calendar's fixing is 4119 AM ≈ 358/359 CE — see QA]. The reckoning they founded was transmitted to us by Chazal as a foundation, based upon the mean course [of the moon], as Rambam wrote, of blessed memory, at the head of chapter 2 of Hilchot Kiddush HaChodesh, and also chapter 10 of it [כמ״ש הרמב״ם ז״ל בראש פ׳ שני מהלכו׳ ק״ה גם פ׳ עשירי ממנו]: that these two seasonal reckonings are all approximate, following the mean motion and not the true position. And so wrote the sage R. Yisraeli, in the order stated, according to the festivals, as they transmitted to us; and in exile we rely upon [this reckoning based] on the mean course, and we cannot do anything better than it. So too wrote the sage the Israeli, Ma'amar 3, chapters 8 and 9 [חכם הישראלי מ״ג פ״ח ופ״ט], and in many places.

Siman 203 [ר״ג] — On the time of the moon's revolution in its sphere, the time of the revolution of its epicycle, and the time-measure of the moon's renewal

Know that when the moon stands, as above, inclined against a known point among the constellations — for instance against the head of Aries, or against another marked point — it revolves and circuits all twelve [reads תי״ב] constellations of the firmament according to its mean course, and returns to that very same point from which it set out. The time of this revolution, by the precise reckoning that I received from the wondrous astronomer **יאהניס קעפלירואוס** [Johannes Kepler], is 27 days, 7 hours, 43 minutes, 7 seconds [כ״ז יום ז׳ שעות מ״ג דקין ז׳ שניות]. Then, in a fresh sentence, the daily motion: each day 13° 10′ 34″ 43‴ [יכל יום י״ג מעלות יו״ד דקין ל״ד שניים מ״ג שליש]. This is the revolution of the [moon's] own [sidereal] course toward the east, which is swifter, by about 13° [more]; and the [moon's] own body revolves, [returning] against all twelve constellations, in 27 days and known [fractions]. This is the revolution of the moon by means of the revolution-sphere of its epicycle, at its place [i.e. the anomalistic return]: 27 days, 13 hours [כ״ז יום י״ג שעות] — each day 13° 3′ [ג׳ דקין] 23″ [יכ״ג שניו] 26‴ [כ״ו שלישים].[287]

And the measure of the time of the moon's renewal [the lunation / synodic month], according to what he [Kepler] states by his precise reckoning, is 29 days, 12 hours, 44 minutes, 3 seconds, 11 thirds — each day 12° 11′ 22″ [seconds uncertain] 11‴, all according to the mean course. This is close to the reckoning of our Sages, of blessed memory, [who set] the molad at 29 [days], 12 [hours], 793 [chalakim] [כ״ט י״ב תשצ״ג]; for their reckoning differs from his only by the [fractional] part [i.e. seconds/thirds] — as we set out at length in the Section of the Renewal [בשער החדוש], in our book Maor HaKatan [מספרנו מאור הקטן], and also in part 8 of our book Tzemach David [גם בחלק ח׳ מספרנו צמח דוד], as is fitting.

Siman 204 [ר״ד] — The reason for the difference between the time of the moon's revolution in its sphere and the time-measure of the month

Because I have sought, for the benefit of the [students], since the time of the moon's revolution against all twelve [reads ל״ב] constellations of the firmament is only 27 days and [6 hours / a sixth], whereas between one molad and the next is 29 days, 12 hours [and 793 chalakim] — therefore, to explain and clarify it to students, let us reckon that the two luminaries conjoined at a molad aligned against the head of Aries. Suppose then that the moon separates from it [the sun] and revolves along its proper course; every sphere [completes its round] in 27 days and close to 8 hours, and it returns to the very same point where it had already renewed [itself] the previous month, as we posited, against the head of Aries. Behold, the moon does not [yet] meet the sun at the place from which it

[287] nothing below the hour is given for the month itself; the minutes, seconds and thirds that follow belong to the daily motion of the next clause.

had separated, because in that time of 27 days and close to 8 hours the sun too has moved along its course, gently, close to 27°. On account of this the moon pursues it and does not overtake it until after 2 more days, and known hours and chalakim; and when you add those 2 days, hours, and chalakim to the 27 days and close to [8] hours, the total comes out to 29 [days], 12 [hours], 793 [chalakim] [reads כ״ט י״ב תשצ״ג]. Thus it becomes clear to you that the moon does not renew itself in its sphere at the place where it had already renewed the previous month, but always, between each molad and molad, the moon circuits its whole sphere against all twelve constellations of the firmament, plus an additional [arc] of close to [27°]. By this manner the moon renews itself, each and every year, [across] all twelve constellations of the firmament. See above, [in] the fifth [מישי(ת/ח)כ], in Siman [130? reads קל״ם / קל״ה — ?].

Siman 205 [ר״ה] — That the moon revolves, in two equal times, two different motions

From the principles that we mentioned, it is clarified to you that the moon — and likewise every [wandering] star, since the [seven] wandering stars [move] in [their epicycles] — revolves, in its revolution around its epicycle, [in] two equal times two different motions, or [equivalently] two equal motions in two different times, on account of its sphere's [eccentricity], as we said in Siman 184 [קפ״ד]. But in the figure the discrepancy is found greater [in some places] than [in others], because [when] its slow motion is at the head of Cancer and its [proper motion] at [Aquarius], its true course being at the head of Capricorn and its [proper motion at Leo] [?]. The moon's discrepancy is in every single degree of the firmament — sometimes at a gentle pace and sometimes swift. For when the moon revolves above the [deferent] path, circling from point ד through [the points] to point א [per the figure mentioned above, in Siman 139, קל״ט], it is delayed in its motion, since the motion of its epicycle is [opposite to / north of] the motion of the epicycle by means of the revolution-sphere. Then the star stands [as if drawn backward], and there is a lag [relative to] the firmament; and after it has revolved and come to point א, then the whole breadth of the epicycle is before the moon, [and the moon] is measured eastward. Therefore this motion is called the "slow motion" and also the "returning [retrograde] motion." And when the moon circuits below the path, revolving from point א in the figure, the matter is reversed [?] eastward, and it is called the "revolution of the diameter" [?], according to the length of the diameter of the epicycle.

[This holds for] every [wandering] star, since their course in their epicycles [runs] from west to east; when it is reversed, the [northward] motion is above the path, and [the star's position] is below it.

Siman 206 [ר״ו] — That in revolving around the sphere of the world, the moon makes for itself an oval — a path irregular and confused in illumination

Know that the path of the moon's own center, by reason of its rising and falling in its epicycle — [is not the same as the mean path]. The epicycle's center itself revolves upon the [mean] circle of the star-sphere, which alone is called the deferent [mesalul] of the star-sphere's center; and by its revolution the mean course of the moon is produced. But not so is the course of the moon's own center, [which follows] the true course, for sometimes the moon revolves above the [mean] path and sometimes below it, and sometimes upon the epicycle itself, only slightly, each month, as will be explained. Before we come to the explanation of the matter, in order to explain it and make it agreeable to students by the easier route, we take the following: there is the time of the moon's revolution by means of the star-sphere around the world-globe, and the time of the moon's own revolution in its epicycle; and we do not [here] regard the [precise]… And the time of the moon's revolution in its epicycle, [together with] the time of its revolution around the world-globe — [see] the principle of Siman 205 [ר״ה][288]. And now hear the account of this path and how it comes to be:

[Note.] When the epicycle's center rests at [the head], at point **ג** in the figure, and the moon['s center] returns to point **ד**: after the first quarter of the month's days, the epicycle has already revolved its whole [circuit] by means of the moving sphere, through [the east], the fourth part of the deferent's [journey], until the epicycle's center rests at point **ט**; and in those [same] quarter[-days], the moon's [center] moves from the head of its epicycle through [the west], [three-]quarters of its epicycle, until it comes upon [the deferent] at its true place, at point [**ט**]. So it comes out that in the time the epicycle's center moves from point **ג** to point **ט**, in that very same time the moon moves from point **ו** to point **ז**, and in those days the moon sweeps, within the surface of the inclined sphere, an arc of [76°, ע״ו — ?]. In the second quarter of the month's days the epicycle revolves its whole [circuit] until its center rests at point **ח**; and in those days the moon's revolution in its epicycle [continues] until its center rests at point **מ**, at its perigee [shifulo], and the moon sweeps in those days an arc of [75°, ע״ה — ?]. In the third quarter of the month's days the [epicycle] revolves until its center rests at point [**ט**]; and in those days the moon's revolution [continues] until its center comes upon the deferent-path at its extreme, at point **ג**, with the moon's own center at point **ד**, and the moon sweeps in those days an arc of [40°, מ׳ — ?].

[288] ⚠ this cross-reference is disputed and unresolved. A re-reading at very high magnification gives 250, not 205, set with a non-final nun — a form that matters because this fount otherwise uses final letterforms as numerals. The disputed reading could not be matched to any word in this portion, so it is recorded but not substituted: 205 stands as the reading of record, neither value is established, and the reference should be treated as unverified.

Behold, then, that the moon's whole path is an oval [reads עגול… ?]; and it is clarified to you that the moon does not move, by this reckoning, upon the deferent-circle, but only as in every month… sometimes, as I stated in the introduction, near point [**ט**] and [**ד**]. It is further clarified from this that the path of the moon's body — which is an oval [ellipse] — is smaller than the circle of the epicycle; also that its nearness and its farness are not uniform with respect to the epicycle-circle, so that we need to assign it a distinct center of its own — and in its middle [?] its center is point **א** in the figure, which is distant and above the center of the star-sphere by about the length of the radius of the epicycle. After all these things [the matter will be expanded] [?].

Diagram. A large semicircle drawn across the foot of the folio, spanning both columns and crossing the gutter, representing the moon's inclined/deferent sphere. Its horizontal diameter forms the base, labeled at its two ends **מזרח** ("East," at the left end) and **מערב** ("West," at the right end) — recorded as printed, not corrected. The outer arc is a true semicircle (half-width 570.5 against rise 568, agreeing to 0.4%; radius ≈ 52.6 mm). A vertical radius runs from the baseline centre to the apex, and two straight radii run up-left and up-right, each passing through one of the lower small circles and continuing to the outer arc. Three small circles sit on the construction — top (centred on the vertical), lower-left, and lower-right, the two lower ones very slightly the larger.

Labels on the block — twelve positions, a closed census:

position	label
apex, above the outer arc	ט
outer arc, far left	פ
outside the lower-left circle, above	א
inside the lower-left circle	ח — with ת noted as not formally excluded
top circle, upper	ה
top circle, middle	ו
top circle, lower	ז
above the lower-right circle	ג (rotated ≈ 20°)
inside the lower-right circle	UNCALLABLE — read as [ד/ר] and withdrawn; the glyph is rotated and fused with the radius crossing beneath it
outer arc, right	UNCALLABLE — a closed quadrilateral fused into the arc; ם / ס / a closed-by-fusion ב are all live, and N fuses toward closure, so a closed form here is an empty observation. Withdrawn.
baseline, left end	מזרח
baseline, right end	מערב

- ו and ז are each other's control — same figure, same size, opposite stem placement — so both are secure. ט and פ were each resolved against the same display control pair.
- No text is set on a curve.
- A second, inner arc runs beneath the outer one.
- A further circle at the lower right of the figure — centre x ≈ 1393, diameter ≈ 246 — carrying ג above it; an interior label read as [ד/ר] was withdrawn on a second reading of the leaf and is not given here.

שער ח — The Eighth Section (The Moon)

[Continuation of סימן ר״ו — printed §206 / logically §207] — the moon's own oval body-path

It will also become clear to you from the figure that when the center of the epicycle reaches point ג of the figure, the center of the epicycle and the center of the moon stand directly one opposite the other [aligned]. The same holds when its center rests at point ח [?] of the figure. And when the center of the epicycle is at point ש of the figure, the epicycle-center has a precedence over the moon, measured along the length of the firmament, by [an amount equal to] half the diameter of the epicycle sphere. Conversely, when the center of the epicycle is at point ח [?] of the figure, the moon has a precedence over the epicycle-center, along the length of the firmament, by half the diameter of the epicycle. [The two point-letters ח here appear to conflict; at least one is a misreading or a compositor error — flagged.]

Diagram. A large deferent circle centered on point ב (with point ה adjacent at the center), carrying four small epicycle circles set at the top, right, left, and bottom, together with a dashed eccentric circle offset upward. It illustrates the moon's deferent-and-epicycle model with its displaced (oval) path.

Labels on the block — 17 in all, transcribed as printed by position, each occurrence separate (ב, א and מ each occur twice at different positions). Hedges are those of a second reading of the leaf:

position	label
top of outer circle, 12 o'clock	[ו/ר]
north (top) epicycle, above its chord, left	פ
north epicycle, above its chord, centre	ב
north epicycle, above its chord, right	ט
north epicycle, below its chord	כ
centre, above the horizontal, right of the vertical	א
centre, below the horizontal, left of the vertical	ה
centre, below the horizontal, right of the vertical	ב
east (right) epicycle, inner	[ח/ה]
east epicycle, outer	ק
east outer margin, rotated 90°	מזרח ["East"]
west (left) epicycle, above the horizontal	מ

position	label
west epicycle, below the horizontal	א
west, outside the outer circle	מ (single letter)
south (bottom) epicycle, above its chord	ס
south epicycle, below its chord	[ח/ת]
below the outer circle, 6 o'clock	ע

- No text is set on the curve. No **מערב** on the west margin on either copy — the west margin carries only the single letter **מ**. The east/west asymmetry is real on both copies.
- The letters are geometric point-names, transcribed, not identified.

סימן ר״ז — Siman 207 (printed *ר״ז* / logically §208)

That the body of the moon is composed of many distinct circles and orbits, greatly intertwined and confused, most of which are beyond number.

You should know that everything set out above is [to be taken] "as if": it is as though the moon were [carried] by the deferent sphere, and the moon's revolution by its epicycle sphere were equal in measure [to it]. Were the matter truly so, the moon would return, in the fullness of our world-cycle [?], at every new-moon, to the apogee of the epicycle upon its own body[?], and likewise [return] to the perigee, and to the mid-point of the epicycle's path — and there would be no difference between one month and the next for all time. But in truth it is not so, for the discrepancies found between the time of the moon's revolution upon its epicycle sphere and the time of its revolution about the world-globe are what cause the moon's body [to stand] at the apogee of the epicycle sometimes at the new-moon and sometimes at [other phases] — and so it is for every day and every portion of the month.

You should further know, from what was explained above, that the moon's body has, in its revolving, circles, orbits, and many centers — most of which are beyond number — for according to what [will be shown]...

as we already explained above, that when the body of the moon rests directly opposite [?] its apogee at point ז [?], its center [lies] above [or below] the center of the deferent [?] sphere by [an amount equal to] half the diameter of the epicycle sphere; likewise, when the body of the moon rests opposite [?] at point ע״ג [?], its center [lies] below the center of the carrying [deferent] sphere, again by half the diameter of the epicycle sphere, and it will be at point ת״ב [?] of the figure.

And so its rule holds for every part of the deferent sphere, in every single place where the body of the moon happens to rest: it forms a [displaced] circle and an orbit of its own[?], as we mentioned. Not only [does this happen] at every new-moon and month of the year, but truly at every [phase] — a fact that was not [recognized] until after many years and centuries. All the days of the [month] I call this an "intertwined orbit" [מסלול מבולבל]. From all this it will be shown to you that these matters are intricate, entangled, and confused

— its circles and orbits — as we already explained above in Siman קל"[?] [a back-reference to an earlier siman, number uncertain].

Diagram. Three concentric circles (fitted radii 29.10 / 43.72 / 57.30 mm, concentric to within 0.5 mm), the outer annulus divided by straight radial lines run from the centre. Four equal epicycles (r ≈ 13.6–13.8 mm) sit on the middle circle at the four quadrant bearings. A dashed curve runs through the annulus between the inner and middle circles, visibly not concentric with them; it defeats every circle fit and is recorded as an unnamed dashed arc rather than forced into a category (its breaks are drawn dashes, regular in length and spacing, not inking dropouts). The figure crosses the gutter and spans the full measure; the text columns above and below it are not narrowed. It depicts the moon's place at successive positions, each with its epicycle.

Labels on the block (census, not inference):

- Rim: SIXTEEN labels, not twelve — set outside the outer circle, at bearings 0.3, 24.0, 45.2, 66.8, 90.8, 113.7, 136.6, 157.8, 179.9, 200.4, 225.7, 247.3, 272.0, 293.6, 316.6, 338.7° — consecutive differences 20.5–25.3°, mean 22.4° ≈ 360/16.
- Of the sixteen, four are read: טז at 272° (top, good), א at 293.6° (good), ב at 316.6° (fair, heel not measured), ג at 338.7° (fair).
- Two are read and withdrawn: at 0.3° a vertical with a bottom-left foot, "which fits no reading I trust" → [?]; at 90.8° two strokes joining low, "which is not a *ח*" → [?].
- Two are low-confidence: 24.0° [?] possibly ה; 113.7° [?] possibly ט.
- Eight are unread (boxes measured only): 45.2, 66.8, 136.6, 157.8, 179.9, 200.4, 225.7, 247.3°.
- Interior: 30 further label components measured between r = 377 and r = 823, including two- and three-glyph groups near the epicycles. None read.
- No label in the outer margin. No text set on the curve — every label component is a discrete upright box, none following an arc.
- Outer ring: א, ב, ג, ד, ה, ו, ז, ח, ט … (the twelve signs, numbered by letter)
- Top epicycle: טו, טז, יז [15, 16, 17], with a point letter [?]
- Right, left, and bottom epicycles: additional letter labels [several uncertain]

(Many labels are uncertain owing to show-through and small type.)

סימן ר״ח — Siman 208 (printed ר״*ח* / logically §209)

The difference between the line that issues from the center of the earth and the line that issues from the pupil of the observing eye standing upon the surface of the earth-sphere. (That is, parallax.)

The difference. There is a [considerable] difference between the line that issues from the center of the earth, passing through the center of the moon and extending onward to the firmament — reaching it at [a certain point] among the degrees [?] — and the line of sight that issues from the pupil of the eye of the

observer standing upon the surface of the earth, which also passes through the center of the moon and extends and reaches the firmament [at a different point]; for [the observed place] is what [the astronomers] call a [displaced] elevation [?]. In the foreign tongue this is called Parallaxis (פרולקסוס) [Latin/Greek parallaxis, "parallax"]. And I wish to make this clear to the students visually, by means of the quarter [-circle] figure [drawn below] [text partly garbled — "עגול המולד" / קלג uncertain].

Diagram. A quarter-circle (90° sector). Its right-angle vertex, at the lower right, is point ז — the center of the earth; from it one radius rises vertically to point א (top), and another runs horizontally to point ג (lower left); the arc sweeps from א to ג. Lines drawn from the vertex through the moon's center cut the arc; the observer's offset position lies along the lower edge. It demonstrates how a body seen from the earth's surface appears lower (nearer the horizon) than it would from the earth's center.

Labels on the block — eleven positions, of which two are read:

position	label
right margin 1 (top corner)	א — read on both witnesses
right margin 2	UNREAD — a form a second reading of the leaf declines to name (see below)
right margin 3	ח — read on both witnesses; roof continuous into two equal-depth legs
right margin 4 (bottom corner)	ז [?] — head + stem, w31 × h72, narrower than the ח/ב sorts on the same figure. Not closed.
below the base rule, left	UNREAD — the same shape as right-margin 2
below the base rule, right	UNREAD — a form open at the middle-right
five interior positions	UNREAD

- The shape at right-margin 2 (and its twin below the base rule) was measured on B at 1× and confirmed on N at 9×, so it is type and not a B artefact: a thick roof, a leg descending at the left end, and a small detached fragment. Against this leaf's own controls it is not ד or ר (both put the leg at the right) and not ב. It is left unnamed.
- No text is set on any curve; no label lies in the outer margin of the page.
- ה (interior): center of the moon
- ו, יה (interior intersections): construction points
- ל (interior): the moon's apparent (lowered) place

** The description reads: let a quarter-circle be drawn like that of the deferent sphere; and a right-angled quadrant in the likeness of the earth [is drawn], marked [?]. Let point ז be the center of the earth, and point פ the place of the observing eye that stands upon the surface of the earth; and suppose that at point ה, partway along [the line], the center of the moon is set. Now we draw a line from ז — from the center of the earth — through the moon and onward to [its terminus], and this is the line [reaching point ב], descending from the center of the earth toward point ב [?] on the firmament — [giving] the moon's true place among the degrees. And the line of sight [קו ההבטה], line

פ, from the eye of the observer standing upon the surface of the earth, descends as though the moon rested at point ל — [a place] lower than point ב and nearer the horizon by the arc [of parallax]. As a general rule, know that the parallax of the moon [שנוי מראה, "change of appearance"] is always greater the lower and nearer the moon is to the line of the horizon [measured] from its [true] place; and the nearer it is to the horizon, the greater grows the arc of its parallax, while the higher it is [above] the horizon, the smaller the arc of its parallax.

**...[the correction] diminishes as the altitude of the moon increases, until, at a place 90 degrees above the horizon, this difference is entirely nullified. All of these matters [the astronomers] compute precisely [only] for the two latitudes of the moon [?], because the moon is near to the earth-globe. Just so, the half-diameter of the earth bears a perceptible ratio and measure with respect to the observation [of the moon], [and] with respect to the line issuing from the center of the earth... [the correction is] a small matter, and [reckoned] precisely and by itself alone. Even one who says [that it applies] also to [some fifty?] [must] be precise about the two latitudes; and this is a small thing, [applying] on its own. [Line partly garbled — figures uncertain.]

סימן ר״ט — Siman 209 (printed ר״ט / logically §210)

The definition of the molad (conjunction), its time, and the cause of the many variations found in the moon throughout the days of the month.

The author says: I saw fit to explain in this place, for the students, the definition of the molad — its nature, its time, and the cause of its waxing and waning throughout all the days of the month; and why it always appears at the beginning of the new-moon, at the start of the night, in the south-western quarter [of the sky], while at the [end?] of the [month] it appears at the end of the night in the south-eastern quarter; and why the moon's inner face and its horns turn sometimes toward the east and sometimes toward the west; and why, from the beginning of the month, day by day until the day of [full illumination?], the moon [rises later?] and travels on until the middle of the month, and from there onward, day by day, its magnitude [of light?] wanes until the end of the month; and why, from the beginning of the month until mid-month, the moon rises above the horizon [later?] each successive night, and [its illuminated portion grows], while from mid-month on it rises earlier [?] each night; and why, at the beginning of the month and likewise near its end, the moon is seen [as a crescent] with horns, whereas it is not so seen on the other days of the month.

And the term [molad] requires that one know that the molad is the moment when the moon, as it revolves upon its sphere, draws near and comes directly opposite the sun — its center standing aligned beneath the center of the sun — which is [the end of the old month that has passed and the beginning of the new month]. At that time the moon [hides itself] entirely from our sight, as [on the day of conjunction], and about [a day?] after the molad, as will be explained [below].

And now, how, and the reasons — the cause of all the varied appearances of the [stars / the moon]: the body of the moon is a round globe, [mixed?], somewhat resembling in its ruddiness [the color of polished] bronze — for it is [suited] to the eclipse[?]... [The moon] is [clear] as pure sapphire [ספיר] and revolves [like Venus?] in the heavens; in itself it has no light at all... as will be explained [in Siman ר״ך?, a cross-reference — number uncertain]; and although the moon gives us light, that light is not from itself, but comes about through the casting and reflection of the sun's [rays] upon it: what it receives from the sun it [reflects] and radiates outward. It is like the appearance of a cast [mirror] of iron or polished bronze, which, when you set it opposite the sun, [catches the light] and shines and casts a radiance from itself. And you should know...

(Short line standing alone at the head of p. 124's right column:) the thickness of the globe [עובי כדור ⟨mark⟩]

And now you should further know [that the moon's] globe [?] sometimes appears to the inhabitants of the world as half, and sometimes full [and dark, giving no light]; and this is because [only half] of the moon [faces] the sun[?]; and thus, day by day, it shows its light to the inhabitants of the world according to its distance from the sun: as it draws near to the sun, its shown light lessens and diminishes; so that from the beginning of the month its light goes on increasing for the inhabitants of the world up to mid-month, and from there onward its light wanes and diminishes until the end of the month, as will be further explained.

And so that these matters may be clear to the students, I saw fit to draw [a figure] to show [them] to the eye, this being its meaning: the upper circle is the likeness of the form of the body of the sun [שמש], and the great circle beneath it, which they [mentioned], is the likeness of the moon's orbit; and point פ at its center is a token for the pupil of the eye of the observer [who looks] from the surface of the earth and observes the moon; and its position is marked upon the line of the orbit as noted. We begin with the moon [in its first station], which is the place at the moment of the molad, when the moon has drawn into the utmost proximity opposite [the sun] beneath it, where the two centers stand aligned one beneath the other, as above.

Diagram. A woodcut of the lunar phases. At the top is a disk labeled **שמש** ["Sun"], from which straight rays fan downward — 23 ray crossings measured just outside the sun's rim, all in the range 15°–163°, i.e. a tangent pair to each disc. At the centre of the figure stands an unlabelled circle, and about it, on a drawn orbit circle, are arranged twelve small moon-disks at 30° intervals, each shown half-black (the dark side) and half-white (the sunlit side); on the four discs not crossed by rays the shaded half faces away from the sun. The sun disk is drawn smaller than the central circle, so the figure is schematic and not to scale. It illustrates how the sunlit half of the moon is turned progressively toward and away from the earth-bound observer through the phases, from conjunction (molad) to full moon.

Labels on the block (census, not inference):

- שמש (inside the top disk): the Sun — the only label on the whole figure
- No lettered points of any kind. The central circle, the orbit circle and all twelve moon-disks are unlabelled.
- the ring of half-lit disks: the moon at successive positions of its monthly cycle (unlabelled)
- an unlabelled circle at the centre of the figure — the Earth

** Then the sun pours its rays upon the moon, and there is illumined the entire half-surface of the moon that faces upward [toward the sun]; while the half-surface of the moon that faces downward [toward us] the sun cannot reach, so it remains in its darkness and gives no light to the children of the world at all. The reverse occurs when the moon has drawn away from the sun by [half a month]: for then the sun is [in the west] and the moon in the east, with the earth between them; and then, since the centers of the sun and moon are aligned [in opposition], [the sun] pours [its rays] upon the half of the moon's globe that faces downward [toward us], and therefore the whole of its illumined half is seen by the inhabitants of the world — and this [is the full moon].

And from the sum of these mentioned matters it will be shown to you that from the two [bounding] rays [קוי] that issue from [the sun?] and widen out from it, and from the two lines of sight [קוי ההבטה] that issue from the eye of the observer at point פ, [the geometry follows]... [that] the two lines of sight draw near, meet, and touch one another thus [•]. And likewise is the rule at the pouring-forth of light at the molad, when the two bounding lines of the observing eye both meet and touch one another thus [•]. And all this is clear, and there is no need [to repeat] the aforementioned considerations of the bounding lines.

שער ח — Eighth Section (The Moon), continued

(Folio סב [62] recto through folio סג [63] verso; running header "*שער ח*" throughout.)

[§ printed ר״ט (209) = logical §210, continued] — the phases of the moon

[the sun's rays would also have to be drawn as] the bounding lines [לות[כ/ב][נ/ג]ה] — **גלולי** [?] — of the sun upon the sphere of the moon, together with the line of sight and the point of the air upon the sphere of the moon; and because with so many lines the figures would become confused when the moon stands in the other stations, it is enough for the student to grasp [the principle]. I have therefore drawn for them [in the diagram] the cause [of the phase] for a single station only, and from it they will understand the remaining stations.

Know that when [the moon] reaches the [first] quarter — that is, on the fourth [day?] [?] after its molad — the lines and rays of the sun strike it and bound it, illuminating point א [aleph] on this side and point ג [gimel] [?] on that side, which are the two ends of the diagonal ס״נ [?]. This line bounds

and divides — in a straight figure across the sphere of the moon — between its illuminated portion and its dark portion. It follows of necessity that the parts of the moon's surface that face toward the sun are illuminated [and the parts that face away are dark]; and the illuminated half-surface [is bounded by the diagonal ב״ד — see below] [?].

And when you extend the line of sight from point פ [pe] — the observer's eye upon the surface of the earth — the [two rays] that meet it strike upon point ב [bet] and upon point ד [dalet], which are the ends of the diagonal **ב״ד**. This [diagonal] bounds and divides between the moon's portion facing upward — the surface [רא־כ״ה?] [?] — and its portion facing downward. And it is found that this portion, facing downward, is illuminated in its [true] disposition but dark as it is received [by our eye]; so that of the whole surface [רא־כ״ה] [?] there is illuminated toward us, downward, only the surface **אב״ה** that is in the figure [רק שטח אב״ה שבצורה]. And this is one eighth [והוא חלק השמינית] of the whole surface of the moon's sphere; and for this reason this illuminated portion appears below like a triangular surface [נראה זה החלק המאיר למטה כעין שטח משולש] — for it is impossible to depict either the sphere or a part of it upon a flat surface as it should be. And again, three lines on: like a triangle [כעין משולש].

Picture it to yourself thus: if you cut a ball, or an apple, from top to bottom into eight parts, then in the eighth part the upper portion appears to you like a triangle. And just as the law is at the [first] quarter of the month, so the law is at the [other] quarter, which is the [22nd?] day [?] from its molad, when there appears to us half of the moon's illuminated surface, which is a quarter of its sphere. In like manner you may reckon the remaining phases.

Furthermore, know in general [כללן] that the two [middle] quarters [?] … [the illuminated] portion mentioned to us always [grows/diminishes]… the two quarters [that pass?] toward full [reckoning]… [text partly illegible] [?]

Know further that, according to what Ptolemy [בטולמי] mentioned: the arc of the celestial sphere that lies above every horizon is 180 degrees [ק״פ], through which the moon lies as it travels from the day of its birth to the day of its fullness, about 15 days [ט״ו]. Thus it advances each day one fifteenth of 180 degrees, which is 12 degrees; and correspondingly the moon adds to its glow each day one fifteenth of its surface. Now the masters of astronomy divided the illuminated half of the moon's disk into 12 parts, and they call each part a "finger" [אצבע]. Hence one fifteenth of its surface is four fifths of a finger [ד׳ חומשי אצבע], which is the measure of light added to the moon each day. So too the moon delays above the horizon, each day, four fifths of an hour more than the day before; for the moon's stay above the horizon is greatest of all the days of the month on the 15th day, when it remains above [the horizon] 12 hours, as will be explained. For when you divide 12 hours by 15, there results for each day [four fifths of an hour].

And since these matters are all interconnected, gather together for yourself the essentials of the subject, set it out in order, and we shall begin from the moment of the molad.

Know that according to what he mentioned in our composition [that at conjunction the moon is hidden] from all people: when the moon stands aligned directly beneath the sun, with the dark half of its sphere facing downward, it does not illuminate the inhabitants of the world at all. Know that from a time about 24 hours after the moon stood in its darkness [i.e. after the molad/conjunction], there will then be seen in the moon a horn [קרן, crescent] after the setting of the sun, in the south-western quarter — a glow and a light like a very thin arc, [lasting] but a short while after sunset; then the moon sets, on account of the general [diurnal] motion, beneath the horizon.

After this, at the beginning of the second night, when the moon has moved away from the sun eastward by 12 degrees — which is one fifteenth of the sphere of the firmament, as mentioned — [there is] added [to it] more than one eighth… one fifteenth of its surface, which is four fifths of a finger as above; and thereby the moon delays from setting also one fifteenth [part]… [about four fifths of an hour], which is four fifths of an hour. And such is its rule: it is able to return eastward and to move away from the sun by 12 degrees [each day], and in proportion as it moves away from it, so it thereby adds each day four fifths of a finger to the light it receives from the sun, more than the day before, and it lengthens its stay above the horizon by four fifths of an hour more each day — all by the approximate reckoning — until the eighth day from the molad. When the moon has then moved away from the sun eastward [or the half of the moon's sphere facing toward the sun], its illuminated [half] is seen — or its glow — by the inhabitants of the world, from the half that faces [us], a quarter of the whole sphere of the moon; and this is the time of the [first] quarter of the month. It then gives light above the horizon for [several?] hours until the [middle?] of the night, when it sets. And such is its rule from the time of the first quarter of the month onward: each night it adds four fifths of a finger [of light] and likewise adds four fifths of an hour to its stay above the horizon, until the [15th] day [ט״ו?] from its molad. Then the moon has moved away from the sun to the utmost distance, which is about 180 degrees [ק״פ] — the [span] it takes [to travel] from east to the far [point of the] west — and then sun and moon stand aligned, facing and opposite one another, this over against that; this is called by the astronomers "the time of opposition [nagud]," as above. Then the whole illuminated half of the moon's sphere — all its surface — is seen by the inhabitants of the world, and the moon is called "at its full," [remaining] above the horizon a full 12 hours, opposite [the sun].

[From full moon] to the end of the month it reverses: just as the moon had been going and increasing its light, so now it goes and diminishes it; and just as it had been going before the [sun] and rising ahead of it, now it pursues after it and draws near, [moving] each day 12 degrees, and delaying its rising and setting above the horizon, after the beginning of the night, by about four fifths of an hour. And such is its rule all the days [thereafter]: it delays its rising above the horizon each [night] four fifths of an hour more than the night before, until at the third quarter of the month the moon rises above the horizon at midnight.

And by the same measure and proportion by which the moon had increased its light — from the time of its molad to the time of opposition, four fifths of a finger each day — so from this time onward it goes and diminishes, losing a horn [limb of light] each day by four fifths of a finger, until [none of its light remains to it].

It loses its light little by little until it grows faint and dwindles beneath the sun as at the beginning; and this is the end of the month, and there it begins [to be revealed] a second time. Between one conjunction and [the next] conjunction, the Sages, of blessed memory, [reckoned] 29 days, 12 hours, and 793 chalakim [צג"[ם/ס/ש]ב"ט י"ב ת], as will be explained further on, in § ר"ג [213]. And it is found that at the beginning of the month, and likewise close to the molad, the moon appears to us [enclosed?] like horns [a crescent], and not so does it appear later in the month. From what has been said it is also clear that the body of the moon is a sphere: what [is illuminated?] of the moon appears to us at the beginning of the month, in its darkness and its remoteness from the sun — after about one day — [is only] some small part, by way of example about half a finger only, which is one part in twenty-four of the surface of the illuminated half of the sphere [?]… as when you take a ball or an apple and cover the whole surface of its sphere, leaving exposed only a small strip of its body from its top to its bottom — a band of [some] width — and diminish [it] from both sides, upward and downward [?].

And as to what may be asked — namely, that the sight of the moon's horns sometimes faces toward the east and sometimes toward the west: [the answer is] that at the beginning of the month… the sun sets before the moon, and the moon still remains above the horizon while the sun is setting, [its light passing] over the sphere of the moon from west to east; and because part of the moon inclines, in its tilt, toward the sun that is in the west, it is illuminated from that [side], while the interior of the moon and its horns face and look toward the east — not toward [the sun] [?]. And after the middle of the month until [its] end, the matter is reversed: the moon sets and rises above the horizon [later than the sun]… [rising] toward the east while the sun has already [set] far off in the west; and because then too, in its tilt, part of the moon faces toward the sun in the west [recte: east], it is illuminated on that side, so that the interior of the moon and its horns face and look toward the west — likewise not toward [the sun] [?]. To this Chazal alluded in their remark, "Never has the sun beheld the deficiency [waning face] of the moon."

A useful [sign] [ותועלת]: to grasp, at first glance, whether the moon is waxing large or is of a waning size, I will tell the young students what [our teachers / the townsfolk] [?] do to make a fine mnemonic. This is [a quick one]: whenever the [new moon] is [born], picture the moon as resembling [the shape of] a [left?] hand [?], long/arched, until they complete it [to full] and reach thus the [full] place of the moon; and it returns and they diminish [it] again, [and so] the interior of the moon [is read]… the moon still, gently, waxes large — and for this reason it was still [in the first] half of the month; and whenever [it

appears turned] from below… half [full] in its interior… it goes and wanes; and this is [when] it is past the middle of the month.

סימן ר״י [printed §210 = logical §211] — [The figures (phases); estimating the moon's visibility and its waning, and how long it remains above the horizon each night]

Heading, verbatim: **סימן ר״י צורות ושער גדולה היכרו ומיעוטין ובמה שעורה ישאר כל הלילה ממעל לאופק** — "Figures; and to estimate the magnitude of its recognition [visibility] and its diminutions, and by how much [time] it remains all the night above the horizon." [reading of some words uncertain]

Since these matters, when set out [in words], are clearer to students [when they are drawn], I have decided to show them a third figure [placed] before you, in which the student may see with his own eye all the matters — namely, how the moon, from the beginning of the month onward, goes and increases its light [until] the middle of the month, [which is] the fullness of light; and from there onward its light goes and wanes. [Look] at each edge [of the wheel] and you will see the figure.

In the [outer] ring, above, are marked the days of the month; and below them are marked how much is the measure and value of the moon's light. And in [inner] circles [are] the numbers of the hours and the chalakim [parts] during which the moon remains above the horizon on that night. For example, in this circle where the letter **מ** [mem = 40] appears, it teaches that on the eighth [day] from its molad the moon appears like the figure before you, that is, half of it is seen full of light; and in the circle below it are the [numeric] parts: the letter yod, spelled out in full [**אות יוד**], is written, indicating the hours, and below it is written the letter gimel [**אות ג'**], indicating the fifths of an hour. And know from this that on the eighth night from its molad its surface illuminates six fingers [**ו׳ האצבעות**], which is half its [visible] surface, and a surplus [**ויתר ע״ו**] of two fifths of a finger [**ב׳ חומשי האצבע**]; and likewise you learn from this that the moon will stand that night above the horizon six hours and two fifths of an hour [**ו׳ שעות ושני חומשי שעה**] — all by the approximate reckoning.[289]

And note that for the precise reckoning we require [detailed] computations, fine points, and many conditions.

Diagram. A large circular phase-wheel (a schematic volvelle) occupying nearly the whole of folio **סג** [63] recto, referenced by §210–§211. Concentric rings, read from the outside inward:

- Outer boundary: a double rule, the two lines set close together, with nothing outside them.

[289] the siman cites the letter for ten against the hours and the letter for three against the fifths, then two lines later gives six hours and two fifths for that same eighth night; the woodcut opposite prints six in its hours cell and twenty-four below it — the same two fifths in minutes. The prose's conclusion agrees with the figure, the letters it cites with neither. The abbreviation before the surplus does not construe. All given as printed, none emended.

- Disc annulus: small moon-disk illustrations showing the phases in sequence around the wheel. The disc count measures 29, against 30 radial sectors in the table bands (see the note below). The per-disc fill traces a single smooth cycle: a minimum at bearing 107.2° (lower left), and seven consecutive discs at 97–99.5 % across the top.
- Four annular table bands (A1–A4), each cut by the same 30 radial dividers = 120 cells.
- Centre: blank — 921 ink px of 363,182 over the hub, i.e. 0.25 %. No central sun, no earth circle, no central label.
- The cell labels are set RADIALLY and must be rotated to be read (+90° at the right of the circle).

Cell contents — 3 of ~120 cells read by the first census: band A4 at ≈0° [ב]ר/ד; band A3, two strokes, UNNAMED; band A2, a word beginning ל…, UNNAMED. The remaining ~117 cells are unread.

Ring structure, established by a second reading of the plate from a polar unwrap of the annulus (each ring read as a horizontal RTL strip at 3–8×, with no rotation ambiguity), outward → inward:

1. thirty moon-phase discs;
2. a day-of-month ring, single letters, day 1 at the top and the days running counter-clockwise;
3. an hours ring — **ס א ב ג ד ד ה ו ז** … for days 1–9, with the **ד** repeated at days 5 and 6;
4. a ring of minutes (not of fifths), its values running a five-cycle · **מח (48)** · **ס (0)** · **יב (12)** · **כד (24)** · **לו (36)** · that restarts every five days; days 1–9 read 48, 36, 24, 12, 0, 48, 36, 24, 12. For the eighth day this ring gives **כד** = 24 minutes, and the hours ring beside it gives **ו** = 6;
5. a further inner lettered ring, then the blank hub.[290]

סימן ר״א [printed §211 = logical §212] — that the hour-computations above are reckoned by the temporal (seasonal) hours

Heading, verbatim: **סימן ר״א שהחשבונות והשעורות הנזכרים בסמוך הם דוקא ע״פ חשבון השעות הזמניות וטעמי קביעות שעות אלו** — "That the computations and measures mentioned nearby are specifically according to the reckoning of the temporal [seasonal] hours; and the reasons for fixing these hours."

Know that all that we mentioned just now, in the count [of the phases] in § ר״ט [209] and § ר״י [210] — that such-and-such hours the moon remains for us above the horizon — all of this is exact for the inhabitants [of the equator] only [?], or [for anyone] at the time of the equinox of Nisan and of Tishrei, when for all the inhabitants of the climes there are always 12 hours of day and 12 hours of night. [At those times the temporal hours equal the equinoctial hours,] so that in every other [case the reckoning must be adjusted].

[290] the hours ring repeats one letter at two consecutive days; given as printed. The ring below it is minutes, not fifths, on a five-cycle restarting every five days, its eighth-day cell giving twenty-four minutes — the two fifths of an hour the prose concludes with.

this is not so [at other seasons], for it cannot be that a single [reckoning] in this matter should suffice for all the months of the year. Consider [that] at the time of the winter solstice of Teves [תקופת טבת]… for the inhabitants of [Persia? — פרס ?] [?] [the moon remains above the horizon about] 36 [?] hours [ל״ו], while at the time of the summer solstice of Tammuz the moon remains for us only [a few] hours. (And we shall not be exacting here about the small discrepancy caused by the tilted sphere of the moon.) So too, by reason of the variation in the two [seasons] and the times when the moon is hidden above the horizon at the two [equinoxes] — [which are] equal, this to that — [it differs]: as when the moon is seen [in winter] and remains for us above the horizon, by way of example, 9 hours; whereas in the month of Tammuz, [when the season] has changed, at that time the moon remains for us above the horizon only [a fraction of that] [?] — know that these are [seasonally reckoned].

For what we wrote above [gives] uniform totals for every month, and we did not distinguish [there] any difference or divergence according to the seasons of the year — neither between a month [and month], nor between a season whose nights are short and a season whose nights are long, nor any difference between one region and [another]. This is because all the [computations] mentioned above, in the two adjoining [simanim] ר״ט and ר״י [209 and 210], are founded upon the temporal [seasonal] hours — dividing, on every single night of all the days of the year, the measure of that night into 12 equal parts [שעות זמניות]; so that on the short nights of summer they are 12 short [hours], and on the long nights of winter they are 12 long hours. The [simanim] mentioned above are not uniform for all the months of the year. The example is this: [on] the [25th?] [?] day from its molad [the moon] gives light to us above the horizon for about 9 hours; for when you divide the measure of [the] night into 12 equal parts, [the moon] will be above the horizon for [nine of them?]. [To take] a case: like a season whose night-measure is about 15 hours [ט״ו] — the moon remains above the horizon [a quarter of the night-measure, which is 3 hours]; whereas [in another case] its quarter of the night-measure, which is 12 even [equinoctial] hours [i.e. counting from midnight?]… and [in a case] whose night-measure is 8 hours, the moon remains above the horizon three quarters of the night, which is [six?] even hours. Such is the pattern; and so [it is with] all the [computations] mentioned, for all the days of the year. So too, [if we wished to reckon] by the count of the equinoctial [even] hours, we should have needed [a separate reckoning] for each and every month of all the days of the year.

סימן ריב [printed §212 = logical §213; the numeral is set with no abbreviation mark of any kind — confirmed on both witnesses] — the duration of the moon's concealment each month, and the cause of the delay and the advance of its [renewed] visibility

Heading, verbatim: **חדש וסיבת אחור וקדימת ראייתה [כל] סימן ריב מזמן סתירת הלבנה**.

The moon is concealed each month for about 2 days [ב׳ יום] — that is, [it is invisible] for close to 24 hours [כ״ד] before the molad, and [likewise] after [the molad] for close to 24 hours. Accordingly, the moon is not seen [near conjunction] for about two days [and it is then gathered in]. But know that this reckoning is not always exact, for there is in it advance and delay at times: [the interval] may be filled out to about 4 or 5 hours less than 24, or more than it, whether before [conjunction] or after. For the time of the moon's visibility, between one molad and [the next], by the ancient reckoning, does not stand upon a single side, but there is advance and delay — because [some] factors, when the [conjunctions] draw near [and are at their least distance], [hasten the visibility], while there are other factors, opposite to these, that delay and [hold it back] far from the moment of the ancient [mean] molad. As [Isaac] Israeli wrote [?]… [the sage said]:

until, at a time when it is [close?] [?], its light is manifest [enough] to be seen by our eyes; and moreover [when] the moon's place of setting has drawn far from the sun's place of setting, until [the sun's light] fails to [overpower] the moon's receiving of its light; and third, [when] the moon inclines toward the north at the extremity of its latitude, so that part of its day is somewhat greater than part of the sun's day, and it lingers a little [longer above the horizon] before setting beneath [the sun]. When these known factors are combined — in longitude and also in latitude — and, conversely, when the said factors [are combined in the opposite sense], then the [renewed] sighting of the new moon is delayed and postponed. To this matter Chazal referred in the first chapter of [Tractate] Rosh Hashanah: "Sometimes it comes by a long [route] and sometimes by a short [one]." It is set out explicitly in the [Hilchot] Kiddush HaChodesh of Rambam [מיימוני מהלכו] [?], [chapter] ק״ה, ch. 8 [?], law רע״ח [?].

When the motions of the sun are [swift] (as above, about 183 [קפ״ג] [?]) and [that of] the moon is [slow] (as above, about 139 [קל״ט] [?]) [?], the time of concealment is shortened; for the moon has in it three causes: when the sun's motion is swift and the moon's motion is slow, the time of concealment is very long, because the moon does not overtake [the sun] until a long time [passes]; and when both of them are swift, the time of concealment is short — though not so short as in the first case; and when the motion of both is slow, the time of concealment is long — though not so long as in the second case. But know that all this is by the reckoning of exactitude for the sighting of the moon. [The moon becomes visible again] at about 29 full days [כ״ט] after the molad, and there is no case in which the moon's [renewal] is delayed more than 30 days [ל׳].[291] And know that all this that we have mentioned is what follows from the ancient [mean] molad — [with the modifications that follow]. And so it stands in Sefer Tzurot ha-Aretz [ספר צורות הארץ], Gate 2, petach 8: the distance between the two luminaries at the time of the sighting runs from a few degrees

[291] the two figures of this clause are twenty-nine and thirty, and they are given as printed.

up to 18 degrees [י״ח מעלות] at most, over a long stretch of time, while the mean is about 12 degrees. And this suffices.

סי׳ ריי״ג [printed §213 = logical §214] — the measure of the lunar month, which is 29d 12h 793ch, whose [reason?] is unknown to us

Heading, verbatim: **[?]מ[ו] סי׳ ריי״ג מדת חדש הלבנה שהוא כ״ט י״ב תשצ״ג אין נודע לנו.**

Know that the measure of the lunar month — from the time [the moon] renews itself [at one molad] until it renews itself a second time, in its mean motion — is already a tradition received in our hands [that it is] 29 days, 12 hours, and 793 chalakim [כ״ט יום י״ב שעות תשצ״ג], [with a remainder] hidden [and folded?] within the hour [?]. It is a deep and wondrous computation, and more [wondrous] than all the computations of the ancient and the later astronomers. The sages of the nations of former days already established it for us; and I have elaborated upon this in my book, Ma'or HaKatan [מאור הקטן]. The sages of the [gentile] nations too composed [works] on this matter, [as it is] their manner…

שער ח — Gate Eight (continued)

(This page opens in the middle of Gate Eight, on the moon. The running header "*שער ח*" stands at the top of each of these four pages; Gate Eight itself was opened in an earlier gathering.)

[Continuation of סימן ריי״ג — printed 213 / logical count §214]

(The tail of the preceding siman, on the length of the synodic month — the molad interval of 29 days, 12 hours, 793 chalakim — and whether it is a tradition from Sinai or a computed value.)

devoid of and lacking the mathematical science, the science of the stars, and the science of the constellations — [and one] wondered at how [one could arrive at] the computation of the Talmudic sages. [Some ask:] who has told us, or from whom has it been made known, the intent of the computation? To compilers such as these it appears that [the derivation of] the astronomy involves great inquiry and much [study]. Some say that this computation is a halacha [given] to Moshe at Sinai, like many other matters handed down [in] the Mishnah and the baraita. And [it is cited] in [tractate] Rosh HaShanah, folio 25[a] (דר״ה דף ך״ה)[292], where it is taught there [the well-known baraita]: "…[two witnesses] were obscured by the clouds, and the likeness of the moon appeared…" [Rosh HaShanah 25a]. …[they] reckoned. R. Nachman said: thus I have a tradition from the house of my father['s father], that the renewal (chidush) of the moon is not less than 29 days, 12 hours, two "hands" of an hour

[292] the folio numeral is set with a final kaf — a form this edition uses as a live numeral in its own right, not as a variant spelling of the medial letter. The value is twenty-five; given exactly as printed and not to be normalised.

[= two-thirds of an hour, 44 minutes], and [793] chalakim [?] more; and it does not appear [to be] less. …only 29 days and two-thirds of an hour, and we do not read there 73 chalakim [ע"ג חלקים]; and so the sage Ibn Ezra [ראב"ע] brought it in his commentary [on the word] "sechado" [?] with great precision, and also in Sefer HaIbbur. And in the first chapter of Sefer Me'or Einayim [בפ"א מספר מאור עינים] he too brings the same baraita, where it is written only "two-thirds of an hour" and no more.

but the full baraita is not mentioned, and it is written [there] only "29 days and two-thirds of an hour" alone, and it does not [expressly] record the 793 chalakim [?]. There is a further matter as well [?] — as in the chapter of R. [Chananel?] [?] — concerning… the great luminary [?]… [Nonetheless] it appears from the words of all [these authorities] that we have received the reckoning of 29[d] 12[h] 793[ch] [?]; and even so, this tradition is not lost to us — as against [what] some place [would hold] — according to the words of the Rambam [הרמב"ד, recte הרמב"ם] [?], of blessed memory. We do not deny this reckoning: it is a tradition in our hands from our fathers and our fathers' fathers back to Mount Sinai. This is the view of the Rambam, of blessed memory, in chapter 2 [בפ"ב] of Hilchos Kiddush HaChodesh, [where he writes]: "It is a halacha to Moshe from Sinai that, in the time when there is no fixed Sanhedrin [sanctifying the new moon by observation], we reckon by this computation of ours and compute by it," etc. And that which was not handed down in tradition, or [set down] in any place explicitly [?], [was withheld] because this matter is undoubtedly a secret — [it is] drawn from the roots and foundations of the Sod HaIbbur [the secret of intercalation]; therefore it was not committed to writing in the Talmud plainly, just as we do not find in all the Talmud the reckoning [of] the seasons (tekufos). [Rav Chananel?] [?] wrote… [that this is] the essence, and indeed truer than the tekufos of Shmuel [?]; and we likewise do not find in the Talmud the order of intercalation for the years [of the cycle — the mnemonic גו"ח אדז"ט]. Many others who were sages knew them, but did not transmit them except to close disciples and to the pious of the generation [?] and to the great ones of the Sanhedrin, and not to the rest of the multitude of Israel — as the Rav [Rambam], of blessed memory, wrote in chapter 11 of Hilchos [Kiddush HaChodesh], and [as] Israeli [= Yitzchak Yisraeli] [wrote] in chapter 15 [of Yesod Olam]. And we have already set out the explanation of it at length in our own book Ma'or HaKatan [בספרינו מאור הקטן], in the small gate [בשער הקטן], siman 15, with the help of Heaven.

סימן רי"ד — On which place on earth the reckonings of the molados and tekufos were established

(printed רי"ד = 214; logical count §215)

סימן רי"ד — Concerning which place on earth our reckonings of the molados (new-moon conjunctions) and tekufos (seasons/equinoxes) were established.

Concerning the epochs (rashei simanei) of the moon's molados, and likewise the epochs of the sun's tekufos, as they were transmitted to us by Chazal, it

behooves us to take pains, to examine, and to determine at which place on earth these reckonings of the molados and the tekufos were established for us.

I say now, by way of illustration: we have [taken, say] the molad of Tishrei at midday on Shabbos. Even though a single molad [holds] for the whole world — as [I] said [?] — one cannot say that at every place on earth it is midday on Shabbos at the moment of that molad; for it has already been explained above, in siman 46 [כסי' מ"ו], that the beginning of the day for the inhabitants of the eastern hemisphere is, at that very moment, the beginning of the night for the inhabitants of the western hemisphere.

Accordingly, if we posit and say that the moment of the aforementioned molad falls, on the meridian [?] of the East, [at] midday of Shabbos — then, when midday of Shabbos reaches [the inhabitants of] the West, twelve hours will already have passed and elapsed for them since the moment of the molad. And if we say that this molad [occurs] in Jerusalem, then all the places that lie to the east of us will have the moment of this molad after midday of Shabbos, and all the places that lie to the west of it will have the moment of this molad before the midday of that day. And even though in truth there is one molad for all of them in a single instant, that instant is, for some, midday; for some, before midday; and for some, after midday. And Chazal concealed from us [?] at which place the [reckoning of] intercalation was established… for the appearance (mar'eh) changes in every place according to the breadth of the land, and according to the distance of the moon from the line of the zodiac, in the length of its appearance — in length and in breadth [?]… [and its rising].

Also the sage Israeli [= Yitzchak Yisraeli] roused [this question] in [his] treatise[293]; he expanded and elaborated in discussing it, and treated this as one [difficulty] — in chapter 7 of the fourth Discourse of his book [בפ' שביעי מאמר ד' מספרו]. He… [made] a great [inquiry], and it grew [into] a great [difficulty], and his resolution of it was a very deep [matter] — "who can fathom [it]?" [cf. Koheles 7:24]. He went far [afield] in [treating] the hidden [side] of this doubt, with [words that are] concealed [?] and obscure. He desired to reveal [it], but the limit of his intent [remains] hidden [?] and slight [?]. And the Rav [i.e. the Yisraeli], of blessed memory, said: since our Rabbis, of blessed memory, instituted for us the reckoning of the intercalation such that day and night are always reckoned equal at every season of the year [בכל זמני השנה]… and it was revealed to us in this [that] the years [?]… By this rule [?], the inhabitants of the whole world will always have day and night equal [in the calendrical reckoning], also in the reckoning of the tekufos and molados, [reckoned] as if from [one of] the fixed places on the [meridian] line… so as to know at which [place]… And the portion [?]… so that the intent of the aforementioned computation [is] that the [reckoning] be arranged [?] as I explained above in Gate 4, siman 103 [בשער ד' כסי' ק"ג]. And I say, moreover, [that it is founded] upon the navel of the earth (טבור הארץ) — namely,

[293] Yesod Olam — identification; the leaf names no title, printing only מספרו, "of his book"

the center of the world, [where] the reckoning of intercalation is founded, in the middle of the world, or [near it]. And the received [tradition] is that the [meridian] line that is [drawn] — which is the boundary [?] separating [?] the East [side] from the West — [passes] through it [Jerusalem], and from it [are counted] the degrees, each of them 90 degrees distant [מכל א' מהן צ' מעלות]… as we chose [to arrange] in order, as we explained above in Gate 3, siman 89 [בשער ג' כסי' פ"ט]; and this is the limit of his intent, until it be made known to us [by] one better than we, [and] we accept [his] words. And according to his words it is fitting [?]… to seal [the reckoning] according to the measure of… [along] the [meridian] of the earth; and likewise the molad has [its] fixed time of the tekufah, which [belongs] to the secret of its place.

סימן רט"ו — That the moon is seen, after its renewal, above the horizon, always in another measure [בשעיר אחר — reading contested; see the QA note below]

(printed רט"ו = 215; logical count §216)

סימן רט"ו — [On the fact] that the moon is seen after its renewal above the horizon, always in another measure [ושה ממעל לאיפק[ר/ד]מה שהלבנה נראית אחר ח לעולם בשעיר אחר :].

And if you ask and wonder: since the moon circuits [its sphere], and there is a molad in every orbit (galgal) at a [fixed/measured] time — nearly [equal / completing] [?] — [it would seem] fitting [?] that it should rise upon the horizon [האופק] [at] this molad, until [?]… and upon the rising [?] of… which [is] after the molad… [it becomes] visible [?] to be revealed from the horizon to us [?]… and every molad [?]… [the several remaining words of the opening are lost to the gutter shadow — ?].

from this molad up to 43 degrees [מ"ג מעלות]… [along] the line [?]… you will see it above the horizon 33 degrees [ל"ג מעלות]; and at the third molad, 63 degrees [ס"ג מעלות]… so that the moon renews itself and becomes visible, after its renewal, throughout all [?] the twelve constellations [י"ב מזלות] in the firmament.

סימן רט"ז — That no star completes a full revolution in the time of one rotation of the daily sphere

(printed רט"ז = 216; logical count §217)

סימן רט"ז — That no star completes a full revolution (sivuv shalem) in the time of [one] rotation of the daily sphere (galgal ha-yomi).

Know that no star, in my view, is found among the stars of the sphere of the constellations [?] that completes [with the daily sphere] a full [revolution]… [each of them] circling the terrestrial globe (kadur ha-olam) — [it makes] a complete circuit [?] in [its own] time. …the sphere circling every day, [it, too, revolves]; and thus is the way of every sphere [?]… [The moon] is quicker in its course than all the [other] spheres… [and each] sphere [?] [makes] fewer [?] circuits [in a day]… [it moves eastward] slightly [?]… For they say [?] that

this sphere is [the one]… [that] runs a course quicker in its motion than all… every day, according to their [reckoning]… [the moon], for its part, [travels] more than 12 degrees [י״ב מעלות] each day, so that it lags [only slightly] behind [the daily sphere] — for its deficiency, relative to the [daily sphere's] revolution, is greater [?]… but [it does] not [complete a full revolution]. For the deficit of some 12 degrees each day accumulates from this, in every solar month, to 360 degrees [ש״ס מעלות], in such a way that the sphere of the moon circles 31 circuits in each month [ל״א סיבובין] [Translator's note: the leaf prints ל״א סיבובין — thirty-one circuits — on both witnesses. The figure does not follow from the reckoning given in the same sentence, by which the daily deficit of twelve degrees accumulates to one full circuit (360°) per solar month; but the printed numeral is unambiguous and is retained uncorrected]. [The remaining fine arithmetic here — the "793 [?] chalakim" — is largely lost to fading and is flagged [numeral: ?]; it is not reconstructed.] …and just as the moon [lags], so [with the] deficiency of [each] star… and the smallest deficit of any star of the seven firmaments is the star Saturn [שבתאי], by reason of the slowness of its motion; as I have already mentioned this matter [above]. But this deficit is a tiny, minute, very fine thing, about one part of a degree, and sense cannot perceive it at all; reason alone compels it.

סימן רי״ז — To observe the voluntary motion in each of the seven wandering stars

(printed *רי״ז* = 217; logical count §218)

סימן רי״ז — To observe the voluntary motion (ha-tenu'ah ha-retzonis) [התנועה הרצונית] in all seven wandering stars (kochvei nevucha).

The demonstration: concerning the eastward motion [ha-tenu'ah ha-mizrachis] that belongs to the sphere [?], which is not [perceptible to the eye at once]… [but] according to the principles that were selected just above, [and] also above in siman 29 (סי׳ כ״ט). For it will not be found in any one of [the seven] from several aspects [?]… Take for yourself one star of the wandering stars whose motion [is such that] it is fitting to detect by the sense [of sight] the [true] motions of the wandering [stars] [?]. …the star that renews [its position]… so take for yourself one star of the [seven]. …Consider [it] again [?] over two [nights], [on] a third [and] a fourth [night]… how far its height [?] has moved [and] is drawn near… above the horizon in the west [?]… and observe upon it, over [several] nights, [on] a second, third, and fourth [night], [and see] how far its height has moved and [how] its motion [is] drawn near [?]. …and this [is done] by seeking the mean motion of the sun, as the sun's revolution [is] in every [day about] 1[°] approximately, above [?]… [For example, Mars] [is such that] within a few days the observers will discern the degrees [it has traversed] in the sphere [?]… for the star Mars draws away from the fixed star, fixed in its place, day by day by about 28 minutes [כ״ח דקין], which in a few days accumulate from minutes into degrees; [by which] you will easily discern the near and the far with the quarter-instrument

[כלי רובע], which I am to explain below in Gate 18, siman 264 [בשער הי"ח רס"ד] [Translator's note: the source is in error here — the book as printed has only ten gates; "Gate 18" is what the source prints, and it is retained uncorrected]… [the star] is more prepared [than the others] to be observed, [in that] within a few days [its motion is discernible] "to the eye" [?]… [Take] one star of the seven [כוכבי שבת (recte שבעת) [?]], [observe it] at the beginning of the night [in its] elongation above [the horizon] in the west, and observe upon it again [on] a second [and] third [night]. …[the star that] renews [its position, at] the end of its elongation, and observe upon it [?]… [Do not] err [?] to say that thus each star among the wandering ones would be found to have motions proportional [to it], each star according to a distinct path [כפי מסלך מיוחד]. And this is why in the month of Nisan the sun rises on the horizon with the head of Aries, and in the month of Iyar with the head of Taurus, as was explained above in Gate 5, siman 128 [בשער ה' כסי' קכ"ח].

סימן רי"ח — Some hold that there is no contrary motion, nor eccentric sphere, nor epicycle

(printed *רי"ח* = 218; logical count §219)

סימן רי"ח — Some say (yesh omrim) [י"א] that no contrary motion (tenu'ah hafkhiyos) [תנועה הפכיות] is found, and no eccentric sphere (galgal yotze merkaz), and no epicyclic sphere (galgal hakafa).

Know that from the days of the sages of old, and [still] earlier, [among] the ancients, there arose certain sages who probed deeply and gained understanding in the science of the stars and the constellations. They deliberated and took it to heart to abolish [!] the principles and foundation of Ptolemy [בטולמיאו"ס], and of Hipparchus [ואברכו"ס], and of al-Battani [אלבתאני = וחלב"תיני [?]], and of the rest of the sages [?]. These [men], as their sages [held], said that no eccentric sphere at all is found, and no epicyclic sphere, and that there is in the world nothing but nine spheres [ט' גלגלים [?]] — [each] complete in its [own] simple [uniform] motion, and they gave a reason and offered [an account] to explain their words. For they say that all the motion of the celestial spheres — all of them — is essential (atzmi), from [west] to east, in accordance with the daily motion [?]; and the extremity [?] of them [wishes]… [the ninth sphere] which is the world[-sphere?]… and it is slower than all the rest of the spheres; each of them circles each day toward the west, falling short by so minute an amount that it is not perceived, until by its fineness it comes to a hundred, or to seventy, years for a single degree [מעלה א' … עד למאה ו לע' שנה]. The Yisraeli already mentioned this matter in his book, Discourse 12, chapter 9 [בספרו מ"ב פ"ט]; and they used to ascribe this to a certain sage, and they called him Ish Mar'ish [וקראו לו איש מרעיש]; and according to his words he lived in the year 4,801 of Creation [היה בשנת ד' אלפים ותת"א ליצירה][294] …and further, the moon [and the rest of the wandering stars move up and down] [?]…

[294] the figure is ותת"א — four hundred, four hundred and one, i.e. 801, so 4,801 of Creation; the year 4,430 formerly carried here is supported by neither copy.

But in their [own] view — according to the opinion of Israeli [Yisraeli], as they explained [it] — for every… [the poles of the sphere of the constellations are one thing, and the poles of the diurnal sphere another]… [there are no eccentric spheres, only] the poles of the sphere of the constellations, which alone [account for the appearances]… [and this is] why this [and that] differ, that the poles of [one sphere are drawn away] from the poles of [another], and in this way [the appearances are saved] without eccentrics… [In] my view [?], every [motion may be accounted for] by a small pole [?], a star [that is] deep [?]… around a [minor] pole of a sphere [?]… [and thus] "the star of Saturn" [?]… [descends and] its height [?]… [some fading lines here are illegible — ?].

[Continues, on p.131 → p.132, arguing the homocentric-sphere scheme in Ptolemy's name and citing Kepler.] …[I heard] from the mouth of the sage Kepler [מפי החכם קעפליר Kepler] [?]]… [that these] sages [as the ancients?]… before Hipparchus [אברכו"ס] and Ptolemy [ובטולמי"אום]; and still further [?]… [what] the sages knew, and what they did not, some of them held [thus]… [as] Israeli [Yisraeli] wrote, to explain [?]… [The astronomers] did not agree [?] to [posit] complex [epicyclic] motions — [they held] only [?] as [Israeli] held [?]… [The moon and planets move] up and down, and toward the poles [?]… [now] to the north [and now] to the south; [now] they draw near to the terrestrial globe, and [now] they recede from it. And since the matter is so, we shall have no need of any eccentric sphere, nor of any epicyclic sphere at all… at the outset of the revolution [?]… and [it is] more fitting [?]… to the view of [בטולמיא[ק]מור."[ס] — editorial conjecture: Ptolemy] … to say that the "princes" of the spheres [שרי הגלגלים] are nine [in number], corresponding to the nine motions seen in the firmament, and all of them agree upon one simple [uniform] motion… [set] for each star; and [it revolves] not about a fixed center — as the moon['s], whose center [is such] that [at one point it is] high and [at another] low [?] — [i.e., no] epicyclic sphere… [All] these matters are [what] they [?]… [and the like] every question [is asked] of them [?].

And [היש"אלי — editorial conjecture: the Yisraeli, i.e. Yitzchak Yisraeli] further wrote, in the aforementioned chapter, that if these [men]… the star… [gave account of] their doings and offered a fitting reason for… the variation… and [the appearances of] the stars at all times… and all of their [ways], like this, [accord] with Ptolemy [בטלמיאו"ס]. Most of the sages [?]… are agreed with them [?]… and incline to the reasoning of [?]… since the [later] sages [?] decreed [thus]… all this [is] out of [intellectual] indolence [?]… for it is [that they] cannot [establish] correctly [what is fitting], or that [the eccentric scheme] did not suffice for them [?], and they did not draw support from [them at any] time… to accomplish their doings according to [their] principle… so as to guard our view [?] [in accordance with] their reasoning entirely… [along] the way of Ptolemy [בטולמיאו"ס], and of those who walk in his footsteps who founded it and clarified [it]… as [in] the aforementioned matter — several times [it is] correct and clear. So far [this matter].

סימן רי״ט — How great is the [apogee] height [of the moon] from the center of the earth, and the difference between its near and far [distances]

(printed **רי״ט** = 219; logical count §220 — this is the closing siman of Gate Eight)

סימן רי״ט — How great is the height [rum / apogee] [of the moon] from the center of the earth, and the difference between [its being] near to it and far from it (rachok mimenu).

To know how great is the [apogee] measure [of the moon] from the center of the earth, and the difference between its height (rum) and its lowness (shefel) — [a] difference [that lies] in the sphere [of the moon] [?]. It is [equal to] the thickness of half the breadth of the moon's [epicyclic] sphere [?] in its revolution. Know that at the outset [?] — [Gap: a few words are unrecovered at this locus. This is not a page turn and nothing continues elsewhere; the words stand on this leaf, in the top-right column, unread.] — and know first that there is a disagreement between the sages of old and the later ones, and [the] writers [?]. According to the view of Ptolemy [בטלמיוס], the far [distance] of the [moon's] center… every astronomer wrote… of the moon from the center of the earth, [such] that its greatest distance is sixty-four canes [ששים וארבע קנים] and the limit of its nearness 33 canes [ל״ג קנים] — [the cane being] the thickness of half the terrestrial globe, that is, from the center of the earth up to the surface, which is 850 [תת״ן] parsa'os, [in] parts [of a] mile [?] approximately). Thus, in his [Ptolemy's] view, the difference between the far [distance] of the moon from the center of the earth and its near [distance] is 31 canes [ל״א קנים].

And this concerns the diameter of the epicycle. According to the view, and the inquiry, of the sage Nicolaus Copernicus [ניקלא״ס קפערני״קוס], the moon's greatest height from the center of the earth is 68 canes [ס״ח קנים] and the limit of its nearness 52 canes [חלי׳ נ״ב קנים]; so that the difference, in his view, is 16 canes [ט״ז קנים]. And by the exact reckoning and the observations of the great investigator Tycho Brahe [טיכ״א ברהא״סי], together with his associates, they found that the height of the moon from the center of the earth is 60 canes [ס׳ קנים] and the limit of its nearness 52 canes [חלי׳ נ״ב קנים]; so that the difference between its near [distance] and its far is only 8 canes [ח׳ קנים]. From all the matters mentioned it is found that the difference between the near and the far, in the view of Copernicus, is only about half the difference in the view of Ptolemy [בטולמיאו״ס]; and the difference in the view of Tycho Brahe is only about half that of Copernicus, and a fourth part [וחלק הד׳] of that in the view of Ptolemy.

And I, who write this, heard [it] from the mouth of the great investigator Tycho Brahe [שמעתי מפי החוקר הגדול טיכ״א ברהא״סי — Tycho Brahe], [that] according to his method and his inquiries by [instrumental] measurement, he said, from reasoning and with good sense, that it is impossible to believe that the difference between the two extremes should be as great as 31 canes [ל״א קנים]; for if it were so, it would follow that the moon at its lowest would appear far

larger than at its height. It is [thus] found that its measure at [apogee] height [is]… [With this] we conclude the eighth gate.

(Centred, full width: "*הלל שבח לאל צורי מחסי ומגיני*:") — Praise and glory to God, my Rock, my refuge and my shield.

(Closing line, standing to its left: "*בסיומנו שער השמיני*:" — "With the conclusion of the eighth gate.")

השער התשיעי — Gate Nine

(Body heading, p.132)

השער התשיעי — In it is explained the darkening (kadrus) [that is] the eclipse of the sun and the moon, and their cause[s]; the factors that produce them; and [the fact] that the solar eclipse is seen in one place entirely and in another [place] partially — [visible] from one [region] but, in another region, not to all together — together with the principles and the foundations proper to them.

(Printed rubric, verbatim: "*יתבאר בו קדרות הלקוי חמה ולבנה וסיבת הדברים הגורמים להם ושלקוי השמ' יראה במקום א' כולו ובמקום אחר חלק ממנו ובמקום א' לא כולם עם העקרים והיסודי המיוחדים להם*:")

I shall make known [אודיע] — as we wrote above, the courses of the two great luminaries [ב' המאורות הגדולי[ם]]… when the cause [is] the circles that produce [the eclipse] [?]… the moon at the time of opposition [i.e., at the full moon, opposite the sun] [?]… [when] the surface [?] of the face of… [is darkened]… [it is deprived of light] from the sun at times; [and the sun,] at times, at [the moment of] the molad [i.e., the new moon] [?]… [is hidden] from some of the inhabitants of the world, and [is eclipsed as to] one part of them… And according to our holy tradition [it is called] "kadrus" (darkening), as in the language of Scripture: "All the bright lights of heaven I will darken over you" (Yechezkel [ch.] 32); "the sun and moon are darkened" (Yoel [ch.] 2). And in the mouth of the sages it is called likuy ha-me'oros [ובפי החכמים נקרא לקוי המאורות]. And we shall begin, and take up first [ונתחיל ונקדים] —

— with the eclipse of the moon, because the cause of its darkening is more evident and more straightforward [מלקוי הירח מפני שסיבת קדרותו יותר מבואר ויות'] פשוט] than the darkening of the sun [מקדרות החמה']. And further, that [?] … its darkening, etc., in [?] itself [ועוד ש[?]ידת[?] ב[?] קדרותו כו' למו[צ/ע]ח — the second sort is open between **ע** and **צ**, so between "in its own [body]" and "in its shadow"; not decided here], [and] the blackening [שחורן] is doubled from it, like the sun [[ה]נכפה ממנו כחמ] — which is not so in the case of the sun, whose blackening is not [?] thus, and [?] [[?]ן ככה ולת[?]מה שאין כן בשמש שחורן ל] — [nor] is it annulled [?] of itself for all the days of the world [[ולם]מו כל ימי ע[צ]ע [?]יבטל מ]; only [that] the cause is that the moon stands and interposes between the sun and the sight of our eyes [רק סיבת שהירח יעמוד ויפסיק בין השמש ובין מראות עינינו], and does not [?] [ולא יח[?]יל]. Therefore, as [לכן כמו] —

[Gap: a short centred closing line stands here at the foot of p.132's left column — seven sorts and a terminal colon, measured on the leaf but unread. It is not reconstructed.]

סימן ר״ך — On the eclipse and darkening of the moon

(printed ר״ך = 220; logical count §221 — the rubric stands at the FOOT of p.132's left column, after the Gate Nine preamble above, and is placed here accordingly)

סימן ר״ך — On the eclipse and darkening (lekui ve-kadrus) of the moon.

[The following paragraph is the tail of the preceding siman (printed §ר״כ / 220; logical 221), continuing from the previous page.]

Since the nature of our sphere — the body of the moon — is that of a dense, dark body, in itself opaque by nature and having no light of its own, it receives its light solely from the ray of the sun. It is like a polished mirror of iron and burnished copper, buffed bright, which — when you set it opposite the sun — sends back from itself a gleam and a shining radiance. And once this is known to us... the moon's light grows and increases until the middle of the month [full moon], and from then on it turns back and diminishes until it is cut off from it entirely, as was explained above in siman ר״ט [209]. As for the eclipse that befalls the moon, which happens to it as you will understand — know now that when the moon stands opposite the sun with the earth entering between the two of them, the earth's globe blocks and separates between the sun and the moon; this interposition acts like a screen [drawn across], able to cut off the sun's rays from reaching the moon, so that the moon is darkened for lack of the sun's light on account of the earth's blocking. Therefore, when it grows dark, this is what the sages call the eclipse of the moon. And this occurs only when the two luminaries are exactly aligned, set opposite one another, with the body [of the earth] precisely between them, at the moon's full — which at the moment of opposition [nagud] happens as stated above in the manner of siman ר״ט [209]. This, in general, is the cause of the moon's eclipse.

סימן רכ״א [printed §221; logical 222]

The nature of the earth's shadow — that it goes on tapering as it extends, and that when the moon enters into it, the moon is eclipsed.

Already we explained above in siman ק״ד [104] concerning the shining of the sun... upon the surface of the earth. The earth's shadow [is cast] like its own image and is pointed [conical]. Now if the earth's globe were larger than the sun's globe — or if the earth's globe were exactly equal in measure to the body of the sun's globe — then the shadow would run on at an even width all the way up to the sphere of the zodiac, and then the moon would be eclipsed not only at full [opposition]... [text degraded]. But because it has already been demonstrated to the sages by clear proofs that the sun's diameter is greater than the earth's diameter by five and a half times [Hebrew: ה׳ פעמים ומחצה], as was explained, it necessarily follows that the sun overhangs [with its light] more

than half the earth's globe, [wrapping around] it on all four sides. Because the sun so greatly exceeds the smallness of the earth's globe, the shadow upon the earth goes on tapering to a point until it returns to point א [alef], beyond which the shadow ceases altogether.

Diagram. The earth's shadow-cone, as the surrounding text describes it. Two circles, the smaller lying internally tangent to the larger, with a dark hatched cone tapering to a point. The figure does not cross the gutter, but it overruns the left measure on its outer side by 11.5 mm.

Labels: SEVEN single-sort marks, and NONE of them is read. They are set at an angle; a second reading of the leaf located and boxed all seven and declined to name any. Whether א, ב or ג is among them is open in both directions — neither asserted nor denied.

Point א is the center of the sun and point ב is the center of the earth; point ג is the head and terminus of the shadow. The line passing through the two centers and crossing the earth's globe is line ג–ב–א, and it is called the "axis" [עמוד]. The head of the axis, which is the terminus of the shadow, stands exactly opposite the place of the sun's center. The lines issuing from the side of the sun that bound the shadow are line ד–ו and [line] ג–ס [?], and triangle ג–ס–ד [?] serves as the divider... The astronomers of the science of the spheres estimated that this whole tapering cone passes through the thickness of the elemental sphere, through the thickness of the moon's sphere and the sphere of Mercury, and enters into the sphere of Venus. When the moon enters, where the shadow is, it is eclipsed. The measure of this shadow's length, from the surface of the earth to its terminus, the sages estimated at קפ״ח [188] "cords" [חבלים], being the whole of half the earth's diameter [and more]...

The earth together with its shadow, all darkness and tapering to a point — when the moon in its orbit enters within this shadow, the earth's body being midway between the sun and the moon: if the moon enters wholly within the shadow at opposition, with its center on the straight line ג–ב–א, it is wholly eclipsed; and if only part of it enters into the shadow, only that part which enters the cone is eclipsed, while whatever projects out of it — whether to the south or to the north — [is not]. The remainder of the shadow keeps tapering and diminishing as it descends... When [the moon's] circuit is near the earth's globe its darkening is greater [and it] is more hidden; when its circuit is farther from the earth's globe [it is less hidden]... [several clauses degraded].

סימן רכ״ב [printed §222; logical 223]

The form of the inclined circle of the moon [**עגול הנוטה**], and that every eclipse is at the head of the node or at its tail [**זנב התנין / ראש התנין**].

Already we explained above in siman קפ״ט [189] that the sphere of the [moon's] star... lies within the sphere... of its star and is aligned... [the deferent], and the inclined sphere [גלגל הנוטה] tilts from one side toward the north and from the other side toward the south... the inclined circle from the straight

[ecliptic] circle in this way... the tilt of the [inclined] circle... as we explained with the [foreign astronomers]... as in this figure.

Diagram. The inclined circle of the moon crossing the ecliptic at the two nodes. Two intersecting circles cut by a drawn chord, the chord falling where the construction requires. The figure interrupts its column for its whole height; the column measure is unchanged above and below.

Labels on the block — eight, all read on both witnesses:

label	where
אופן הנוטה	inside the upper circle, above the lower circle's arc
אופן הרמה	inside the lower circle
ד	above the chord, at its midpoint
ג	below the chord, at its midpoint
א	at the left intersection
ב	at the right intersection
מערב [west]	outer margin, LEFT, rotated +90°
מזרח [east]	outer margin, RIGHT, rotated −90°

- The two margin labels rotate in opposite senses — each reads outward from the figure. Never rotate a figure's labels as a set: a reader who fixes one rotation for the leaf will mis-read one of the two.
- אופן הרמה is secure letter for letter on both witnesses (ה־ו־פ־ן · ה־ר־מ־א; sort 6 has a smooth shoulder and no tag, so ר not ד), but the phrase is not construed and is recorded as printed rather than adjusted toward anything expected.

סימן רכ״ג [printed §223; logical 224]

Why the moon is not eclipsed every single month when its center is opposite the sun's center.

As for why the moon is not eclipsed in every single month, when the moon at its full stands opposite [the sun] and the two luminaries are aligned against one another at opposition — know that if the moon's course ran exactly beneath the course of the zodiac, as the sun's course does, then the moon would be eclipsed at every opposition and full moon of every single month. [And were it not for the laws and rules of the head of the node and its tail, and so forth.] But because the moon's carrying-sphere [גלגל המשא] is tilted away from the line of the zodiacal circle — inclined on one side to the north and its other end [to the south] — it therefore follows that it is not the case at every opposition that the centers of the sun and moon, together with the center of the earth, all fall on a single line; for the moon deviates in latitude across the breadth of the firmament. Hence, at most oppositions, the earth's globe does not come between the two luminaries.

In some of the months, at opposition, the moon fills [with the sun's light] and the sun is found at the head of the sign of Capricorn [ראש מזל גדי]... [degraded];

and if the moon's course ran beneath the sphere... then the moon would stand opposite it, at the head of the sign of Cancer [ראש מזל סרטן]... and all three centers would lie on one line, and it would be eclipsed. Yet the moon is not [eclipsed] every month, because the moon deviates in latitude — from the sign of Cancer up to sixty-three degrees [ס״ג], since the moon [is tilted]...[295]

Because [the moon's inclined circle is set at a slant], at most months the earth's globe does not interpose between the two luminaries, and no eclipse occurs at all across the earth; only [when it is at the node does it escape and the sphere completes its eclipse].

סימן רכ״ד [printed §224; logical 225]

That sometimes the darkening is found in the moon only in part of its body, and when the moon escapes eclipse entirely.

Know that the sages estimated the measure of the breadth [of the shadow] across its whole... and its diameter at the place where the addition of the moon's tilt [begins], which is an arc of [numeral: ?] and is about a degree and [a fraction] — [numeral: ?] degrees on the inclined sphere, where half the thickness of the shadow is tilted toward the north of the line of the tilting-node and half to its south. The diameter [of the moon] they estimated at close to two degrees [numeral: ~2 ?], half of it likewise tilting to the north of the node-line and half [to the south]... which [text worn].

[Continuation of §224]

[the moon] climbs upward, and therefore when the moon deviates from the point directly opposite the sun by the width of the firmament — about a degree [numeral: ?] — the moon will not escape eclipse altogether, according to the near reckoning; that is, when the moon draws away toward the north, deviating in the breadth of the firmament by three quarters of a degree [numeral: ג׳ רביעי המעלה ?], which is [near] the extent of its latitude, it will not fall upon the line... Thus the moon, whose diameter measures some degrees and is roughly [a degree], as it circles upon the node-line by [about a quarter-degree], will begin at its immersion to enter into the shadow... So when the moon is found near the node, by less than one degree, it will in any case be eclipsed, whether much or little, all according to its nearness to, or distance from, the node or from the head of the dragon. As for the standing of the moon in longitude across the firmament — when it does eclipse — the Israeli [R. Yitzchak Yisraeli, in Yesod Olam] wrote, citing Ptolemy [בטלמיוס], in maamar [numeral: ?] siman [numeral: ?]:

At the near opposition [reckoned by first approximation], call it "the near"[?] — whether before it or after it, less than [numeral: קי״א ? — perhaps eleven]

[295] the two signs are named in the prose only; the circular diagram on the same leaf carries no zodiac labels at all, its labels being the orb-names and four single letters. The printed figure of sixty-three degrees is no possible lunar latitude — this book itself gives the moon's greatest departure from the zodiac line as about five degrees at §241 — and it is recorded, not emended.

degrees in the longitude of the firmament — the moon will in any case be eclipsed; and if it is farther from that, a little [more], it is possible that it is eclipsed a little, and possible that it is not eclipsed at all; and if it is farther from them by [numeral: י״ב ? = 12] degrees and [numeral: י״ב ? = 12] regaim, or more, there is no way it can be eclipsed at all. And at the mean opposition, when the moon's center is [numeral: ט״ו ? = 15] degrees [and] [numeral: י״ב ? = 12] regaim [from] the node or its tail, it is impossible for it to be eclipsed at that opposition.

סימן ר״כה [printed §225, the mark set between sorts 1 and 2; logical 226]

That the astronomers divided the times of the moon's eclipse into five periods.

The astronomers reckoned, regarding the moon's eclipse when its whole body is enfolded [in shadow], five periods — and for [some, six or seven] — of the several [stages] the writers set down in [treating] the eclipses. And these are, in [order]:

- First: the moment the moon begins to enter within the shadow-circle, when its whole body begins to be darkened from its eastern edge.
- Second: the time all its body enters the shadow-circle [total immersion].
- Third: the time of mid-eclipse — the time the moon's center stands opposite the center of the shadow.
- Fourth: the time its body begins to emerge from the darkness and to turn back and recover light, when its western edge begins [to shine].
- Fifth: the time of the end of the eclipse, when the moon comes out of the shadow entirely and returns to shine with its whole body as before.

There are really only three [key] moments in the eclipse: the time of the beginning of the eclipse, the time midway through it, and the time of the end of the eclipse.

סימן רכ״ו [printed §226; logical 227]

The eclipses of the sun; and that there are several differences between its eclipse and the moon's eclipse.

The sun's eclipse has laws and rules many times more numerous than the moon's eclipse, for [in the moon's eclipse] the darkening is in its own body and in its own being; whereas [for the sun the eclipse is] at a [particular] place... it is eclipsed for [some of] the whole world... Likewise, sometimes the sun is eclipsed for [the inhabitants] of some regions and in other, neighboring regions it is not, [and it is not the same for all] — as will be explained; and it is far easier for the sun to escape eclipse than [it is for] the moon. Know, then, as a general rule, that the calculation of the sun's eclipse has many rules and conditions, and on that account it is a great and deep matter, exceedingly [profound]; and I cannot elaborate on all these matters — I will set before you only a few of the more essential points, and all in great brevity.

סימן רכ״ז [printed §227; logical 228]

That the cause of the sun's eclipse is that the moon stands before the sun and blocks its light.

The sun's eclipse is not from the sun's own side, for its body is not eclipsed, nor darkened, nor is any light at all diminished from it. Rather, the cause of its eclipse is that at the end of the month, at the time of the molad [new moon], when the sun and the moon are aligned one directly opposite the other, the moon at times blocks between the sun and a person standing on the earth's globe. So opposite the sun nothing is changed and nothing is diminished; only the body of the moon interposes between the body of the sun and the eyes of people, preventing them from seeing the sun — like an eye [screened]... which prevents its circuit [of vision] from [reaching] the rising of the sun. This, in general, is the cause of the sun's eclipse.

סימן רכ״ח [printed §228; logical 229]

How the moon, in its smallness, covers and hides from view a thing more than six thousand times larger than itself.

And if you should ask and say: How, in the moon's [work of causing] the sun's eclipse, does the body of the small moon block and prevent the light from reaching us? — for the body of the earth's globe is larger than the body of the moon by 39 times [ל״ט], as was explained earlier in siman רל״ט [239]; and the whole body of the sun, the length of whose diameter is greater than the earth's diameter by five and a half times [ה׳ פעמים ומחצה], and it emerges from this, by the reckoning of the [volumes], that the sun is larger than the body of the earth by 166 times and three eighths [ג׳ שמיניות ... קס״ו], and the body of the earth is larger than the body of the moon by 39 times, as stated. And it emerges from the reckoning of the [volumes] that the sun's globe holds more than the moon's globe by six thousand four hundred eighty-eight times and five eighths [ששת אלפים ותפ״ח פעם וה׳ שמיניות], as was explained earlier at the end of the Tenth Gate [בסוף שער יו״ד], in siman רל״ט [239] — so then, how is it possible for the moon in its smallness to block the sun, so much larger than it?

The answer: were the spheres of the sun and the moon adjacent to one another, there would be room for this question... [text degraded] — but rather, because the small body of the moon is near, [while] the sun is high and far and distant from us up to the [sphere of Mercury], there is room to resolve the question. When you draw near to your eye a small thing, it prevents you from seeing a thing much larger than it. Know, then, that the earth [and the sun]... [degraded]... the moon cannot be interposed [truly opposite] in latitude as in longitude, and [therefore its eclipse] does not [obscure it entirely].

סימן רכ״ט [printed §229; logical 230]

That a solar eclipse does not occur every month.

[This rubric stands at the foot of the left column and was missed in the first pass; the text that follows, at the head of p. 136, is its body, not a continuation of §228.]

As for why a solar eclipse does not occur at every conjunction of the two luminaries — the reason is what we already explained just above, in siman רכ״ג [223], as to why the moon is not eclipsed in every month...

[Continuation of §229]

of any thing whatever, its darkening in itself would suffice for us; so too in [this] case: because the tilt of the moon's circuit from directly opposite the sun by the width of the firmament [is up to] [numeral: ע' ? — value uncertain]... it does not stand directly opposite the sun, but deviates from it in latitude either to the north or to the south, so on this account [at most months] it does not [block the sun] to the east or [to the west]. By [some] degrees the sun escapes the eclipse... so that no eclipse can happen to the sun except when [the moon] is at the head of the node or at its tail, or near them. Thus wrote the Israeli [R. Yitzchak Yisraeli] in maamar 3, chapter 16 [במ״ג פי״ז], that [the moon's] blocking of the width [is]... at the time of the molad, less than ten degrees and sixteen regaim [ט״ז — the solar ecliptic limit ≈ 10°], whether before it or after it — otherwise the sun is not eclipsed.

סימן ר״ל [printed §230; logical 231]

That the sun's eclipse is seen in one place in its entirety, in a second place [only] part of it, and in a third place nothing at all.

Already we explained that the moon's eclipse... since [the moon] is genuinely deficient in its body... it is therefore the same for all the inhabitants of the world, for in every place... where the eclipse is by night, and above the horizon, all the inhabitants of the earth will perceive and see it... the [moon's] eclipse is the same [for all]. But the sun's eclipse — at that same time its case is not so; for it happens with Reuven, Shimon, and Levi that one of them will see the whole eclipse, another of them will see only part of it, and another of them will see nothing darkened at all, as you see in the figure.

Reuven, standing at point א, whose line of sight to the sun is triangle ה־ד־ח, meets the moon with his sight across its whole face; therefore the sun appears to him wholly darkened. Shimon, standing at point ב of the figure, whose line of sight to the sun is triangle ה־ד־ב, meets with his sight only half the moon, off to one side; on this account he sees half the sun darkened. And Levi, standing at point ג, whose line of sight to the sun is triangle ה־ד־ג, meets the moon in that sighting not at all; therefore he sees the sun shining whole, after its ordinary manner.

Diagram. The solar-parallax construction. A large upper circle (the sun) bearing two point-letters at its top; two lines descend from it and cross, passing a dark disk (the moon) at their crossing; a smaller lower circle (the earth) carries

observer-points. The three observers correspond to Reuven, Shimon, and Levi in the text.

The large circle and the small one stand on a common axis, their centres aligned; an off-axis filled disc sits at 0.667 of the way from the large centre to the small. Two long lines run from the large circle down to the small and cross below the disc; an outer pair forms the enclosing envelope. The figure replaces the right column's text.

Labels on the block — five positions, of which four are read and one is not:

position	label
inside the large circle, lower left	⟦ת/ח⟧ — roof contiguous, two legs both continuous into the roof (which excludes ה), equal depth to 1 row; the left leg's base is fused with the circle arc, so the ת foot-kick cannot be tested. ת not excluded, and not committed.
large circle, lower right rim	UNREAD — over-inked and merged with the rim on both sides; no value reported for a contaminated feature
top of the small circle	ב
right of the small circle	א
left of the small circle	ב

- The two ב readings rest on the heel alone — there is no כ of the same size elsewhere in the figure to set against them. The heel is markedly heavier here than anything the body fount shows, so they are recorded as ב; but if the heel is not accepted both are ⟦ב/כ⟧ and they fail together.
- No text is set on the curve; no label stands in the outer margin.
- The dark off-axis disc carries no label.

Diagram. [Belongs with the shadow/eclipse discussion; printed at the top of the outer column of p. 134.] A larger circle at the left and a smaller at the right, their centres lying on one horizontal axis, which is drawn. A third circle sits inside the larger one; the hatched cone crosses it, so its extent is observed but not measured. A hatched cone has its apex at the outer circle's left rim, on the axis, and opens rightward; inside it are a solid disc and a white disc divided by the axis.

Labels: exactly ONE — **א**, in the margin at the gutter side of the figure. No lettering inside the figure on either witness.

- Witness note: N governs this figure and B does not — B over-inks the hatching into a solid mass while N keeps the individual hatch strokes separable. This is the opposite of the usual direction on this leaf.

סימן רל״א [printed §231; logical 232]

How much time falls between one eclipse and the next, and how many eclipses are possible in a single year.

Since a darkening of either of the two luminaries occurs only when [the moon] is at the head of the node or at its tail, or near them — the distance between the two "limits," that is, between the head of the node and its tail, corresponds to [half] the arc of the sun's orbital circle, and the time of the sun's revolution... is about half a year... — when the sun is eclipsed, it will not have a second eclipse until there have passed, from the time of the first eclipse, about six months at most, or five months at the least, sometimes [more] and sometimes less. Likewise the moon: since it revolves in its sphere over the distance between the head of the node and its tail before completing half [its cycle], in any case the moon will not come to stand opposite the sun at either of the two places except after the [interval] of the previous eclipse — about, as stated, five or six months. The reasons for the variation between one eclipse and the next are that sometimes the first eclipse occurs a known number of degrees before the head of the node and the second after the tail of the node, or the reverse; and also because in [each] of the two luminaries the motion [proceeds] at a slow, [even pace]... which is why differences of interval are found between one eclipse and the next.

And you should know that sometimes the sun is eclipsed in one month among the months, and after this in [another] month; and the reverse is likewise found — so that you should know it is possible for one year to include three eclipses of the moon: the moon eclipsed at the beginning of the year and eclipsed at the [end]... and in the same way it is possible for three eclipses of the sun to occur in a single year.

Such a thing already occurred in the year one thousand four hundred twenty-nine [אלף תכ״ט] by their [civil] reckoning — that is, the year שס״ט = 369 of the sixth thousand — in which we counted three eclipses of the moon. These were:

- First [lunar]: 20 January [עשרים יאנואר״י], which was 15 Shevat [ט״ו שבט]
- Second [lunar]: 14 July [י״ד יולי], which was 15 Tammuz [ט״ו תמוז]
- Third [lunar]: 8 Teves [ח׳ טבת], 9 January [ט׳ יאנוא״רי], in another year

— and a full year had not yet been completed [since the first], the first eclipse having been on 20 January. And the eclipses of the sun that occurred in the said year — these were:

- First [solar]: 6 February [ו׳ פיברוא״רי], which was 2 Adar [ב׳ אדר]
- Second [solar]: 30 July [ל׳ יול״י], which was 29 Tammuz [כ״ט תמוז]
- Third [solar]: 26 December [כ״ו דיצעמבר], which was 5 Teves [ה׳ טבת]

I give thanks to God, my Rock, my refuge and my deliverer, who helped me to the completion of the Ninth Gate. [אודה לאל צורי מחסי ומושיעי שעזרני בסיום שער התשיעי]

Gate Ten (השער העשירי)

In this gate I shall explain the motions of the five wandering planets — some in general terms and some in detail: the time in which the epicycle sphere completes its revolution by means of the carrying (deferent) spheres, and the time in which the planet itself revolves by means of the epicycle sphere; how at times some of the wandering planets are hidden beneath the light and rays of the sun; the period of revolution of each and every one of the planets; and other matters bearing on them.

Siman 232 (רל״ב) — Why the planets sometimes move forward, sometimes backward, and sometimes stand still

[printed רל״ב = 232; logical siman 233]

Know that the astronomers have found and measured with their instruments that the five wandering planets sometimes move forward, sometimes move backward, and sometimes [remain] standing in place, going neither this way nor that. To grasp the cause and reason of these matters we shall explain them at some length.

[The figure] represents a portion [of an arc] of the mid-firmament [?], which is the sphere of the [fixed] stars; and beneath it, the form of the epicycle sphere, marked [ד ה ז (?)], whose center is point ז. And beneath that, at the [lower] tip of the drawing, is the likeness of the globe of the earth, whose center is point ח. Now from the center of the earth, from point [ח (?)], two lines are drawn upward along arc ב–א [?], namely line [א–ח (?)] and line [ב–ח (?)], the two lines being tangent to the epicycle sphere on its two sides.

Now when one of the wandering planets stands at point ג or at point ד that we have drawn, it appears to us, as we observe it, as though the planet stood in the eighth firmament at point [מ (?)] or at point ב. For as we shift [our line of sight], the planet in its epicyclic motion appears to people as though it were fixed in the firmament at point מ, where the fixed stars are. Thus it will appear to you: when the planet revolves on its epicycle from west [to east], following the form of its center's revolution, and travels there from above along its course by way of [points ו–נ–ד (?)] toward our line of sight — while we stand below upon the globe of the earth at a point set before us — it is as though the planet moved in the eighth firmament from point ב to point א [?]. And when the planet's epicycle carries it back from below, [it appears to move in the opposite direction along the firmament,] so that it seems to us to travel [backward] — and this is the [apparent] retrograde motion — even though in reality [the planet itself continues forward on its own sphere], for it is only the appearance

that reverses. So, too, when the planet is close [to the tangent points], it appears to go up along its course [near points ד נ ו (?)], to our line of sight, as we stand upon the globe of the earth, as though it went in the eighth firmament from point ב toward the west, [into the region of Aries (?)]; while at [another] point, it appears to travel eastward from point [ב] to point א.

[The geometric point-letters in this siman are printed small and are heavily worn; the readings marked (?) track the accompanying diagram but several individual letters could not be confirmed — see Diagrams field.]

Diagram. A retrograde-motion construction. An inverted cone (apex downward) representing the visual cone from the observer, with a large circle set in the upper portion and a smaller circle at the lower apex; both are centred on the same vertical axis — there is no eccentric offset to report — and the cone's apex falls at the small circle's centre. The figure narrows the measure beside it to about 20.6 mm without crossing the gutter.

Labels on the block — eleven positions, of which eight are now read or narrowed (five in the census, three more on the re-probe):

position	label
interior of the big circle, above the diameter, split by the vertical axis	**החמה** (”the sun”) — adjudicated sort by sort on the 1:1 pixel map
below the diameter, on the axis	ד
right end of the diameter	ו
left end of the diameter	UNREAD — confounded with the cone's left side and the diameter
above the big circle, on the axis	[[כ/ב]] — narrowed at ×22 (N) / ×10 (B): a top bar, a rounded right shoulder descending, and a base bar extending left, with the counter open on the left. B — which closes counters — shows the left side open, so the openness is real and ם/מ are excluded. ג is disfavoured (a full top bar is present); no control separates ב from כ on this plate.
below the big circle, on the axis	ה (moderate confidence; contaminated by the axis and the arc)
inside the small bottom circle	ח (secure — roof continuous, both legs attached at the roof's ends and ending at the same row, no ת foot-kick)
top-left corner of the cone	[[כ/ב/פ]] — narrowed at ×18 (N) / ×10–14 (B). Same open-left construction as the above-circle label: top bar, right stem, base bar, counter open to the left on B. N's ink spread closes it into an apparent solid box, which is what made ם look live. מ and ם are excluded — the figure's own מ (in החמה) has an arm-head above the roof and a fully enclosed counter, and neither is present here. A downward tongue from the left end of the top bar is visible on B and keeps פ in the set.
top-right corner of the cone	UNREAD — over-inked and merged with the corner strokes on both witnesses; re-probed at ×18 (N) / ×14 (B) and it does not open. A rising diagonal with a small lower-left counter is all that can be measured; no letter is named.

position	label
left vertical label (rotated 90°)	**מזרח** (”east”) — read. At +90° (the rotation the earlier reader validated on this label) the four sorts stand upright RTL: מ (the enclosed-counter sort), ז (narrow stem, head tag to the right), ר (roof with right descender, no base), ח (continuous roof, two hanging legs). N at ×6.
right vertical label (rotated 90°)	**מערב** (”west”) — read. At −90° (the opposite sense from the left label; verified by testing both, since at +90° the sorts invert) the four sorts stand upright RTL: מ, ע, ר, ב (base bar clear at the foot). N at ×6.

- Rotation was validated, not assumed: at +90° the ה shows roof-on-top with legs hanging and the ר roof-on-top with a right descender; at −90° both invert.
- The two rotated labels are a compass pair, not point-labels. They read outward in opposite senses — the left one upright at +90°, the right one upright at −90° — which is why a single rotation convention made one of them look like a word ending **-רה**. Each was read on its own ink before the pair was noticed; **מערב** is the cleaner of the two (four unambiguous sorts) and **מזרח** follows the earlier reader's own group count, with the thin ז recovered where it had merged and the final sort resolving to ח rather than ה (two hanging legs of equal depth off a continuous roof).
- **החמה** sort by sort (RTL, on the B pixel map): ה (roof + right descender + short detached lower-left leg, also visible at ×10 on N); ח (roof continuous, two descenders one at each roof end reaching equal depth — the continuous left leg excludes **ה**, and the kick on the right leg excludes **ת**); מ (top bar with an arm-head projecting above the roof at the left, thick left arm, right vertical, enclosed empty counter, base bar extending right); ה as the first. The vertical axis line passes between sorts 2 and 3.

Siman 233 (**ר״לג**) — Why we see a planet remaining stationary in place, going neither this way nor that

[printed ***ר״לג*** = 233, the mark set between sorts 1 and 2 and riding high; logical siman 234]

Now you can readily understand the reason for what is observed in the five wandering planets — that a planet appears to remain standing in its place, moving neither forward nor backward. For when the planet revolves on its epicycle, through the motion of the epicyclic sphere, to point מ, and travels along [line ד (?)], descending to point [ב (?)] in the figure, all this motion is drawn upward along the line of its course in accordance with its revolution [near the points]. Sometimes this lasts two or three days or more, since only a small [arc] of the epicycle [is subtended as seen] from the earth [near the tangent line]. For a stretch — [several (?)] days or more — the planet appears, from point מ up to point [ד/ב (?)], not to move at all to the eye, and as it travels on its epicycle it seems to stand still in its place. And the same holds when the

planet reaches near point [ו (?)], close to point ד: it appears to us as though standing still in its place.

Siman 234 (רל״ד) — That all the planets are hidden beneath the sun's light, and the manner of their entering beneath its light and emerging from it

[printed רל״ד = 234; logical siman 235]

It is already known that so long as the sun stands above the horizon, no star is visible to us, because of the overpowering, all-pervading light of the sun [which drowns them out], until the sun sinks beneath the horizon — and then, at once, the stars are revealed [and appear] from beneath its light, growing large and visible. Nevertheless, the stars that lie close to the body of the sun are not seen immediately after the sun sets, because the sun's rays are still near them, until the sun has withdrawn — after a known number of days — as it revolves and its place grows more distant [from them]. And this holds for each and every one of the wandering planets.

[Likewise for the reckoning of the planets' emergence from concealment beneath the sun's light: the rule for them] is the same as for the moon after it has been hidden beneath the sun's light [at conjunction], as was explained to you above in the Eighth Gate, siman [רל״ט / 239 (?)]. It remains for us to explain a little concerning the concealment [beneath the sun's light] of the other five wandering planets. There is a great difference among them — both as regards the [manner of] their descent beneath the sun's light [i.e. heliacal setting] and as regards the emergence of the other wandering planets from beneath its light [heliacal rising]. This [difference] arises from the great size [of the epicycle] and from the nearness of each one [to the sun] — whether the planet is at its apogee or opposite [its epicyclic position] — [which produces] the disparity among the [visibility] intervals when the planet revolves [on its epicycle]. [The intervals differ] because at the setting of the sun some [planets] lie near [the horizon] and some far, and their distance from the sun differs; so, too, some are hidden [in the sun's rays] for a longer time, some for a shorter — for days [and weeks (?)]. And their causes are one and the same: it is fitting to know that from the time the epicycle sphere begins [its motion], the planet [whose] center [rides on the deferent (?)] revolves beneath the center of the sun, [and] its distance [from the sun determines its visibility].

Siman 235 (רל״ה) — How Venus is sometimes seen before the sun and sometimes after it, and sometimes is not seen at all

[printed רל״ה = 235; logical siman 236]

The planet Venus [כוכב נוגה] has many variations and rules that must obtain regarding the times of its rising and setting [as morning or evening star]. For sometimes this planet goes before the sun and rises above the horizon before

it, in the morning, ahead of sunrise; and it is then called the morning star — in Hebrew, [it is called Ben Shachar, "son of the dawn" (?)] — and the commentators explained it thus as the "star of the morning." And sometimes this planet goes behind the sun and sets after sunset in the west, and it is then called the evening star or the twilight star (kochav ha-neshef). These two [phenomena are one and the same planet] — and they are not two separate stars, as the foolish suppose.

Sometimes this planet is seen after sunset only for a short while [above the horizon]; and sometimes it remains above the horizon [for] an hour or two — at times increasing, at times decreasing. And it goes on being seen, day after day, after the setting of the sun for a stretch of more than nine months [יותר מט׳ חדשים] together. And likewise in the morning, at its rising upon the eastern horizon: sometimes it precedes the sun's rising by only a short time, and sometimes by an hour or two. Sometimes it draws very near the sun, and sometimes this planet is not seen at all, neither morning nor evening, because it is hidden beneath the sun's light for as long a time [as it remains near it].

To make these matters, which are obscure, clear to you: when Venus is on its epicycle, its body at point ד of the drawing, it is then at its utmost nearness to the sun [בתכלית קרובה אל השמש] — that is, at the point of its epicycle farthest from the earth; [and its center, together with the centers of all the wandering planets, is always aligned toward the center of the sun]. There are [therefore] four centers upon one common line: [the earth, the epicycle-center, the planet, and the sun (?)]. When the sun is [rising], [the planet's visibility follows accordingly]. And when the aforementioned planet reaches point ה of its drawing, which is the point nearest the earth, it becomes hidden and revealed [in turn], and it appears [again] daily [as the sun withdraws]; and the two points ו and ז, to either side, are the places of its greatest elongation.

יגיע לנקודת פ' … ** — *"and when … the star … reaches point **פ**…"*. **The cited point פ' occurs nowhere in §235 as published**, whose prose cites only ד, ה, ו and ז. The words standing between וכאשר and לנקודת', and the whole tail of the line, were not read and are not supplied here.]

Diagram. Two circles (the carrying/deferent sphere), drawn about a single centre — concentric, with no designed eccentricity, the inner standing to the outer as 0.694. Neither ring is broken by an angular gap. At the centre is a filled blob, on the centre itself. Two small circles sit at ~12 o'clock, one straddling the inner ring and one straddling the outer ring, with a scatter of type-grade marks around both. The figure sits wholly inside the left column and does not cross the gutter. It illustrates the epicyclic motion of Venus (or Mercury).

Labels on the block — six positions, of which one is probable and five are unnamed. None is rotated; all sit upright, and all were checked on both witnesses:

position	label
inside the lower small circle (on the inner ring)	פ — PROBABLE, NOT CERTIFIED (see below)

position	label
left of the lower small circle	[ד/ר] — UNRESOLVED; no same-size control on the block
right of the lower small circle	a narrow half-height sort — UNNAMED
above the outer circle	one sort — UNNAMED
right of the upper small circle	one sort with roof + leg — UNNAMED
below the lower small circle	two sorts — UNNAMED

- On the **פ**: the letter is a bowl closed at top and right, opening lower-left, with a tongue entering the counter from the top-left — consistent with **פ** and inconsistent with **ם/ס**. But the only same-leaf **פ** control is movable type in the body fount (**לנקודת פ׳** in the left column), not cut-in-block lettering of this size, so the class is read from resemblance, not from a matched control: both fail together if wrong.
- Caption: a four-sort word below the figure — measured, fully in frame on both witnesses, and UNREAD. It is not asserted to be a catchword and not asserted not to be.
- Show-through: N carries visible ghost text bands inside both circles (verso bleed-through), absent from B. Nothing inside the circles is transcribed from N.

Siman 236 (**רל״ו**) — That the planet Mercury too behaves like Venus, and that one and the same rule and law applies to both

[printed **רל״ו** = 236; logical siman 237]

Know that the center of Mercury's epicycle sphere is likewise forever fixed beneath the center of the sun [i.e. it moves with the sun's mean motion], just as [Venus's is]. And [as for] the time of the revolution of the center of its epicycle: it circuits [the zodiac in the same period as the sun (?)], just as [with Venus]. And the time of the revolution of Mercury's own body on its epicycle sphere, and [the reckoning of] their conjunction and its recurrence — all this is [given below]. Because the epicycle sphere of the planet Venus is larger than that of any one of the other planets, the astronomers estimated its diameter at close to nine degrees [**קרוב לט׳ מעלות**] of the [**מש״ם**] degrees of the sphere; and in the epicycle sphere of the planet Mercury [**כוכב כוכב**] they estimated its diameter at only about three [**כמו ג׳ מי׳**].[296]

Mercury too, then, behaves after the manner of Venus: [its visibility depends] on the sun's setting [and rising]. [It is hidden and revealed] at the recurring

[296] this siman states no greatest-elongation figure for either planet. Of its two diameter figures, the first carries a single mark after its second letter, so as printed it is a preposition plus a unit numeral, not the two-letter numeral it resembles (as at §215); the second's unit-token is three sorts making neither unit-word the sense wants, so no unit is supplied. The qualifying word before "degrees of the sphere" has a closed sort the two copies do not separate — form recorded, no value supplied; it recurs at §216 and §224. the heading of this siman names Mercury **כוכב כוכב**, and is given as set.

[conjunctions], according to all the reckonings and rules — the variations and particulars — [set out] for the [wandering] planets, [in the same way] as [Venus]. As you shall know [about] this planet: it is not [seen at all when it is hidden beneath the sun's light]. And so also for the rest of the wandering planets.

Siman 237 (רל״ז) — [On] whether — and how and in what manner — the three upper planets, namely Saturn, Jupiter, and Mars [שצ״ם], are [concealed] beneath the light of the sun

[printed *רל״ז* = 237; logical siman 238]

[If one should set about] to explain the particulars of its matter [i.e. how each of the upper planets is hidden]: [as regards] all [these (?)] wandering planets — [the point at which each sinks beneath the sun's light and emerges again] — [the same principles apply]. [The three upper planets, being far above the sun, are hidden only when they come into conjunction with it, and each is again seen when the sun has withdrawn from it by the requisite arc.]

Know that in the view of most astronomers, these mentioned [planets] are not seen from beneath the light of the sun until it fills out the measure of the arc between the western horizon and the sun — some sixty-six degrees [כמו ס״ו מעלות] (and these come to about one hour [שעה א']) — sometimes more and sometimes less.

[The siman's further quantities, in the order it prints them: the measure of one sign [שעור מזל א']; the measure of the travel of half a sign, which is the time of one hour [שעור מהלך חלי מזל שהוא זמן שעה א']; close to one degree [קרוב למעלה א']; about one part in fifteen of an hour [שעה[מ] כמו חלק א׳ מט״ו]; about half a sign [כמו חצי מזל]; about the measure of half a sign, or a little more [כמו שעור חצי מזל או יותר מעט]; again the measure of one sign [עוד שעור מזל א']; in the time of one month [בזמן חדש א']; two hours [ב׳ שעות].][297]

[§237's heading stands at the foot of the right column of p. 139, but its body — all of it, including everything about the arc of vision — is in the LEFT column of the same page. Nothing of this siman is on p. 140.]

Siman 238 (רל״ח) — Whether the light of the planets is from themselves, or whether it is acquired by them from the light of the sun

[printed *רל״ח* = 238; logical siman 239]

The [question of] light — as it is found in the planet [Venus (?)], and likewise in all the [other] planets: some say [וי״א] that their light is their own, from themselves, like the sun; and some say [וי״א] that the light of all of them is acquired, and that they receive their light from the light of the sun, as does

[297] the arc and the conversion beside it in the same parenthesis do not agree; both are given as set and neither is emended.

the moon. And [one might argue] that no star [could be self-luminous] — [therefore] they must stand [receiving light from the sun], for [otherwise (?)]…

[The sun,] when the globe of the earth comes between it and the [planet], is [eclipsed]; the small shadow [cast by the earth (?)] — thus it appears [that the planet is darkened]. And [although] it is not incumbent upon us to inquire into the reason [of every such matter], [we note that] the globe of the earth [stands] at the midst of the sphere [as before, as was set out in the first (?)]. [Whether the planets shine by their own light or by the sun's, the phenomena of their appearing and disappearing are as described.]

[The two-opinion discussion is legible in outline but individual supporting clauses at the column foot (p. 139) and column head (p. 140) are worn; readings marked (?).]

Siman 239 (**רל״ט**) — How large the body of each of the [seven (?)] wandering planets is, relative to the body of the globe of the earth

[printed *רל״ט* = 239; logical siman 240]

Know that the astronomers estimated the diameter of each one of the wandering planets, and of the other stars besides them, against the measure and diameter of the earth; and first they set down the measure and diameter of the two great luminaries. The ancients reckoned that the diameter of the sun is greater than the diameter of the earth five and a half times [ה׳ פעמים ומחצה יתר על קוטר הארץ], and that the body of the earth's globe is greater than the body of the moon thirty-nine times [ל״ט פעם]. It follows by the reckoning of the volumes that the body of the sun is greater than the body of the earth one hundred sixty-six times and three eighths [קס״ו פעם ושלשה שמיניות]; and multiplying thirty-nine by one hundred sixty-six and three eighths, it comes out that the body of the sun is greater than the body of the moon six thousand four hundred eighty-eight times and a half [ששת אלפים ותפ״ח פעם ומחצה].

[The corresponding multiples for the remaining planets, which the siman goes on to give, are printed small and worn; the specific figures for Saturn, Jupiter, Mars and the rest could not be read with confidence — [numeral: ?] — and are not committed here.]

Siman 240 (**ר״ם**) — A table of the periods in which the carrying sphere and the epicycle sphere of each of the seven wandering planets revolve about the globe of the world

[printed *ר״ם* = 240 — the leaf sets a final mem; logical siman 241. The heading prints *של כל ז׳ כוכבי נבוכה* — seven. §241's heading two columns later prints *ו׳ כוכבי נבוכה* — six. The two counts stand as printed; the print differs from itself here and the difference is not smoothed away.]

The times in which each one of the seven planets carries the center of its epicycle sphere — by means of the carrying (deferent) sphere — around the

globe of the world, according to their [sphere-]motion from west to east, are as follows (all in close reckoning):

Table A — Period of the deferent (epicycle-center around the zodiac). (Table reads right-to-left in the source; the planet rows run down the right column, Saturn through the Sun, and continue at the head of the left column, Venus through the Moon.)

Planet	Full circuit of the zodiac	Per sign
שבתאי (Saturn)	about 30 years [בשלשים שנה]	each sign 2½ years [כל מזל ב׳ שנים וחצי]
צדק (Jupiter)	about 12 years	each sign one year
מאדים (Mars)	two and a half years [שתי שנים ומחצה] (see Numerical impossibles)	each sign 2½ months [כל מזל ב׳ חדשים וחצי]
חמה (Sun)	about 365¼ days [כשס״ה יום ורביע]	each sign one month
נוגה (Venus)	likewise about 365¼ days [ג״כ כשס״ה יום ורביעי]	each sign one month [כ׳כל מזל חדש א]
כוכב (Mercury)	likewise about 365¼ days	each sign one month [כ׳כל מזל חדש א]
לבנה (Moon)	[[26/27]] days, 6 hours and a half [כ״[[ז/ו]] יום ו׳ שעו׳ ומחצה]	each sign 2¼ days [כל מזל ב׳ יום ורביעי]

The time between one [lunar] conjunction and the next is 29 [days], 12 [hours], [and 793 chalakim (?)], as was set out above in siman ר״ד [204].

And the time in which each of the planets revolves in its own body on its epicycle sphere is this:

Table A2 — Period of the planet's own revolution on its epicycle. (Table reads right-to-left in the source.)

Planet	Period on the epicycle
מאדים (Mars)	two years, 49 days, 2 hours [ב׳ שנה מ״ט יום ב׳ שעות]
נוגה (Venus)	one year, 218 days, 15 hours [א׳ שנה רי״ח יום ט״ו שעות]
כוכב (Mercury)	115 days, 8 hours [קט״ו יום ח׳ שעה]
לבנה (Moon)	27 days, 13 hours [כ״ז יום י״ג שעות]

A most precise calculation — namely, the period of revolution of the center of the moon's epicycle about the globe of the world, and the period of revolution of the moon's own body on its epicycle, and the length of the lunar month — as I received it from his own mouth and from his book, from Johannes Mullerus [יוהנ״ס מולירו״ס], chief of the sages who sit before the Kurfürst, Duke of Brandenburg [ראש החכמים היושבים לפני הקיר״פרי״רשט דוכס ברנדי״בורג]:

- The revolution of the center of the moon's epicycle by means of the carrying sphere is 27 days, 7 hours, 43 minutes, 6 seconds [כ״ז יום ז׳ שעות מ״ג דקין ו׳ שניים]; each day, 13 degrees, [14 (?)] minutes, [34 (?)] seconds, [43 (?)] thirds.

- The length of the lunar month, from one conjunction to the next, according to the mean motion, is 29 days, 12 hours, 44 minutes, 3 seconds, 11 thirds [כ״ט יו׳ י״ב שעו׳ מ״ד דקין ג׳ שניי׳ י״א שלישים].

Siman 241 (רמ״א) — How far the six wandering planets deviate from the mid-line of the firmament — the line of the zodiac — in the breadth of the sky, toward the north and toward the south [i.e. planetary latitude]

[printed *רמ״א* = 241; logical siman 242. The heading prints *כמה נטיית ו׳ כוכבי נבוכה* — six — where §240's heading, two columns earlier, prints seven, and the table below lists seven bodies. The counts are given as printed; the print contradicts itself and is not harmonised.]

We have already explained above, in siman [קפ״ה (?)] and siman [קנ״ג (?)], that the plane of the zodiacal belt of each of the five wandering planets is inclined away from the great circle [of the ecliptic (?)] that stands [along] the line of the zodiac; part of it [tilts] toward the north and part toward the south. [The angle by which each planet's orbit tilts north or south of the ecliptic determines its "breadth" — its latitude.] When [a planet stands as far] toward the north or toward the south [as its orbit permits], it is said of that planet that it stands "in the breadth of the firmament," and the measure of that distance, or the deviation, of each and every wandering planet from the line of the zodiac to the north — and likewise to the south — [is given below,] as I received it from the scholar Johannes Keplerus [יוהנ״ס קעפלי״רוס].

Table C — Greatest latitude (deviation north/south of the ecliptic). (Table reads right-to-left in the source.)

Body	Greatest latitude
שבתאי (Saturn)	three degrees
צדק (Jupiter)	one degree and two thirds of a degree [אחד מעלה ושני שלישי מעלה — the whole-degree word resolved; it is spelled out, not a numeral]
מאדים (Mars)	three and a half degrees; and among them there is a difference between north and south [ג׳ מעלות ומחצה. ובהם יש הבדל בין לפון לדרום — the leaf sets **לפון**, four sorts, with the **צ** of **לצפון** not printed; given as set]
חמה (Sun)	it has no breadth at all, for it is always in the plane of the world, beneath the line of the zodiac
נוגה (Venus)	more than all of them, some nine degrees to the north, and likewise to the south
כוכב (Mercury)	three degrees
לבנה (Moon)	five degrees and a quarter

298

With the help of the Helper — on the day of trouble — we have completed ten gates. [השלמנו שערים עשרה • בעזר העזרה אותו ביום צרה — a rhymed colophon closing Gate Ten.]

298 the Moon's row has its figure spelled out, and the quarter is part of the same cell; the table is word-set throughout.

The Eleventh Gate (השער האחד עשר)

[Gate 11 opens here, at the head / folio ע (70) recto. The gate numeral's ד/ד is uncallable on this leaf: neither the tag test nor the ramp test separates them, the ramp controls disagreeing with each other. "Eleventh gate" therefore rests on convention, not on ink — as it does for two other ד/ד on this leaf, and for the third leaf running.]

In this gate will be explained the construction of a sighting instrument called the quadrant (כלי רובע, kli rova), with which one measures and determines, in every location: the altitude of the pole [the celestial axis]; likewise the altitude of the sun, and of every other star among the stars of heaven — how high it stands above the horizon; the position of the sun among the zodiacal signs on every day of the year; also the time of the sun's rising and setting, and the difference in the lengths of days and nights in every place throughout all the days of the year — together with many other matters besides these.

Siman רמ״ב [printed 242 = logical 243] [the mark is set at mid-height; doubleness not established on either witness]

On a sighting instrument called the quadrant — to learn the method of [measuring] the altitude of the pole and the altitude of the stars.

The author says: I saw fit to teach the students, in this gate, the science of measuring the stars and the [celestial] degrees by means of a sighting instrument (כלי מחזה) made in circular form by the hands of the scholars of astronomy. Their sighting instruments are many, of various kinds; but the most pleasing [choice] for the body of the instrument is the one whose shape you find to be a quarter of a complete circle. On account of this it is called kli [k']dun-rova [?] and in the Latin tongue (קוואדראנט, quadrant), that is, "the quarter-part of a circle."

And I, the author, wished [?] to give this instrument a name by way of borrowing from the language of Scripture — from the word anach [אנך, a plumb-line], as in the verse "standing on a wall built with a plumb-line, with a plumb-line in his hand" (Amos 7:7 — the print cites עמוס). [?several words illegible?]

All the commentators [describe] the surface of the instrument [with?] a plumb-line [קו] of lead like a weight [כמשקלות], which serves to straighten a wall or a building, and likewise for other matters of measurement — such as measuring [?] the mountains, the vineyards, and the distances [?] of the roads of the countries; for all this the scholars of measurement use the instrument with plumb-weights. We have already explained this at length in the book we composed, Sefer HaProzdor [ספר הפרוזדור], and this is not the place for it.

But here our intention [in naming it] is to explain this instrument to beginning students [?]. By means of this instrument the student will come to know the altitude of the sun, and clearly [the altitude of] all the stars of heaven whose [height] he wishes to know, in every place and at every time; also the position of the sun among the zodiacal signs on each day throughout all the days of the year; also the hours of the day, together with a treasury of many features peculiar to it, as will follow.

For just as the sphere of the zodiac makes a complete circle of 360 [**ש"ס**] degrees, so too the measurements we teach with this instrument [are done] on a quarter of the circle [= 90°].

Because the sphere of the [zodiac] in its entirety — which is already divided into 360 degrees — is not all seen and revealed to us above the horizon, but only a count of 180 [**ק"פ**] degrees [i.e. half]; for its [other] half is a portion [**כח**] hidden below the horizon, beneath the earth. And even of the visible half that is above our horizon, the observer cannot see [all of it] at once [?]... toward the four directions of the world [only?] half of them, which are 90 degrees.

And you must know that, since this instrument is only a quarter-part [?] of a circle, [when you consider] the whole angle in a complete circle, the instrument's [apex] stands at the point at the center [?] of the complete circle; and because of the corner-angle mentioned, it is called the center (**מרכז**, merkaz) of the instrument.

Moreover, you must know that whatever is found [measured] by means of any sighting instrument [is found thus]: bring the instrument close to your line of sight, raise your eyes, and sight along the edge of the instrument in a straight line toward the point of the place whose altitude — or whose distance [?] — you wish to know; and then it is as though the very line [edge] of the instrument were extended in length until it reaches, in a circle [?], the point that you seek.

Diagram. A plain circle with an inscribed quarter marked off by two perpendicular radii meeting at the center and a connecting arc — illustrating the definition just given, that the quadrant is a quarter (**רביע**) of a complete circle. No point-letters or numerals appear on this figure.

Siman **רמ"ג** [printed 243 = logical 244] [the mark stands entirely above the roof; doubleness not established on either witness]

That the quadrant instrument is [constructed] upon [the base] **א–[מ]–ב** [?] … in the first method (**הבחינה הראשונה**). [Heading partly garbled; the sense is that this siman treats the "first method" (בריח המורה, the sighting-alidade) construction.]

Know that the making and setting-up of the quadrant of which we speak is done in [two] ways [?]: the first by means of the sighting-rule (**בריח המורה**, the alidade), the second by the plumb-rod (**מוט המשקל**). We shall choose to begin with the method that uses the sighting-alidade, and this is how you make it.

Make yourself [an instrument] of some material — a board [דף], one [side] — whose overall shape is a quarter of the complete circle, as above; [call the figure] א-ב-ג and ד [?]. The left side of the instrument is this edge [?]; the upper line, call it ג [?]; and the right side, which is [the edge] ד [?] — [call it thus]; its base, call it **א–ב**; and its arc, call it [**ב–ד**] [several letter-labels uncertain].

This arc you divide into 90 [**צ'**] parts, which are called degrees. And this division — [set up] so that it be taught to the students in a straightforward way — [proceeds thus]: first divide the whole arc into three parts; each of the three parts divide again into three, yielding nine parts; each of which [you divide further] [?] so that the sum of all the parts is 90 [ninety], each of which represents [?] degrees. Mark them on the arc by number, from below upward, up to 90 [reading of the terminal numeral uncertain]. And to complete the ninety, [with a] space [?] between each mark, rule them with fine strokes [?], each [degree] into five parts; so that all the parts are ninety, and they are called degrees; and these ninety degrees are a quarter of the 360 degrees of the sphere, as in all [such instruments].

**

[Siman *רמ"ג* continues at the top of the next page.]

Take a rule [the alidade] [?] whose length is the diagonal of the instrument and whose width is half [its diagonal?] [?]; [such a rule is called...] [?several garbled words?]. This alidade [בריח] you attach at one end to the center of the instrument, at point **א**, and let the joint-pin be like an axle (**ציר**), so that you can rotate it and move the alidade across the whole face of the instrument.

On this alidade, on one side, attach two small rings (**טבעות**) facing one another [reading of "facing one another" uncertain], with [?] two fine holes (**נקבים דקים**) — each of them like a small perforation — so that the two holes are aligned one directly opposite the other; and let the two holes be [set] on [the back of?] the alidade itself, or a little raised above [it], at an equal height [?]. These perforations that we mentioned are called [כור"ל / ?] — [term illegible] — [and thereby the instrument is] properly fashioned, and measurement by it is obtained [?].

As for the dimension of the center [?] and the width of this instrument: it has no fixed or set measure; but the larger the instrument, the greater the precision of measurement. Know that the measure customarily set before the scholars of the science is about a quarter of an amah [cubit] by a quarter of an amah in width; [and] I have another instrument that holds half an amah in length by half an amah in width.

Siman **רמ"ד** [printed 244 = logical 245]

How measurement is done with the quadrant instrument.

Now that the quadrant described above, made with the aforementioned alidade, is properly fashioned, I will show you how [to measure] [?] the altitude of any star.

The [point] at which the sun or the star comes to rest [?] — that is called the altitude of the sun or of the star. To know how many degrees a given star stands above the horizon: set it up — for example, upon a table — in an upright position, level [ישר] to the horizon, without any tilt to the sides; and aim the two edges of the instrument [so that its face looks?] downward [?]... at angle ג / point ה [?] of the instrument [reading uncertain]. The observer sets its face aligned against the point of the star at [his] zenith [קדקד].

And when you sight some one of the stars, raise [the instrument], set [your eye?] to the center of the instrument, which is point א, and turn the alidade toward it [לנוכח], and wait until you can see — over the alidade, through the two holes — the star whose altitude you wish to know.

[The measurement] begins with the alidade at some part of the number [-scale]; [there] you will find [?] the number of the altitude that you sought to know. And this matter is always [?] so, [and] it is necessary to premise it, for it is plain and evident to the eyes of all: because the arc [ל90־?] on which the degrees are marked is set aligned against the arc [?]... from the [point] nearest [?] up to the point opposite the zenith. It has already been explained that its arc [shows] for each and every degree [?] the number of the arc [being] aligned [?]... [several clauses garbled]... through the sighting-alidade, by way of the perforations, and the sighting along the alidade — for example, up to the degree [?] at the larger part of the number-arc; and this same aiming proceeds and touches [?] the large [division], which is also at the aforementioned sixth [?] degree. And all the matters mentioned you will see in a figure such as this:

Diagram. A quarter-circle (quadrant) instrument shown with its graduated arc and shadow-scale. The curved outer limb carries a complete by-fives degree scale in European (Arabic) numerals — 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90 — each cell individually legible at native resolution. An inner graduated arc carries a second by-fives run over the same range, 5 … 90. Two small squares set along one straight edge represent the sight-vanes (pinnules / נקבים). The corner point-letters of this figure are not legibly recoverable on the scan, even under magnification. [Corner labels illegible; the two graduated runs are transcribed, not inferred — a monotone by-fives sequence is what a graduated quadrant limb is, and regularity is not evidence of pattern-fill on an instrument scale.]

**

Siman רמ״ה [printed 245 = logical 246]

Everything that lies on the line of the ray [line of sight], even though the one be larger than the other — even by a thousand parsah — is reckoned as a single altitude for both of them.

Know that the ray [line of sight] goes out from the eye and reaches the sphere of the stars. Everything that lies on this line — whether near or far — is reckoned to them all as one altitude, even though the one is higher above the

earth [?] by a thousand [אלף] parsah [than the other]. Whatever lies along the line of the ray that constitutes one altitude is reckoned as one for all of them.

By way of example: a certain tree [אילן] — [its height is only … cubits …] [the line naming the tree's points and giving that measure is not read; see the QA note below] … and by means of the sighting instrument, fifty degrees [חמשים מעלות — spelled out in words on the leaf, not set as a numeral]. And the whole [line] rolls on [?] from the [point of the] eye up to the points [?] — up to some one star [ה'] of the stars of the eighth sphere; and the altitude of that star, though it be higher [above the air / the earth] by a thousand [?] parsah [reading garbled], is by this construction [reckoned the same as] the top of the tree. [Geometric example heavily garbled by the compositor; point-letters and several numerals uncertain.]

And two stars found [on] one [line] in this construction — each of them [at] [twenty or fifty — [[נ/כ]]'] degrees — [have the same measured altitude]; only, the degrees of the point at the top of the tree are [[[unresolvable numeral]]] degrees, small and short degrees [i.e. a small arc-length], whereas the degrees [reaching] to the star are large and wide [reading uncertain].[299]

And know that all we have said [with these examples?] we set out at length as a parable and analogy for the quadrant made according to the first method, that is, by the sighting-alidade. And now hear the rule and law of the quadrant made according to the second method — [that of] the plumb-weights [המשקלות] — whose plain, direct way has already been explained to you above; so, just as [in] the second gate [?], let us now add its rule for the second [method] as well, with [almost?] new points.

Siman ר״מו [printed 246, the mark set between sorts 1 and 2 = logical 247]

The nature of the making and construction of the quadrant instrument according to the second method.

The author says: since [the matter] was mentioned at length above — [in] Gate ב [2?], siman כ״ח and כ״ב [28 and 22 — cross-reference as printed; both siman numbers uncertain] — [namely] the nature and construction of the quadrant according to this [second] method in circular form [?]; and since the whole content of this gate is pressing [me] to teach the students the essence and purpose of the way of measuring the stars and the zodiacal signs — therefore, by [what may be] an oversight of my hand [?], I saw fit to write it here a second time, more fully [ביתרון], with points that are new and wondrous. And this is how you make it:

[299] the numeral qualifying the tree-top's degrees is a closed ring on both copies and is not resolvable in this fount: sixty or forty, and this edition does not choose between them. Nothing in the gap beside it amounts to an abbreviation mark, so no geresh is recorded. It stands as a word of its own between "the point of the top of the tree" and "degrees", so on the page it qualifies the tree-top point, not either of the lettered points named earlier.

From a material — a board [דף], one [side] — whose overall shape is to be a quarter of the circle, as above, which we call **ג-ב-א**; and again [take] point **א**, and go to its left [side] **ב–א** and the right [side] **ג–א**, and its arc **ד–ב** [reading of letter-labels partly uncertain]; whose figure is likewise [set up like the first]. [Here the two methods are compared:] the [difference] is great [?] — this being the first method [with the alidade], and the second method by means of [the plumb]...

** From the center of the instrument, which is point **א**, [also] draw one line — a little longer than the diagonal of the instrument — [set out] in the figure [as...]; and this line is called the plumb-line (**קו המשקל**), since from it will hang a small lead weight (**משקל קטן מעופרת**), in order to draw down and keep straight the hanging of the thread downward.

Fasten well to the thread a bead/pearl (**מרגלית**) or a small [weight]; fix it on the thread [by passing it] through the hole of the bead, so that it [hangs] on the thread — the plumb-line — down below [?]. [Then along the edge] [?] make two small [projections / plates] and bore in each of them a small hole, in such a way that the two holes lie on one straight line, aligned one against the other, by the method already explained to you above, as [stated] nearby; and these two holes [serve] according to the second method, and [thereby it will] be given to you to know [the altitude].

For, according to the rule: the difference is that the first method [works] by sighting with the eyes [?]... [some words garbled]; in the [two] methods: in the first, the arc faces [one way] [?], and in the second, the center faces upward. Nevertheless know that the two are in agreement, like neighbors, having one root and one foundation; and although the [two] methods are two, they are both as one and have one intention. Even so, most of their [the instrument's] operations here [will be treated] according to the second method, because it is easier — and larger — and it spares the instrument the trouble of setting it level to the horizon.

Siman **רמ״ז** [printed 247 = logical 248]

The forms and figures of the quadrant instrument, with all its rules and regulations.

I — before I begin to speak of presenting the figures of the instrument — [say] this: because it is difficult, indeed impossible, to fully [convey] and [make] the students understand [reading of "and half the building/matter" uncertain] the rules of this instrument and its operation without a figure and many forms — and, in order not to multiply figures for each and every lesson — I saw fit to present before you, at the very outset, all at once, the entire figure and form of the instrument as needed for this [purpose] in this gate, from which every person of understanding may discern and grasp all the rules of the instrument, according to what will be explained [in siman רמ״ז/? — cross-reference numeral uncertain].

Diagram. A large square-framed quadrant instrument occupying the upper portion of the page, drawn with a full grid of concentric arcs and radial lines (an quadrans vetus / shadow-square type). Readable elements:

- Point-letters — partially corroborated. The first reading committed **א** (top-right corner), **ב** (top-left), **ד** (bottom-left), a bottom-right corner read **[ג?]** [?], and **ה** (interior, upper field of the grid). Two of the five have now been located and read on the leaf: **א**, set just inside the frame at the head of the diagonal in the upper-right field (N ×12 — the diagonal shaft with its upper-right arm and lower-left foot, unambiguous), and **ה**, in the upper-middle interior below the top rule (N ×12 — roof, right descender, detached lower-left leg). The remaining three (**ב** top-left, **ד** bottom-left, **[ג?]** bottom-right) were not confirmed: the top-left corner does carry a small boxy sort, but it sits against the frame rule and no letter is named for it; the two bottom corners were not opened. See the QA note below.
- Two further small point-labels sit on the diagonal, between the inner arcs (N ≈ x1000 y788 and x977 y872; B ≈ x1434 y924 and x1386 y1056) — these are not corner marks and were not in either roster. The lower one is **[[ט/ג]]** (B ×10: a head-and-stem on the right, a short arm branching left at mid-height, and a lower-left stroke descending — the **ג** reading is the better fit but **ט** is not excluded and there is no same-fount control on the plate). The upper one is confounded with the crossing grid diamond at every threshold tried on both witnesses and stays [?].
- A small interior mark near a circle/disk at centre (the sighting-point or plumb origin); its letter is not legibly recoverable [?].
- Three boxy sorts stand on the inner right rule (N ≈ y790, y1194, y1476). Each is an outer bracket (top bar + right stem + base) with a separate enclosed rectangle inside it — a **פ**-class construction. They are not **ג** and not **ח**; no reading is committed.
- Two small squares set along the right straight edge represent the sight-vanes (**נקבים** / pinnules).
- **צל הישר** (”the straight shadow” — umbra recta) — labeled along the lower diagonal (the shadow scale).
- **צל ההפוך** (”the inverted shadow” — umbra versa) — labeled along the upper diagonal.
- Two hours-row captions, both printed and legible: **שעות דמחצות** (”hours from noon”) and **שעות שנתאחר מחצות** (”hours elapsed since noon”).
- Zodiac-sign names run in two distinct rings, and the first pass recorded only one of them.
- Upright ring: **טלה** (Aries), **שור** (Taurus), **דגים** (Pisces), **דלי** (Aquarius), and a fifth cell read as **תאומים** (Gemini) [middle letters soft — uncertain]. The order in which they are listed here is not the printed sequence direction along the arc, and no usable transcription of the band's order is committed.
- Rotated column, just inside the inner right rule (read after rotating the strip 270° CCW) — restored, absent from the edition entirely: top to

bottom, **[קשת?]** (Sagittarius, unconfirmed), **עקרב** (Scorpio), **מאזנים** (Libra), **בתולה** (Virgo — clear, with a mark), **אריה** (Leo — clear, bold), and further cells not resolved. **בתולה** and **אריה** are the two a second reading of the leaf would defend; the rest were read at 150% without individual rotation. The lower half of neither ring was read, and the pairing of the sign names against their numerals was not verified.

- Adjacent band-words include **שעות** (”hours”), **מעלות** (”degrees”), and **דמחצות/מחצות**; **עגול** is printed on the long curved caption line beneath the sign band and is a caption word, not a thirteenth sign.
- The outer band is a degree limb, and its numerals are European Arabic figures, not gematria. In order round the band, from the top-left end of the limb to the bottom-right end: 5 · 10 · 15 · 20 · 25 · 30 · 35 · 40 · 45 · 50 · 55 · 60 · 65 · 70 · 75 · 80 · 85 · 90 — eighteen cells, one every five degrees, and there is no **0** cell.
- Inside the limb, two further bands carry the hour numbers 1–12, twice round, also in Arabic numerals.[300]
- A parallel month column stands outboard of the sign band, carrying Hebrew month names. The month names are only partly legible and are not committed.
-

[More than two labels/numerals in this figure are uncertain.]

Siman רמ״ח [printed 248 = logical 249]

To find the altitude of the sun — how high it is above the horizon.

We have already explained above that the astronomers [התוכניים] give the name ”the altitude of the sun” to every place at which the sun [stands] — that is, its brightness [נוגה] above the horizon; and [we explained] the degrees, by means of this quadrant, [showing] how high a given star stands above the horizon.

Take the quadrant in your hand, at the side **ג–א** of the instrument — the one side that has the sight-holes — and aim the two sight-holes [?], [holding the instrument] upright [נצב] [?], toward the [celestial] bodies [הגרמים], aligning [them] in such a way [?] as explained above. Place [the instrument] near the pupil of your eye and look and sight along the edge of the instrument, through the perforation [?] of [point] **ג** [?], by way of point **א**. Raise and lower the center of the instrument — which is point **א** — up and down, until you see, through the sight-holes, the sun (or whatever other star) whose altitude you wish to know; and once you have caught it [?], hold [the instrument] firm, and look below on the numbered arc [to see] how many degrees the plumb-line

[300] the outer band is a degree limb marked every five degrees from five to ninety, numbered in Arabic figures where the prose around it uses Hebrew letters. This book's woodcuts are numbered in Arabic figures throughout — likewise the triangle on a later leaf and the mountain-and-tower figure — so a band of figures on a plate is not evidence of a series in the text.

[קו המשקל] cuts there — those are the numbers of the degrees of the altitude you sought to know.

And as for measuring the sun: since it is impossible for a person to look through the sight-holes straight against the disk [גלגל] of the sun, therefore know that you need not look with the pupil of your eye at the sun [directly], but only...

[Siman *רמ״ח* continues beyond this page.]

שער י״א (Gate 11) — the quadrant, instruments, and surveying (continued)

סימן רמ״ח (printed §248; logical §249) — [continuation: finding the sun's altitude with the quadrant]

you need only raise and lower the center of the instrument until the sun facing [the sights] passes through the two observation sight-holes [נקבי ההבטה]. Then look below at how many degrees the plumb-line (קו המשקל) cuts [on the graduated arc], and so forth — and that is the number of degrees of the sun's altitude (גובה השמש).

סימן רמ״ט (printed §249; logical §250) — that the determination of the stars' altitude is done in one of three ways

You should know that determining the altitude of the sun or of the other stars is done in one of three ways. The first: how high it stands above the southern horizon when it reaches the meridian [קו חצי יומם], and this is the chief object of precision [?]; [it serves] the investigation of the positions of the stars [מעמדי הכוכבים], and by this examination the astronomers scrutinize the motion and position [?] of a star. The second, likewise: how many degrees each star stands above the horizon — whether the western, the northern, or the eastern horizon. And the third: how many degrees the sun, or any of the other stars, gains in altitude at any moment as it revolves between the western horizon [האופק המערבי] and the meridian, and likewise in its descent — how many degrees it reaches as it revolves between the eastern horizon [אופק המזרחי] and the meridian. This [third case] requires more precision than the first two, and further [detail will be added] as it is described [below], God willing [?].[301]

סימן ר״ן (printed §250; logical §251) — to find how many [degrees] the northern pole [ציר הצפוני] rises above your horizon, in every place and every time

Finding [the altitude of] the northern pole is a matter of great and general importance, much needed — the cornerstone [אבן הפינה] [?] of the science

[301] the third method as printed puts the ascent between the western horizon and the meridian and the descent between the eastern and the meridian — reversing both the physical case and the second method a few lines above on the same page. Given as set; no reconciliation attempted.

of the stars and constellations, and [essential] for knowing all the places and boundaries of the terrestrial globe, of benefit to others [?]. I saw fit to set down in my book, in this place, the matter of finding it by four straight and pleasant methods.

The first method I have already disclosed, and we explained its procedure clearly above, at the end of the Second Gate, siman נ״ג (§53). But so that all four methods be found together, I saw fit to write this one a second time here as well. And this is how it is done:

Take, at the beginning of the revolution of a star, one of the stars that never set below your horizon — these being the stars near the northern pole [הסמוכים לקוטב הצפוני] — [to determine] the altitude of the pole above your horizon, or the [angular distance by which] your zenith [קדקדך] is distant [from it] [?], as [explained] above, siman [?]. Observe [ותשב] one of the recognizable stars [when it stands] to the east of the meridian line; and when the star revolves by way of the west and reaches the meridian [קו חצי יומם], where its altitude above the horizon is greatest, then measure with the quadrant how many degrees its altitude is above your horizon, and keep this number.

After some 12 [?] hours, when the star has revolved another revolution and reaches the meridian a second time — where it is now at its lowest [בתכלית שפלותו] — measure its altitude above the horizon likewise, and keep that number too. And half [מחצה] of [the sum of] the two kept numbers is the number of degrees of the pole's altitude above the horizon. An example of this: at its greatest altitude you found it 70° [ע׳ מעלות] above the horizon, and at its lowest 30° [ל׳ מעלות]; then the sum of the two numbers is 100° [ק׳ מעלות], [and its half, 50°, is the pole's altitude] [?].

סימן רנ״א (printed §251; logical §252) — another way to find the pole's altitude in every place — and it is quicker and easier

Take a star whose distance from the northern pole [מרחקו מציר הצפוני] is already known to you; take specifically one of the stars that never set below your horizon, as above. If the star you choose is found to the east of the meridian, keep [watching] it until [it reaches] the meridian, [and there] it is at its greatest altitude; measure how many degrees the star stands above the horizon, and subtract [?] its northern distance from [the number of] its altitude. And if the said star is found to the west of the meridian, keep [watching] likewise for its arrival at the meridian, where it is at its lowest; [there] add the number of its altitude to the number of its northern distance, and the result is what is sought.

An example of this: a star whose distance from the pole is already known to us — say the outer star of the Great Bear [שכוכב החיצון מדוב הגדול], mentioned above, siman כ״ד (§24) — its distance from the pole being [ל״ם] degrees and 43 minutes [מ״ג דקין] — and we found its light to the east of the meridian. Here in the city of Prague [עיר פראג], at its arrival at the meridian, where it was at its greatest altitude, we found it above the horizon 81 degrees [פ״א מעלו] and 22 minutes [כ״ב דקין]; there remains for us 50 degrees 6 minutes [נ׳ מעלות ו׳ דקין]

as the [pole-altitude] number. [At its lower culmination we found it likewise [some value [?]] degrees above the horizon; adding gives the same figure.][302]

סימן רנ״ב (printed §252; logical §253) — to find the altitude of the northern pole in the daytime, by the course of the sun on the days of the Nisan and Tishrei equinoxes [תקופת ניסן ותשרי], in every place, whether at sea or on land

On the day the sun enters — not [merely near] the equinoctial point [נקודת היושר], that is, but [exactly] at the beginning of the sign Aries [מזל טלה] or the beginning of the sign Libra [מזל מאזניים], which are the two days of the true equinoxes [תקופות השלמיות] — determine at midday how many degrees the center of the sun stands above the southern horizon; that [altitude] is at present [the sun's meridian altitude]. [Then subtract it from 90°, and] the complement to 90° [תשלום צ'] is the number of degrees of the northern pole's altitude above the horizon.

An example of this: here in the city of Prague [פראג], on the day [of the equinox] I found the sun above the southern horizon at [ל״ם] degrees and 24 minutes [כ״ד דקין]. Add [it] to make up ninety; the addition [i.e. the complement] is fifty degrees, seven minutes [חמשים מעלות שבע דקין] — and so is the number of degrees of the altitude of the northern pole [above the horizon at Prague].[303]

סימן רנ״ג (printed §253; logical §254) — to find the altitude of the [northern] pole in every place, by the course of the sun on each and every day of the year

Should you wish to know from it [the sun] the pole's altitude, take the meridian [midday] altitude of the sun on some one day, and consult the table [luach] to see the sun's distance [from the equator] — [its declination] on that day, and whether it is [north or south] [?]. [Adjust the meridian altitude by the declination:] if the sun is [then] in the southern signs [במזלות הדרומיים], [add] the number of its distance [i.e. declination] [to the co-altitude] [?]; and if it is in the northern signs, [subtract] it. [Working the sun back to the equator this way yields the equinoctial altitude, from which the pole's altitude follows as in the previous siman.]

And you should also know that this reckoning holds by way of [both] the mentioned known [stars] and [the sun] [?] — [these being valid] according to the astronomers, on the authority of the [observers] [?].

---

[302] the degree figure of the star's polar distance is set with a final form of its second letter and is not a well-formed numeral; it stands identically on both copies, so it is in the setting, and is given as printed, unemended. The same malformed figure is set at the following siman. Altitude and result are likewise as printed; no arithmetic is asserted among the four figures, the polar distance being unread.

[303] the altitude and its stated complement do not add to ninety degrees. The altitude's degree figure has a final form of its second letter, as at the preceding siman; the complement is spelled out in words beside a numeral. Both as printed, neither emended.

[Catchword, foot of p. 145: **כלפ** followed by two sorts left UNREAD — five sorts in all, of which sorts 4 and 5 matched none of the controls taken on a second reading of the leaf. The obvious completions (כלפני, כלפיו) are not recorded: they would be reason, not ink.]

[Line 1 of p. 146's right column, standing above the §253 rubric and absent from the edition entirely: [זוי ממעל להוסיף כאן עיר פראג **ונטעס אלב** דברי[ס/ם?]. The line names the city of Prague [**עיר פראג**] and, immediately beside it, a second name printed **ונטעס אלב** — letters as printed, ס-ע-ט-נ-ו then ב-ל-א. It is transcribed and deliberately NOT construed or identified. The first sort of the line is an over-inked blob and is not read; the final sort of ונטעס is a closed form not separable from a final ם, as is the last word דברי[ס/ם].]

סימן רנ״ד (printed §254; logical §255) — that every observing instrument, in every place, must be set [according to] the pole-altitude [of that place]

Know that all the measurements and devices that will be explained [below] to the wise are, in [their proper] time, [performed] with the quadrant instrument [כלי הרובע] — sufficient for all who share the same latitude [רוחב] of the world, that is, all who dwell on one [parallel] line. But in every place, from north to south, each and every one of them needs an instrument specific to the pole-altitude that obtains there. Therefore know that this whole quadrant instrument depicted [in the figure] above is made according to the pole-altitude that obtains here — [namely] at Prague [פראג], [where the pole is] above our horizon 50° 6' [נ' מעלות ו' דקין]; and further, [as stated below] in siman ר״ע [270], according to the [local latitude elsewhere it must be re-made].

[Know further:] when there comes into your hand an instrument like this — one such as you have never before seen — you will be able, from its very form, to determine and verify to what pole-altitude it was made [?].

סימן רנ״ה (printed §255; logical §256) — to inscribe on the face of the instrument three principal arcs: one [middle, for] the equator [Aries–Libra], one for Capricorn, and one for [Cancer] — and how much the sun's altitude is on each of them

Divide [?] [the graduated edge]. [The instrument's] arc-of-number [קשת המספר] runs from [0°?] to 90° in equal degrees [?], as [explained] above; and now measure [and mark] on the [instrument's] center: the arc ס״ו (66) [?] is for the circle of Capricorn [עגול גדי]; the arc מ״ט (49) [?] is common [מצורף] to two circles — the circle of Aries and Libra [עגול טלה ומאזנים, the equator]; and the arc כ״ג (23) [?] is for the circle of Cancer [עגול סרטן].

[The three arcs are set out and continue with the meridian construction of the next siman.]

סימן ר״נו (printed §256, the mark set between sorts 1 and 2 and sitting high; logical §257) — to inscribe on this quadrant instrument the arc of the meridian line [קשת קו חצי יומם]

After the greatest altitude of the sun on each of the three [reference days] has become known to you — as the sun arrives at the three points [the two tropics and the equator] mentioned above — now set about inscribing on a quadrant instrument like this the arc of the meridian line. And this is how it is done:

Below, on the arc-of-number, at the [degree-]mark corresponding to the altitude-value, [set the plumb-line] true at the head of Capricorn [ראש מזל גדי] — which is at [degree] 66 [?] — [as in the diagram], and at the point [?] where the plumb-line cuts the arc of Capricorn (which is arc 66, already drawn there), make a mark; let it be point מ״ז [?]. Likewise draw the plumb-line to the degree-value of the sun's altitude at the head of Aries or Libra [ראש טלה או מאזניים], which lie on the equator [קו היושר], the degree [on the arc-of-number] being [ל״ט / 39 [?]]; and where this line cuts the arc of Aries–Libra (which is arc 49 [?], the equator itself) make a second mark; let it be point פ' [?]. In the same way draw the plumb-line on the arc-of-number to degree 24 [?], which pertains to [the sun] when it is at the head of Cancer [ראש מזל סרטן]; and on the arc [66/23?] assigned to Cancer make a third mark; let it be point ת' [or ח'] [?]. Then draw one arc from [these marks] — an arc which corresponds to the meridian [חצי היומם] line. And in the same way you shall investigate the arc of the remaining signs, from which the sun's altitude on all the days of the year becomes known to us, as will be explained further below, God willing.

סימן ר״נז (printed §257, the mark set between sorts 1 and 2; logical §258) — to describe with a compass one circular arc that will pass through any three [given] points, whatever their configuration, provided they do not all lie on one straight line

Although this is not really its place at all, nevertheless — for the benefit of the work [of instrument-making] in this place, which we require — [I set it down here]. [To teach the students the reality of this matter, let us give an example.]

Diagram. A compass construction for passing a circular arc through three given points that are not collinear. Two large intersecting circular arcs form a pointed-oval (vesica) shape rising above a lower circle; short chord-arcs cross near the top and the sides, marking the intersection points from which the center is found. Label census: EIGHT labels — א at high confidence; ב / ד / ח / ג at moderate confidence; two UNNAMED; and one at low confidence. The figure carries no graduations and no numerals. It crosses the gutter: the left column narrows from ≈1001 to ≈708 B-px beside it, and the right column is replaced entirely below y1690.

Construction. A full circle crossed by two large arcs that rise well above it and cross, so the figure reads as a circle with two pointed lobes, plus a smaller lens inside the right lobe. The cut is printed inside §257 and is the figure for the siman's construction.

Labels on the block — eight point-letters, **א–ח**:

label	position
א	right flank of the circle, rotated ~90°
ב	apex, top centre, upright
ג	lower-left flank, rotated ~90°
ד	top right, at the tip of the right lobe, upright
ה	inside the right-hand lens, below its lower cusp
ו	left flank, at the crossing of the two arcs
ז	bottom centre-left, just under the arc
ח	bottom centre, at the cusp where the two great arcs meet

- ה is set rotated and reads as three separate strokes, the detached left leg identifying it.
- ו is the one uncertain sort. The reader's hedge, verbatim: "a single letter with a short left-extending head and a slanted right-hand descender, the same family of shape as ר/ד. It is not the same cut as the ד at the top right of the very same woodcut, whose head is about twice as long and carries a tag; measured against that control on both witnesses (B at 3.4× and 7.6×, N at 6.8×) the left-flank letter's head is roughly one stem-width, which is what ו measures in this fount. Read as ו, but a reader who wanted to call it ר/ד would not be contradicted by the ink alone."[304]
- No numerals and no graduations anywhere in the figure, so the graduation-numeral caution that applies to the p.142 and p.144 quadrants does not arise here. No text is set on the curve; no label sits in the outer margin.
- No eccentricity or centre value is reported for the construction: the least-squares fit is contaminated by the two arcs, and a second reading of the leaf declines to publish a number from it.

Let the three given points be ח, ב, ג, already drawn there. To describe an arc or circle passing through all three: set one leg of the compass at point ח, and with a wide opening set the second leg to swing an arc through [more than half] the interval toward point ב, marking there; keep the compass open at that setting, place one leg at point ב, and with the other leg reversed [swing] toward point ח [א], drawing a second arc. The two arcs cut one another at point ד and at point ה. Do the very same thing between the [other] two points, that is between point ב and point ג, and the places where those two [next] arcs cut are point ו and point ז. Then draw two straight lines — the one through ה–ד and the second through ז–ו — and the place where the two lines cut one another is point א; there is the center of the [required] arc or circle. Set the fixed foot [חוד] of the instrument at the center, which is point א, and widen

[304] this cut is a page-foot block running under both columns; a rubric stands above it on the right and another above its top edge on the left, and nothing is printed beneath it.

[the compass] to the distance of [any of] the points ח, ב, ג, and describe a circle or arc: its course will pass through all three points.

סימן רנ״ח (printed §258; logical §259) — to know the sun's altitude at the head of each of the 12 signs of the firmament [מזלות רקיע]

When we scrutinize and investigate, through the three arcs [drawn above], the heads of the [remaining] signs, to find how many degrees the sun's altitude is in each and every sign, you must first know that the sun [as a fixed measure] [?] — that is, that the work I am doing is always to one measure and gauge; it neither lags nor hastens in its revolution from one time to another. Nevertheless, [the values of] the sun's altitude at the head of the [several] signs are not [all] near or [all] far, [equally spaced] on the meridian by a single measure and ratio; for sometimes the difference in altitude between one sign and its fellow is only three degrees and a half [רק ג׳ מעלות ומחצה], and sometimes the difference is found to be about eleven degrees and a half [כמו י״א מעלות ומחצה] — all according to their nearness to, or distance from, the heads of Capricorn and Cancer [ראשי מזל גדי וסרטן].

[We divided the circle by its points into equal parts, marking on each point the name of a sign, and reckoned it out] [?] — the signs nearest Capricorn [being] more crowded [in altitude] than the rest [?], and [the others spaced] as they are drawn in the [figure of the] circle. This you shall test and see, as depicted in the circle [כצורה שבעגול].

Diagram. A two-circle figure — an outer and an inner circle, concentric (any offset is within drawing tolerance and not a designed eccentric), enclosing an annulus 8.2 mm wide. FIVE chords cross the inner circle; they run very slightly off the horizontal, the leaf being a little skew. Inside the inner circle the ink falls into three label bands with two zones POSITIVELY EMPTY (zero ink). The outer circle is BROKEN — one connected component over 296°–204°, and empty over roughly 205°–295°, with separate displaced fragments below; the break stands at the same angles on both copies of the book, so it is in the block itself and not an accident of reproduction. Whether it is a cracked rule or a deliberate break is not claimed. The figure crosses the gutter and narrows the left column beside it by about 15 %, recovering below. Caption above the figure: **כמו שתראה [ב/כ]צורה** (”as you will see in the figure”).

Labels on the block — read at 8–20×, each rotated upright before reading, checked on both witnesses. The zodiac labels are set horizontally; the two annulus labels are set tilted along the arc and were rotated individually (−12° and +10°), never as a set.

position	label
Zone A, right	קשת (Sagittarius) over עקרב (Scorpio) — secure
Zone A, left	דלי (Aquarius) over דגים (Pisces) — secure
Zone B, right	מאזנים (Libra) — secure
Zone B, left	טלה (Aries) — secure

position	label
Zone C, right	בתולה (Virgo) over אריה (Leo) — secure
Zone C, left	שור (Taurus) over **תאומי** (Gemini — printed defective, with no final mem; left unnormalised) — secure
annulus, bottom	סרטן + [ס]ד/ר (Cancer)
annulus, top (the position opposite סרטן, where a zodiac ring would want Capricorn)	**י[ד/ר]י** — NOT **גדי**. See the note below.
annulus, right ~2 o'clock	two sorts — UNREAD (tilted, rotated, still unread)
annulus, right ~4 o'clock	**נא**, no abbreviation mark — secure
annulus, right ~5 o'clock	ס (single sort, closed ring) — secure

- A candidate mark in the top-left annulus was WITHDRAWN — resolved on the pixel map as arc, not type.

Chord census (the cold sweep, C035). The figure is a circle inside a second, outer circle, crossed by parallel chords, each band labelled at its right and left ends with a pair of signs of equal declination, and a few numerals standing in the annulus between the two circles:

band (top → bottom)	right label	left label	numeral in the annulus
1 (top cap)	**?די** — see note	—	—
2	קשת	דלי	a two-letter numeral formed of כ and ד
3	עקרב	דגין	—
4	(blank band — no labels)		—
5	מאזנים	טלה	—
6	בתולה	שור	**נא** = 51
7	אריה	תאומי′	ס = 60
8 (bottom cap)	**ס״ד סרטן**		סד = 64

305

By this scrutiny — as you shall test and see, in the figure of the circle — you find the altitudes, and you have to note the recognized measures. [At Prague, above our horizon, by a pole-altitude of ~50°…] [?] the sun's meridian altitude at the head of each sign is:

[§258 prints no ruled table. What follows is the siman's own PROSE LIST of altitudes, set in the right column below the figure, tabulated here for the reader.]

[305] the diagram pairs signs of equal declination at the two ends of each chord and carries a few numerals, none of them marked, in the ring between its two circles; one band carries no labels at all. The top band's label is three sorts: the sense wants Capricorn, but on both copies the first sort is a short-stemmed letter, not the one that name needs. Given as printed.

Sign (head of)	Meridian altitude at Prague (as printed)	Note
Capricorn (גדי)	16° 30′ [ט״ז מעלות ומחצה]	lowest (winter solstice)
Aquarius (דלי)	20° [עשרים מעלות]	
Pisces (דגים)	28° 30′ [כ״ח מעלות ומחצה] [?]	
Aries (טלה)	40° [מ׳ מעלות]	equinox
Taurus (שור)	21° 30′ [כ״א מעלות ומחצה] — as printed; [recte: **נ״א** = 51]	breaks the ascending sequence; carried as printed
Gemini (תאומים)	60° [ס׳ מעלות]	
Cancer (סרטן)	64° [ס״ד מעלות]	highest (summer solstice)

[Continuation of §258:]...as you will now see, eye to eye, that the near and the far [signs] in the circle are all equal in their spacing one from another, [reckoned] from the meridian line according to the run of the chords one from another [?]. And this is why the signs Aquarius and Sagittarius [דלי וקשת], which incline to the oblique [לאלכסון], do not stand far from the region of Capricorn [מקצת גדי] — only about thirty degrees and a half [רק כמו ל׳ מעלות ומחצה]; whereas Pisces and Scorpio [ודגים ועקרב], since they incline to the oblique yet further, stand further off. In the circle, Sagittarius and Aquarius [קשת ודלי] approach one another by about eight degrees [ויתקרבו לכו כמו שמנה מעלות]; and the signs Aries and Libra [טלה ומאזנים], which incline still further to the oblique [שנוטים עוד יותר לאלכסון], approach — from the circle of Scorpio [מעג״ל עקרב] — by only sixty-one degrees and a half [ס״א מעלות ומחצה]. [?][306]

As a general rule, know: the more precisely one [computes], the [truer] the sun's meridian altitude at the head of each and every sign [becomes]. [The correspondences are:] Cancer with [the summer band], Taurus with [Virgo?], Aries [with Libra] at the equinoctial band, Scorpio with Pisces, and Sagittarius with Aquarius [each pair sharing one declination-band]. All this you shall test and see, as [depicted] in the figure. And you have to note [?] the recognized measures — [reckoned] by a pole-altitude of [50° [?]] above our horizon here in the city of Prague [פראג], as [holds] for all who share our latitude [ברוחב] — that is, those who dwell [on our parallel] [?].

סי׳ רנט (printed §259 with no gershayim at all; logical §260) — how the arcs of the signs [קשת המזלות] are drawn on this quadrant instrument

Make, against the right [side] of the instrument, near its edge, two parallel lines [שני קוים מקבילים], set apart [?] a little less than [a certain distance] according to the [width] [?]; and let the lines run from a little [above] Capricorn and descend downward, passing crosswise [דרך שתי וערב, "warp and weft," i.e. transversely]

[306] the sentence names three pairs of signs and gives a figure for two of them; the second has its marks split across the two letters and reads as sixty-one and a half, where the siman's own list of altitudes would want eleven and a half. Both figures given as printed.

over the arc of the circle of Aries [קשת עגול טלה] until they reach the circle of Cancer [עגול סרטן] — [at the marks] כ״ה [?], ז״ח and ט״ל [?] [that are] in the figure above. Apart from these two lines, mark crosswise the place of the head of each and every sign...

[The construction of the individual zodiac-arcs on the instrument continues; the operative letters/numbers of the marked points are heavily garbled here — the sense is the transverse ruling of the twelve sign-heads across the three principal declination-arcs already drawn.]

You divided [the graduated arc] into equal parts, marking on each point the name of a sign, as the astronomers do; and the place of each is fixed [מקומו כל היום] [?]. Only [the belt of] the signs [inclines] according to the [obliquity]: on the arc [?], and the signs are drawn true [?], [each] to [its] left [and right] [?], the northern [signs and southern signs at their respective marks: ל״ד ש״ן ק [?]]. [When the sun is in any given sign, being in the firmament,] draw the meridian line [קו חצי יומם] [?] — the same lines, ל״ד [?] — and the signs [are set out]...

[The remaining lines of this siman detail, for the sun in each sign, drawing the meridian arc to the marked degree, and are too garbled to render word-for-word; they conclude that from the figure one may read off the sun's altitude at any hour and in any sign, for the days of the year.]

Gate Eleven [שער י״א] — continued

[Continuation of §259 (printed רנ״ט; logical §260).] …[the reckoning] varies, as will be explained shortly. Know, too, that the signs from the head of Capricorn through the end of Gemini are marked and reckoned [on the quadrant] as descending from above downward [ממעלה דרך מטה], whereas from the head of Cancer through the end of Sagittarius the rule is reversed, for they are marked and reckoned as ascending from below upward [ממטה דרך מעלה]. All of this you will find properly laid out, in accordance with its rule, in the form of the quadrant, as above.[307]

§260 [printed סימן ר״ס; logical §261] — Finding the place of the sun among the signs by means of the quadrant, at any time, on any day of the year

Be precise at the very moment of noon, for that is when you must seek to know its place. Sight [the sun] straight against the [line of the] sun[?] until it comes to rest[?] on the two threads of the sight-vane, and observe at which place [of the zodiac scale] the plumb-line cuts across the meridian line — which is line פ״ת–׳מ [?], as above, as in [siman] רכ״א[?] [231?] above. Note the graduation-mark on the plumb-line[?] that rests upon the meridian line, and transfer[?] the bead that is on the plumb-line, as above, as in [siman] רע״ו[?] [276?]. Draw the

[307] the directions are as the leaf assigns them, though the assignment runs against what the rising meridian altitude of those signs would lead one to expect. Not emended.

plumb-line toward the right side[?] to the place of the signs, and at whatever place and degree of the zodiac the bead reaches — that is the place of the sun. For example: suppose the cutting-point[?] falls[?] at the place [numeral: ?] from the meridian line; there transfer the bead and draw the plumb-line to the places of the signs, and you will find the bead falling[?] on the flattened arc at the beginning of Scorpio[?]. [Several tokens of this passage — the specific siman cross-references and one worked-example value — are abraded and are flagged; the procedural sense above is committed.]

[A body numeral **פ״ה** = 85 stands in the right column of p. 149, on the line reading **קו חצי יומ[ם/ס] שעות קו ק׳ פ״ה** ("the meridian line … hours … line ק׳ … 85"). No 85 appears anywhere in §260 as published, and the clause it belongs to was not read; it is recorded here as a present-and-unplaced value rather than worked into the prose.]

§261 [printed **סי׳ רס״א**; logical §262] — To find, on any day of the year, how far the sun has moved, and [how far] every star [stands] from the line of rectitude [the equator]

By the general rules already stated for [finding] the altitude, in siman **רנ״ח**[?] [258?], in exactly the same way you may know [how far] any star's altitude [stands]: a star whose[?] altitude is [numeral: ?], as against the [known] course of the sun, [and its] rising and setting on that day, so that you take the star's altitude and compare it: how much is that [altitude] above or below[?] the number of degrees the sun's altitude reaches — [that is] the star's distance from the sun, and this you learn from the tables[?] of the star's altitude.

[Continuation of §261, top of the left column, p. 149.] …degrees. [The siman first fixes the equator's altitude at Prague:] the crookedness of the altitude of the line of rectitude … is, for those who dwell at Prague, forty degrees [**מ׳ מעלות**]. And when we found the altitude of one star above our horizon at fifty degrees [**חמשים מעלו**', spelled out], we knew from this that the star's distance and its declination from the line of rectitude toward the south [**לצד דרום**] is ten degrees [**יו״ד מעלות**]. And when we found the altitude of another star, for example, at thirty degrees [**שלשים מעלו**', spelled out], we likewise knew that its distance … toward the north [**לצד צפון**] is ten degrees [**יו״ד מעלות**].[308]

§262 [printed **סימן רס״ב**; logical §263] — To know the distance of any star from the point of your zenith [**נוכח נקודת קדקדך**]

Thus: the star whose distance you continually wish to know and to observe — set your heart to it. Sight it at noon [at the meridian line] and observe its altitude; then, from the number of altitude-degrees, subtract from 90[?], and this remainder is [the star's] distance from your zenith, [measured] on the

[308] the magnitudes close twice, but the direction-words run opposite to what the two altitudes imply — the star higher than the equator is called southern, the lower one northern. The distance figure is a letter-name spelled out in both places, as §210 also sets it, and is ten, not fourteen. Given as printed.

sphere set toward[?] the globe of the earth, as far as[?] the star's…. And to know how many parasangs [פרסאות] this distance is — for every degree [of the sphere corresponds to] some number of parasangs, and it is necessary [to reckon] how many parasangs there are — this distance you must multiply: the aforementioned distance, 15 times 60[?], yields 900 parasangs. [Arithmetic check: 15 × 60 = 900 ✓.]

§263 [printed סימן רס״ג; logical §264] — To know, when the sun enters the head of each sign, how high each sign stands above the horizon at every single hour of that day

The altitude of the sun above the horizon on the day it enters the head of each of the twelve signs of the sky, at noon [half-day], has already been explained above in siman רכ״ח [228]; and now we shall explain how to know the altitude of each sign.

[Should] you seek to know the altitude of the sun one hour after noon — and the hour is already known to you — [proceed] in the manner explained above in siman רכ״ח [228], namely, that the sun's altitude above your horizon on the day it enters the head of the sign Aries is [set at] 40 degrees [מ׳ מעלות]; therefore [transfer it to the instrument] [?] …[309]

And I saw fit to set out for you a small table [לוח קטן], by which you may know — with no reckoning at all — the altitude of every sign at every hour of the day, from morning to evening. And the boxes in which the signs are marked are only seven, because five of them are pairs of signs equal in their altitude, as stated above in siman רכ״ח [228]. Know also that in [every] pair of hours of the day the altitudes of the sun and of the signs are equal [?] … [The table appears on the facing page.]

[The siman closes at the foot of the column — the operative instruction, four lines:] …[Aries] holds forty degrees. Therefore shift and draw the plumb-line [ע״כ תעתיק ותמשוך את קו המשקל], together with the beads [מרגליות] [[that are on it]], until it meets the arc of the hour after noon. Then look below, upon the arc of the [[מספר/מספח — unresolved]], to see how many degrees the plumb-line cuts upon it; and you will find an altitude of [[36/37]] degrees [ל״[[ו/ז]] מעלות]. And in this same way you shall work exactly and find the sun's altitude at every hour [וכן עד״ז תדקדק].[310]

Table. The altitude of each zodiacal sign above the horizon at each seasonal hour of the day. The table is arranged in seven bands, one per sign or symmetrical sign-pair (paired by equal noon-altitude), each band having a degrees

[309] this siman refers back three times to a siman numbered two hundred and twenty-eight — the siman on the moon obscuring a larger body, nothing to do with sign altitudes; the material actually meant is §258. Both copies agree at all three places, so the wrong number is the edition's own and is given as printed.

[310] the instrument is a quadrant — a suspended plumb-line, sliding beads, an hour-arc, and a lower graduated arc which the line cuts. Three words of the procedure do not resolve and are left unrendered rather than supplied.

row [מעלות] and a minutes row [דקין] running across the day's hour-columns. The sign-labels stand at the left of each band and carry that sign's meridian (noon) altitude; two footer rows of Arabic numerals index the hour-columns (the morning hours ascending and the afternoon hours descending, symmetric about noon). The table reads right-to-left in the source: the right-hand column is the eighth hour from noon and the left-hand column is noon itself, so each band's values climb from left-hand-column sunrise altitude to the sign's meridian altitude. The bands are not locked to a common left-hand origin — each sign's row begins at its own first column of visibility, so Cancer fills nine columns, Gemini/Leo eight, Taurus/Virgo and Aries/Libra seven, and Capricorn only three.

The degree-rows are given below as printed, in right-to-left order. The minute-rows are printed beneath them; their individual cells are legible but their alignment to the degree-columns is not secure in every band, so they are listed as a sequence rather than paired cell-for-cell, and the cells that cannot be read are left flagged.

Sign(s)	Meridian (noon) altitude	Degrees row [מעלות], right → left	Minutes row [דקין], right → left
Cancer [סרטן]	63° [ס״ג]	סב · ס · נד · מה · לו · כז · יח · ט · א (1, 9, 18, 27, 36, 45, 54, 60, 62)	ל · ט · ד · נג · מו · [[יז/יח]] · יוד · יג · [[נ/ג]] (13, 10, [[3/50]], [[16/17]], 46, 53, 4, 9, 30)
Gemini / Leo [תאומים / אריה]	60° [ס']	נט · [[ז/ו]]נ · נא · לד · לד · לד · טו · ו (6, 15, 34, 34, 34, 51, [[56/57]], 59) — the three consecutive לד cells are set as three identical sorts on the leaf and are given as printed	יב · א · ח · יט · טו · לד · ו · ל (30, 6, 34, 15, 19, 8, 1, 12) — [311]
Taurus / Virgo [שור / בתולה]	51° [נ״א]	נ · מח · מג · לו · כז · יח · ח (8, 18, 27, 36, 43, 48, 50)	ל · יד · לה · יד · [[ז/ו]]ל · [?][[טז/מן]] · נה
Aries / Libra [טלה / מאזנים]	40° [מ']	לט · [[ז/ו]]ל · לג · כו · יח · ט · נ (50, 9, 18, 26, 33, [[36/37]], 39) — the opening cell is set as נ (50) in a band whose meridian altitude is 40°; given as printed. [312]	[SLOT EMPTY] · כו · ב · כו · יב · יט · [SLOT EMPTY] — 7 degree-columns against only 5 minute-values; the first and last דקין slots are blank on the leaf

[311] the two scans positively DISAGREE at this sort and NEITHER yields ח: the bitonal gives a two-run form (ת) and the greyscale a one-run form (ה). 8 is unsupported by either witness.

[312] a second reading of the leaf left this sort OPEN as [[נ/ב]] at 7.49×. The "confirmed as printed" claim made twice here is not corroborated, and the anomaly resting on it is therefore not established either.

Sign(s)	Meridian (noon) altitude	Degrees row [מעלות], right → left	Minutes row [דקין], right → left
Pisces / Scorpio [דגים / עקרב]	28° [כ״ח]	ח · ח · ט[[ז/ו]] · כב · כו · כז (8, 8, [[15/16]], 22, 26, 27) — [313]	א · [[מד/מו]][[?]] · יד · יז · ט · ל
Aquarius / Sagittarius [דלי / קשת]	20° [כ׳]	א · ח · יד · יז · יח (1, 8, 14, 17, 18)	ט · [[ה/ח]] · ד · לו · מח (9, [[5/8]], 4, 36, 48)
Capricorn [גדי]	16° [ט״ז]	ה · יוד · יד (5, 10, 14)	לח · נח · [[ד/ך]] (38, 58, [[20/4]])
Hour-index (footer row 1)	—	printed Arabic, left → right: [[12/21]] · 1 · 2 · 3 · 4 · 5 · 6 · 7 · 8	
Hour-index (footer row 2)	—	printed Arabic, left → right: 11 · 10 · 9 · 8 · 7 · 6 · 5 · 4 — [314]	

[315]

§264 [printed **סימן רסד**, with no abbreviation mark; logical §265] — The reckoning of the hours[?] of the day by the sphere-instrument [כלי הכדור], and that their reckoning begins from noon

Root [principle]: Keep this in mind, to reckon and to instruct with this instrument in matters of the hours: [as with?] a matter [numeral: ?], the beginning of each day… [The intervening clauses of the opening are abraded and flagged.] …so that it may be set right[?] toward its [proper] place, and toward the correspondence[?]…

[313] same class as the Gemini/Leo minutes cell — the two scans disagree at this opening sort and neither gives ח. A second reading fixed the ח/ה discriminator on this leaf as VERTICAL INK RUNS in the leftmost sixth (one run = ח, two = ה), and found WIDTH decides it wrongly here: two sorts of w38 on this leaf are one of each.

[314] ⚠ THIS FIGURE IS THE ONE BROKEN SORT IN THE ROW, AND 5 IS EXACTLY WHAT THE ARITHMETIC PREDICTS.** The two footer rows are complements — every column of rows 1 and 2 sums to 12. A second reading read every digit of both rows, noticed the complement pattern only afterwards, found this sort broken, and refused to supply it from the sum, recording [[5]]. Whether or not 5 is right, it is not established by the ink, and a value that closes an arithmetic is the class this edition has been caught filling before.

[315] eleven cells of this table carry a choice between two readings rather than a single value: two independent readings of the leaf differ there, and neither is preferred.

[Continuation, left column, p. 150.] …the setting of the sun, and the midpoint of the hours of night… the rising of the sun in the east[?], and the fourth quarter[?] [is] noon of the day. Enclosed in these [reckonings] you will observe a great disagreement and divergence of opinions, and a great confusion, and much difference between the custom of one country and another. We have already spoken of them in the gate where we began[?] our reckoning, earlier[?], in Gate 4[?], siman ק״ה[?] [105?]. Therefore know that most of our astronomers[?] have found it fit[?] to begin the reckoning and numbering of the hours from noon of the day, and upon this foundation the Ashkenazim have fixed their clock-hours[?] [שעות] — [reckoned] from the timepiece[?] that indicates the sun for us, [numeral: ?]… a timepiece made from a [gear-]wheel[?]. [Several proper terms in this passage are abraded and flagged; the topic — the dispute over when the day's hours begin, and the German practice of counting from a mechanical clock — is committed.]

[Foot of p. 150: the leaf's last ink is a word standing alone toward the left end of the left column — the catchword position — five sorts, fully measured and UNREAD (three ל-class tall stems, the rightmost a wide counter-bearing form). It is left unread; no completion is supplied. A second reading of the leaf adds a caution: the right column carries a parallel single-word final line, and a leaf has only one catchword, so at least one of the two is a paragraph's short last line set left.]

[Continuation of §264, top of the right column, p. 151.] …the sphere[?] and its brass[?] and the star, by the weights[?] and by the power of the counter-weights[?], and it announces[?] the number of the hours, and it begins to count from noon up to חב״ג[?] and so on, up to 12 hours; and at its completion[?] hour [numeral: ?] and the moment of noon; and likewise at hour 22, the moment of midnight. Upon this foundation the instrument [numeral: ?] is made. And now you will know: when you find [the hour] marked on the instrument, and it is [numeral: ?] — those are the hours [named?] "before-noon," reckoned from midnight; and if [it is] also "after-noon," reckoned from midday. Know, too, that there is some hesitation[?] regarding the hours of the day, from which one begins the reckoning: for example, on Shabbos one begins its reckoning from noon of the day before Shabbos — that is, from noon of the sixth day (Friday) — which is 6 hours before our [ordinary] starting-time; whereas the [others?] hold[?] that their reckoning begins from noon of Shabbos day, which is 18 hours after our starting-time. They have not stated the matter correctly[?].

§265 [printed סימן רס״ה; logical §266] — Graduating the arcs of the hours [קשתי השעות] on the quadrant

Know that as regards constructing the arc of the meridian [half-day], by the method explained above in siman [ר״ס?], in exactly this same way, by the aforementioned procedure, is the constructing of the arcs of all the hours of the day done. How? At the fifth hour after noon we take the sun's altitude — we found it, on the day of the winter solstice [Tekufat Teves], when [the sun]

circuits at the head of Capricorn, [to be] 13 degrees above our horizon. We draw the plumb-line down to the number-arc, to degree 13, and at the place where this line cuts across the arc of Capricorn we make a mark. Likewise take the sun's altitude at the hour after noon at the time of the [summer] solstice[?], when it circuits at the head of the upright[?] circle — that is, on the straight [equinoctial] line, when it stands at the head of Aries — and make a mark there, as at siman ב'[?]; and so on [for the successive hours]. And draw the arc[?] on the three reference-points [נקודות], in every manner just as you observe them for the arcs of the signs[?], on the arc [of the] half-day [meridian], the arc מ״פת [?], as stated above; and so on. Make, and graduate[?], the arcs of all three [reference] arcs — Capricorn's[?] and Cancer's[?] falling at the second hour[?]; so that, after noon, [you graduate] all three arcs [named] "heads," at hour ג'–ד'–ס'[?] up to hour ח'[?].

Behold, it has been explained to you how to graduate the hour-arcs from noon of the day up to night; and I have graduated the hour-arcs of the past hours[?] of the day. Why is it necessary to graduate and place[?] each of them separately[?] at [its] hour? Because after noon, at the arcs [named] "heads," their placement[?] must be set at the hour, just as before noon; because the times[?] the sun rises in their altitudes above the horizon, and likewise in the remaining hours[?], as when their altitude [numeral: ?] is above the horizon — as they [stand] before noon, so they [stand] after noon. And now you know: after [subtracting?] degrees, and their number [numeral: ?]… the marked signs[?] drawn on the plumb-line down to the number-arc [numeral: ?]; and so is the rule at [numeral: ?] and at [numeral: ?], and so [at] each [numeral: ?] and so [at] each [numeral: ?] of the numbered [marks]. All these varied [marks] are shared in one arc[?], as you will see in the form of the quadrant.

§266 [printed סימן רס״ו; logical §267] — That not every hour-arc is always constructed by all the mentioned arc-heads

Know that with the arc of Capricorn on the instrument you cannot use it for graduating[?] the hour-arcs [for more than] 24 hours[?] after its noon, for that is the measure of its half-day [as measured?] by the sun on its arc. Therefore know: when the hours may be placed[?] on the arc of Capricorn — even[?] when the day lengthens and the sun tarries above the horizon after [its] rising, 20 hours and more[?] — then you make the hour-arcs by the two arc-heads, Capricorn and Cancer, that is the arcs of Aries[?] and Cancer, and you proceed with the marks by the aforementioned procedure. And because, when the sun is on the line of rectitude [the equator] at the head of Aries or Libra, its day lasts only six hours after its rising[?], therefore[316] when you finish[?] the hour-arc from the Aries-arc — that is, when the sun tarries above the horizon [numeral: ?], seven hours[?] after noon — you draw the two lines according to the measure of the sun's altitude in them; and the seventh[?] arc, together with the [equinoctial] circle[?], or the arc of Taurus and Virgo, and the arc of 40°,

[316] the six hours here are spelled out, where every other figure in this siman is set as a numeral.

will be near[?] their horizon. All these matters, [being] the ones mentioned, you will see plainly, "eye to eye," above; and it is drawn in the form of the quadrant depicted above.

---

§267 [printed סימן רס״ז; logical §268] — To know the time of the sun's rising and setting, and the measure of the length of the days and nights throughout the year

When[?] you know the place of the sun among the signs by the method explained to you above in siman רל״ח [238], then the reckoning of the aforementioned matters at the time the sun enters the heads of the signs is a very easy thing, requiring neither measurement nor computation, for this is already marked on the hour-arcs at their beginnings[?] on the left[?], up to the beginning [of the arc]. And when the sun's altitude is joined[?] to arc ה[?], from the arc of the signs, at the point[?] [numeral: ?] which is at the end of the arc — a table[?] is filled with the numbers of the hours[?]… [Pisces?] or Scorpio[?] its[?]… shared at the arc [numeral: ?], at the point[?] where the sun[?]… at the seventh hour[?] which is below in the number-arc [numeral: ?] and so on. Behold, [thus] you take the number of the hours: as when the sun stands at the head of Aries[?], its rising is 7[?] hours from midnight and its setting 5[?] hours after noon[?]; so that, by this, the length of the day will be [numeral: ?] hours, and to complete the 24 hours, the length of the night will be [numeral: ?] hours. And so is the rule at the remaining heads of the signs. And when the sun is not [exactly] at a sign's head but has entered [some] known degrees into the sign, then you judge by the proportion of the degrees between the two adjacent sign-heads — the one below and the one above [it] — and further[?], set opposite the arc of the signs[?].

[Note: the source line for the day/night example gives day and night lengths that must sum to 24 hours; the individual figures are worn and are flagged rather than committed.]

§268 [printed סימן רס״ח; logical §269] — To know, on any day, whether it is the time before noon of the day or after noon

Simple: [the body continues at the head of the next page].[317]

[Continuation, right column, p. 152, headed "**הוספת**" — Supplement.] We reckoned this only when the sun is near the meridian line [line of the half-day]; but to know this matter you must [take] a second sighting[?] of the sun's [altitude] by the method explained to you above, and remember the number of its altitude. Then, after a little while — for instance, after a tenth part of an hour — seek a second time the sun's altitude, and remember that altitude too. If

[317] Catchword, foot of the left column of p. 151: four sorts, none of them read. A–C each show a roof, verticals and a closed base; D, the final letter, carries a descender below the others' baseline, consistent with a descending final form (ץ / ף / ך / ן / ק) — which is not named. No word is supplied.

the [second] number is greater than the first, know that [the sun] has risen and has not yet reached the completion[?] of the meridian, and so it is [still] before noon of the day. And if the reverse be the case — [the second] less than the first — it is known that [it is] after noon. The reason for this matter, to make it plain: it is already known that before noon the sun rises higher and higher, and after its noon it descends lower and lower [numeral: ?]…

§269 [printed סימן רס״ט; logical §270] — To know, at any time, how many hours of the day have passed

On the day you wish [to reckon], be precise to know: seek with the instrument the place [numeral: ?]… of it, [where] the sun [stands]; on that day, for example, take [its altitude?] by the procedure explained to you above, as in siman רל״ח[?] [238?], in the fourth[?] quadrant of sign ט״ה[?]. Therefore, drawing[?] the plumb-line[?] over the signs' marks, set the bead on the aforementioned place of the sun; then extend the thread and set the instrument[?] toward the sun until the second[?] [reading?]… Within[?] the arcs, where the bead of the plumb-line[?] falls[?] below in the number-arc[?] — the number [numeral: ?]… below[?]… [that is the count of the hours that have passed]. [This siman's numerical particulars are worn and are flagged; the procedure — sighting the sun, setting the bead to the sun's place, and reading off where the bead falls among the hour-arcs — is committed.]

[A second worked example stands in this column and is absent from the edition: דמיון אחד כשהחמה במעלה ט״ו ממזל שור — "one example: when the sun is at degree 15 of the sign Taurus [*שור*]." Its continuation was not read and is not supplied.]

§270 [printed סימן ר״ע; logical §271] — To know how high is the axis [the pole] upon which the quadrant is made [i.e., the pole-altitude = latitude]

We have already explained above that every regional instrument must be set right[?] for the place according to the altitude of the axis [pole] there. Now, [suppose] a quadrant [numeral: ?] is likened[?] to your hand and you do not know at what altitude [it is set] — how is the altitude of the axis of the place upon which it was made to be learned by you? Take the point where the meridian line [half-day line] intersects — as above, the arc מ״פת [the meridian] with the arc of the sign Aries [the equinoctial line], which is the marked[?] line — [and] as in the figure above, [with] point[?] ט'[?] as before[?]; then understand the plumb-line, and see how many degrees the plumb-line cuts below on the number-arc.

[Continuation, p. 152 — the full-width block at the head of the leaf, not the two-column setting below it.] And you will find 40 degrees. You know from this that the arc of the sign Aries, which is the line of rectitude [the equator] itself, rises above your horizon on the southern side forty degrees [מ׳ מעלות]; and since it is already known that from the horizon to the point ככח ראשך [the

crown of your head — the zenith] there are ninety degrees [תשעים], therefore add to the number [ה״מ] to complete [[[צ/נ]]' — fifty or ninety; the printed sort is not settled], and the result [editorial: the leaf prints no figure here at all — the sentence's result must be supplied from the two numbers it does print, and since the completion figure above is unsettled the result is not settled either] is the number of degrees of the axis's [pole's] altitude above your horizon.[318]

For it is already made plain above [numeral: ?] that by however much [a place] is distant from the line of rectitude, by that much does its axis [pole] rise above its horizon.

[The author's remark — אמר המחבר.] After I had arranged the matters of measuring the altitude of the sun, the moon[?], and the other stars — the arts[?] of measurement — I resolved[?] to put [them] into practice[?] [numeral: ?]. Therefore I saw fit, for [the benefit of] some of my students who have gone through[?] the [science of the] spheres, to teach them also the arts of measurement by means of the sighting-instruments — height and breadth — and, according to the nature of the subjects, the height of tall things[?] and towers[?], the depths[?] of rivers, and [numeral: ?] of mountains[?], slopes[?], valleys[?], and orchards, and their [numeral: ?]. Now this measurement, done with precision, requires us to know the science of number, geometry [surveying], and engineering — of which there is no place [to treat here]. (And I have already composed a book on this, which I entitled Sefer HaProzdor [The Antechamber] — a book that, to my sorrow, was lost from me [נאבדה ממני].) Nevertheless, to instruct my students, I will teach a little of this measurement in a simple and easy manner, in such a way that they will not need the introductions of the mathematical sciences [as] mentioned.

§271 [printed סימן רע״א; logical §272] — In it is explained the matter of the perpendicular [נצב]

[Heading, second word: the leaf prints "כוכב" ("star") — סימן רע״א יתבאר בו מענין כוכב ניצב — which does not fit the subject of the section, since what follows treats the perpendicular and the right triangle. The printed word is given as it stands; no emendation is made. [recte: מענין נצב]]

And at the outset: First you must know, in the matter of the perpendicular, the [numeral: ?] and the rule of a right [perpendicular] triangle [משולש נצב]. Therefore know that any column, or line, standing upright in a fully erect posture, without any inclination to the sides, is called an "upright column" [the perpendicular, הניצב]; and when you attach to the column two lines — the horizontal line and the sloping line [hypotenuse] — that triangle is called a "right [perpendicular] triangle," as you will see in the figure, in the form of triangle ג־ב־א. So, for you to understand: the line standing upright plumb,

[318] the leaf prints the zenith with a doubled letter where the idiom has a different one; both copies carry it, so it is in the setting. Given as printed and not normalised. the completion figure is set in one of this edition's bare numeral forms. The sort after it is not settled — two letters remain live and give different values — so the addition is left open, not computed.

which is line ב־א [as depicted], they call the perpendicular [הניצב]; the line below, which is line ג־ב, is called the base line; and line ג־א is called the sloping line [hypotenuse]. And now know that in every case[?], by the sighting-instrument a right triangle is formed for you. To put it by way of example: suppose you wish to know the height of a tower א, and the tower is line ב־א [the perpendicular, as depicted]; when you sight from point ג, standing off at a distance, to the top of the tower א, you will find that this observation forms triangle ג־ב־א — for the sighting from the eye, from point ג to the top of the tower, which is point א, is line ג־א, and that is the sloping line; the line drawn from the top of the tower down to its root or its foundation, which is line ב־א, is the perpendicular; and the distance from the tower's foundation to the place where you stand[?], which is line ג־ב, is the base line. And we shall know—

[The section breaks off here; §271 continues onward.]

[Continuation of **סימן רע"א** — printed §271, logical §272]

And know that — as we chose above, at the head of this Gate — the several observations [שמירות] mentioned above are performed in two ways. The first is by means of the instrument [ברית המורה — the demonstrating/sighting instrument? — reading uncertain [?]]; and the second by means of an instrument fitted with the thread of a plumb-line [חוט המשקל]. In the same way, all the measurements before us are likewise performed as described above, in two examinations [בשתי בחינות]. We proceed neither by [?] nor by exact reckoning [צמצום], but only by the examination of the sighting-line [קו המורה]. From this every intelligent student may learn to employ all these measurements, also by means of the second examination.

סימן רע"ב [printed §272; logical §273] — "**ביאור המדידה**" (an explanation of measurement)

And before we come to the explanation of the measurement, let us preface a short introduction [הקדמה קטנה], in which we shall set out a broad principle in brief terms: that anyone who wishes to measure heights [or lengths] [reading uncertain [?]] and wishes to descend to the foundation [ליסוד]...

[The lemma of similar triangles.] The point of this — one must know and understand it — is that in every triangle, when a further line is added upon it [namely a perpendicular], parallel [כדומה, "similar/parallel"] to [?] the lines mentioned, there are formed within it two triangles: one smaller and one larger than it. Their sides stand in proportion [יתכנו ערך] — the sides of the small triangle in the same ratio as the sides of the large triangle. An illustration of this: we have triangle ג־ב־א [alef-bet-gimel], upon which is erected a standing column [עמוד ניצב], namely line ה־ד [dalet-he], for example. From this there arise two triangles: triangle ג־ב־א, the former and the larger; and triangle ג־ה־ד [dalet-he-gimel], the smaller. And since line [כ"נ? [?]] and line [ח"נ? [?]] are both common [משותפים] to the two triangles, therefore the ratio of the small

triangle [ה־ג? [?]] is as the ratio of the large triangle ג־ב־א — that is [ר״ל]... [remainder of clause not legible: [?]].

Diagram. A right triangle in the right-hand column. Legible vertex labels:

- ג [gimel]: bottom-left corner (with a small foot-mark).
- ב [bet]: bottom-right corner (the right angle).
- [apex, top-right]: label not legible [?] (expected א).

[More than two labels effectively uncertain.]

[Continuation of §272, left column, p. 153:]...so that the ratio of the large triangle [הו״ד? [?]] is as the ratio of the small [הקטן, "the small"], such that the ratio of line [ס״מ? [?]] is to line [מ״ט? [?]], and the ratio of line [כ״ז? [?]] to line [ו״ז? [?]], and so on likewise. And whenever a line is added upon the triangle in a slope, the standing line [הניצב, the perpendicular] and the recumbent line [השוכב, the base] being common to the two triangles — therefore the ratio of the small triangle is as the ratio of the large triangle. Likewise, when a perpendicular triangle stands upon a sloping line — as triangle ה־ד־ג [gimel-dalet-he] upon the sloping line א־ה־ג [gimel-he-alef? [?]] — the sloping line alone being common to the two triangles [?], then when the two triangles are completed [broken and reassembled] the small triangle's face is inverted [פניו מהופך], the recumbent side lying uppermost, as in the figure.

Diagram. A right triangle in the upper left-hand column (partly obscured by ink show-through). Legible vertex labels:

- א [alef]: apex (top).
- ג [gimel]: on the base near the right angle.
- ב [bet]: lower-right corner.

Diagram. A second right triangle lower in the left-hand column. Legible vertex labels:

- א [alef]: lower-left corner.
- ג [gimel]: upper-right corner.
- [a further corner label, ה/ד]: not securely legible [?].

סימן רע״ג [printed §273; logical §274] — the construction/adjustment of a sighting-instrument [מחזה]

Although there are many sighting-instruments [מחזים] that the geometers [חכמי המדות, "the masters of measurement"] employ, there is nonetheless one common root [principle] to them all; therefore I shall explain to you [its construction] from the beginning.

I shall explain to you at the outset [כתחלה] the matter of which they [the instruments] are made, so that you will understand also the rest of the instruments [and] why [each is] made as it is; and all the rest of the instruments... their source and root [מקורם] — take for yourself [as an example] the instrument of [?]... [remainder of this passage is degraded and only partly legible: [?]].

[p. 154 — running header p. 154: שער יא — "Gate 11". Right-hand column sits against the binding gutter; right-edge words are clipped.]

upon [the plate], the more finely worked it is, the better; for the larger it is, [the more] precise is its measurement. Always turn the face of the instrument [פני הכלי] according to [?]... in such a way that the instrument be well fitted [יתקן], [the instrument] being made a square [נתרבע הכלי], and you draw line ח [chet] upon all four of its sides, near the edge [שפתים] by about a finger's breadth or less, in such a way that 24 lines [כ״ד קוים [?]] are set out... as established in the figure, the marking [being] as in §272 [כסימן רע״ב [?]]... the two [points] at the angle ג [gimel] of the figure, namely line [כ״נ? [?]] and line [?]... divided and dense in number, it is to be divided into [more] parts, and a large number is better: the more parts, the more precise and complete... Therefore we chose to divide each of the lines in this place into **ל״ם** parts only, as in the figure. [The token is printed ל״ם — lamed, gershayim, and a closed final mem. It is not a valid gematria and no value is supplied for it; it is given exactly as set. `[recte: ?]`]

Therefore it is more fitting [more valuable] to divide each one of the [main] lines into [?] parts, as shown in the figure.

Furthermore [**אחר**]: All this you shall do with line ח [chet]; you compose [construct] the diagonal [אלכסון] of [ח״ך? [?]] and the width of the figure like [?]... — [the remainder of the "Furthermore" paragraph describes an attached metal fitting: upon the thickness of the figure you attach [a piece], whether of copper or of tin [מבדיל], and it passes [?]...; and you make in each of them a small perforation for sighting [לחזום], and likewise a small [one];... the motion of the [gauge] of [?]... upon half a degree [חצי מעלה [?]]... and the smaller [it is], according to its smallness, and the more numerous, the better you can reckon [לחשבן] the [?] of the parts, also upon the whole length of the figure... you join this figure together with [?] in the parallel [בהקבלה] of angle ח [chet], and [?]" — this stretch is largely degraded; specific values and several labels are not securely legible: [numeral: ?] / [?].]

סימן רע״ד [printed "**סימן רע׳ר**" — units letter worn; = **רע״ד**, §274; logical §275] — "**מדידת רוחב השטח שהוא בארץ המישור**" (measuring the width of an expanse that lies on level ground)

[This heading is printed clearly at the head of the inner (gutter-side) right-hand column of p. 154, reading "**רע׳ר**"; the units letter is worn, but the surrounding sequence requires **רע״ד** (§274). A prior reading mistook this for §275 and posited a separate gutter-illegible §274 — there is no such extra siman.]

And after I have shown [how] to know the adjustments of the instrument, [and] how it is to be used, we shall now begin to explain [the procedure]:

[When you wish to measure] the width [of an expanse] — [as] the choicest and most excellent [example] of them all — you will [need] to know the distance between point ב [bet] and the point [?] below. You set up the instrument, the [square/level — כלי האנ״ך [?]], upon the ground in such a way [כאופן] that in the figure [one line] faces the sky [פני הרקיע] and line ג־ב [bet-gimel] faces the

[ground]; and it faces the surface of the place, or the point, whose [distance] you wish to know...

and you [must] set the [square/level] instrument [האנ״ך] so that it stand upright and straight in its place [ישר ופות במקום...], and place upon it a mark (and again, to this belongs the line of the plumb-level [קו המשקלת], so that the line [?] — this being necessary for the standing of the [square/level]) — in such a way that [the sighting be] complete [גמורה]. And when you have set the whole matter in order according to its rule, you shall [place] the [?] peg of the sighting [יתד המורה], and look [ותראה] through the sighting-holes [חורי הצנורה] downward, until you see through the sighting-holes that are upon the [tube] the point whose distance you wish to know. And [?]... [the passage continues into the left column of p. 154; the concluding lines — ״the point ק [kof] on the [square] instrument האנ״ך, through the sighting-holes...״ — are legible only in part: [?]].

Caption above the figure (centred in the left column): **עד נקדת פ׳ ⟦?⟧⟦?⟧צורה** — ״as far as point **פ** … figure״. Two sorts between פ׳ and צורה are WITHDRAWN and left unread; the fluent completion שבצורה is not written.

Diagram. A right triangle (with an internal diagonal). Legible vertex labels:

- א [alef]: apex, upper-right.
- ג [gimel]: on the base, at the right angle.
- ב [bet]: lower-right corner.
- ה [he]: lower-left corner (and a point ה marked on the hypotenuse).
- **פ** [pe]: the acute vertex — the point the caption cites.

[Body continuing beneath the figure, left column p. 154 — the worked numerical example:] Now you will find in this figure two triangles, one large and one small [הקטן] — the large one [being] the part outside the instrument, [triangle ה־ד־ח? [?]]; and, as we have already shown above [שכבר גלינו [?]], the parts of line ה־ד [dalet-he] of the small triangle stand in the same ratio as the parts of line [פ״כ? [?]], the base, [and] line [כ״מ? [?]] of the large triangle, so that you may reckon how many of the instrument's parts [correspond]. And I say, for example, that line ה־ד [dalet-he] is set at 12 [י״ב] parts, while the width of the instrument is 60 [ס'] parts; so line ה־ד, the standing [perpendicular], is the fifth part [חלק החמישית] of the width of the instrument האנ״ך. Therefore [the corresponding portion] of line ב־א [alef-bet] of the large triangle — whose parts are 60 [ס'] — [is likewise] the fifth part [ה']... and from the recumbent line [it works out]... And if the breadth of the instrument is two feet [שני רגלים], then the breadth sought is twenty feet [עשרים רגלים]. [The intermediate line-labels and factors here are degraded: [?].][319]

[319] the ratio, the physical breadth and the answer do not agree — a fifth part of two feet is ten, and the siman answers twenty. All three given as printed, none emended.

סימן רע״ה [printed §275; logical §276] — ”להאריך קו הניצב לדקדוק המדידה” (lengthening the standing [perpendicular] line for precision of measurement)

[This siman's heading and text are printed at the foot of the outer (left) column of p. 154. This is the span into which a prior reading had wrongly carried a verbatim echo of the p. 153 similar-triangles lemma; the actual printed text, read glyph-by-glyph, is the following — it does NOT reprint that lemma.]

We explained above that the larger the sighting-instrument [מחזה] is, the greater the precision of measurement to be found in it. So when the instrument האנ״ך is small in size — such as half an amah by half an amah, or an amah by an amah [?] — the measurement will not carry you out to a distant limit with precision. The remedy for this: you lengthen and enlarge the standing [perpendicular] line [קו הניצב]. How? You raise the האנ״ך and set it upon a column [עמוד]..., and you take a sighting [בהבטה] along line [?]... [numeral / label: ?]....[reckoning] in the instrument along the length — the mark ח [chet] down to the ground, to the point [?] — and we say, for example, that it stood at 6 [ו׳] feet [רגלים]. And now [?]... we say [that] line ה־ד [dalet-he? [?]] of the instrument is the sixth part [חלק הששית] of line [ס״כ? [numeral: ?]]..., [and that] line ד־ח [chet-dalet? [?]] is the tenth part [חלק עשירי] of line [ז״פ? [numeral: ?]]..., [giving] 6 [ו׳] feet... [This siman's remaining worked values are degraded and only partly legible: [numeral: ?] / [?].]

Diagram. A right triangle with an inscribed instrument-square near the right angle and an internal diagonal, at the foot of the outer (left) column (it may be a second impression of the same woodcut as fig-p154-1). Partly-legible labels:

- ד [dalet] / ה [he]: at the top.
- א [alef]: on the hypotenuse.
- ג [gimel], ב [bet]: at the inscribed square.
- ה [he]: lower-left corner.
- UNREAD: a further corner-mark at the lower-right.
- פ [pe]: the acute vertex — as on fig-p154-1.

[More than two labels uncertain.]

[p. 155 — running header p. 155: שער יא — ”Gate 11”; folio עז (77).]

סימן רע״ו [printed §276, set ”ר׳עו”; logical §277] — the manner of measuring the elevation and height [רום וגובה] of towers or other things [המגדלות או שאר דברים]

When you wish to measure the elevation and height of a tower [מגדול] or other tall things, you set up the instrument upon the ground in the reverse posture from [that of] measuring [horizontal] width. How do you set it up? — In such a way that line ד־א [alef-dalet; printed ד־ח?] faces the ground [פני האדמה], line ג־ב faces the sky, and you aim [ותכוין] the sighting-tube [הצנורה] up and down

until you see, through the sighting-holes fixed upon the tube, the point at the top [ראש] of the tower or the height whose measure you seek. For example: in this [case] you seek to know the height of tower ח [chet] which is in the figure — the recumbent line [being] נ־ב [bet-nun? [?]] — and you sight from point א [alef?; printed ח?] to point ג [gimel] in the figure. And, according to what we have chosen [as our principle], there are formed in this figure two triangles, one large and one small: the large one [is] that which extends outside the whole surface [שטח] of triangle ג־ב־א, and the small one [is] that within the instrument [itself], [namely] triangle ה־ד [dalet-he]. Now, according to what we have already explained, the ratio of line ד־א [alef-dalet], the large, to line ה־ד [dalet-he] of the small triangle is as the ratio of the parts of line [כ״א? [?]], the large [line] — namely line ג־ב [bet-gimel] of the large triangle — to the parts of line ה־ד [dalet-he]... — [it is] a computation, for you can see how many parts the length of the figure [has] and [how many] the parts of the instrument [are divided into]. And I say, for example, that the parts of line [ל״ס? [?]] are 80 parts [פ׳ חלקים], which are two thirds of 120 [שהם ב׳ שלישים מק״ך].[320]... [several further values and line-labels in this derivation are not securely legible: [numeral: ?]]. And after this it will be known to you from this that line [?] of the large triangle... [continues; present on the leaf but not construed: [?]] — which are 60 cubits [שהם ס׳ אמות] — the number sought [המספר המבוקש].[321]

סימן רע״ז [printed §277; logical §278] — [the case] when the sight-line [המורה] cuts the upper edge [צד העליון] of the instrument [מהכלי]

When you sight through the sighting-holes of the tube from [?] to point ט [tet] in the figure, the sight-line [המורה, the ray] cuts, in the manner [?], the upper edge of the instrument... [the remainder of the heading-paragraph and its opening lines are only partly legible: [?]].

[320] figure and sentence are both corrected here from the ink. The leaf prints פ׳ חלקים שהם ב׳ 80" — שלישים מק״ך parts, which are two thirds of 120" — on both copies; the edition's "of which 150 stand against the instrument" is not on the page, and the note objecting that 80 is not two thirds of 150 goes with it. Settled on the letter: the sort descends below the line of writing, so the foot cannot decide between the two descending final forms, but its head is a bar overhanging the stem far to the left and ending abruptly — a final kaf — where this fount's final nun tapers into the stem. That the sum now closes is a consequence of the reading, not a reason for it. The line-label ל״ס remains untested.

[321] the span passed over here is not illegible: under magnification every sort across the five lines before the closing clause stands separate and whole — no loss of ink, no damage, no bleeding, no blurring. What defeated the reading was the writing — dense abbreviation-clusters and numbers written as letters, which did not assemble into Hebrew that could be committed to. Nothing is supplied across it, and nothing should be: the passage is untranslated, not unreadable.

Diagram. A large right triangle representing a tower with an instrument-square set at its foot, with a cevian and an inner rectangle; a sight-line runs from the base up to the tower-top.

Labels on the block — eight positions, seven read, all checked on both witnesses, with the components corresponding one-for-one between the two (itself a registration validation):

position	label
apex	ט — bowl closed at the bottom, interior opening at the top, left arm hooking inward; ם and ע excluded
outside the vertical, to its right, at the cevian's endpoint	**[א/ג]** — UNRESOLVED. See the note below.
above the rectangle's top edge	ז favoured (ו disfavoured, not excluded) — the head overhangs the stem well to the left and barely to the right, the ז signature; no **ז/ו** pair in the same fount stands elsewhere in this figure to set against it, so not certified
right of the rectangle's right side, upper	ה — its left leg is a separate component, detached and shorter, on both witnesses
inside the bottom-right corner	ב — roof, left upright, base with a right-protruding heel clear of the figure's base rule
right of the rectangle's right side, lower	ד favoured — right extent reached within 1 row (square corner) against a ר ramp of ~17 rows; no ר control in this fount on this leaf
bottom-left inside the rectangle	א
the rectangle's top-left corner	UNREAD — CONTAMINATED. It sits on the corner and is fused with both rules, so it never separates as a component; the left leg's depth cannot be measured and **ת/ח/ה** cannot be discriminated. No value asserted.

- All labels are Hebrew; no European Arabic numerals appear in this figure. No text is set on the curve, and no label stands in the outer margin.

Caption beneath the figure (reading uncertain): "[The] place ו [vav], and it is doubled [ונכפל], for example, so that they are 80 [פ']… 30 [ל'] parts, which are 3 [ג']." [The caption is untested: no second reading of the leaf has reached it.]

סימן רע״ח [printed §278; logical §279] — how one measures the elevation and height of a tower when one cannot approach the tower [לקרב אל המגדל] and also cannot see its base or foundation [שרשו או יסודו]

When you wish to measure the height of a tower and you have a pool of water [בריכת מים] cutting off [the ground] between you and the tower, so that you cannot approach the feet [רגלי] of the tower, you measure — from a distance — the [span] from the place where you stand [ממקום שבין מצבך] to the feet of the tower, by the method explained above; and it is said [that] you take account of that distance and complete it in a "sphere"-fashion [כדור? [?]], as is written [in the passage] nearby, §6 [סימן ו'? [?]]. And if there falls out for you in your

locality a hill [הר] or [some obstruction] that cuts off [the ground] between you and the tower, so that you cannot see the [base] of the tower but only points on its upper part [נקודות גבהו], its height cannot be known to you [directly]. In such a case you must [work] toward the source [i.e. reduce it to a known] by way of [?]... upon the measure of the great recumbent line [קו השוכב הגדול] — that is, [the span across] the hill that lies between the place of the feet [of your instrument] and the feet of the tower, even though you cannot see that line at all; and for the sake of knowing this you mark the place of the foot of your [instrument] and you sight along the line of the sighting-tube [דרך המורה], looking toward the top-point of the tower's height, and it is said, for example, that [the ray] cuts the bolt [הבריח] on the instrument at [numeral: ?] parts, of which [numeral: ?] are [set] against [a division] on the instrument; and afterward you walk [?]... [the derivation continues, working the proportion of the instrument's graduations against the parts of the recumbent line; the specific values and several line-labels are degraded and only partly legible: [numeral: ?] / [?]. The page ends within this proportion — "…100 parts stand to 20 divisions as the recumbent line of the large [triangle] stands to the first-station line of the triangle…" — the reading of the numerals is not secure: [numeral: ?].[?][?]ולם‘; it is left unread rather than completed.]

[p. 156 — running header p. 156: שער יא — "Gate 11". This verso's inner (right-hand) column runs into the binding gutter; right-edge words are clipped. §278 continues and concludes in this inner column.]

[Continuation of §278, top of the inner right column, p. 156 — largely obscured by show-through and gutter shadow; only fragments legible:] "...[the parts] according to [what is] still hidden [נעלם] from him [i.e. the inaccessible quantity], and therefore [?]..." [not securely legible: [?]].

Diagram. A tall right triangle for the two-station observation of an unapproachable tower. Its apex [ב? [?]] is at the top; two sight-lines descend from the apex to two stations on the base line, where three small boxes bear woodcut numerals. The three numerals of this worked example are set as Arabic numerals inside the woodcut, not in the Hebrew text. Reading the figure — a large right triangle, apex lettered ד at the top, base running left to the lettered vertex ב at the right, with two small boxes standing on the base: **100** below the base line at the left-hand box; **20** above the base line, in the gap between the two boxes; **80** below the base line at the right-hand box, immediately left of the point-letter א.[322]

[Text below the figure, inner right column p. 156 — the conclusion of §278, legibly printed here:] Or [alternatively] you take the proportion [תעריך]. You say: "20 [ך'] parts of the graduated divisions [מעלעים] — how many are they [worth]?" — [that is,] in the second position [מצב הב'], how many of the graduated divisions [is] the graduation [worth] in the recumbent line, which in the figure is line ב־א [alef-bet]; and there comes out for you [numeral: ?]

[322] this figure's three numerals are set in Arabic figures inside the block, and the prose of the two simanim on this leaf carries none of them.

divisions, which is the number [i.e. length] of the great recumbent line, which is line ב־א [alef-bet]. And after this it will be known to you [the span] that is between you and the feet of the tower; you complete your measurement by the method [set out] nearby above, §6 [סימן ו'? [?]], and there comes out for you [ג״ן = 53? [numeral: ?]] divisions…

And [as for the case of] a tower [א? [?]] standing upon a hill [ההר], where you seek to know the measure of [the tower's] height and the measure of the hill's height: then you measure, by [means of] two rods [מקלים; printed מלכים], how much the top [ראש] of the tower [rises above] the surface of the ground, by the method explained to you above, §[מ' = 40? [?]]. And afterward you measure in the same way the height of the top of the point [?]. And when the measure of the hill's height is known to you, you subtract [it from] the number of the tower whose measure you have already completed [found] from the surface of the ground, and there remains the height of the structure [בנין] of the tower that stands upon the hill.

סימן רס״ט [printed thus; recte רע״ט? — printed §279; logical §280] — the manner [איכות] of measuring [depth] from a mountain to a valley [מהר לבקע][323]

After we have come to the measuring of width and of height, there remains for us [to explain] the manner [איכות] of measuring from a mountain [down] to a valley [מהר לבקע]. And by the shorter constellations [ובמזלות קצרות? [?]] its matter will be explained to you, since they are [analogous]: [going] from valley to mountain, and from mountain to valley, in every way [בכל דרך] alike — the triangles [משולשים] that fall out in measuring the mountain [being] like the triangles [?]… the triangles within the instrument [being] like those triangles… [and] all of them fall out in measuring the valley just as [?]… for when one looks [כשהביט] from the mountain [down] to the depth [לעמק]…

[Continuation of §279 into the outer (left) column of p. 156:]…the recumbent line will always be [as described]; and likewise will be the measurement from valley to mountain, or from valley to valley.

Diagram. An instrument-square right-triangle figure (with an inner sub-square and an internal diagonal), in the upper part of the outer left-hand column (partly obscured by show-through). Labels: THREE positions, and NONE is read. All three are over-inked blobs on the greyscale witness, and two are additionally crossed by the figure's own diagonal; the bitonal witness blobs them worse. א is the leading shape candidate for one of them but is not asserted. Per the contaminated-feature rule, all three are UNNAMED. A marginal note running along the left edge reads, in part: "…as in the figure: the small triangle — mark it line ו [vav]; and the large one, ג־ב־א; and so it will be with the

[323] the two rubrics on this leaf do not stand in the order they run down the page — the later is printed about a third of a leaf higher than the earlier, in the second column. Reading order and top-to-bottom order disagree: a real spatial disturbance, not a numbering fault.

triangles when you look from a mountain to a valley [בהביטך מהר לעמק], as from point ג [gimel]... to point [?], the small triangle ה־ג [gimel-he? [?]] being similar [דומה] [to it]..." [More than two labels uncertain.]

סימן ר״פ [printed §280, the mark set between the sorts; logical §281] — three kinds of measuring from a mountain to a valley [ג׳ מיני מדידה מהר לעמק]

And if you stand upon a mountain [הר] and see a great tower standing within the valley [תוך העמק], and you seek to know the measure of the mountain's height — which is line [כ״ב? [?]] — and you also seek to know the recumbent line, which is line ג־כ [kaf-gimel], and you further seek to know the height of the tower standing within the valley, which is line ג־ה [he-gimel]: [proceed] by this [same] measurement. You investigate first the measure of line [כ״ב? [?]], filling it out by means of two rods [מקלים? [?]], by the method explained to you nearby, §[?]. You take hold along the line of the sighting-holes [חורי הביט], sighting from point א [alef?; a point [?]] to point ג [gimel], which is in the figure, and it is said that [the ray] cuts the bolt at, for example, [ט״ס? [numeral: ?]] parts of [תר״ך? [numeral: ?]]; and you walk backward from the tower, for example, [מ״ן = 90? [numeral: ?]] paces [פסיעות], and there you sight a second time, from point ד [dalet] to point ג [gimel], and it is said that there the bolt cuts [ט״מ? [numeral: ?]] parts. Now the [difference] between the two numbers is twenty [עשרים] parts. And according to what we have already chosen above [as our principle], the ratio of this number [i.e. the twenty] to the number of the fewer parts — which are [ש״מ = 340? [numeral: ?]] parts of the second [reading] — is as the ratio of the number of the [?] paces to the number of the paces of line ג־כ [kaf-gimel], which is the recumbent line hidden [הנסתר] from triangle ג־ב־א. Therefore you take the proportion [תיחס] and say: "4 [ד'] parts of the divisions are [ש״מ = 340?]; how many are 40 [מ']?" — [reckoned] as before [וכנ״ל] according to its rule; and there comes out for you the measure of the great recumbent line, 680 [תר״ף] paces[324]; and you have filled out, as [now] known, the recumbent line of triangle ג־ב־א. And you already know, with you, the measure of the recumbent side and the perpendicular of the small triangle which is in the instrument, namely triangle ה־ב־א [alef-bet-he? [?]] in the figure. From all this [כלל], now, there will be revealed to you the height

[324] the closing sort is a final pe, not a final kaf: it carries a short detached tongue at the right end of its roof and its descending stroke falls at the left, where a final kaf descends at the right and has no such tongue. The leaf therefore prints 680, not the 620 formerly given. Limit: the two sorts before it were taken from their shapes as tav and resh without being control-tested on this line, so 680 rests on them; what the ink establishes is that the last sort is not a final kaf.

of the mountain [גובה ההר]. [The specific worked values in this paragraph are degraded; those flagged [numeral: ?] were not verified glyph-by-glyph.][325]

Gate Eleven (**שער י״א**), continued — surveying

[Conclusion of Section 280 — printed סימן ר״פ; logical §281]

(This computation continues from the previous page — the mountain-and-valley survey: standing on a mountain and sighting a tower in the valley, deriving the mountain's height, the recumbent line, and the tower's height by the two-station method.)

from this you have line **כ־א** [a–kaf]. Set up the proportion and say: [530 = תפ״ן?] parts in the recumbent line correspond to [340 = ש״מ] in the hypotenuse of the small triangle; so [numeral: ?] paces in the recumbent line of the large triangle — how many are they in the hypotenuse of this large triangle? You obtain the great hypotenuse, [340 = ש״מ] paces. And to know the depth at which the tower stands in the valley, find the distance from the first station, from point **א** to point **ס** [samech], and reckon by the difference of the bolt-readings; the parts come to [numeral: ?]. Now there arise from this two conjoined triangles, the one the general triangle and the other the partial triangle, which returns to it. Therefore set up the proportion and say: [530 = תפ״ן?] parts in the recumbent line are [240 = ר״מ] in the hypotenuse; [numeral: ?] paces in the recumbent line — how many in the hypotenuse? You obtain [226 = רכ״ו?] paces. Take a third of this number and subtract it from the number of paces of the mountain's height, line **כ־א**, which you already found to be [340 = ש״מ] paces; there remains the measure of the height of the tower: 113 [קי״ג] paces and 3 paces [קי״ג פסיעות וג׳ פסיעות — the leaf repeats the word **פסיעות**; there are no "ninths"]. [The source is in error here: 340 (ש״מ) − 226 (רכ״ו) = 114, but the leaf prints 113 (קי״ג). The printed reading is the printer's; the translator records the printed value and flags the discrepancy rather than emending it to 114.]

Section 281 [printed סימן רפ״א; logical §282]

In it is explained: measuring in the case where you cannot walk toward the object — such as measuring from a tower down to a valley.

To stand upon a tower [numeral: ?] and to measure the depth of a valley below, and to measure the depth of a pit — with the base [of the instrument] set upon the tower's top — set the instrument [with] its openings [aligned] upon [numeral: ?] divisions of the scale.

Diagram. A masonry tower at the right — walls 12.7 mm apart, 75.4 mm to the finial — standing on a ground line, topped by a sighting device and a banner. Two sight-lines run from the tower to a common vertex at the far left,

[325]Foot of p. 156: no signature, no page-number, no folio — the band is blank. Whether this leaf carries a catchword is open: one copy shows foot content at the left column that the other does not, and no reader has read it.

at 43.6° and 18.3° to the horizontal. The figure crosses the gutter, reaching a little way into the left column's measure.

Labels: א (secure) and one [ר/ד] at the far-left vertex, unresolved — the ramp test gives 6–7 rows against this leaf's display ר at 13, which leans ד, but no same-fount control exists, so the reading is conventional rather than read.

You will say: the observer stationed his instrument upon the tower [numeral: ?]; and [the sight] cut [numeral: ?] parts of the scale, which are the [numeral: ?] of the recumbent line. And the number [of parts] between the two measurements — 240 [= ר״מ] parts of the recumbent line… [computation continues with several interior values illegible: numeral: ?]. It has already been explained to you by the methods given above [how to find] the measure of line ד״ה [he–dalet]: [numeral: ?] degrees. And [thus] the tower standing in the valley is measured, together with the height of the [wall] in the valley. From the first station, from point א to point ס [samech], you reckon by the bolt of the sight through the openings of the instrument… and it comes out [numeral: ?] paces and 3 paces. [numeral: ?]

(The full worked interior of this section is numeral-dense and largely illegible on the scan; the recovered structure is the two-station reduction from the tower-top, but the specific tabulated values are flagged.)

Section 282 [printed סימן רפ״ב; logical §283]

In it are explained the innovations of measurement by means of sighting-instruments when they lie level, together with their great usefulness. [חדושי המדידות — restored from both witnesses; the **הדרושי** reading is withdrawn. The decisive evidence is letter count: the word is FIVE glyphs on both leaves (ו-ש-י-?-?), and הדרושי requires six, with ד and ר consecutive. Verified on 20763 p. 156 at 500× (400 ppi bitonal, the crisper witness here) and on NLI p. 157 at 1100×; two independent cold readers, denied the existing English, returned חדושי from each witness separately. The הדרושי reading inserted a ר that is not on the leaf, and was defended on sense — "דרוש in mathematical writing is a proposition" — which is the reasoning class that has supplied every confirmed failure in this book.]

Now you, O reader, know and understand well: that all the measurements we have set forth above are all of them by [numeral: ?], for they are [numeral: ?] demonstrated, as is fitting, with uprights and perpendiculars. And now I shall make known to you further measurements by the instrument — for by them you will measure whatever you wish, as the stars [are measured] and as the surveyor [measures]. And they are more general and more inclusive, more precious and more honored and more refined [in] measuring by them, than every instrument of sighting. And [these are] all the refinements — "from this you know that" [numeral: ?]. And these learnings [teachings] before us will be explained to the students who add [to their knowledge] on this basis, [so that] every matter and its reason will be revealed to them, both this and that. This is the whole matter. And when it happens that a wall of a [tower] is

near, or a place is distant, and you cannot approach it — because it lies across a river or the like, and you cannot walk there — you can [still] measure its height, [measuring] its distance from you by the [angle at which the] sight-line [crosses] two [scale-divisions]… [interior values: numeral: ?]. This matter has not been explained above [among] the [prior] learnings; and it is a third kind of measurement, this one newer [and more refined]. It will be explained further: for from the distance between two towers [numeral: ?] you can proceed to know [both] and [derive] a fourth [quantity]. For when the recumbent line is distant and remote, and the place of the recumbent line is remote by [numeral: ?] paces [and more], you cannot [reach it]; yet by measurement it is [found]. [numeral: ?]

(Numeral-dense; interior values flagged.)

Section 283 [printed סימן רפ״ג; logical §284]

In it is explained: to know two positions [**שני מצבים**] — this one beside that one — and also [the] height and [the] depth [**גובה ורום**].

And when you have wished to know, in this way, the height of a great tower [numeral: ?], even though you cannot [reach] its foundation at all — [seeing] only its top — from a single [numeral: ?] point: nevertheless you can find and know the measure of the height of the tower, [and] the height of the great tower as well… [interior computation with the isosceles-triangle figure: numeral: ?].

Diagram. A tall crenellated tower (right column of the verso), topped by a sighting ring and banner, with a long sight-line descending to a vertex at the left, forming a large right triangle. Readable labels: נ, ג ["נג" on the upper block], צ, ה ["צה" at the foot], ב, א, and ל [an inner point]. (Verso page — the right edge sits in the binding gutter and is faint.)

Diagram. A large isosceles triangle (left column) with apex at the top and a horizontal base; two small squares are inscribed along the base (the shadow-squares of the two sightings), and a line drops from the apex to the base. Readable labels: the apex ד [or ר — uncertain]; along the base ג, ה, ז, ב, ד; an inner point ח; and the label יד [yod-dalet] beside the left flank. (More than two labels uncertain.)

You measure line כ־ז [zayin–kaf] by measurement… [interior: numeral: ?]. It has already been explained to you that a measurement of more than [numeral: ?] parts, and you say [numeral: ?] parts — then there arise [numeral: ?]. And you say [numeral: ?] parts in the small [triangle's] hypotenuse are [numeral: ?] in the recumbent line; and [numeral: ?] paces in the [large] recumbent line — how many are they in the [large] hypotenuse? And you obtain the measure of the great recumbent line [numeral: ?]. Now, since the [degrees] amount to [numeral: ?] degrees, and it is [numeral: ?] paces in the small [triangle], and [numeral: ?] paces in the great [triangle] — how many are they in the recumbent line? You obtain 105 paces [**ויצא לך ק״ה מצעדים**].

(The section's arithmetic is largely illegible; recovered as a two-station triangulation reduction. Values flagged.)

Section 284 [printed סימן רפ״ד; logical §285]

In it is explained: to know the distance between the [two] points at the tops of two towers, even though you can [reach] only their tops.

To measure the distance between the two tops — the [two] points — of two towers, even though you have no [access] except [to] their tops: measure them by [numeral: ?]. Their points [numeral: ?] — even though there is [nothing] between them but [numeral: ?] points, [set] on the ground; where they are [numeral: ?] and distant from one another, and you need to know the measure of the distance… [The distance is derived] by the reckoning of the measures, [as with] the "cistern-fraction" [כ״א = 21?], and the place is [numeral: ?] upon you… [interior: numeral: ?].

(Worked example — the two exemplar towers:)

Diagram. A large triangle at the head of the right column, illustrating the two exemplar towers. The right (vertical) side is labeled with the large numeral 7300 — cut in the block, rotated to run along the vertical, and read cleanly at native resolution on both witnesses; the second digit is a 3 (two stacked bowls, both open to the left, no base bar) — and the sloping side (hypotenuse) with 5000; the apex is marked ח [chet]; a lower-left sort reads ר on a 16-row ramp, though no negative control exists in that lettering class; and the left apex, the bottom vertex and a mid-right sort are UNREAD — contaminated. Captions above the figure name the towers: מגדול השן ["the Tower of Ivory," Shir HaShirim 7:5] and מגדול הלבנון ["the Tower of Lebanon," Shir HaShirim 7:5], used here as the two standing towers whose separations are given in the block as 7300 and 5000 units. The block carries these two figures and no others: the interior enclosed by the rules is otherwise blank.[326]

You wish to know the distance between the two points at the tops of the two towers, as from ב to ג; and to that end [take] the Tower of Ivory and the Tower of Lebanon. So must you first know the distance of each one from the place where you stand, by the fourth method explained to you above in the [section] immediately preceding… [reckoning by the sighting]. We found that the distance of the Tower of Ivory is six or seven thousand [[ז/ו]]' אלפים [= 6000 or 7000] and complete [numeral: ?] degrees[327], and the distance of

[326] the figures 3,000, 4,000 and 6,000 belong to the worked reduction in the prose below, set in ordinary type; they do not stand in the woodcut. Block and body do not agree, and the disagreement is left standing: the woodcut prints 7300 on the vertical, while every figure in the tail of this siman's prose is a round number of thousands, so 7300 has no counterpart in the prose examined — an examination covering the siman's tail only. The body figure answering to it is itself unresolved, six thousand or seven thousand. Both recorded as printed; no cause assigned, no reconciliation attempted.

[327] the single letter carrying this figure is either ו (six thousand) or ז (seven thousand). The two cannot be told apart here, no second copy yields the place, and no value is chosen; the earlier reading "seven thousand" is withdrawn as unsupported, not refuted.

the Tower of Lebanon is five thousand [ה׳ אלפים = 5000] degrees. Take the instrument of sighting and set the sight-bolt to its notch, and observe through the sighting-openings toward the point of the top of the Tower of Ivory, and leave the instrument in its place — do not move it at all — only the sight-bar you turn toward the width of the instrument until you sight, through the sighting-openings, the point of the top of the Tower of Lebanon. Then there arise for you two triangles: the large one is the whole triangle ג־ב־א [alef–bet–gimel], and the small one, [inscribed] in the instrument, is triangle ס־ד־א [alef–dalet–samech]; and this small triangle [is similar to] triangle ג־ב־א. [Since] it is triangle כ־ל [numeral: ?], you must divide it into two right triangles, as is the rule…

You draw a line from point ג [numeral: ?] up to line ב־א [numeral: ?], reaching as far as point ז [numeral: ?]; and there arise two large similar triangles, [namely] triangle ז־ד־א [?] and triangle ג־ב־ז [?], according to what has already been set out in [terms of] their proportions above… [interior computation: numeral: ?]. Line ד־א [alef–dalet] of the small triangle [is to] line ב־ז… by the proportion [numeral: ?]. And behold, line ד־ה [is] [numeral: ?] parts. Therefore reckon and say: if [numeral: ?] are [530 = תפ״ן?] in the small triangle, [and] three thousand [ג׳ אלפים = 3000] in the hypotenuse — how many are they in the recumbent line of the large triangle? You obtain four thousand [ד׳ אלפים = 4000] degrees; and this you subtract from six thousand [ו׳ אלפים = 6000]. And the complete degrees, which are the number of degrees of line כ־ז [numeral: ?]. And to know [the number of degrees of] line ג־ב [bet–gimel], it is made known to us by the reckoning of the theorem [i.e. the Pythagorean rule]: you square the numbers of line כ־ו [numeral: ?] and line ג־ז [numeral: ?], each of the two of triangle ג־ב־ד [numeral: ?] by itself, and add together what arises from this, and from it extract the square root; and there comes out for you four thousand four hundred and sixty paces [ד׳ אלפים ות״ס מצעדים]. And this is the number of paces from the point of the top of the Tower of Ivory to the point of the top of the Tower of Lebanon, and so forth.

Section 285 [printed סימן רפ״ה; logical §286]

In it is explained: to know [the measure of] the height of a tower or a tree by its shadow, in a very easy way.

If a tower, or a tree, or [some other] single [thing] stands on level ground, then you can know its height by [means of] its shadow. Chazal already anticipated us in this, in Tractate Eruvin[328]: how you measure the ratio of the whole of your body when you stand at [some] place; and [reckon] the length of your shadow [in proportion] to the length of your stature; or the ratio of the shadow of a wall, or of a staff, in proportion to its height — and from this you know the measure and extent of the height and elevation of the tower, according to the ratio of its shadow.

[328] the tractate name is given without its printed Hebrew and is untested — see the QA note at the end of this siman

An illustration of this: thus, the measure of your stature, say, is 7 feet [ז׳ רגלים], and the measure of your shadow is 9 feet [ט׳ רגלים], and you have measured the shadow at the tower, say, at 100 feet [מאה רגלים]. Set up the proportion and say: the nine feet [of my shadow] correspond to the seven feet [of my stature] — likewise, the hundred feet [of the tower's shadow], in the same manner, how many [feet of height] are they? Complete it according to the rule, and it comes out 77 [feet] and seven-ninths [ע״ז רגלים ושבע תשיעיות = 77 7⁄9].

Section 286 [printed סימן רפ״ו; logical §287]

In it is explained: knowing the height of a tower by its shadow, apart from [using] the measure of your own body.

If, with the sighting-instrument mentioned above, you observe through the sight-openings where the ray of the sun [falls], and [read] the ratio of the division which the sight-line cuts on the upper part of the instrument in proportion to the side of the instrument — that is the "straight shadow" [צל היושר, umbra recta], [which gives] the height of the tower. And [if you read] the divisions which the sight-line cuts on the lower part of the instrument in proportion to [the side of] the instrument — that is the "reversed shadow" [צל ההפוך, umbra versa].

Diagram. A right-triangle shadow-square (drawn at the foot of the page, spanning across the columns), representing the two shadow-scales of the instrument. The hypotenuse/upper scale is labeled **צל היושר** ["the straight shadow" — umbra recta] and the inner/lower scale **צל ההפוך** ["the reversed shadow" — umbra versa].

An illustration of this: you have found the shadow of the tower to be 100 feet [numeral: ?]; and when you sight through the sight-openings [along] the ray of the sun, the sight-bar cuts, against the lower [scale] of the instrument, 80 [= פ׳] divisions, which are 240 [= ר״מ] by the measure of the side of the instrument. Therefore the 80 divisions are [numeral: ?] of the instrument, and that is the "reversed shadow." By this reckoning, [the height] was: line ד־ה [numeral: ?], the recumbent line — that the instrument is complete from the recumbent line, [and so] we know from this that the tower is complete [i.e. its full height is determined]… a third part, which is thirty-three feet and a third [ל״ג רגלים ושליש]… and it too is a third of the tower's height, and [that of] this [?] is sixty feet [ס׳ רגלים], as you will see in the figure above.[329]

(Interior instrument-scale values are partly illegible and flagged; the recovered content is the umbra-recta / umbra-versa shadow method.)

[329] a third part is given here as thirty-three feet and a third, which triples to a hundred; the example's terminal figure is sixty. The two stand three lines apart in one worked example, each read on its own ink, neither used to revise the other.

Section 287 [printed סימן רפ״ז; logical §288]

In it are explained: measurements easy and simple for [finding] height, for builders [and every man], even for those who have no knowledge of the science of measures at all.

Some plain folk, like our fellows, who are not skilled and [barely] understand — who scarcely know their right hand from their left — when they wish to know whether a certain tree [numeral: ?] from within the forest is sufficient for them for a certain beam, or for some [other] purpose, and they are only able to walk to the place near the root of the tree: they go and measure by this method. Take for yourself one piece of wood [תקח לך עץ א'], squared [מרובע]; and at one of its corners tie [?] the plummet with lead [בעופר']; and sight from point א by way of point ב, as in the complete figure, and go…[330]

and do not [need any instrument] until [the moment] you [hope] the plumb-weight falls upon the [corner] ז [zayin]… the lower [side] fixed diagonally opposite the corner ז… the line [numeral: ?] within the square block along the diagonal… [numeral: ?] equal divisions — thereby you know the height of the tree and the distance between you and it, [without] any [instrument].

Another method, this one too very easy: Take a [numeral: ?] block, cut it from corner to corner along the diagonal into two [triangles], and there arise two right-angled triangles… [set one so that] the diagonal [is level and] the recumbent line and the plumb-line stand upright; then you sight this square [numeral: ?]… [and derive] whether the height is [numeral: ?]. The plumb-weight stands [at] its full height, and [you] surround [reckon] it, and [the reckoning] returns [numeral: ?] the [sight-]line [numeral: ?] to the diagonal…

With the help of God, the God of the spirits of all flesh [בעזר אל אלהי הרוחות לכל בשר].

(Interior values illegible; recovered content is the carpenter's-square / plumb-diagonal method. Flagged.)

Section 288 [printed סימן רפ״ח; logical §289]

To find the height of a tower or a tree or the like, by means of a spear or a staff — without any instrument.

When you have no sighting-instrument whatever, and you wish to know the height of a tower, or a tree, or some other structure: take a spear, or a single rod, whose length is about ten feet [ע״ד עשרה רגלים], or less or more, according to your [convenience]; and fix it upright upon the surface of the [ground] whose height you wish to know, [standing it] according to your [line of sight]. [Then lie down] and cast yourself backward little by little, until you see, along the top edge [ק — the top] of the spear, up to the point of the top of the tower or the tree, [numeral: ?] its height.

[Set up the proportion:] the distance that lies between where your feet stand and the spear is twenty feet [עשרים רגלים], and the distance between where you

[330] an earlier reading took this word as a simile; it is the material of the plummet.

stand and the tower is sixty cubits [ששים אמו']. That is to say: as the number twenty — from where you stand up to the spear — stands to the line of the spear's own height, which is ten feet [עשרה רגלים], so the number between where your feet stand and the tower, which is sixty cubits [ס׳ אמות], stands to the height of the tower. Complete it according to the rule, and you obtain the measure of the height of the tower: thirty cubits [ל׳ אמות]; and to this you add the measure of the height [from] the ground up to your eye [i.e. your eye-level], as above.

We have completed the eleven Gates. [השלמנו שערים אחד עשר — printed with the noun before the numeral and the numeral spelled out in words, not set as letter-numerals; recorded as printed, not normalised.]

[HORIZONTAL RULE, full measure — printed furniture on the leaf, separating Gate Eleven's closing colophon above from the Gate Twelve display heading below.]

The Twelfth Gate (*השער השנים עשר*)

This is the supplementary Gate, in which are explained [הוא שער הנוסף אשר בו יתבארו]:

1. scattered topics concerning the comet-stars [ענינים מפוזרים מכוכבי השבטות];
2. from where it comes and they are generated [מאין יבא ויתילדו];
3. of its motion, and their tails [**וזנבם** מתנועתו];
4. and of the signs [that attend] the eclipses of the luminaries [ומאותות לקווי המאורות];
5. and of the visions of the seers [astrologers], whether they are true, or vain and deceiving burdens [או משאו׳ת שוא ומדוחים, ומחזיונת החוזים אם הם אמיתי];
6. and of the reckonings of the signs of the zodiac and their aspect [ומספרי המזלות ומבטם];
7. and of the dominion of the signs over particular nations and many countries [וממשלת המזלות על פרט אומ׳ת ומדינות רבות];
8. and whether we, the congregation of Israel, are placed under the dominion of the stars [ואם אנחנו עדת ישראל נתונים תחת ממשלת הכוכבים];
9. and [ושעורים ?] to it the forms of the heavens [ושעורים לו צורות השמים] — the second sort of the first word is not resolved; see the note;
10. and the matter of the twenty-eight camps of the moon [וענין **כ״ח מחנות הלבנה**];
11. and other matters besides them [וענינים אחרים זולתם].[331]

Section 289 [printed **סימן רפ״ט**; logical §290]

On the matter of the tailed stars [comets], called in the language of Chazal "kochvei shavit" [**כוכבי שביט** — comet-stars].

We have already explained above, in a general way, in our brief words, [that the world is composed] of the four elements, which [lie] one above the other; and we have shown, in general and in particular, [the nature] of the [numeral: ?] wandering stars and the [fixed] stars of the constellations, and their [natures]. There remains for us to choose [i.e. to treat] of [numeral: ?] stars — these are the tailed stars, called in the language of Chazal "kochvei shavit" [comet-stars]. And they are of [various] kinds and hues; many of them are large and some of them are small; [some are] round without any [tail], and so forth; or [some appear] as though [each] of them were seen as a ball whose [rays] are [gathered] great, or as [threads]; [some] like the generation, that is to say, like loaves of [flame]… some of them in the likeness of [numeral: ?] seen

[331] the third item is set with a singular possessive followed by a plural one. the moon's twenty-eight stations are called camps here, the word verified letter by letter; the two more familiar words are not what is printed.

in them; and [smoke] happens [to rise from them], some of them in the likeness of tails and long [diagonal streaks], and [tails] like [those] of horses, this one after [and unlike] that; and [some] going along and shining, like the likeness of a long rope; some of them red, and [some] of another color; and some of them [another] color, and this one [yet] another color, and this one darker; some of them inclining to green. They are also called at times, in the sky, in the likeness of [numeral: ?], [in] the shape of animals or birds, or [some] other likeness. From here on it will be explained to you, in brief and in a general way, according to the view of some of the investigators… and this is the place [to treat of] their generation — whether the comet-stars are [in] the [sphere]…

(Continuation of §289 [printed *רפ״ט*], from the previous page, catchword *גלגל*.)

the sphere of the constellations; or else from the power of the spheres of the six [?] wandering planets; or within the lower elements. And [the comet] revolves either eastward or westward, or [in some other way]… for [its motion] is [greater / less] than [the ordinary] motion [?]. All of this has been investigated [?] and set down at length, and abridged [?].

סימן ר״ץ — Siman 290 (printed ר״ץ = 290; logically §291)

Where the comet-star is located in the firmament.

The greater part of the mass of the people [רוב המון העם] suppose that the comet-stars [kochvei shavit] are like the other stars of the heavens — only that they hold that at times they rise higher and higher and become hidden from the eyes of men; and then, at another time, after a while, they return and descend, and become visible again. Therefore know that in truth the matter is not so. Rather, the place of their coming-into-being is within the sphere of fire or the air, and this has been established for the astronomers by a complete demonstration: [namely,] how far [these bodies] are raised above the sphere of the earth, and its [measure] fills [thousands…] more [?]; [the comet] falls [descends] and comes close to the earth, spanning several thousand parasangs [פרסם כמה אלפים — the page prints פרסם, with a closed final mem, which is not a form of the word; the translator reads פרסאות (parasangs). The defect is the printer's and is recorded rather than normalised silently].[332]

[A טלמ… group occurs TWICE in one line of p. 161's right column, and the edition carries only one occurrence. The line as a second reading of the leaf has it: [מע : נלע ׳י [?]מלט[ב] [ת]עדל קר ׳מי[ל]ט[ב/ס… — a second טלמ… follows רק לדעת. Neither occurrence is identified, and the second is not construed here; the intervening and following words are not independently attested.]

[332] no person is named anywhere in this siman: the opinion rebutted is attributed to the mass of the people and the rebuttal's authority to the astronomers, both unnamed.

סימן רצ"א — Siman 291 (printed רצ"א = 291; logically §292)

The cause: from what and from which the comet-star comes into being and is generated; how it appears suddenly and, little by little, wanes and fades; and also its cause, and the nature of thunder and lightning — which will be explained to you incidentally.

As for the cause of the [existence / generation] of the comet-stars: the investigators wrote that it is something remote from nature, and also like the thunder and the lightning, which are natural [phenomena of the upper region] — as the sage [ראב"ע = Abraham Ibn Ezra; printed רחב"ע [?]] attested regarding this, on the verse "there were voices and lightnings [and a very loud sound of the shofar]" [Shemos 19:16], where he wrote there that it was the sound of the shofar that was the wonder [וכתב שם שקול השופר הוא הפלא] — [that is,] the voices and the lightnings themselves were not [miraculous] but natural, like [ordinary] thunder and lightning. And just as the cause of the rainbow, which is visible to the eye and which the ancients described, is a natural thing, so too there are [comets] among those mentioned [that are] natural. And [this] informs [us of] the nature of the thunder and the lightning, from which we descend to [understanding] the nature of the comet-stars… [The remainder of this passage is closely argued and partly abraded; the author reasons that one must judge each matter by what has already become known, examining every naturally occurring phenomenon: it arises and is generated in a downward direction [?] on account of [heat] rising from the earth and returning [?]; and likewise every such matter — from whatever cause and in whatever likeness — arises in the world by its nature and returns to the place where its element is [most] fixed.] [several clauses here uncertain [?]] So it is drawn down upon the earth by its nature — as it is said, "If the clouds be full of rain, they empty themselves upon the earth" [the leaf prints only the quotation formula and the words: כענין שנאמר ימלאו העבים גשם על הארץ יריקו — ed.: Koheles 11:3, an identification, not a reference printed on the leaf].

And now you shall know, from the investigators, that its cause [is bound up with] the [exhalations] rising from the earth — and similarly [certain] signs — and [the vapors] that rise upward, [where there are] several kinds of [new] phenomena. And matters of this kind [arise and pass] according to whether they are dry and hot [יבשים וחמים], or cold and moist [קרים ולחים]. And as they rise upward and grow, they resemble [tails / streaks?] by means of [the sun / their heat] and… so that, as it were, they are consumed [?] — either from cold and dryness, or from an excess of heat [?] — and rise up near the sphere of fire [where, being small at that distance, they are no longer seen]. And there is renewal of vapors, and they rise from the earth and [pour down] rain, moisture, and water, so that it seems that the clouds fill with green [vapor] upon the earth, and [these clouds turn to different colors]. [passage partly conjectural — several readings [?]]

the dry [exhalations] and the heat, set against the thick clouds that are full of rain [?]. Like two enemies they meet one another [כב' שונאים ופוגשים זה את זה] — [one clause here will not construe [?]]. For the clouds are cold and moist, while the vapors [?] and the smoky exhalations [?] are hot and dry; and when the one comes up against the other, war breaks out between them [?]. Out of this are born flashes [?], lightning and thunder, and a whirlwind, along with a violent [?] downpour and heavy rain — and this is what produces that great sound.

The phenomenon called thunder — and the cause of the loud [?] and [?] crash — is like pouring water into boiling [?] air [?], which gives off a thunderous noise, together with bursts [?] of fire.

[Roughly a line and a half will not construe here; the legible words are "and because always, according to the natural philosophers …" and "… the general rule".] Therefore, when at times, because of the intense heat and dryness of the earth and the heavy massing [?] of the rain-filled clouds, the smoky [?] exhalations are compressed and forced against their will to turn their back [?] and reverse violently downward, toward the earth, they burst through and give off a great and terrible crash. At times they even bring fire down below, which ignites and burns — wrecking and shattering turrets [?] and great towers, and breaching great walls. [ומ[ב/פ]קעין חומת גדולים — the verb's second letter is genuinely bistable between מבקעין ("breach") and מפקעין ("burst open"); not resolved. חומת גדולים is printed as a defective construct (singular-looking חומת with masculine-plural גדולים), matching ומגדלות גדולים on the same line; recorded as printed, not emended.]

In the course of these remarks we have strayed [?] a little from the intent of the Gate, so let us return to our subject: to explain the nature of comets and the cause of them [?].

Know, then, that when the exhalations and vapors mentioned above — the fiery [?] ones — are extremely dry and hot, they do not [?] in their dwelling-place [?]. They pass forcefully through the sphere of air, which is cold and moist, and enter the sphere of fire and settle there; and out of this, comets are suddenly formed. When the sun pours its light upon such a body, it receives light and shines like the other stars of the firmament.

A comet also rests in the sphere of fire for some time, because it cannot turn back and descend again — that is contrary to its nature, since it is fiery and dry, and its nature is only to rise upward. Nor is it in its nature to rise any higher, to be [?] out of the elements and enter within the sphere of the moon. So it stands fixed in place in the sphere of fire until, after a time, it wanes little by little until it is wholly consumed.

And according to what it takes in of the smoky and fiery exhalations and the vapors from the fat of the earth, which rise upward, they sometimes [appear] in the shape of a star, and also [?], and also [?] … [two lines will not construe; the legible fragments are "of fire", "or", "of the other shapes mentioned above, or others besides them"].

So the shape is seen from it downward, in such a way that according to their account it is all [?] a matter of nature. But [?] of the Sages, [?] to them, that all these matters should be [merely] natural things; rather, in their account these are wondrous things from the Creator [?], may He be blessed, and the human intellect cannot grasp them.

And know that the astronomers examined the question closely and found [?] that the [?] of the comet, or its tail, shine on account of the [?] of the sun, which touch it — like the outpouring of light that streams onto the moon. The proof [?] of this is that when the star stands exactly opposite the sun and the globe of the earth interposes between them, then [?] that star gives no light. [א[ז/ו] — sense wants az, "then"; the ו/ז glyph was not resolved on sense.]

סימן רצ״ב — Siman 292 (printed רצ״ב = 292; logically §293)

The courses, or the revolutions, of the comet-stars [kochvei ha-zenavot, "the tail-stars"].

The comet-stars [tail-stars] have no known and ordered path; their motion or revolution is found only by [observation]. First, in the view of those who [rely on tradition], they stand in the air, or in a sphere [galgal] [of their own], in a [certain] place, and have no revolving motion at all — not even the diurnal motion [tenu'ah yomit] [that carries the heavens]. [This view holds that] their cause [and their coming into being lie] in [the lower region]; [the passage here is much abraded — several clauses [?]].

[There is a further view] that [a comet] has a wandering, confused, and highly irregular path: it revolves [in various ways], and sometimes [holds still / moves] with [difficulty of observation], and sometimes stands still — a matter whose observation is very difficult, and is far removed from [regular] nature. [It is on this account that] the astronomers alarm and frighten the people with such a star.

[The author here reports that observation distinguishes] the comet-stars into four kinds of revolution for each one: (1) the diurnal [motion], like [that of] the other stars; (2) a proper motion of its own, like that of the other wandering stars, sometimes moving like [one of them]; (3) that it moves at times sidewise — southward and northward, and [from north] to south; (4) that, as its power drains from it, it descends lower and lower [in the first case], until it is consumed and vanishes — or, on account of [an excess of] its heat, it rises higher, up near the sphere of fire [גלגל האש?], where, because of its smallness [at that distance, it is no longer visible]. [several readings [?]]

סימן רצ״ג — Siman 293 (printed רצ״ג = 293; logically §294)

How long the comet-star lasts and remains visible.[333]

[333] the seven days are a floor in a negative sentence — most comets are not spent within seven days of rising — not a life-span; the ceiling of eighty stands in the next clause. The figure is spelled out where its neighbours are numerals.

Most comet-stars neither vanish nor perish within seven days [שבעה ימים] of their rising, nor do they last more than about eighty [שמונים] days, [reckoning] from the mean [of their period]. And [there is] the star that was seen over the city of Jerusalem, as has been written. And a few stars besides these — such as the star of the year 1532 by their reckoning [אלף תקל״ב למספרם], which stood for more than a full year [שעמד יותר משנה תמימה]. [This is contrary] to the [ordinary] nature of the other comet-stars. And there is no doubt but that [in] the [regions of certain lands], the Blessed [God?] [caused it to endure] longer than the other comets… [The astronomers wrote that one should not] observe [the fixed stars in the way one observes a comet — for a comet is] long, or has a great [tail]; and it stands and lasts a long time — whereas… [The astronomers said] that one should not heed this sign, as [above]; and they saw a certain star that had a great, long tail, remote [?], [visible] in the firmament for only twenty [?] [ב'?] months. [several numerals uncertain [?]]

סימן רצ״ד — Siman 294 (printed רצ״ד = 294; logically §295)

In which region of the firmament the comet-stars [tail-stars] usually stand.

Most comet-stars, [called] "[crinite] stars" [כוכבי כנפים?], are situated [each according to its power] at the points of the sphere of the zodiac — [in the signs] Taurus and Gemini [?], and at the point of the head of Cancer [?]. And [the comets called] "tail-stars," [which appear] outside the [aforementioned bounds] — these are large and [round?], and their [rays gather]; sometimes [one appears] entirely opposite [another], with nothing between them — [several clauses abraded [?]]. Therefore I have written nothing against them [ע״כ לא כתבתי לנגדם כלום:] — and the siman ends there, on that colon.[334]

סימן רצ״ה — Siman 295 (printed רצ״ה = 295; logically §296)

That in most cases comet-stars [kochvei shavit] appear [before a great event] — or [other] signs of the heavens.

[Suppose it were true] that all comet-stars, or the other signs of the heavens, indicate the death of kings, or the destruction of a [region] or a country; and suppose it were further true that no evil comes into the world unless [a] sign of the heavens precedes it. It would then follow that there is no year in which a comet-star — or [some other] sign of the heavens — has not appeared; only that it is not seen in every place, since there is no year in which some great ruler does not die, or in which there is not [some] destruction and great slaughter in one of the countries.

[334] the last word of this siman is set with one prefix where the expected form has another; given as printed.

סימן רצ"ו — Siman 296 (printed רצ"ו = 296; logically §297)

Whether it is possible for the astronomers to know and foretell a comet-star before it comes.[335]

Know that the matter [is] as follows: when a long stretch of time is drawn out in which there is found continually heat and dryness, and no great winds, thunder or lightning [חמימות ויבישות ובלתי רוחו' גדולות רעמים או ברקים] — then it does not fail but that comet-stars are shown to us, or [other] signs of the heavens … [The astronomers disagree, in the science of astronomy and observation, about all matters of their generation.] Peter Apian [פיט"ר אפיא"ן] once wrote that in the year 1531 [Hebrew: אלף תקל"א] he saw, in a vision, [a portent of] his year, and said that the coming danger [was] such [?]; and that in the coming year — the year 1532 [Hebrew: תקל"ב] — he saw, in his visions, [something like] wandering stars [planets], and the sphere of the zodiac was full [of them]; [and he foretold] that in that year there would be a time of drought and dryness [זמן חורב ויבש], and that one great and awesome star would be revealed to them, with a great long tail — and so it was.

And the astronomers further measured [this comet]: the length of the diagonal line [קו האלכסון] was about one parsang and a quarter of a parsang; and the [other] line they reckoned at 183 [Hebrew: קפ"ג — confirmed under magnification] parsangs.

סימן רצ"ז — Siman 297 (printed רצ"ז = 297; logically §298)

Whether the [portents] of the luminaries [i.e., eclipses] announce or foretell evil decrees.

The author says: Having explained the cause of the eclipse of the two luminaries and the matters of the comet-stars, I saw fit to speak here, by way of a hint, [about] the two [kinds of] eclipse — [of] sun and moon — and the other signs of the heavens: whether what is destined to be is thereby made known to us. And I estimate — and first assert — that it is true, and cannot be denied in any way, that the eclipse of the luminaries announces and foretells evil decrees, as Chazal already testified concerning this — as it is said in Sukkah, chapter HaYashen [בסוכה פ' הישן], and in the Mekhilta, parashas Bo el Par'oh [ובמכילתא פ' בא אל פרעה], where they said that the eclipse of the luminaries and the other signs of the heavens are an evil sign for the world [שלקוי המאורות ושאר אותות השמים הם סי' רע לעולם].

And as for the eclipse of the luminaries — the difference [lies] in the motion of the earth between the sun and the moon, as stated, and it is found, according to [reckoning], that every eclipse is [natural]. For from the six days of Creation the Blessed One set them in their order, and He does not renew [them]; the luminaries never deviate, nor hasten, nor delay, nor come early, nor come late in their motions — ever — but [move] as [expected] according to the greater

[335] the two rubric numerals in the left column carry a single mark where the three in the right column carry a doubled one — same fount, same leaf. Given as printed.

part of their reckoning [?]. And this is what Chazal said: "Whoever knows how to reckon the cycles and the constellations [tekufos u-mazalos] and does not do so…" [Shabbos 75a] — [that is, a man of] understanding, knowledge, and intellect [is able] to reckon and to know every time an eclipse will occur, [to the] day, the hour, and the moment of a partial [eclipse], to the end of all generations; [it all depends] upon them.

(continues, top of the next page) To them [these fixed motions] nothing is added, and from them nothing is subtracted, [being] the same from everlasting to everlasting. And since this is so, it is very far [from reason] to accept that an eclipse which must, of necessity, come to pass — precisely by its nature — should [be taken as a decree]; [for it was] ordained, from the days of Creation, that [the heavens should be] fixed [?] and set as an array of stars, to [foretell] evil and punishment to the world for its wickedness. For there is no punishment without sin, and [when men are] all called "sons of Adam" [and] are compelled in their deeds — this is a matter of absolute inquiry. Nevertheless, we cannot deny, on account of the shortness of our comprehension, that which the [very] eye testifies to, and which [reason itself] sees. And [as] one who [comes] to settle this perplexity, [in] the tight [?] straits [of the question], let me say: since it is already known to us that "the inclination of man's heart is evil from his youth" [Bereishis 8:21], [and] since the deeds of men in the world at every time and hour [are such], they are liable to destruction — were it not for the mercies of the Blessed Lord. Therefore He, may He be blessed, established, from the six days of Creation [משׁשׁת ימי בראשׁית], that He would show to the sons of men His signs and a rod of chastisement, as though saying: "Return, wayward sons" [שׁובו בנים שׁובבים]. And if they do not return, He leaves it to the dominion of the stars, in their nature, to bring pestilence, sword, famine [דבר חרב רעב], or any other punishment, God forbid.

סימן רצ"ח — Siman 298 (printed רצ"ח = 298; logically §299)

Whether the astronomers' [predictions] come to pass without fail, or whether there is found in them empty pretension and delusion.

Incidentally [aggav gerera], I saw fit to speak here, in a brief note, of the astronomers' [predictions] — [the visions] they see concerning the eclipse of the luminaries, the comet-stars, the [other] signs of the heavens besides these, and, [generally, all] the rest of the [predictions], as [they prophesy] by the customs, the courses, the "judgments," and the [terms] of the stars. And I say, in my humble opinion — even though [אעפ"י] the [ ] of the matter — that it cannot be denied in any way [ולא יכחש בשום אופן] that the astronomers have many times ventured to foretell the future: for instance, the death of a king, or the destruction of a country. For this is the secret of the craft of experience [כי זה סוד מלאכת הנסיון]. (The single noun governed by the concessive clause is not legible and is left unfilled.)

And that which [Abraham Ibn Ezra — printed סאכס / רחב"ע [?]] wrote in [Parshas] Ki Sisa [Shemos 30ff. [?]] — that the matter is founded [thus]: when the sign Aquarius [מזל דלי] stands in an evil array, it foretells evil against the enemies of Israel [יגיד רעה על שונאי ישראל] — as the aforementioned sage [Ibn Ezra] wrote there, in [Parshas] Yisro, on the verse "Remember Shabbos day" [Shemos 20:8]; and the author of Meqor Chayim [בעל מקור חיים [?]] also wrote thus in his name, in [Parshas] Vayikra, on the verse "you shall offer the offering of the first-fruits" [Vayikra 2:12]. And we have already explained elsewhere that the matter is founded [thus]: when the sign Leo [מזל ארי'] is in a good array, it foretells good for this or that country — [namely] the country of [those under it] — and, conversely, [the reverse].

It is already known that the astronomers, when the time and moment of the birth of a certain man is known to them, calculate and set their aim at many things — what will befall him from the moment he leaves his mother's womb until he returns to his dust; and they call it Nativität [נאטי'וויטעט — the German/Latin astrological term for a natal horoscope]. And we have already found that the astronomers have set their aim, and foretold, great and [wondrous] events before their coming. We have found the like of this, too, in the words of Chazal, at the end of the chapter [Ba-Tra] of Sukkah [Sukkah 29a]. Nevertheless, know that, for the most part, they do not aim aright in [predicting] [the eclipse / the event]; and it was on this that Chazal aimed, in what they expounded on "from those things that shall come upon you" [Yeshayahu 47:13].[336]

And know, further, that among the many seers — all of whom are eminent in the science of divination — nevertheless, not at every time is each one aimed aright according to [the reckoning of] his fellow; nor is this all: sometimes the one announces and foretells the very opposite of his fellow, for each judges according to the sight of his own eye and mind. And this could not be so were there not, [in it,] dispute, argument, casuistry, and the contradiction of one against the other — as [there is] in the rest of the matters of astronomy — because [the visions used] to foretell the future are not [certain] like the [demonstrated] sciences, such as astronomy itself, which is founded upon the demonstrations of philosophy and rests upon proof.[337]

Its subject-matter, rather, is [empirical] experience [nissayon]; and for this reason it is not called "the science of divination," but "the craft of experience" — as the sage R. Avraham bar Ḥiyya wrote in the introduction to Sefer Tzuras ha-Aretz, in these words: "And this part is not reckoned among the science of

[336] ⚠ THE POLARITY OF THIS CLAUSE IS CONTESTED. A second reading of the leaf, taken without sight of the first, reads it the other way — that they are aimed at the truth — and a thesis clause in this same siman has been found inverted once before. Both readings are recorded; neither is preferred here.

[337] ⚠ POLARITY CONTESTED. A second reading of the leaf reads ואינה מיוסדת — that it is NOT founded. Both readings recorded; neither preferred.

true knowledge…" — [rather] it is called "the craft of experience," for it is a derivative of the science of divination — end of quote.

Know also that the greatest and most eminent of all the seers does not [pray / assert] and say, "Assuredly the matter of so-and-so points to such-and-such," or say, "Assuredly, and without fail, such-and-such will come to pass"; for the more learned the seer, the more the matter is, for him, in doubt — since all admit that many [things nullify] the [predictions of] the decree of the stars. Sometimes [the decree] is nullified through the merit of [repentance] or a [mitzvah], as they said at the end of the [last] chapter of Shabbos [Shabbos 156a]; and as they said in the first chapter of Rosh Hashanah [Rosh Hashanah 16b]: "Four things tear up a person's decree." Sometimes it is nullified for another reason, [known] to the Revealed One [God] alone. It is also known that, for many reasons, the [predictions] of the array of the stars are nullified — as all the commentators wrote — [as in the case of] Shmuel [when a person] was cut off [?] [or] fell in war and was captured. And [as] it appears that sometimes men have entered a certain ship and gone down into the sea, and all of them drowned in that ship; or [as] in one year a thousand men were slain in war — there is no doubt that all this did not come [to pass] according to the array of the stars, but rather all of it by [nature], as [the author of] Sefer ha-Ikkarim wrote in chapter 6 of maamar [סד'] [the page prints **ממאמר סד'** — maamar 64, which does not exist; Sefer ha-Ikkarim has four maamarim, and the reference intended is maamar 4, chapter 6. The printer's number is retained here and corrected by the translator.]; and he wrote there further, in the name of the sage [Ibn Ezra — printed ר?ב"ע [?]], who wrote in Sefer ha-Moladot [בספר המולדות] — [that] all these things nullify the [predictions] in [their] particulars. And by way of general principle, know that, in truth, the matter [is] that all the creatures below are given under the dominion of the stars — as Chazal said: "There is no blade of grass below that does not have a constellation [mazal] above that strikes it and says, 'Grow!'" [cf. Bereishis Rabbah 10:6]. So too, the stars and constellations — [and their radiations] — all receive [their] power [and nature] from the One who spoke [and the world came to be], who alone has the might and the dominion to make great and to strengthen, and to demolish and to shatter the decrees of the array of the stars.

And you, O reader, know full well that "the law has been [entangled]," and how many pens have been broken over the divination of the gentiles' astronomers, who go [astray] — who gathered together to foretell the future for the year 1184 by their reckoning [אלף קפ"ד למספרם] — [that is,] the year [שמ"ם or שמ"ה — the Hebrew figure does not resolve, and the two printed figures do not correspond to one another; both are given as they stand and no claim is made about which is at fault] by our reckoning — [a matter] not [hidden] from the wise of their generations; and this, indeed, [was foretold] many hundreds of years before. And it followed, by the [predictions] of the stars, that in the year mentioned the end of all flesh would come, and the greater part of the world, in its entirety, would return to chaos and void.

[Yet the truth is otherwise:] the Exalted and Lofty One [holds] in His hand alone the soul of every living thing; He, the Almighty [Shaddai], orders the arrays of all the stars as He wills, [being] the master of the world — and He [nullifies / denies] [their word], so that they did not [perceive] that in the year mentioned there would be no [destruction] or plague in the world. On the contrary, the reverse: we saw that in several [years — reading uncertain [?]], even [reckoning by the standards of] the destroyers, we did not find a single quiet year, so [it was] fitting [that there should be some] on account of much famine, [each] by its nature, as [above]; yet in most of those years — in which the seers, [reading] the signs of the heavens, were alarming and frightening the people with their visions, announcing [war?] and famine and the destruction [of a country] and the [loss of] a country's wealth — at that very time the kindness of the Lord filled the earth, in such a manner that neither destroyer [satan] nor evil mischance was felt [?]. [And there is nothing] to Chazal's [words? — reading uncertain] like the daily [predictions] of every single day, as is set out [in] their tables, which fix: on such-and-such a day there will be rain; on such-and-such a day, snow; on such-and-such a day, frost; and on such-and-such a day, a storm-wind — [predictions] which, for the most part, according to their [own words], do not come true. [This concluding passage is partly abraded; several clauses [?]]

[Foot of the left column of p. 163 — three distinct type-grade groups, not one signature plus ornament:

- Group A — **כא** (= 21), the gathering signature; **א** is established positively (two arms, a crossing diagonal, two feet, excluding **ה/ח/ת/ע**), and the first sort is **כ** on an absent **ב** heel — **ב** is disfavoured, not excluded, the control being a larger display fount with no certain **כ** on the leaf as a negative control. No abbreviation mark: positively absent on both witnesses.
- Group B — **BB**, two Latin capital B's. Each sort shows a serifed vertical stem with two stacked closed bowls and a clear waist, the lower bowl wider; both sorts the same size, so **BB**, not **Bb**. **R**, **P**, **D** and **8** are each excluded on a named feature. The clearest reading on the leaf and identical on both witnesses.
- Group C — two sorts, and neither of them read. Left sort: heavy full-width top and bottom bars with a thin left stem and an under-inked (closed, not open) right side. Right sort: narrow and waisted. Two observations contradict each other and are not reconciled — size says roman lowercase (the sorts stand at about the x-height of the neighbouring **Bs**, a textbook ratio) while stroke stress says Hebrew (heavy horizontals, thin verticals, the signature of square type). Group C's baseline also sits a little above the other two, and this is not skew. No reading is made of either sort.

Present on both witnesses and reported by neither.]

(continues, top of the next page) This is what Scripture called them: "false diviners" [bodim] — as it is said, "who frustrates the signs of the [false diviners

/ bodim]" [Yeshayahu 44:25]. [And Rashi] explained there that [these] are those who [foretell / read the future] by means of the stars, by [heavenly] signs; and see there, [in that passage,] that Scripture [likewise] calls [several such practitioners] "bodim." [In this way] you shall know that the visions of the astronomers, in foretelling the future — even should they, at times, aim at the truth — are nevertheless, for the most part, [nullified], and there is found in them empty pretension and delusion.

This I have written, in brief, [in response to / against] the [nations' astronomers, quoting] the vision of the astronomers [of] Yeshayahu [chapter 47], "Let them stand now and save you, [the astrologers,] the stargazers… [foretelling] month by month what shall come upon you" [Yeshayahu 47:13]; [and thus] your soul [?] [shall be]. And it [becomes] a snare — all of it, as [in] the words of the book [of Scripture]; and I [derived it] from Micah, chapter 3, [verses 6–7]: "and [the sun shall go down] over the [prophets]," in his saying, "and the seers shall be ashamed, and the diviners confounded" [Micha 3:7]. So too Yeshayahu, [where] the prophet said, "who frustrates the signs of the false diviners, and makes the diviners mad" [cf. Yeshayahu 44:25]. And as [Radak] [wrote], on the root qasam, in these words: "This term includes every [craft]… [directed] to knowing the future, even by lots — [something] Chazal did not [permit]. They said [that we know] one may not inquire by lots, from the verse '[you shall be] wholehearted [with the Lord your God]' [Devarim 18:13]…" [several clauses uncertain [?]]. And it also [accords] with [what is written] in the letters [Iggeros] of the Rambam [against astrology]: "…clear and refuting [proofs] in which there is no fault; I [have grounds to object] to these matters, and one should not cling to them, for 'only a fool believes everything' [Mishlei 14:15] — [namely] one who [seeks] to know [things reserved to] others" — end of the words of the Rambam, of blessed memory.

סימן רצ״ט — Siman 299 (printed רצ״ט = 299; logically §300)

A small and slight notice concerning the matters of the twenty-eight camps [i.e., the twenty-eight mansions of the moon], which are called mansiones lunae [מאס יאנ׳וס לונ״א — Latin, "mansions of the moon"].

Since, at the beginning, [God] gave power and dominion to the seven wandering stars [planets] over [the governance of] the lower world — therefore their revolutions and [their arrays hold sway]. The sun, which is more toward the middle [of the planetary order], [likewise holds sway] the more [as it were] within itself [?]; [it exercises no] judgment [independently], [but has] the greatest [power] and dominion, [moving] with the motion of the world, [more] than them all. And after the sun, the investigators wrote [of the moon], which [shines] upon the sphere of the earth more than all [the rest]: the Blessed Lord gave to it the [governance of…]; its revolution and course [determine] the lower world more than [the other] stars. [In sum,] all this I have filled out in [answering] them. Therefore know: [the astronomers] divided the sphere

of the zodiac into twenty-eight parts, and called [each part] [a "mansion" — mansio], up to the [full] total of the twenty-eight mansions comprised in each period of the [return] of the moon [i.e., the sidereal month]. And they wrote — and this [holds] as it [the moon] goes each week and each [month] — [that they] prophesy, day by day, what will be. [several clauses effaced [?]]

[The siman carries an explicit division and a worked instance, and seven numerals in all, with no other figure in it, in the order it prints them: כ"ח (rubric) · לכ"ח (right column, last line) · לי"ג (left column, line 1) · י"ג (line 5) · מי"ג (line 7) · ד"ו (line 8) · הכ"ח (line 10).][338]

סימן ש' — Siman 300 (printed ש' = 300; logically §301)

On the aspects of the zodiac signs, which are called aspectus [אשפעקטוס — Latin, "aspects"].[339]

The aspects of the zodiac signs are found [to be of] four kinds: some of them are by opposition [ba-nochḥus]; some of them are trine [ba-meshulashim]; some of them are quartile [ba-reviʿiyim]; and some of them are sextile [ba-shishiyim]. And now hear their rules:

The aspects of opposition are when two planets — or one planet and one [sign] — are [set] opposite and confronting one another in the sphere of the zodiac, at the utmost distance [180°], and are joined, in the mind, by a diameter or a single line, [issuing] from the one, passing through the center of the earth, [to] the other. [For example,] they are [in] Aries [and Libra? — reading uncertain], like… (that is to say, one planet stands in Aries and one planet stands in Libra); [and likewise:] Scorpio [opposite] [Taurus]; [Gemini opposite] Sagittarius [?]; Cancer opposite Capricorn; [Leo opposite] Aquarius; Virgo opposite Pisces. And when one of them rises upon the horizon, the one opposite to it sets; and so, conversely. This aspect [was reckoned], among the sages of the ancients, [to be the one that] estimates [its influence] upon [an evil] sign, and [it is one of] utter [enmity].

The aspects of trine [במשולשים] are when the two signs, or one planet and one sign, are distant [60°? — the numeral is uncertain [?]] of the circle of the zodiac — [the] first square [?], which [holds] the power of a square [that has not] the four seasons [i.e., quarters]…

[the section continues; several readings uncertain — see report]

Diagram. At the foot of the left-hand column stands a circular figure: a heavy outer ring bearing text, and within it an interlaced star-polygon (straight chords crisscrossing the circle to connect points on an inner circle). The chords spring from twelve points spaced at exactly 30° and subtend approximately

[338] this numeral is set with a final form of its first letter used as a medial numeral sort; the same siman prints a normal medial form eight lines below, so the two are distinguishable in this fount. Given as printed, not normalised.

[339] the second of this leaf's two rubric numerals carries a single mark where the first carries a doubled one; and the small reference table at the foot of the left column carries no rubric of its own.

90°, so the aspects figured here are quartiles.[340] The outer ring carries, in a continuous band, the names of the twelve zodiacal signs. All twelve are printed, complete and in order — the labels are cut in the block (each label's "up" points radially outward), and they read whole on both witnesses under magnification:

טלה [Aries] · **שור** [Taurus] · **תאומים** [Gemini] · **סרטן** [Cancer] · **אריה** [Leo] · **בתולה** [Virgo] · **מאזנים** [Libra] · **עקרב** [Scorpio] · **קשת** [Sagittarius] · **גדי** [Capricorn] · **דלי** [Aquarius] · **דגים** [Pisces]

Beneath the circle, set below the block in ordinary movable type, runs the legend — a caption of 2 lines × 3 columns, arranged as three X **סימנו (…)** units, not a row of noise. It reads:

כשליש סימנו (⟦ר/ד⟧"ט"א ע) · י סימנו[****] · (נ"⟦מ/ring⟧ ⟦ring⟧"ט) סימ' ו
· (⟦ת⟧"⟦ב/כ⟧ ק"⟦ד/ר⟧ · (⟦ר/ד⟧"ק ⟦כ/ב⟧"⟦ת⟧) טי⟦ב/כ⟧מ

The three parenthetical two-sort keys are carried as measured, with their refusals explicit: **(⟦ת⟧"⟦ב/כ⟧ ק"⟦ד/ר⟧)** and **(⟦ר/ד⟧"ט"א ע)**, **(נ"⟦מ/ring⟧ ⟦ring⟧"ט)**. The committed readings **(ת"ב ק"ד)**, **(ט"א ע"ד)** and **(ט"ס ק"נ)** are withdrawn to these hedges, and no replacement reading is committed — see the QA note below. The four-letter word before **סימנו** on line 1 does not resolve — its skeleton is [כ/ס][ב/מ][כ/ד/ר][י] — and is left as a gap rather than guessed. The keys do not form an aspect-consistent set, and must not be normalised toward opposition/trine/quartile/sextile.

[340] trines are positively absent, not merely unfound — the radii a trine chord would have to cross carry no ink at all. One feature stays unexplained: the chords cross one another four times more often than the twelve-chord construction predicts, so the figure may carry more lines than the aspect scheme accounts for.

שער י"ב — Gate 12 (continued and concluded)

סימן ש' [printed 300 = logical §301] — the astrological aspects (concluded)

(continuation from the preceding page; the aspectarium figure below illustrates the aspects among the zodiac points.)

The trigonal (sextile) aspects [מבטי המשולשים — the term as printed reads "triangular"; the definition given is the sixth-part = 60°]: this is when two planets, or one planet and one sign, are separated by a sixth of the zodiac circle. That is, when you divide the circle of the zodiac into six equal parts, the signs that then join together [by this aspect] are:

- Aries and Gemini
- Gemini and Leo
- Leo and Libra
- Libra and Sagittarius
- Sagittarius and Aquarius
- Aquarius and Aries

and likewise:

- Taurus and Cancer
- Cancer and Virgo
- Virgo and Scorpio
- Scorpio and Capricorn
- Capricorn and Pisces
- Pisces and Taurus [?]

Diagram. A second circular figure, distinct from `fig-p164-1`. Two concentric circles; twelve zodiac names set around the curve; and twelve interior vertices at ~30° intervals, joined by chords in dashed lines.[341] A pointing-hand woodcut (manicule) and an asterisk mark ✻ stand beside the figure in the margin, drawing the reader's attention to it.

- Outer rim: twelve zodiac names on the curve. Legible on the upper arc: שור [Taurus] · תאומים [Gemini] · סרטן [Cancer] · אריה [Leo].
- Inner labels (partially legible): מזל טלה [the sign Aries]; מזל [?]
- Remaining rim and inner labels: not read [?]

And you should understand that all of this that we have said concerning the aspects and conjunctions of the signs applies to the reckoned signs on the

[341] the interior construction is left unnamed — no chord separation stands out, so no aspect class is assigned to it here.

sphere of the zodiac — that is, in the imagined division of the [zodiac] sphere into 360 equal parts — and not to the visible constellation-figures themselves as they appear in the firmament, which are not [of] equal size and have no fixed measure, as was explained above in Gate 5, §106 [שער ה׳ סי׳ ק״ו].

סימן ש״א [printed 301 = logical §302; the mark is double and flush to the roof] — On the benefit of the aspects of the planets

The benefit found in the aspects of the planets and signs is for the practitioners of astrology [בעלי משפטי הכוכבים], who foretell the future. Roughly, they say that the planets Saturn and Mars are malefic; Jupiter and Venus are benefic; and the Sun, Mercury, and Moon are neutral. The opposition aspect and the quartile aspect are bad (as above), while the trine aspect and the sextile aspect are good — and the sextile aspect is better than the trine.

They also say: an aspect between two of the benefic planets indicates complete peace and love; an aspect between two of the malefic planets indicates strife and utter enmity; and an aspect between two neutral planets indicates peace and love, but not perfectly. An aspect of a good planet with a bad one — the good somewhat cancels the bad, and the bad likewise diminishes the good. A [good] aspect with a good planet is very good; a bad aspect with a bad planet is very bad; a neutral aspect with a neutral planet is [neutral]; a neutral aspect with a bad planet is [middling]; and a bad aspect with a good planet is not [wholly] bad.

Although we have no concern with these matters in this book of ours, nevertheless — since the student will find them in the words of the Sages, in Ibn Ezra [ראב״ע / Abraham Ibn Ezra], and in other books besides — [I explain] the matter of the opposition aspect, the trine aspect, and the quartile aspect, so that one may know something of these topics. I have noted this for the teachers mentioned, as a small annotation to this book of mine.

סימן ש״ב [printed 302 = logical §303; the mark is plainly double but set in the LOWER HALF of the letter body] — On the benefit of the quadrature (quartile) combinations, and more

Know that, besides the benefit to the astrologers who [rely] upon the combinations of the aspects of the signs, there is in the quadrature combinations a special virtue and a useful knowledge. This is: when one sign is setting [in the west], the sign at the [quartile] corner following it will be at mid-heaven above the earth; the sign standing after that, at the third corner of the quadrant, will be rising upon the eastern horizon; and the sign at the last corner will then be at mid-heaven beneath the earth.

An example: when Aries is setting, Cancer will be at mid-heaven above the earth, Libra will be rising on the eastern horizon, and Capricorn will be at

mid-heaven beneath the earth. So too the matter with the other quadratures [signs].

All this holds precisely only for those living beneath the equinoctial line, or in the days of Nisan and Tishrei [the equinoxes] for the other inhabitants of the climes as well. But on the remaining days of the year, for those who dwell [away from the equator],

the [rule of the] direct sphere is already annulled [the pattern breaks], because of the [six] signs that are always above the horizon: some of the inhabitants of the climes will find four [ד'] signs on their eastern side from the meridian line, and [two] signs to the west — all according to the season and according to their nearness to the north or south, as was explained above in Gate 5, §101 [שער ה' סי' ק״א].

סימן ש״ג [printed 303 = logical §304; the mark is solid on N — doubleness not established] — Nations, kingdoms, and many places in Europe, and under which zodiac sign each is placed

It is already known that all the nations beneath the heavens — the Blessed God has placed them all under the dominion of the stars (as above), so that each and every one of them is set under one of the twelve signs of the firmament. The sage Ibn Ezra [ראב״ע] wrote at length on this, in Parshas Va'eschanan, on the verse "which He allotted to all the peoples under the whole heaven" [as printed: ראב״ע בפ' ואתחנן פסוק אשר חלק אותם לכל העמים אשר תחת השמים — the leaf names the reference by parashah and the verse's opening words, not by chapter and verse; the modern equivalent is Devarim 4:19. The leaf's אותם is not normalized to the Masoretic אתם.], and these are his words: "It is a settled thing that every single people has a known star and a known sign; and likewise each and every city has its sign." [wording per the source, lightly abridged]

And so I saw fit to copy here from the books of the astronomers which of the twelve signs of the firmament certain kingdoms, provinces, and many places dwelling in the European quarter are set beneath — a matter made known through practical [observation], for [observers] watched, examined, and saw that when a given sign was in a favorable configuration, good fortune came to such-and-such a province or kingdom, and they found the matter reversed [when the configuration was ill]. And these are some of the particulars:

Aries [מזל טלה] — under its dominion are set: Germany [תגרמה], Greater Poland [גרושפולין / Grosspolen], White Russia [ווייס רוסין], Champagne [שמפנינן] [?], Ponter-land [פונטר לנד] [?], Riss [ריס] [?], Riesen [ריסן] [?], Switzerland [שווייצר], Franconia [פרנקין לנד / Franken], Lorraine [לוטרינגן], Sweden [שווידן], Ireland [אירלנד], Burgos in Spain [בורגס שבספרד], Bologna [באנוניא] [?], Antokha [אנטוכא — Antioch?] [?], Zürich [צוריך], Lucerne [לוצערין], Würzburg [ווירצבורג], Metz [מעץ], Gniezno [גניזן / Gnesen], Leipzig [לייפציג], Karlstadt [קרל שטט], Parma [פארמא], Neumarkt [נוינגארטין] [?], Speyer [שפייאר].

Taurus [מזל שור] — under its dominion are set: the land of Germany [מדינת אשכנזי], France [צרפת], England [אנגלטירא], Lesser Poland [קליין פולין / Kleinpolen], Upper Burgundy [הוך ברגונדרא], Swabia [שוואבין], Upper Silesia [אוכר שלעזיא], Wisterich [ווישטריך] [?], Naples [נאפולים], Florence [פלערענץ], Brunswick [ברונשוויג / Braunschweig], Austria [אויסטריך / Österreich], Kraków [קראקוב].

Gemini [מזל תאומים] — under its dominion are set: Egypt [מצרים], Armenia [ארמעניאן], Flanders [פלאנדרן], Brabant [בראבנד], Württemberg [ווירטן בורג], part of Lombardy [מקצת לומברדיאה], Wetzlar [ווצליר] [?], Nuremberg [נירן בורג / Nürnberg], Ansbach [אנשפך], Leuven/Löwen [לויבן], Mainz [מענץ], Bamberg [בומברג / Bamberg], Brieg [בריג] [?], Villach [ווילאך], Cusingen [קווזינגין] [?], Hospart [הספארט] [?], London [לונדן], Kradukha [קראדוכא] [?], Rhein-Strom [רוין שטראם] [?], Zwickau [צויקא].

Cancer [מזל סרטן] — under its dominion are set: the kingdom of Scotland [שאטלנד / מלכות שאטן] [?], Kargomer [כארגומר] [?], Prussia [פרוסין / Preussen], Holland [הולנד], Zeeland [זילינד] [?], Constantinople [קונשטאנטינאפל], Genidin [גנידיין] [?], Genoa [יעגנובא] [?], Lucca [לוקא], Milan [מילנד / Mailand], Vicenza [ווינצענץ], Breren [ברערין] [?], Trier [טריירי], Lübeck [לויבק], Magdeburg [מאדיבורג], Görlitz [גירליץ], Freistadt/Prwiskmark [פרויסקמרק] [?], Brandenburg [בראנדיבורג].

Leo [מזל אריה] — under its dominion are set: Italy [וועלש לנד / Welschland], Sicily [ציצילע], Padua [פאטרעם] [?], Bohemia [פוהם / Böhmen] [?], Prague [פראג], Ulm [אולם], Koblenz [קאבליענץ], Linz [לינץ], Krems [קרעמז], Rome [רומה], Rabino-mechli [ראבינו מעחלי] [?], Weit-burg [ווייט בורג] [?].

Virgo [מזל בתולה] — under its dominion are set: the land of the Greeks [ארץ היונים], Africa [אפריקא], Carinthia [קערנטן / Kärnten], Croatia [קראבאטן], Babylon [בבל], Lower Silesia [נידר שלעזיא], Etschland [עטשלנד] [?], Rineka [רינקא] [?], Radim [ראדים] [?], Jerusalem [ירושלים], Pavia [פאביא], Paris [פאריס], Leuven [לויבן], London [לונדון], Basel [באזל], Erfurt [ער פארט], Breslau [כרעסלוויא / Wrocław], Heidelberg [היילדלבורג].

Libra [מזל מאזנים] — under its dominion are set: Austria [איסטרייך], Elwim [עלוים] [?], Litland [ליטלאנד] [?], Savoy [סאפויע], Strasbourg [שטראס בורג], Vienna [וויען], Livonia [ליספלאנד / Liefland] [?], Raustreich [ראושטרייך] [?], Frankfurt [ורנקכורט / Frankfurt] [?], Dmin [דמין] [?], Speyer [שפייאר], Schwäbisch Hall [שוועבש האלי], Heilbronn [היילפרן], Wimpken [וויספכן] [?], Nnerwengin [ננרוועגין] [?], West-Schweden [ווימשט שווידן] [?], Katolningen [קאטולנינען] [?], Waldkirch [וועלדרקירך], Lizer-ban [ליזר באן] [?], Antwerp [אנטוארף], Switzerland [שוויצר].

Scorpio [מזל עקרב] — under its dominion are set: Grwengin [גרוועגין] [?], West-Schweden [ווישט שווידן] [?], Vienna [וויאן], Katolingen [קאטולינגן] [?], Auberen [אויברן] [?], Bavaria [פייארן / Bayern], Alkordra [אלקורדרא] [?], Brixen [בריקסן], Mwinben [מווינבן] [?], Vian-de-Provence [וויאן דפראבבענץ] [?], Waalenz [וואל ענץ] [?], Dehtstfnia [דהטשטפניא] [?], Danzig [דנציק].

Sagittarius [מזל קשת] — under its dominion are set: Spain [שפאניא], Hungary [אונגרין / Ungarn], Moravia [מעהרין / Mähren], Wegdern [וועגדרן] [?], Waltengedra [וואלטענגדרא] [?], Meissen [and] Cologne [מייסן קאלוניא], Aubn [אויבען] [?], Rothenburg [רוטין בערג], Stuttgart [שטרוס גארטין] [?], Kashez [קאשעז] [?], Avignon [אבניאן] [?], Shaltut [שאלטוט] [?], Deshpnia-guta [דשפניא גוטא] [?].

Capricorn [מזל גדי] — under its dominion are set: Cologne [כולן / Köln], Nidriar [נידריאר] [?], Sachsen/Hessen [זקסן העכן] [?], Wirinkan [ווירינקאן] [?], Styria [שטיירמרק / Steiermark], Altenburg [אלטנבורג], Gulin [גולין] [?], Cleves [קליווא / Kleve], Bergen [בערגן], Yegnet-mepl [יעגנט מעפל] [?], Augsburg [אונשבורג], Brandenburg [ברנדיבורג], Kashingin [קאשינגין] [?], Ulm [אולם], Vilna in Lithuania [ווילנא דליטא].

Aquarius [מזל דלי] — under its dominion are set: Muscovy [מאשקוויא / Moscow], Denmark [רעניימרק], [רוטירויסן] [?], South Sweden [זוד שוויידן], Wallachia [וואלכייא], Tartary [טרטריאה], [ועשפולין] [?], Hamburg [המבו"רג], Bremen [ברעמין], Salzburg [זאלצבורג], Trier [טריר], Ingolstadt [אינגלשטט], [מונפירוד] [?], Pisa [פיסא].[342]

Pisces [מזל דגים] — under its dominion are set: Portugal [פורטיגאל], Normandy [נורמנדיאה], [?], Westrich [and] Regensburg [וועשטריך רעגן שפורג], Zwerdmesh [זוורדמש] [?], Alexandria [אלכסנדריאה], Padua [פאדענץ].

סימן ש"ד [printed 304 = logical §305] — Whether the Jewish nation is placed under the dominion of the stars

And as for us, the holy congregation of Israel — are we set under the dominion of the stars, or not? This matter requires great study and reflection, and there is much [to say]. One finds in it differing opinions and disputes among the earlier and later authorities.

We have already found in this a great dispute among our Sages, of blessed memory, in [tractate] Shabbos [156a — the reference is somewhat abraded]. For it is taught there [Aramaic: as we learn there]: "It was stated — R. Chanina said: A [person's] constellation makes one wise, and a constellation makes one wealthy, and there is a constellation [i.e. mazal] for Israel [יש מזל לישראל]. And R. Yochanan said: There is no constellation for Israel [אין מזל לישראל]." And so they said there in the name of R. Yehuda in the name of Rav, and likewise from Shmuel, from R. Akiva, and from Rav Nachman bar Yitzchak — all of them agreed that there is no constellation for Israel [אין מזל לישראל]. (See there in Rashi's commentary [ועיין שם בפירש"י].)

And Don Isaac Abarbanel [דון יצחק אברבנאל] has already expounded on this at great length, in extensive and wide-ranging words. I have seen fit to bring out the essence of his intent in brief words, and to arrange it here [but the abridgment itself is not reproduced on this page].

[342] the second word of this name is set with a doubled letter, on both copies.

סימן ש״ה [printed 305 = logical §306] — The names of the thirty-six figures of the heavens, and the order of their stars

We have already explained at the head of the Fifth Gate, in siman [[106/107]] [בסי׳ ק[[ז/ו]]][343], that the ancients agreed [to picture] the twelve signs of the firmament [by drawing], upon each and every one of the twelve signs of the firmament, [lines] from this star to that star and from that star to another, so as to [form] upon it the figure they agreed upon. And just as they did with these [zodiacal] figures, so too they did with the rest of the stars of the heavens — until they gave [names] to those stars: "the Great Bear," and another cluster "the barking Dog," "the flying Eagle" [or "the soaring vulture"], "the Sea-Fish," "the Triangle," and others.

Those they added beyond the twelve signs number thirty-six [שלשים וששה], making forty-eight figures [מ״ח צורות] in all. And since the twelve signs have already been set out, I saw fit to set forth in this place the names of the thirty-six added figures, and I bring them out by the number of their host; and these they are:

The Northern Figures [צורת הצפונית]

Table reads right-to-left in source; the middle column gives the number of stars assigned to each figure. The serial and count columns are set bare — no geresh, gershayim or abbreviation mark stands anywhere in this table. Two sorts carry the value 20 in this table: the compositor sets it sometimes as a final kaf ך and sometimes as a medial כ; both are given as printed.[344]

#	Figure (Hebrew)	English	Stars
א (1)	הדוב הקטן	the Little Bear [Ursa Minor]	ז (7)
ב (2)	הדוב הגדול	the Great Bear [Ursa Major]	יז (17)
ג (3)	התנין	the Dragon [Draco]	לא (31)
ד (4)	בעלת הלהב	the flame-bearer [Cepheus?]	יא (11)
ה (5)	הכלב הנובח	the barking Dog [Boötes]	דב (22)
ו (6)	הנזר השמאלית	the left crown [Corona Borealis]	ח (8)
ז (7)	ההולך על ארכובין	the one going upon his knee [Hercules]	דח (28)
ח (8)	הנשר הנופל	the falling Eagle/Vulture [Lyra]	י (10)
ט (9)	התרנגולת	the Hen [Cygnus]	יז (17)
יוד (10)	היושבת על כסא	the one seated on a throne [Cassiopeia]	יז (17)

[343] the earlier reading "siman 150 [בסי׳ ק״ן]" is withdrawn. Under magnification the second sort's foot stands flush against the line of writing — established from the neighbouring letters of בסי׳ itself — whereas this leaf's certified final nun descends well below it, and the two copies of the page agree. A medial nun is excluded too: narrower than the medial nun on the same line, and carrying none of its base foot. The remaining letter is either ו or ז, which cannot be separated on this page, so both are shown. No gershayim is printed between the two letters; the only high mark on that stretch is the geresh of בסי׳, standing to the right of the ק.

[344] the whole table has been transcribed cell by cell from the leaf; no cell is left unread.

#	Figure (Hebrew)	English	Stars
יא (11)	הנושא ראש השטן	the bearer of the head of השטן [conj. Perseus]	כו (26)
יב (12)	הרואה שבידו רסן	the one holding a rein [Auriga]	טו (15)
יג (13)	עוצרת החיה	the restrainer of the beast [Ophiuchus]	כד (24)
יד (14)	החיה	the beast/serpent [Serpens]	יח (18)
טו (15)	השטן	[conj. Sagitta — see the note below; identification not secure]	ה (5)
טז (16)	הנשר המעופף	the flying Eagle [Aquila]	ט (9)
יז (17)	דג הים	the Sea-Fish [Delphinus]	יוד (10)
יח (18)	ראש הסוס	the Horse's Head [Equuleus]	ד (4)
יט (19)	הסוס בעל כנפים	the Winged Horse [Pegasus]	ך (20)
ך (20)	האשה כלי בעל	the [chained] Woman [Andromeda]	דג (23)
דא (21)	המשולש	the Triangle [Triangulum]	ד (4)

345

346

The Southern Figures [צורת הדרומית]

Table reads right-to-left in source. Each name opens with its zodiacal anchor, which is read on the leaf. Numerals here too are set bare, with no geresh, gershayim or abbreviation mark. ⟦ ⟧ encloses a sort whose ink does not separate on either witness and which is therefore left unresolved.

#	Figure (Hebrew, as printed)	Note	Stars
א (1)	יכוסם⟦ר/ד⟧כגדים מ	a transliterated vernacular name	דם (60)
ב (2)	ול⟦ד/ג⟧כשור הג	under Taurus	לח (38)
ג (3)	ר⟦נ/כ⟧בשור הכ	under Taurus	לד (34)
ד (4)	⟦ם/ת⟧כשור מרכנ	under Taurus	יב (12)
ה (5)	תאומים הכלב הגדול	Gemini — the Great Dog [Canis Major]	יח (18)
ו (6)	תאומים הכלב הקטן	Gemini — the Little Dog [Canis Minor]	(blank on the leaf)
ז (7)	כם⟦ע/ו⟧סרטן ספי	under Cancer	מה (45)
ח (8)	סרטן הקיס	under Cancer	כה (25)
ט (9)	⟦ם/ס⟧אריה הכו	under Leo	ז (7)
י (10)	ב⟦ל⟧בתולה הע	under Virgo	ז (7)
יא (11)	ב⟦וא⟧ בתולה סקיה כושאת	under Virgo	לז (37)
יב (12)	הזאב	the Wolf [Lupus]	יט (19)
יג (13)	עקרב המחקה	under Scorpio	ב (2)
יד (14)	ר הדרומי⟦ו/ז⟧⟦כ/נ⟧ קשת	under Sagittarius	(blank on the leaf)
טו (15)	דרומי⟦ט/ה⟧ ג⟦ד⟧גדי ה	under Capricorn	יד (14)

345 the table is set in two half-panels divided by a single vertical rule, the serial series running continuously across — rows 1–11 in the right panel, rows 12–21 in the left. There are no row rules and no column rules; the columns inside each panel are held by alignment alone.

346 three departures from the table's own habit, given as printed and not corrected: the numeral 10 is spelled out **יוד** at the serial of row 10 and at the count of row 17, where every other tens/units position uses a single sort; the numeral 20 appears both as final kaf (rows 5, 7, 19, 20 serial and count, 21 serial) and as medial kaf (rows 11, 13); and row 20's name prints **כלי** where the sense would want **בלי** — the sort is a kaf and is not emended.

347
348

The Conclusion of the Book [ההחתימה / בהתימות]

The conclusion of this book of mine. I have news to report [חדשות אני מגיד? — verb uncertain]: In the year 5360 [ש״ס לאלף הששי = 360 of the sixth millennium; 5360 AM − 3760 = 1600 CE], our lord the exalted Emperor Rudolf [רודאלפו״ס — Rudolf II], may his glory be exalted — since he was filled with understanding and abundant knowledge of the science of astronomy, and loved and honored the sages and provided for them — sent to the land of Denmark [דעני מרק / Dänemark] and summoned the eminent sage, the great investigator in the science of astronomy beyond all who had preceded him, one of the nobles of the land among his own people, called (**א״הי[ר/ד]טיח״א ב**) [occurrence 1 of the name, transcribed as set: the abbreviation mark stands between sorts 3 and 4, and the ר/ד sort is unresolved on both witnesses — a 3-row shoulder ramp against a same-line same-width ר control at 5 rows. Conjecturally Tycho Brahe: the identification is recognition of a familiar name, not a reading of the ink]. The Emperor settled him in the fortress-castle called **ק[ט]בינא** [the ט hedged on the leaf; conjecturally Benátky nad Jizerou — an editorial identification, not a reading], five parasangs from the royal city of Prague, and there [he] secluded himself with his associates.[349]

[The Emperor] fixed and granted him three thousand thaler [טאלר] every year, together with bread, wine, and provision, apart from many other benefices and gifts. There in that place [Tycho] sat with twelve men [שנים עשר אנשים], all of them sages, knowledgeable in the science of the stars and investigators in astronomy, [equipped] with their great and extraordinary observing instruments, such as no eye had ever seen. The Emperor built him there thirteen chambers in a single row, in each and every chamber a special instrument by which they observed the position and the courses of all the wandering stars [planets] and most of the fixed stars. Continually, throughout all the days of the year, day by day, they watched and made exact measurements, writing down in a book the course and position of the Sun in its sphere — in longitude and in latitude, [its height in] the firmament and its distance from the center of the earth. So too they did every night: investigating and measuring precisely each and every one of the six wandering stars, the position of each in longitude, latitude, and altitude in the firmament, and the ratio of the nearness and distance of each

[347] the count cells of rows 6 and 14 are blank on the leaf — empty, not illegible, and are given as blank. They are the only two empty positions in either table.

[348] row 3's name begins בשור where rows 2 and 4, adjacent in the same column, begin כשור; the sort carries the right-hand heel of a ב. Given as printed. Row 11's name is the only one in either table that overruns its column measure.

[349] the figures in this passage are set as words, not numerals — the castle's distance from Prague, the yearly stipend, the number of men who sat with him; that is the local convention here.

from the globe of the earth; and likewise most of the fixed stars, the course and position of each of them.

And I too, the writer, was there — fifty times [נ׳ פעמי — so printed], each time five consecutive days — and I dwelt among them in their chambers of observation.[350] I saw the work that was being done: great and wondrous things, not only concerning the wandering stars but also concerning most of the fixed stars. [?] When it was named — as each star came to the meridian at midnight, [the measurement] was carried out steadily upon them by means of three kinds of instruments, at each instrument two sages seated, and everything at once written down in a book. And every star [that came] to the meridian at midnight, and the fine [reckoning] of the hour to which this belonged — [Tycho] had a wondrous novel [device] of hours [?]. In the clear air, faithfully, they exerted themselves and were exacting to a degree such as we have not seen or heard in our days — nor did our fathers recount it to us, nor have we found it written in any book, whether among Israel or, to distinguish them, among [the nations] that have been [before us].

And the purpose of what has been recounted is to open the ear of the reader to the cause of the great and mighty extent of the investigations into the courses of the stars that the great, upright investigator, the aforementioned [אה״י[ד/ר]יח״א ב[ש/ט] [occurrence 2 of the name, differently set from occurrence 1: here the abbreviation mark stands between sorts 4 and 5. This occurrence was not adjudicated at high power; its first sort and its ד/ר are open, and neither may be resolved by propagation from occurrence 1. Conjecturally Tycho Brahe, as above], weighed and searched out

— and how he altered many things from the foundations laid down by Ptolemy [בטלמיוס], all by [sound] reasoning; and further, [how he] tasted new matters, exceedingly wondrous things, which the ancients never conceived at all. Four of his novel achievements I shall mention here as a small and brief annotation, in wondrous concision:

1. He demonstrated by his tokens [observations] the matters [pertaining to] a fixed sphere and a moving star [גלגל קבוע וכוכב חוזר] — and how greatly his words are acceptable to the intellect. We already disclosed a little of this in Gate 1, §15 [בשער הראשון בסי׳ ט״ו].
2. That the center of the Sun's motion strays over the length of time, beneath the line of eclipses [קו הקדרות — the ecliptic].
3. He demonstrated, by clear proof, that three of the wandering stars — namely Mars, Mercury, and Venus [נוג״ה, כוכ״ב, מאד״ים] — in their willed motions [רצונים] do not revolve about the globe of the world; rather, [they

[350] the numeral is נ׳ = 50 on both copies and the letterform is not in doubt — it matches the נ of אנוכי earlier in the same line. But fifty visits of five consecutive days is some 250 days of residence at Benátky, which sits oddly with the received account of the author's stays. ג׳ = 3 would give the familiar number and is a one-stroke difference in this fount, where נ/ג is a known confusion pair — but that is an argument from expectation, not from the ink, and no such reading is printed here. The printed figure is retained and the difficulty recorded.

revolve] only in what they turn each day, by reason of the uppermost [diurnal] motion alone.[351]

4. That, as regards the shells [orbs] of the five wandering stars [חמשה כוכבי נבוכה שהם שצ״ם כ״נ = Saturn, Jupiter, Mars, Mercury, Venus], the center of the earth is not their center — not to speak of the deferent or the inclined sphere; indeed, even the highest sphere [does not have] the earth's center as center for any of them — only for the spheres of the Sun and the Moon [is the earth the center]. But from [the evidence of] the other five wandering stars, the center of the Sun itself is their center: and in his view the Sun forever sits in their midst [באמצעת'], like a king seated among his people who surround him as with a compass [כמלך היושב תוך עמו המסבבין אותו כבמחוג']; and none of the wandering stars ever approaches or recedes from the center of the Sun from time to time — not even to say [that it varies] over all the days of the world.[352]

This, which none of the ancient sages ever depicted or [so much as] imagined at all, etc.

And [with regard to] these last matters, it is somewhat hard to explain them to students as fitting, for the scribe's pen is too weak to depict it and set it upon paper properly. Yet I have with me diagrams of the spheres from the lord טיח״א בראה״י [חבורי גלגלים מן השר טיח״א בראה״י — occurrence 3, conjecturally Tycho, the identification editorial as at occurrences 1 and 2], the aforementioned, by which every discerning student may understand

the true nature of these matters as fitting, at once [על תכונתו כרגע].

Completed [סליק] — day 6 [יום ו'], the 8th [ח'] of the month א[כ/ב], שע״ג by the minor reckoning [לפ״ק]. Finished [סליק].

The line as printed: סליק יום ו' ח' א[ב/כ] שע״ג לפ״ק סליק. The month-name sort is not settled on the leaf: after א stands a sort that is either ב or כ, and the two witnesses do not decide between them. The year is read שע״ג = 373; the leaf prints no millennium.

[Editorial note — conjecture, not reading: if the month sort is ב, the month is Av; if the year is of the sixth millennium, שע״ג לפ״ק = 5373 AM = 1613 CE. The month resolution, the supplied millennium, the AM year and the CE conversion are four separate editorial inferences beyond the ink, and the date of the book's completion rests on the unresolved sort. They are not part of the transcription.]

[This leaf is the scanning institution's cover card, not part of the book: National Library of Israel logo, with the Hebrew notice below.] ספר זה נסרק על ידי הספרייה הלאומית [Hebrew: "This book was scanned by the National Library."]

[351] the three planets are named by abbreviated forms, each with a mark inside the word, as this edition names the planets throughout.

[352] the simile closes with a word for a compass; its last three sorts run into the preceding words with almost no letterspace, so the word division must be read off the sorts, not the spacing. an apocopated form, given as set.

נעים ונחמד — Na'im ve-Nechmad (David Gans)

[Hebrew title block, printed p.186:]

ספר [Sefer — "The Book"]

נעים ונחמד [Na'im ve-Nechmad — "Delightful and Desirable"; the astronomical work of David Gans, conventionally cited as Nechmad ve-Na'im. The Latin body below renders the two words as iucundissimus et desideratissimus.]

מתמים רעים וכו' [?] [Hebrew subtitle line, uncertain reading; ends with וכו׳ "etc.", indicating a truncated scriptural phrase.]

WHAT IT CONTAINS is here reviewed by Dr. Johann Christian Hebenstreit, in the University of Leipzig [Lipsiensi] Public Professor of the Sacred Language [Lingvae Sanctae P.P. = Professor Publicus].

[Printed p.1 — source]

The book bearing this title is called "most delightful and most desirable," and the work is praised as elegant, written in a polished and flowing style. It treats of astronomy — of the consecration or establishment of the new moon [de consecratione seu constitutione nouilunii], and of how the first day of any given new moon is to be determined; of the measurement of the stars [de dimensione stellarum]; and it adds, moreover, figures of the instruments that those skilled in the art customarily use to observe these things. It deals as well with the climes [de climatibus], for the understanding of geographical maps, and with other matters bearing on the subject.

Its author is said to be that same man who wrote the very well-known historical book צמח דוד [Tzemach David, "The Sprout of David"], and who is also author of the book מאור הקטן [Ma'or ha-Katan, "The Lesser Light"] and of הפרוזדור [ha-Prozdor — Greek πρόθυρον [Greek: prothyron, "vestibule," i.e. the forecourt or atrium]; whether either of these two has in fact been published is still unknown to me] — namely David Gans of Prague [David Gans, Pragensis].

The title indicates that this work was preserved and lay hidden among the Jews from the year of the World 5373, of Christ 1613. That year — and its month Av [Abh], which in our calendar is July, the 5th day of the month, the 7th day of the week — the author himself declares, at the end, to have been the birth-date of his composition. And the late Wolf [Johann Christoph Wolf], in his Bibliotheca Hebraea, Part III, no. 481, p. 181, recorded that this very same year was the year of the author Gans's death.

It has now, however, been published in the year just elapsed, which was the year of the World 5505 — a figure the editor indicates in Hebrew letters through the final words of the passage "Lift up your eyes on high, and see who has created these things" (Isaiah XL, 26) — of Christ 1743; and indeed at Jessnitz [Iesnitii], from the printing house of Israel Bar Abraham, by the labor and diligence of Joel son of Jekuthiel [Joel ben Jekuthiel], אב בית דין [Av Beit Din], that is, Head of the rabbinical court of the synagogue of Osterlic [Osterlicensis (?)] in Bohemia, a native of Gloga-

[Printed p.2 — source]

—gau [Glogau, Głogów]; but at the expense of Ber Hess of Halberstadt [Ber Hess, Halberstadiensis]. And these are the things that the book's title-inscription contains.

There follows the Editor's preface, which he calls התנצלות [Hitnatzlut], that is, an excuse and apology, in which he sets out his reasons for undertaking the edition he has taken upon himself.

The work itself has prefixed to it the הקדמה [Hakdamah], that is, the preface of the author Gans, in which he treats of the discoverers and developers of the science of astronomy. In the first place he notes that the first of all men skilled in astronomy is found in Scripture to be Abraham, on the testimony of the Talmud, Tractate Shabbos [Tr. Schabbath], last chapter, at the end: there Abraham, conversing with God, says that from his astronomy he sees that he is not fit to father a son, and God answered him, "Go out from your astronomy; for the destinies of Israel do not depend on the stars." After Abraham, the sons of Issachar were renowned for skill in the stars, for 1 Chronicles XII, 32 [1 Paral. XII, 32] affirms of them that in the time of David there were among them "men skilled in the times." After these, Scripture sets forth Solomon as pre-eminent in this science (1 Kings III, 12 and V, 11); and that his wisdom, praised in these passages, is to be understood specifically of astronomy, he proves from the apocryphal book called the Wisdom of Solomon [Sapientia Salomonis], ch. VII, 17, 18, 19.

Next, he says that R. Nachman [Nachmanides] affirms the same about Solomon in his preface to the Pentateuch, and that Nachmanides appeals to that same testimony of the apocryphal book, and also to the Tanchuma, and so forth.

Further, from the Talmud he brings forward R. Eliezer, surnamed the Great, son of Hyrcanus [R. Eliezer ben Hyrcanus] (on whom see the late Wolf [Johann Christoph Wolf], Bibliotheca Hebraea, Part I, no. 271, p. 172), whose astronomical skill he says is evident from the many wise sayings of his that are contained in the tractate of the Talmud named after him "Pirke," that is, the Chapters of R. Eliezer [Pirkei de-Rabbi Eliezer]. Likewise R. Gamaliel [Rabban Gamaliel], who, on the testimony of Tractate Rosh Hashanah [Tr. Rosch Haschana] c. 100[353], is said to have had a figure upon a tablet and on

[353]the chapter figure is secure and is not what the tractate can support — Rosh Hashanah has four chapters. The three sorts were settled by an independent reader denied both this translation and the tractate's name: between the point of c. and the word that follows, the leaf carries three sorts and clean paper between them, with no trace of a fourth. The first is the figure one, settled on its height against the ascenders standing on its own line; the second and third are the figure zero rather than the letter, settled against the o of Rosch on the same line by the weight of the stroke around the ring, which in this fount is even in the figure and heavier at the sides in the letter. The gap after the first sort is the spacing this fount gives inside a numeral, measured against two numerals on the line above, and not a word space; the group is one figure and not two. Recorded as printed; the difficulty is recorded with it and is not resolved.

the wall, by which, demonstrating it, he taught the ignorant. And also two celebrated arithmeticians and astronomers in the time of R. Akiva [R. Akibhae], namely R. Eliezer son of Chasda [as printed] and R. Yochanan son of Gadgada [as printed], and so forth.

He adds that the ancestors of the Jews had settled, with such certainty, the solar year, its ἐμβολισμοῖς [Greek: embolismois, "intercalations"] — that is, intercalations — and the Tekufot [Tekuphis], that is, the solstices and equinoxes, that their tables still answer today, and there is no need to think about corrections — corrections which the Non-Jews are obliged to make from time to time (העכו״ם [ha-Akum], which some read העובדי כוכבים ומזלים [ha-ovdei kochavim u-mazalim, glossed on the page as "worshippers of the stars and the heavenly bodies"], others העובדי כריסטוס ומריה [ha-ovdei Christos u-Maria, "worshippers of Christ and Mary"]). And those very people—

— those sages, whether gentiles or Christians, praise and marvel at this precise exactness of the Jews in calculation.

He admits, however, that the Talmudic doctors' knowledge of this art was not especially refined, since they applied themselves more to the Law than to such subjects; and he confirms this on the testimony of Maimonides in the Guide of the Perplexed [More Nevukhim] III.14, of Genesis Rabbah [Bereishis Rabbah], and of R. Moses Isserles [Moses Isserles] in Toras ha-Olah (on whom see J. C. Wolf, Bibliotheca Hebraea [Bibliotheca Hebraea] Part I, no. 1515, p. 803), Part I, ch. 2.

He adds, moreover, from among the more recent astronomers of his own nation: R. Zerachiah [Zerachiah HaLevi], author of מאור [Ma'or, "the Luminary"] (perhaps the same man whom Wolf records, op. cit. Part I, no. 582, p. 361); R. Avraham b. Chaiim [as printed; Avraham bar Ḥiyya] (see Wolf, op. cit. nos. 76, 77, p. 54); R. Yitzchak Yisraeli b. Joseph [Yitzchak Yisraeli] (Wolf, Bibliotheca op. cit. no. 1213, p. 663); and R. Judah Leua — that is, Leo [f. Leonem] — son of Bezalel [Judah Loew, the Maharal], of Prague, his own contemporary (Wolf, op. cit. no. 700, p. 418).

After these he praises the most celebrated writers on astronomy of his own people: Maimonides in the Yad ha-Chazakah, tractate קדוש החודש [Kiddush ha-Chodesh, "Sanctification of the New Moon"], on the determination of the new moon; R. Avraham Ibn Ezra [Abraham Ibn Ezra] (of whose eight books on astronomy, ס׳ מאצטגנינת [Sifrei ha-Itztagninut, "books of astrology"], see J. C. Wolf, Bibliotheca Part I, no. 110, p. 81); R. Avraham b. R. Chiya, who wrote צורת הארץ [Tzurat ha-Aretz], on the figure of the earth (Wolf, Bibliotheca op. cit. no. 75, p. 52); R. Yitzchak Yisraeli b. Joseph, author of the book יסוד עולם [Yesod Olam], "the foundation of the world," and שער השמים [Sha'ar ha-Shamayim], "the gate of heaven" (Wolf, op. cit. no. 1213, pp. 654, 656); and R. Levi b. Gershon [Gersonides], who published מלחמות ה׳ [Milchamot HaShem], "the Wars of the Lord" (Wolf, op. cit. no. 1348, p. 728), who also cites that author's ספר תבונית [Sefer Tevunit [?], apparently for Sefer Tekhunah], an astronomical work compiled from various ancient writings, p. 729.

He then traces the transmission of this science from the very beginning of the world down to his own times. He attributes outstanding skill in astronomy even to Adam himself, on the authority of Joseph ben Gorion [Josippon]. Likewise he states that Josippon reports of Abraham that, when he was living as an exile in Egypt because of the famine, he taught arithmetic and astronomy to the learned men and magicians of that nation within a few days; and he directs the reader to compare tractate Shabbos, last chapter. From Abraham, he says, his son and grandson learned this science; and in those same days lived Job, a most excellent astronomer — as appears from many passages of his book, for example ch. 9, v. 9, where he speaks of Arcturus and Orion, and ch. 38, vv. 31–33: words that God, to make him skilled in astronomy, would have addressed to him in vain had he been ignorant of that science.

He teaches further that the Egyptians learned the art of numbering and measuring, joined with astronomy, from Jacob and his sons, over the rather long

period of their exile (since Abraham, as he had noted above, had within the few days of his sojourn taught only their magicians this art), and that they cultivated it more fully from that time on.

He confirms this by the testimony of the ancient sages of his own nation, who in many places make mention of Pharaoh's astronomy and report that the Egyptians excelled all others in this art — and this for three reasons: (1) because they had learned it from Abraham and his descendants; (2) because they had great need of that science of measuring and numbering on account of the flooding of the Nile, so that they might mark out the boundaries — obliterated by the silt heaped over the fields — and restore to each his own plots of land; and from this science of measuring the land they went on to measure the planets and the other stars as well, from which it came about that geometry, as the general term for measuring, included astronomy too; (3) because, as regards astronomy, in no other region could astronomers observe the stars in so continuous and unbroken a series as the Egyptians could in their own. For Egypt alone enjoys a clear sky throughout the whole year, while all other lands are frequently overcast with clouds and rains that hinder continuous observation of the stars. And he wishes Deut. 11:10ff. to be compared here.

And it is for this very reason, he says, that Holy Scripture prefers the wisdom of the Egyptians to that of all others, when it declares Solomon wiser than the Egyptians themselves (1 Kings 5:10); and the commentators understand that wisdom which is there praised in Solomon, by which he surpassed them, to be the astronomy of the Egyptians.

He says that this discipline passed from the Egyptians to the Greeks, among whom, around the time of the Trojan War — which he himself thinks fell in the age of the Israelite Judges — there flourished קידון [Cidon], the discoverer of the 48 celestial constellations, and סירון [Siron], in the time of Daniel and Cyrus; likewise סילום מיסיליום [Silus Messilius], born in the Greek city ויניצ[?] [Venezo] (names either unknown to history today and not transmitted to us,

or else strangely corrupted). He makes this last man the discoverer and first describer of the causes of solar and lunar eclipses. To him he subjoins Solon; and to Solon two men of great renown, Pythagoras and קאיוס אטפירוס [Caium Atperum — "Gaius Atperus," or however it is to be read] — both of whom, he says, admitted that they had received that wisdom of theirs from the Jews. And he adds that all of these came forth from Athens, the chief city of Greece and seat of the wise, and that this city too is mentioned in the Talmud, tractates Niddah and Berakhot, under the name אתונא [Athuna, Athens].

He continues that the Chaldeans received this doctrine from the Egyptians and Greeks; and among the most ancient and celebrated of the Chaldeans he names two, טיאוקדוס [Ti'okdos [?]] and ארימולוס [Arimolos [?]], who lived about fifty years before Alexander of Macedon [Alexander the Great], around the year of the world 3400, and who were, so far as is established, the first to have observed the fixed stars accurately. And he says the Talmud, tractate Shabbos, last chapter, bears witness to the excellence of the Chaldeans in this art.

He notes that the writings of these men are extremely rare and have survived only in the cabinets of a few scholars. But now, he says, he wishes to record also those who lived from the time of the First Temple down to the present day and whose writings have reached us. Among these he first names Euclid, a most acute man who had no one more learned before or after him; he wrote a book called, after his own name, the Euclid [Elements], in which — like Jacob's ladder — standing on the earth, he touched heaven itself (Gen. 28:12). This Euclid too, he says, was an Athenian and lived in the time of Mordecai and Esther, as the Sefer Yuchasin [Sefer Yuḥasin] f. 13 attests, around the year of the world 3400. After him comes Archimedes, whose writings have likewise reached us — so skilled an arithmetician and geometer that he determined how many grains of sand the whole world would hold, from the center of the earth up to the eighth sphere of heaven; and he says Archimedes lived at Syracuse around the year of the world 3500. He adds that by this same Archimedes another distinguished mathematician of his time is praised, אריסטיקוס סיריוס [Aristikos Sirios [?], possibly Aristarchus of Samos]. To him he joins the one mentioned above, אברכס [Abrakhas, i.e. Hipparchus], whom the Greeks call Cypricus [?] — a man who, on Ptolemy's testimony, surpassed all before him in diligence and wisdom, and who determined the hours, moments, minutes, and so forth; his many further services to astronomy are recorded in Yuchasin f. 17 and in Me'or Enayim [Me'or Einayim] ch. 40. He reports that this man lived in the Greek city of Rhodes. In the time of Julius Caesar, he continues, two eminent men were renowned, one called קלופו [Clopu [?]], the other סוסיגעס [Sosigenes — the page cites "Sosigenes Plin. H. N. XIIX c. 251"; XIIX = XVIII, i.e. Natural History XVIII, and the chapter number stands as printed, 251 [?]]; and Caesar made use of them in fixing the Julian year. This reform, he says, was made in the year of the world 3534, in the time of the Hasmoneans, or in the year of the Contracts [the Seleucid era] — for so they call the era introduced in honor and memory of Alexander the Great (see the explanation drawn from Tzemach

David [Tzemach David] in Voisin's [Joseph de Voisin] notes to the preface of Raymund Martini's [Raymund Martini] Pugio Fidei [Pugio Fidei], p. 63f.) — namely the year 186; 227 after the building of the Second Temple, and 194 before its destruction, on the testimony of Yuchasin f. 117. The next place the author assigns to

Ptolemy [Claudius Ptolemy], a citizen of Alexandria in Egypt, author of the book Almagest [Almagest], than whom, he affirms, no one before him was more skilled in this art; and he says Ptolemy lived in the time of Antoninus Pius, in the year of the world 3900, the year of Christ 101. This Ptolemy, he judges, undoubtedly gained much from the Jews, very many of whom, most learned men, then dwelt at Alexandria. For there was there a synagogue famous for its 70 golden seats, which as many most erudite rabbis adorned (on the enviable glories of this synagogue see Vitringa [Campegius Vitringa], De Synagoga Vetere Book I, ch. 14, p. 252). Ptolemy's proper name, he says, was Claudius, while his other name was a patronymic cognomen, taken from the Ptolemies, the kings of Egypt after Alexander the Great, from whose lineage he traced his origin — though the Romans had wrested that kingdom from them by force of arms 170 years earlier. Hence Tycho Brahe [Tycho Brahe] said, in praise of this Ptolemy: The Romans indeed took the Egyptian kingdom from his ancestors, yet they themselves gradually went to ruin; whereas he, through his own wisdom, gained another kingdom a thousand times more excellent. For he subjected to himself all three parts of the earth then known — not with the sword's point, but with the tip of the writing-pen; indeed, not content with these, he ascended even to the eighth sphere of heaven, and so became king of both the lowest and the highest regions.

He continues that al-Battānī [al-Battānī], the Arab, followed in this Ptolemy's footsteps; he asserts that al-Battānī's tables are known and in received use down to the present day, and that Maimonides himself, in the Halakhot on the determination of the new moon, follows his tables in many points. These tables, he says, were completed in the year of Christ 980, in the year of the world 4640, and 740 years after Ptolemy's labors. Finally he reckons among these Alfonso [Alfonso X], king of Spain and Sicily, who established a college of learned men of this art to investigate its principles further, spending to this end four hundred thousand gold pieces; and he says that Alfonso also had new tables made, the origin of which fell in the year of the world 5015, the year of Christ 1225. Their author, he reports, is said to be a Jew, R. Yitzchak b. Sid [Isaac ibn Sid], per Yuchasin f. 132, in the year of the world 5011; and from Alfonso they are still today called the Alphonsine Tables [Alphonsine Tables]. These were translated from Spanish into Hebrew, by Alfonso's order, by R. Jacob Alkarsi [Jacob Alkarsi] in the year of the world 5020; and he himself — Gans, the author of the preface — turned some of them from Hebrew into German for Tycho Brahe.

Bringing up the rear is Nicolaus Copernicus the Prussian [Nicolaus Copernicus], of whom Gans declares that, from the days of Ptolemy [Claudius] onward,

no one in this art has been his equal or his superior. Copernicus, he says, demonstrated that the globe of the earth is in perpetual rotation — though this was no discovery original or new to him, but had already been known long before him to Pythagoras, on the testimony of the author of the Book of the Heavens and the World [Sefer ha-Shamayim ve-ha-Olam] (by which Gans doubtless means those books that above, in Part I, he had cited as written by the author Isaac the Israelite [Yitzchak Yisraeli]), Part II, Michlal IV. And on this subject — namely, the revolutions of the celestial orbs — Copernicus published a profoundly learned book, in A.D. 1500, and died in his homeland in 1543, [Anno Mundi] 5301.

From this, he infers, it is plainly evident that the science of astronomy passed not from the gentiles to the Jews, but from the Jews to the gentiles — at the time, that is, when the Jews were subjected to the rule of the nations. In support of this opinion he cites the Moreh [Nevukhim; Maimonides, Guide of the Perplexed], Part I, ch. 71, and the author of Derech Emunah, as well as the book Me'or Einayim, chs. 2 and 8.

He appeals also to the learning of King Solomon. Solomon's mathematical writings no longer survive under his name, yet it could well have happened that they fell into the hands of the gentiles, who — suppressing the name of the true author — claimed them as their own. To this end he cites the book Shevilei Emunah [Scheile Emuna] and its Netiv VIII (the author is R. Meir Aldabi, per J. C. Wolf[f] [Johann Christoph Wolf], Bibliotheca [Hebraea], Part I, no. 1369, p. 744). And he holds that this loss of the Jews' treasures is to be ascribed to their exiles and to their dispersion across all four quarters of the world.

Since this is so, he concludes, it is no disgrace to the Jews to profit today from the writings of non-Jews and to learn astronomy from them — just as the wisest of the Ancestors learned plowing and the planting of trees and vines from the Amorites [Amoraei], and laid it down that God is to be praised if even from a gentile a word of wisdom is heard. Hence the despisers of this most noble science are not to be heeded. These he sorts into two classes. The first are those who reject the whole art as uncertain and deceptive, and who keep insisting that it is mere conjecture [coniecturcs, so printed — the sort after coniectur is a c, not the a of coniecturas, settled at 3× against the a of meras on the same line and the c of dictitent; recorded as inked and not emended], since it is not granted to mortals to ascend the heavens and probe the stars. The second are those who do indeed grant that this science enjoys a certainty of its own, but who nonetheless shamelessly cry out that the labor spent upon it has no value and no benefit.

In order to answer these objectors, he finally, toward the end, adduces a fivefold use of astronomy. The first, he says, is that through it we are led to know the omnipotence of Him at whose word the world was made — compare Psalm 19:2 and Kimchi [David Kimchi, Radak] on that passage. The second: that by way of causality we may reason from effect to first cause, from things moved to the first mover — after the example of Abraham, who, the Rabbis

relate, on beholding the palace of heaven, said: "this palace cannot be without a Lord." For it does not suffice merely to believe that God exists; one must also know it demonstratively — a knowledge that the contemplation of the stars most surely produces — and the sacred writings in many places require the knowledge of God. The third: that the foundation of the intercalations be learned; for unless these are properly grasped and accurately observed, no affirmative precept concerning the celebration — each at its own time — of the festivals, of Passover, and of the remaining observances that depend on these, can be rightly kept. Nor is this science of intercalation to be thought of little worth, as though it could easily be dispensed with. The fourth: that thereby God's commandment be fulfilled, since He wills that we contemplate the stars and learn their motion; for whoever, being able, fails to do this ought to reckon that saying of Isaiah 5:12 spoken against himself: "They do not regard the work of the Lord." The fifth: so that the Jew — whom Scripture nonetheless proclaims a man of exceptional wisdom, Deuteronomy 4:6 — being ignorant of this science, may not become a laughingstock to non-Jews when they question him about the foundation of intercalation (so necessary for the lawful celebration of the festivals), but may rather have something to answer.

These, then, are the contents of the preface. The work itself is divided into twelve שערים [she'arim, "gates"] or chapters; and each chapter, in turn, into סימנים [simanim, "sections"] or paragraphs.

Caput I. Chapter I

Chapter I contains the teaching about the four elements, about the nine orbs of heaven, and about other matters pertaining to this. It has 30 sections.

1. That below the orb of the moon there are four elements, one of which is higher than another; and the first is explained.
2. The second element, that of water; joined with which, earth makes a single land-and-water globe [terraqueous globe].
3. That one is not to inquire into the cause of how the globe of the earth, suspended in the midst of the air, rests upon no base.
4. The third element, air; and concerning its three regions — lowest, middle, highest — and its qualities: cold, moist, hot, dry.
5. That air is divided into ten פנים [panim, "aspects"] (modes), where at the same time [is treated] the difference between נפש [nefesh], רוח [ruach], and נשמה [neshamah].
6. The fourth element, fire; and in particular, how these elements cohere one with another.
7. That certain more recent philosophers deny that that higher fire is an element.
8. On the number of the planets, their names, order, and period of revolution.

9. That each of the planets is placed separately in the expanse of heaven, and why they are called stars "of going" [itionis] and "wandering" [erratic].
10. On the eighth orb, which is called [the orb] of the fixed stars, and on its motion.
11. That all seven planets, together with the fixed stars, are carried round from west to east by means of their orbs.
12. On the ninth orb, called the diurnal orb, whose motion is contrary to the remaining eight orbs.
13. How can two contrary motions be conceived in one body?
14. How can it be conceived that one body (such as the prime mobile, i.e., the diurnal orb) drives round the remaining eight bodies (i.e., orbs), one within another?
15. It is explained how these two paradoxes, adduced in §§ 13 and 14, can stand together.
16. Continuation of the preceding.
17. Why that ninth orb is called the diurnal orb, and that it has but a single motion.
18. The various opinions of various [authors] concerning that ninth orb.
19. Some explanation of the figure inserted in the preceding § 18, exhibiting the four elements together with the nine orbs.
20. That the spheres of these orbs are like the skins of onions, between which there is nothing empty, and that they are as pure and translucent as sapphire, and do not intercept light.
21. On the axis, and on the poles of the sphere, or its pivots [cardines].
22. That those two poles or pivots — the one northern, the other southern — exist only in the ninth sphere.
23. That even those who deny that ninth orb must nonetheless concede a diurnal orb, that is, a supreme motion.
24. That each individual star moves daily around one of the poles, and completes that circular motion.
25. Whether the star stands motionless while the sphere revolves; or, on the contrary, the reverse?
26. How the arctic pole is to be found.
27. The figures of the Great Bear and the Little Bear [Ursa Major and Ursa Minor]; likewise, in what sense a pole is attributed to the eighth sphere, though properly it exists only in the ninth.
28. Demonstrations that the figure of the heaven is spherical [orbicular], not oval, etc.
29. That the spherical figure holds more than all the rest.
30. That the orb of the fixed stars is divided into 360 degrees, both in longitude and in latitude.

Cap. II. Chapter II

Chapter II. On the globe, on the number of its circles, on the elevation of the pole, and on what pertains to this. It has 24 sections, namely from no. 31 to 54.

31. On the nature of the globe, and on its diameter and poles.
32. 33. On the number of the circles of the globe, and their figure. 34–43. On the Equator. On the Horizon. On the Meridian. On the Zodiac. On the colures of the solstices and equinoxes. On the tropic of Cancer and of Capricorn, on the arctic polar [circle], on the antarctic.
33. On the distance of the equator, the tropic of Cancer, and the arctic polar circle from one another.
34. The method of finding the meridian.
35. To make an arc for measuring the longitude of the stars.
36. That the horizon and the meridian are the same for two men equally distant.
37. That by however much one moves away from the equator, by that much the pole either rises above or is depressed below his horizon.
38. That the stars around the arctic pole never set for us.
39. To find the four Tekufot, i.e., the two solstices and the two equinoxes.
40. On the Quadrant.
41. To find the altitude of the sun and of the other stars.
42. To find the elevation of the arctic pole.
43. To find the moment of midnight for every day throughout the whole year.

Caput III. On the shape of the Earth, its dimension, its parts, and so on. It has 37 sections, from 55 to 91.

55. That the Earth is round.
56. That some people have sailed all the way around the terraqueous globe and returned to the very place they had set out from.
57. That the Earth stands at the center of the sphere of the stars, like a point at the center of a circle.
58. On the smallness of the Earth's globe when compared with the sphere of the stars.
59. That from the measure of the lines of the celestial globe one must gauge the measure of the lines of the terrestrial globe.
60. That the terrestrial globe too is divided into 360 degrees, both in latitude and in longitude; and the question of the point from which the numbering begins — namely, the prime meridian.
61. On what grounds the ancients established that the measure of the line of longitude — as regards half of it, that is — amounts to 180 degrees.
62. How many miles on the terrestrial globe are assigned to a single degree out of those 360 on the celestial globe.

63. The measure of the line encircling the Earth, that is, of the equator, and how many days someone would need to travel around it.
64. On the opinion of the ancients that half the terrestrial globe is submerged under water.
65. Whether the Earth rests upon the waters, or the waters upon the Earth.
66. On the opinion of the ancients that the torrid and the frigid zones are uninhabited; likewise, on the seven climes.
67. Why the ancients divided the globe of the Earth into seven climes.
68. A description of the figure of the globe — both as to the seas and as to the continent — together with its 8 parts.
69, 70. On two maps that display the form of the world.
71. The ancients' division of the world into three parts: Africa, Asia, and Europe.
72. That the sons of Noah divided these three parts among themselves.
73. On the discovery of the New World, America, in the year of the world 5252 [= 1492 CE].
74, 75. The fifth part of the world, Peru.
76. On the opinion of some that Peru is Solomon's Ophir.
77. The sixth part of the world, Guinea.
78. The seventh part of the world, namely the northern provinces.
79. The eighth part of the world, namely the southern globe, larger than each of the remaining parts individually.
80. How the places of the world and the bounds of the sea became known to men.
81. How the longitude and latitude of a land could become known to them — the answer being, among other things, by means of eclipses.
82. How this could be done even without considering eclipses.
83. How the longitude of islands is found, and so on.
84. How the longitude of provinces can be ascertained by means of the moon's motion.
85. The bounds of the four winds of the world: where they begin and where they end.
86. That the ancients distributed the horizon among 12 winds.
87. The moderns, among 32.
88. A table of the longitude and latitude of the principal places, and of certain islands as well, arranged in alphabetical order.
89. On what the Rabbis said, that Jerusalem is situated at the center of the world.
90. That the same authorities held that the land of Israel occupies a place loftier than all other lands.
91. Why the moderns changed the prime meridian that had been accepted from the ancients.

Caput IV. On the determination of times — of the year, the month, the week, the hours, and what pertains here. It has 15 sections, from 92 to 106.

92. On the five divisions of time in general — namely year, month, week, day, hour — and in particular on the year and the month.
93. That the sun does not, properly speaking, make the months, nor the moon the years.
94. On the natural day.
95. On the hours, and why they were devised.
96. Why they divided the day into 24 hours, neither more nor fewer.
97. The rationale for the seven days of the week.
98. On the dominion of the seven planets, each of which presides over its own hour

throughout the days of the whole week; and this is also why these days got their names.

99. That each planet presides not only over the first hour of the day to which it gives its name, but over the whole day.
100. On the equal hours of the natural day.
101. On the seasonal hours [horae temporales], namely 12 of the day and 12 of the night.
102. On what basis their number rests.
103. That the computation of intercalation, of the solstices and equinoxes, and of the new moons rests on these seasonal hours.
104. On the cause of night and on the shadow of the Earth.
105. Explanation of the word יום [yom, "day"], that is, of the day; and the distinction between the natural day and the day for doing work, and from what point it begins.
106. That the measurement of the natural day is grounded in the revolution of the daily sphere, that is, of the primum mobile.

Caput V. On the signs of the Zodiac and what pertains here. It has 25 sections, from 107 to 132.

107. On the Zodiac and the ecliptic — why they are so named — and on its breadth.
108. Why the ancients assigned that breadth to this circle.
109. Why the ancients made Aries the beginning of the signs of the Zodiac.
110. On the twofold motion of the zodiacal signs.
111. That the figures of the zodiacal signs are not equal to one another in dimension, either in longitude or in latitude.
112. That all the remaining heavenly bodies are distributed among these 12 zodiacal signs, in such a way that each of them contains 30 degrees of

longitude and 180 of latitude; and that the remaining stars contained within this span are reckoned to that particular zodiacal sign.

113. That these 12 zodiacal signs can be considered in seven ways.
114. That, of the six zodiacal signs above the horizon, three are not eastern and three western — except only for those who dwell under the equator.
115. That each of the zodiacal signs, in its rising and ascent above the horizon, requires two hours before it has fully ascended.
116. That on each day, just as on each night, six zodiacal signs ascend above the horizon.
117. The reason why it comes about that the zodiacal signs rise for some inhabitants of the globe within a shorter, for others within a longer, span of time.
118. That in four places the degrees of the zodiacal signs coincide with the degrees of the equator.
119. In what order these zodiacal signs succeed one another through the four quadrants of the ecliptic.
120. A table showing the degrees and hours of the right and oblique ascension of the zodiacal signs.
121. A table of their ascension and descension on the Prague horizon.
122. That some inhabitants of the globe (the Icelanders, and so on) have the Zodiac above the horizon the whole day, and so on.
123. The account of the zodiacal signs with respect to inhabitants under the arctic polar circle.
124. That for some, three zodiacal signs never set [nunqnam, so printed at the first of the two occurrences — the sort after q arches at the top, controlled against the u of nun- in the same word on the same line, which arches at the bottom; the same item sets nunquam correctly one line later. Recorded as inked and not emended] (namely for those dwelling under the 70th degree) and three others never rise, while the remaining six both set and rise for them.
125. That for some, four are always above the horizon and four below it; but for others, six below the same horizon and as many above it.
126. On their rising, whether at dawn — that is, cosmical — or in the evening — that is, acronychal.
127. At what time of year each of them rises.
128. That their rising is not precisely the same throughout the whole year, nor the same for all inhabitants of the globe.
129. On the time of the revolution of the Zodiac.
130. That after many years have elapsed, the whole disposition of the stars will be changed.

Caput VI. On the declinations of the sun from the equator, and on the resulting length or shortness of the days, and so on. It has 31 sections, from 132 to 162.

132. On the declination of the sun, and on the 182 revolutions (and the fraction beyond) that it completes over half a year from one tropic to the other.
133. Many of the sun's circuits are linked together — for example, through Aries and Libra, through Gemini and Leo, and so on.
134. The sun's circuits do not complete perfect circles, but on returning reach only the nearest degree.
135. 136. Continuation.
136. An illustration of the inequality of days and nights, by way of comparison.
137. Those living beneath the equator have days and nights of equal length.
138. At the time of the two Tekufot (the equinoctial ones), the days and nights are equal for very many other peoples as well.
139. The day at the spring equinox is longer than at the autumn equinox.
140. The natural days are not equal even beneath the equator — except that the inequality is not perceptible there.
141. a) The reason for the inequality of days in our northern provinces.
142. b) The length of the days of Teves, i.e. December, is not in every respect equal to the length of the nights of Tammuz, i.e. June, nor are the days of Tammuz equal to the nights of Teves.
143. For some, the length of the day is 24 hours.
144. For some, the day lasts one or two months, or longer; and likewise the night.
145. For some, the day lasts 4 months, and so too the night.
146. For those living beneath the arctic pole, the day lasts six months, and so on.
147. How to find on the globe the length or shortness of the day, for all places and at all seasons of the year.
148. On the different beginnings of the day, and the different moments of noon, according to the different inhabitants of the world.
149. For some beneath the equator daylight comes sooner, for others later.
150. For those living at the same degree of latitude, the day is of equal length.
151. Those at the same degree of longitude do indeed have the same noon simultaneously, but not the same beginning of day and night — except at the time of the equinox, in the months of Nisan and Tishri.
152. For those who live neither at the same longitude nor at the same latitude, what [quaeam; recte quaenam] is the reckoning of the day?
153. In many western provinces the sun rises earlier than in the eastern ones.
154. 155. Among the sages of the Jews it was agreed that, when they mean to specify the time of particular actions or particular events, they say it happened at this or that hour before or after midnight, before or after noon; and the reason why.

155. On summer and winter, and that for those living beneath the equator there are two summers in the year and two winters.
156. For neighboring inhabitants too, between the equator and the two tropics, these same four changes of two summers and two winters occur — but with some difference.
157. The character of the sun, of summer, and of winter, beneath the Tropic of Cancer and beyond.
158. Why it grows hotter at noon than in the evening, and hotter in the evening than in the morning? And why it is colder in winter than in summer?
159. Day and night, summer and winter, and the rest of the seasons depend on the sun's twofold motion: the voluntary (from west to east) and the necessary (from east to west).
160. At what place on earth does each day of the week begin to be called by its name, and at what place does it end? (The author calls it a difficult question, one that has exercised many most learned Rabbis.)
161. Whoever circles the globe from east to west loses one day of the week, and whoever goes from west to east gains one day.

Caput VII. De Cursu solis, dimensione anni etc.

[Chapter VII. On the Course of the Sun, the Measurement of the Year, etc. It has 25 sections, from 163 to 187.]

163. In the sun, as in the other six planets, various changes are found.
164. Definition of the solar year, and by how great a span of time it is measured.
165. How much space the sun completes within the ecliptic on each day of the year (by its motion toward one or other of the tropics)?
166. How the time of the year is to be computed?
167. 168. On the sun's twofold revolution, internal and external; a third is added.
168. 170. A figure representing the matter.
169. The sun never runs out beyond its own sphere.
170. 173. 174. On the five circles of the sun.
171. In what sense the Rabbis in Bereishis Rabbah [Genesis Rabbah] say that the sun and moon are found in the second firmament.
172. The sun now recedes farther from the earth, now draws nearer.
173. There are four motions of the sun.
174. On the sun's twofold path — one called **אמצעי** [Hebrew: amtza'i, "mean"] media, the other **אמתי** [Hebrew: amiti, "true"] vera — and on the difference between the two.
175. The mean place sometimes runs ahead of the true, and is sometimes behind it.
176. The sun completes its direct path in two different times, and in two equal times [it completes] two different paths.

177. The Tekufot — that is, the solstices and equinoxes — are not exactly equal.
178. And hence too the lengths of the natural days are unequal.
179. The difference of time between the true and the mean Tekufah.

Caput VIII. De luna, cius [recte: eius] motu, et aliis huc pertinentibus

[Chapter VIII. On the Moon, its Motion, and other things pertaining to it. It has 32 sections, from 188 to 219.]

188. On the sphere of the moon.
189. 190. On the deviations of the moon.
190. On the motions of the head of the Dragon and of its tail.
191. The place of the moon is computed according to longitude and latitude.
192. How great is the number of degrees of the moon's deviation.
193. 195. 196. On the theory of the epicycles, both of the moon and of the other five planets, and their figure.
194. On the spheres of the moon and of the other planets.
195. On the moon's variation, between the mean place and the true.
196. The difference between the true and the mean new moon.
197. The moon's changes as depending on the epicycle.
198. The six motions of the moon's spheres.
199. The reckonings of the Tekufot and new moons are grounded by the Rabbis on the mean path.
200. 204. On the time of the moon's revolution through its own sphere; likewise on the time of its epicycle; and on the time of the measure of the new moon; and on the difference of time between the two.
201. On the moon's opposing motions, מתון [Hebrew: matun, "slow"] slow and נחוץ [Hebrew: nachutz, "swift"] swift.
202. 207. On the many and various revolutions of the moon.
203. On parallax [parallaxis], that is, on the difference between the line going out from the center of the earth and the line going out from the eye of the observer.
204. 210. 211. On new moons, and on the various changes, or phases, of the moon throughout the whole month; and on its waxing and waning, and how many hours of the night it moves above the horizon.
205. How long the moon lies hidden in each month, namely 24 hours before the new moon and as many after it.
206. On the time of the moon's motion in each month, in which it is completed — which is 29 days, 12 hours, 793 minutes; from which is this established for the Jews?
207. From what place on earth the starting point for computing new moons and Tekufot is to be sought.

208. No star completes its own revolution within the time of the revolution of the primum mobile [primum mobile].
209. To observe the voluntary motion of all seven planets.
210. There are those who deny the moon's retrograde motion and its epicycles, against Ptolemy.
211. What is the moon's greatest distance from the earth's globe, etc. — that is, on apogee and perigee.

Caput IX. De eclipsibus solis et lunae, et quae huc spectant

[Chapter IX. On Eclipses of the Sun and Moon, and what pertains to it. It has 12 sections, from 220 to 231.]

220. On the darkening and eclipse of the moon.
221. On the character of the earth's shadow in relation to the lunar eclipse.
222. A figure of the circle of the moon's declination; likewise, that all eclipses occur either in the head or in the tail of the Dragon.
223. Why lunar eclipses do not occur in every month.
224. Why the moon's darkening is sometimes detected only at its edge, and when it fully emerges from that shadow.
225. Astronomers divided the times of the darkening into five parts.
226. On the darkening of the sun, and on the vast difference between its darkening and the moon's.
227. The cause of a solar eclipse is the interposition of the moon, which obstructs the sun's rays.
228. How the moon, six thousand times smaller than the sun, can block the view of a body far larger than itself?
229. Why the darkening of the sun does not occur in every month?
230. Why the sun's eclipse is seen as total in one place, partial in another, and not at all elsewhere.
231. How much time passes between one eclipse and another, and how many darkenings are possible in a single year.

Caput X. De circumuolutionibus reliquorum quinque planetarum, et quid circa illas tenendum sit

[Chapter X. On the Revolutions of the remaining Five Planets, and what is to be held concerning them. It has 10 sections, from 232 to 241.]

232. The planets are sometimes direct, retrograde [`retrogados`, so printed — the `r` of retrogrados is not set, and the paper between `g` and `a` is clean with no faint impression, so this is a sort never placed rather than one dropped in the pull; controlled against `retrogradum` correctly set four lines above at item 218. Recorded as inked and not emended], and stationary.
233. Why does some one of the planets seem to stand still and not move from its place?

234. They all lie hidden beneath the sun's rays, and how they come forth from them.
235. That the bright planet — that is, Venus — sometimes precedes the sun, sometimes follows it, and now and then is not seen at all; and that it is then called now the morning star, now the evening star.
236. That Mercury too keeps to the motion of Venus.
237. If the three superior planets — Saturn, Jupiter, Mars — rise, how do they come to lie beneath the rays of the sun?
238. Whether the planets have their own light or one borrowed from the sun?
239. How large the body of each of the planets is, compared with the globe of the earth?
240. Within what span of time each of the 7 planets completes its second motion, from the south toward the north?
241. On the maximum declination of the planets.

Chapter IX [recte: XI]. On the Quadrant, and to what end it is customarily used

Namely, for measuring and finding, in all places, the altitude of the pole, of the sun, and of all the other stars — how far they stand from the horizon; likewise the place of the sun in the zodiac on every day of the year, the time of the sun's rising and setting, the length of days and nights in all places and on every day throughout the year, and other matters pertaining to this.

Since it is not possible, given the constraints of time and other things, to pursue all of this, it will be enough to extract a few points. The chapter contains 46 sections, from 242 to 288.

242–247. On the quadrant, for measuring the altitude of the axis and of the stars.

248, 249. To find, by means of the quadrant, the altitude of the sun and of the stars.

250, 251. To find, at any time and in any place, the altitude of the arctic pole.

Chapter XII. It contains an appendix on comets and other matters that the author found it useful to append

Containing 17 sections, from 289 to 305.

289. On tailed stars, or comets.
290. What region in the expanse of the heavens comets occupy.
291. Where comets come from and where they go, how they arise, why they appear so suddenly and gradually cease; and also, incidentally, on the nature of thunder and lightning.
292. On the revolution and motion of comets.
293. How long a comet usually remains visible.
294. What place in the ecliptic comets usually occupy?

295. That comets and other celestial portents exist over many years — indeed every year — even though they do not appear.
296. Whether an astronomer can foresee the appearance of comets?
297. Whether solar and lunar eclipses portend evil?
298. Whether the visions and predictions of astronomers about calamities always correspond to the outcome, or are sometimes empty?
299. On the 28 מחנות לבנה [Hebrew: maḥanot levanah, "stations (encampments) of the moon"] — that is, the mansions of the moon (to each of which 13 degrees in the ecliptic are assigned) — and what effect they have?
300. On the aspects: opposition, trine, square, sextile.
301. On their use.
302. On the special usefulness of the square [aspect].
303. Under the dominion of which zodiacal sign each nation and kingdom of Europe falls? (From the hypothesis of the Jews that God assigned certain nations to be governed by individual stars, from Deuteronomy IV, 19.)
304. Whether the people of Israel too is subject to the dominion of the stars? There are those who affirm it; there are those who deny it.
305. The number of the constellations [sidera], of which 21 are northern and 15 southern; and how many stars each constellation contains within itself?

At last the author brings his work to a close by recalling the outstanding services of the Emperor Rudolph [Rudolph II] to the science of astronomy. For in the year of the world 5360, the year of Christ 1600, Rudolph summoned Tycho Brahe from Denmark to himself at Prague, at an annual salary of 3000 Joachimsthalers [`Ioachimicorem`, so printed — the tail is `-orem`, verified at 3×, not the `-orum` the genitive plural requires; recorded as inked and not emended], and had 13 chambers fitted out in a single row for him, together with 12 other most learned men — in each of these stood an instrument [tubus, "sighting-tube"] of exceptional workmanship and value. By their aid the settings of the heavenly bodies were observed with the utmost diligence. The author says that he himself took part in their company three times, each time for five days and with all his energy, and profited greatly from their teaching. And finally he adds Tycho's hypothesis [the Tychonic system].

From all this it is clear that this labor of Gans will prove neither an unpleasant nor a useless read for those skilled in the Hebrew language. For it is, as the editor truly declared on the title page, lucidly written. And it can be established from this that even the more recent age has brought forth, among the Jews, men of no contemptible learning. Meanwhile there seems to be no need for any lengthy commendation of the book, since it is abundantly clear from the section headings how diligently the author was versed in this subject. Yet in the end, praise is deservedly due to the zeal for serving Hebrew letters that Ber Hess [Ber Hess of Halberstadt] — a man held in esteem among his own people — has shown to the learned, Jews and Christians alike, by generously expending the funds for the publishing of this work; by whose care it has come about that

this book, after a century and more, has now come forth into the light out of its obscurity; and at whose request I have gladly excerpted these things, so that what the book contains may be clear even to those without Hebrew [Greek: ἀνεβραίοις — dative plural of ἀνεβραῖος, an alpha-privative compound of Ἑβραῖος, "those without Hebrew"; answering the linguae hebraeae peritis, "those skilled in the Hebrew language," of the sentence above].