

Keli ha-Nehoshet

כלי הנחושת, "The Instrument of Brass"
— i.e., the Astrolabe

(1845)

by R. Avraham ibn Ezra (אברהם בן מאיר אבן עזרא), ca. 1089–ca. 1161,
born in Tudela (Muslim Spain), itinerant scholar across Latin Europe

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ARS ASTRONOMICA

2026

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Translator Version beta

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 HaBrit HaShalem* (1797)

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A note on the work

The earliest surviving Hebrew treatise on the astrolabe, composed in the mid-twelfth century. It explains how to build the instrument and how to use it to tell time, determine latitude, locate the stars, and cast astrological judgments, and includes a table of bright stars with their celestial coordinates and Arabic-derived names. Remarkably, a surviving astrolabe bearing Hebrew markings that follow its instructions came to light in Verona in 2024 — the very city where the work was composed.

A note on the translation process

This translation was produced with the [translation-pipeline](#). See the linked repository for details on the process.

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Acknowledgements

Translated with the assistance of Claude. The translator thanks the [Anthropic](#) team for making this work possible.

Keli ha-Neḥoshet (The Instrument of Bronze)

by R. Abraham ibn Ezra

[Title]

Sefer Keli ha-Neḥoshet [The Book of the Instrument of Bronze] by R. Abraham ibn Ezra,

being

an exposition of the working of the astrolabe [Hebrew: כלי האצטרלוב] according to Ptolemy — comprising the knowledge of the configuration of the heavens, and the measurement of the earth by means of this instrument.

Brought to press for the first time

in the royal capital city of Königsberg, in Prussia, may it be built up.

In the year 5605 [5605 = ה"תת"ה AM = 1845 CE] of the Creation [lit. "of the World's reckoning," לב"ט].

[Lower imprint, in Latin script:] *Kli nechosches. Königsberg 1845. Gedruckt in der Hartungschen Hofbuchdruckerei.* [German: "Printed at the Hartung Court Printing-House."]

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[The Author's Introductory Poem]

First stanza:

To You, O living God, I make my plea — grant aid to the son of Ezra. His soul, in exile, is afflicted; upon Your mercy it leans. May the hidden understanding be revealed to him — and establish his deeds. For He raises up the heart of the wise and graces it — and so, fittingly, will I sing of His Name and exult.

Second stanza:

Blessed is He who set in order the power of speech [?], who endowed and made wise the children of Shet [Seth]. By number He gave them discernment, and measures — the forms of the circle and the bow [arc], and the likeness of the work of my God: He set it down in plates and in a net [the rete]. Let one of understanding heart come and learn the Book of the Instrument of Bronze.

Says Abraham the Sepharadi [the Spaniard], the author.

. The poem puns throughout on the instrument's parts: לוחות (the latitude *plates*/tympan of the astrolabe) and רשת (the *net* = the rete), which is also the rhyme-word echoing נחושת ("bronze") in the title.]

Keli ha-Neḥoshet

Word from the Publisher [דבר מאת המוציא לאור]

This book came into my hands through several manuscript copies, and the brightest among them — the one my eyes beheld — was the copy found in the possession of the renowned scholar, our teacher and master R. Shlomo, son of R. Yoel of Dubno [Dubnow]; and likewise the copy found in the possession of the famous scholar R. [?] [Wolf?] Heidenheim, of blessed memory (which is now among the treasures of the book-collection of my dear friend, the rabbi of great learning and abundant understanding, the eminent and esteemed magnate, R.

Yosef Michael — may his Rock protect him — son of R. Chaim, of the city of Hamburg, may his Creator preserve and sustain him). And also the remaining copies of the body of this book — I found them all to rise up [agree] in one and the same form, without the least difference between them. The copy that came into my hands was from the manuscript of the scribe — first among those called by the name "scribe" — R. Moshe Sofer of the city of Prague, which was completed, its copying done, on Thursday, the fifth [?], the fourth of [the month of] Cheshvan, in the year שצ"ג [5393 of] the sixth millennium of Creation [= 5393 AM - 3760 = 1633 CE]. And this copy too was brought into the collection of the manuscripts of the Gaon, our teacher and master R. David Oppenheim, of blessed memory.

And inasmuch as I know that the words of the great scholar Ra'ava [Rabbi Abraham ibn Ezra] are precious to all who know his name and have heard of his fame — my heart prompted me freely, this day, to bring this book of his to the light of print, which until this very day still lay hidden and concealed in the treasuries of manuscript books. Yet my heart was not stirred to add an interpretive explanation [פשר] to the matter of this very pamphlet, since it is well known that nowadays the astronomers of our times follow a different path, according to the opinion of Copernicus [קאפערניקוס]; and on that account I found no great usefulness in this. Only the body of the copy [the text itself] of the aforesaid great scholar do I hereby set before every discerning reader, this day — and may my name be remembered for good. — The Publisher.

Author's Preface [הקדמת המחבר]

Said the author: There is no power in one who understands [a subject] to translate one language into another except by a difficult path — and all the more so the Holy Tongue [Hebrew], of which we know only what is written in Scripture. Now, this instrument, called the *astrolabe* [אצטרלוב], which belonged to Ptolemy [בטלמיס] — its names are many and varied across many languages, and I shall mention them as far as my hand can reach. As for the Name that instructs man with the knowledge of opinion [i.e., the God who teaches man understanding], my mouth shall teach by the way of truth. And I shall give a clear exposition of that instrument across thirty-six gates [שערים]. From God may my help come.

[The table of contents of the thirty-six gates follows. Source: (folios ה-ו).]

The Thirty-Six Gates [Table of Contents]

- **The First Gate** — concerning the mention of the names of the instrument and of the markings that are upon it.
- **The Second Gate** — concerning the knowledge of the sun's altitude by day, and the altitude of the stars by night.
- **The Third Gate** — concerning the knowledge of the sun's distance [equality?] from the circles which are behind [below] the daytime [horizon].
- **The Fourth Gate** — concerning the knowledge of the sun's true place from the rete [מן הרשת].
- **The Fifth Gate** — concerning the knowledge of the sun's opposite point [nadir].
- **The Sixth Gate** — concerning the knowledge of how many seasonal [unequal] hours of the day have passed.
- **The Seventh Gate** — concerning the knowledge of how many seasonal hours of the night have passed.
- **The Eighth Gate** — concerning the knowledge of how many equal hours of the day have passed.
- **The Ninth Gate** — concerning the knowledge of how many hours of the night have passed.
- **The Tenth Gate** — concerning the knowledge of the arc of the day or the arc of the night.
- **The Eleventh Gate** — concerning the knowledge of the equal [equinoctial] hours from the seasonal ones.
- **The Twelfth Gate** — concerning the knowledge of the seasonal hours from the equal ones.
- **The Thirteenth Gate** — concerning the knowledge of the altitude of whatever degree you wish.
- **The Fourteenth Gate** — concerning the knowledge of the declination [נטיות] of whatever degree, or of whatever star you wish.
- **The Fifteenth Gate** — concerning the knowledge of whatever degree or whatever star you wish, whether it will rise by day or by night.
- **The Sixteenth Gate** — concerning the knowledge of the rising degree [ascendant] and the setting degree [descendant], when it is at mid-heaven [meridian], and that which is at the center of the earth [nadir].
- **The Seventeenth Gate** — concerning the knowledge of how many degrees each zodiacal sign rises by in the equator [the line of equality, קו השווי].

- **The Eighteenth Gate** — concerning the knowledge of how many degrees each zodiacal sign rises by in your own land.
- **The Nineteenth Gate** — concerning the knowledge of the two twilights [נשפים].
- **The Twentieth Gate** — concerning the knowledge of the equality [length] of shadows.
- **The Twenty-First Gate** — concerning the knowledge of the altitude from the shadow.
- **The Twenty-Second Gate** — concerning the knowledge of the taking of the latitude of any city.
- **The Twenty-Third Gate** — concerning the knowledge of the place of the moon and of the five wandering stars [the planets, כוכבי נבוכה].
- **The Twenty-Fourth Gate** — concerning the knowledge of whether the star [planet] will be retrograde [נזור] or direct [ישר].
- **The Twenty-Fifth Gate** — concerning the knowledge of the hiding [eclipse/concealment] of the moon and its appearance.
- **The Twenty-Sixth Gate** — concerning the knowledge of the place of the moon's "camp" [מחנה הלבנה — its station/mansion?].
- **The Twenty-Seventh Gate** — concerning the knowledge of the erecting [setting up] of the twelve houses of the heavens [the astrological houses].
- **The Twenty-Eighth Gate** — concerning the knowledge of the place of the stars that are in the seven planetary aspects [המבטים הרצים].
- **The Twenty-Ninth Gate** — concerning the knowledge of the great stars that are in the sphere of the zodiac [בגלגל המזלות].
- **The Thirtieth Gate** — concerning the knowledge of which degree the star rises with above the earth.
- **The Thirty-First Gate** — concerning the knowledge of which degree the star sets with.
- **The Thirty-Second Gate** — concerning the knowledge of the day-arc of the star and the night-arc.
- **The Thirty-Third Gate** — concerning the knowledge of the height of any tower or tree.
- **The Thirty-Fourth Gate** — concerning the knowledge of the height of any low object [that is below your position] and the knowledge of the depth of any deep object.

- **The Thirty-Fifth Gate** — concerning the knowledge of the whole construction of the instrument [its repair/setting up] whose breadth is not according to the breadth [latitude] of your own land.
- **The Thirty-Sixth Gate** — concerning the knowledge of the whole construction of the instrument by means of an imperfect [incomplete] alidade [בלחי שלם].

[The treatise body proper begins here. Source: (folio recto)]

The First Gate — concerning the mention of the names of the instrument and of the markings that are upon it.

This is the instrument called the *astrolabe* [astrolabe]. I have called it *Keli Neḥoshet* [The Instrument of Bronze], because the craftsmen make it of bronze; and whoever wishes to make it of silver or of gold has leave to do so. The instrument of bronze [the astrolabe] consists of these [parts]: a ring [טבעת], a *kores* [the mater/womb — the body of the instrument, כרס], a rim [the limb, אמ — literally "mother"], plates [the tympan, לוחות], a rete [the net, רשת], an alidade [the sighting-bar, בריח], a *kos* [?], and a rider [the index/pointer, רוכבו]. Now I shall explain each one in its place.

The beginning of the instrument is the *ring* [the suspension-ring], which is the chain [the cord/suspension] by which the instrument is raised up. It is fitting that it be made as a ring within a ring [a swivel-ring], so that the instrument will not be jointed [rigidly fixed] in your taking it up in the proper manner.

After this is the *kores* [the mater] in which the ring is fixed; and it is a protrusion [a boss] that projects out from the *em* [the rim/limb]. Each craftsman makes it according to his own will, in order to suspend [chain] the instrument.

After this is the *em* [the rim/limb], which is the rounded surface that is hollowed out [recessed], within which are all the plates [the tympan]. Upon them [their faces] lies the rete [the net], and its reverse [the back of the instrument] is the alidade [the sighting-bar]. It is called the *em* ["mother"] because the rest of the plates are after the likeness of daughters to it [are like daughters born to it].

The *em* [rim/limb] has upon it two diagonals [perpendicular lines, אלכסונים]. The one — higher up, from the head of the ring which is the chain by which the instrument is suspended — descends downward [to the bottom]; and the second cuts across within the rounded surface [the circle]. The head of the diagonal that is at the left of the man holding the instrument is toward his right *; and the head of the diagonal that cuts across within the circle, which is at the left of the

man, is called *east* *; and that which is at the right of the man is called *west* *. And the descending diagonal, which runs from the head of the *ring* down to the bottom — the head, which is with the ring, is called *south* *; and that which is below is called *north* *.

Now, this rounded surface [the circle] is divided into four equal parts *: the one part begins from the east and ends at the south; and this fourth [quadrant] is divided into ninety parts, which are called *degrees* [מעלות] *. And the rule of the craftsmen is to set down one line, larger [longer], at every five degrees.

and they write over the first one [the first digit] a 5, and after it a 10, and over it a 5; then it [the value] is 15, because, as already explained, they put the 10 first, and after it a 5 — and so it is 15. * In this way the craftsmen write the count of the degrees [מעלות], on up to ninety. *

And as for this quadrant [רביעי]: by it one takes the altitude [גובה] of the sun, or of a star, or of one of the celestial bodies [lit. "the servants," i.e. the planets], in order to know its altitude. * And by means of this quadrant, anyone skilled in geometry [lit. "master of the measures"] can ascertain, from this altitude, the height of anything tall — a tower, a tree, and the like. *

The second quadrant begins in the south and ends in the north. It too is divided into ninety parts, and this serves to ascertain anything that lies below your position, or deep — that is, depth. * The third quadrant begins in the west and ends in the north. It too is divided into ninety parts; and there are two lines [קוויים], and each part is further divided into twelve sub-parts, which are called *etzba'ot* [אצבעות, "fingers/digits"]. * Over them is written one line, and this serves to ascertain the count of the digits. * And it serves to ascertain the direct shadow [צל הישר] and the reversed shadow [צל ההפוך]. * The line of the reversed shadow begins from the west and runs to the half of the quadrant, which is between north and west. * The line of the direct shadow begins from the north and ends at the half of the quadrant. *

And forever, the half [point] will correspond to forty-five degrees, and the direct shadow will always be equal to [or "lean against"] the reversed shadow at that point — for at this point the count is equal: the direct shadow equals the reversed shadow, and the shadow will be like its own [original] measure, with no addition and no diminution, when the sun reaches it. *

The fourth quadrant begins from the west and ends in the south. It too is divided into ninety parts. There are craftsmen who place upon it circular [arc] lines, to bring out the chord [יתר] from the arc [קשת]; but most do not put them there,

because in most instruments this is not accurate as a single [reading] — it would only be approximate. Yet by calculation a person can indeed bring it out well, so we will not speak of these. *

These three quadrants — the eastern-northern, the western-northern, and the western-southern — were not divided into ninety degrees, as were the eastern-southern and the southern-eastern [quadrants], for any [astronomical] need; rather, only for the purpose of the leveling [equating] of the sun [שיווי השמש]. And in a place where they do not make the circles of the sun's equating, there is no need to divide them [into ninety]; for the eastern-southern [quadrant] alone suffices for taking the altitude of the degrees. *

* And there are, on the back of the rim [אם, "mother"], circles [עגולות] for the equating of the highest [uppermost] sun. * Some of them were divided into degrees — and that is the circle which is the fourth of the four [quadrants] I mentioned. * Below it, another circle, on which is written the twelve constellations [מזלות]. * Each constellation [is divided] into thirty degrees. * Below that, another circle, divided into days. * Below that, another circle, on which is written the days of the year — these being the months of the gentiles. * And if you wish to make [a circle] for the degrees and for the days, the choice is yours, [by] either method. *

These circles are for ascertaining the equating of the sun, and by an approximate, not an exact, method — because there is an addition over the days of the year, a quarter of a day [the leap-quarter], and the quarter cannot be set down [precisely]. * Moreover, the quarter itself is not exact, [for] in every year a day is lacking [in the reckoning], as I will explain with fine precision in the *Sefer ha-Toladot* [Book of Generations / Genitures]. * Therefore there are some instrument-makers who do not make these circles at all; instead they divide the face [פנים] of the rim — and it is divided into degrees, and is called a *ḥiq* [חיק, "bosom/lap"], and is also called a *ḥagorah* [חגורה, "girdle/belt"]. *

And there is great need for it. Upon it they begin to count the degrees, beginning at the head of the *shalsholet* [chain/suspension-cord]: five [degrees], ten, fifteen, [and so on] toward the left side of the rim, until they end up opposite the head of the *shalsholet*, at the right of the rim. *

On the back of the rim there is also a long part [כלי, "tool/piece"], in the likeness of a bar, which is called the *ma'atzar* [מעצר, "stop/restraint"], because by it a person halts in order to take [read off] the degrees, and it is also called a *beriah* [בריה, the sighting-bar / alidade]. * The *ma'atzar* [alidade] has two ends; on it are set two

plates [לוחות] of brass. * Each plate is pierced with a perforation, the one perforation being large — and that is for ascertaining the altitude of the sun; * and the second perforation, smaller than it, and that is for ascertaining * the altitude of a star, or of one of the planets [המשרתים, "the servants"]. * One also ascertains the sun's altitude when clouds conceal it. * Within the rim are likewise plates [לוחות], also called the "daughters of the rim" [בנות האם]. * The plates [tympan] are interpreted [used] according to a person's desire, this one or that one. * If they are made according to the number of horizons [האופקים], they make three or four of them, and they write upon them their proper names [?].

And on the back, the face of the rim — these are seven [horizon-plates]. * And they write [upon them] seven circles [?]. The settled [northern] zone is the northern quarter, and it is divided into seven parts, called horizons [אופקים] or climes [אקלימים]. *

Now I will speak about the plate [tympan]. On it there are three [principal] circles. * The first is the line that bounds [encircles], and it is the circle of the head of Capricorn [ראש גדי, "the head of Gedi"], for no constellation passes above it — only the head of Capricorn alone is over it, and [the sun] turns back; it is called the circle of [the winter solstice], the reverse of summer [הפך הסתיו]. * The second circle is the circle of the head of Aries and Libra [ראש טלה ומאזנים], for upon it pass the heads of [those signs]; it is called the circle of the celestial equator [משווה היום, "the equalizer of day," i.e. the equinoctial]. * The third circle is the circle of the head of Cancer [ראש סרטן], for no constellation passes above it; from the beginning of Cancer [the sun] turns back, and it is called the circle of [the summer solstice], the reverse of [winter] [הפוך הקיצי]. *

And so it is: just as in the right-hand brass instrument, so the matter is reversed in the left-hand brass instrument [the two mirror-image astrolabes]. For the larger circle is the circle of the head of Cancer, and the smaller is the circle of the head of Capricorn; only the middle one is equal [the same] in both instruments. *

So too there are on the plate two diagonals [אלכסונים]. * The one diagonal cuts from above [from the top] downward, from the side of the *shalsholet* [the suspension-cord side] down to below; the part from above to the middle of the plate is called the "line of the half of heaven" [קו חצי השמים, the meridian]; and from the middle of the plate downward is called the "line of the extreme of length" [קו יתר האורך] or the "line of the limit" [קו התחום]. * The second diagonal cuts across the middle of the plate, and is called the "line of equality" [קו השווה, the east-west line]. *

From it [these lines] you can ascertain how wide the plate is — that is, how far the place is distant from the line of equality on which this plate is constructed. * And in this way you make a count of the bridges [גשרים] that are beneath the line of equality, and according to their number, that is the width of the plate. *

If the brass instrument is whole [full-size], each [bridge counts] for two [degrees]; if it is half the instrument, you reckon each [bridge] for three; if it is a third of the instrument, you reckon each [bridge] for three [?]. * If a fifth, [reckon] its fifth; if a sixth, its sixth; * if a ninth, its ninth; and if a tenth, its tenth. *

[recte: the ratios should read — whole: 2 each; half: each counts double the whole; third, fifth, sixth, ninth, tenth scaled accordingly. The second "three" appears to be a compositor repetition; see Numerical impossibles.]

You can also ascertain the width of the plate from the circle of the head of Capricorn [ראש גדי]: count how many bridges [גשרים] it stands at [above the equator-line], add twenty-four [$24 = כ"ד$] to it, then subtract from [ninety], and the remainder is the width of the plate.

that is the width of the plate. * You can also ascertain the width of the plate from the circle of the head of Aries and Libra [ראש טלה ומאזנים]: count how many bridges [גשרים] it stands at, subtract that from ninety [מתשעים], and the remainder is the width of the plate. * You can also ascertain [it] from the circle of the head of Cancer [ראש סרטן]: count how many bridges it stands at, subtract twenty-four [$24 = כ"ד$] from it, then subtract [the result] from thirty [$30 = מל'$], and the remainder is the width of the plate. *

There are also bridges [גשרים] on the plate, and in the whole [full-size] brass instrument they total ninety [$90 = תשעים$]; in the half [instrument], forty-five [$45 = ארבעים וחמשה$]; in the third, thirty [$30 = שלושים$]; in the fifth, eighteen [$18 = שמונה עשר$]; in the sixth, fifteen [$15 = חמשה עשר$]; in the ninth, ten [עשרה $10 =$]; and in the tenth, nine [$9 = תשעה$]. * The other parts [fractions] will not come out even [will not divide cleanly]. *

These bridges — some of them are arcs [קשתות] and some are circles [עגולות]; and they are in the half of the upper plate, descending beneath the line of equality [קו השווה] according to the width of the plate. * They begin from the left of the man holding the instrument — there "east" [מזרח] is written, and that is the eastern extremity — and they rise toward the right of the man, where "west" [מערב] is written, and that is the western extremity. * The first bridge among them is called the horizon [האופק]. * And it is what separates between what you know

and what you do not know — for what is above the bridges is what is revealed to us of the celestial sphere [הגלגל], while what remains is hidden from us. *

And the rule of the craftsmen is to write upon each bridge the number of the instrument's parts [degrees]. * There are also instrument-makers who engrave, upon the bridges, lines that cut across the bridges; these are called "lines of the zenith" [קווי הקדקדן], and are also called *al-sumūt* [ג"כ אל ס מ ת — Arabic: *al-sumūt*, "the azimuths"]. * But they are not truly accurate, even in a full-size brass instrument; they would only be approximate. Therefore we will not speak of them. *

There are also on the plate eleven [11 = אחד עשר] lines, and they are in the half of the lower plate, and they are the twelve [12 = י"ב] hours [שעות] — the uneven [seasonal] hours [שעות מעוותות], not the equal [equinoctial] hours, as I will explain. * The sages of the Ishmaelites [the Arabs] are accustomed to place upon them lines: at the beginning [of the line for] *al-zuhr* [א ל ט ה ר — Arabic: *al-zuhr*, the noon prayer], and at the end of *al-zuhr*; also at the beginning of *al-aṣr* [א ל ע ר — Arabic: *al-aṣr*, the afternoon prayer], and at the end of *al-aṣr*. But we will not speak of them. *

There is, on the back [face] of the plate, a net [רשת], which is also called a *shabakah* [ג"כ שבכה — Arabic: *shabaka*, "net" = the rete], and it is the one on which are the constellations [מזלות] and the stars [הכוכבים]...

on the rete [רשת = *shabakah*]. There is on it a circle divided into two unequal parts. The one part is the larger, and it is called the southern signs [מזלות הדרום], namely: Scorpio [עקרב], Sagittarius [קשת], Capricorn [גדי], Aquarius [דלי], Pisces [דגים]. The other is the smaller part, and it is called the northern signs [מזלות הצפון], namely: Aries [טלה], Taurus [שור], Gemini [תאומים], Cancer [סרטן], Leo [אריה], Virgo [בתולה].

Like the form of the bridge [גשר], it passes over from the head of Aries to the head of Libra [מאזנים]. There is no other use for it except to bind together these two circles [העגולות] of which I have spoken. Thus it is on the brass instrument [כלי]. Only, on the left-hand brass instrument the matter is reversed, so that the northern signs are the larger part and the southern signs the smaller part.

There are arcs [קשתות] cut out within, toward the circle of the signs [עגולת], and a small circle [עגולה קטנה] set inside it; these are for placing the stars [הכוכבים]. The rule the artisans follow for placing the great stars [הכוכבים הגדולים] that are on the sphere [גלגל]: on those very arcs, or on the small circle, each star

is set in its proper place. And they do not place any but the stars that are of the first magnitude [הכבוד השני] or of the second magnitude [הכבוד הראשון].

The reason: for Ptolemy the King [תלמי המלך = Ptolemy] divided all the stars [כוכבי שנת — i.e. the fixed stars] into six grades, by the measure of their bodies [גופם]. The largest are 15 [ט"ו] in their value [שערם] — these are equal [in size] — and they are of the first magnitude. The others, whose value is equal [to one another], are of the second magnitude; after them, the third magnitude; after them, the fourth magnitude; after them, the fifth magnitude; and after them, the sixth magnitude.

There is no star set [on the rete] except [those] of the first magnitude and the second magnitude, since they are within the circle of the signs [מזלות]. As for Leo [אריה] only — it is attached to the circle of the signs because it has no others. For some [stars] have one [near them], and there are some near the circle of the signs, while others are far from them, according to their distance from the signs. This distance is called latitude [רוחב].

The stars that are on the southern side [פאת דרום] are set outside the circle of the signs; those on the northern side [פאת צפון] are set within the circle of the signs. Thus it is on the left-hand brass instrument [כלי נחושת השמאלי]. But on the right-hand brass instrument [כלי הנחושת הימיני] the matter is reversed, so that the northern stars are set toward [outside] the circles, and the southern ones within it — yet this does no harm.

There is no need to mention the [number of] horse [הסוס], brass, and rider [רוכב] of the instrument [הכלי], nor the nails [המסמרים], for each maker fashions them according to his wish.

The Second Gate [השער השני]: On knowing the altitude [גובה] of the sun by day, and the altitude of the stars by night.

When you wish to know this, hang the brass instrument [כלי הנחושת] on your right. If you are before midday, turn your face toward the eastern side; if you are after midday, turn your face toward the western side. The general rule is: set your face opposite the sun, in a place where you stand, and raise and lower the alidade [המעצר] until you find the place where the light of the sun enters through the larger of the two holes [הנקב הגדול] — that is, the hole on the end of the alidade that is at one corner of the square [הריבוע האחד], and exits through the smaller [hole], which is the larger hole on the end of the alidade at the second corner of the square. [recte: read "exits through the smaller hole" — the printed

text reads "the larger" here, but the procedure requires the beam of light to pass through both holes; flagged below]

When you have done this, begin to count the [degrees] from the eastern edge and look at the head of the alidade — at how many degrees it stands. Thus is the altitude of the sun, when you are in the east. And you can do this likewise from the smaller hole, when you are in the west. If you have no large [instrument] — and if you wish to know the altitude of one star of the stars of the sphere of the signs [גלגל המזלות] or of the planets [המשרתים] — hang the brass instrument on your right and set your face opposite the star whose altitude you wish to know, and shut your eye. Sink all the air [i.e. line of sight] toward the second [eye], and raise and lower the alidade [המעצר] — that is, in the small hole [הנקב הקטון] which is in the corner of the square at one corner [recte: the hole nearer to you] — until you see the star through the hole nearer to you, [sighting] toward the hole nearer the alidade [אליך]; until you see the star through the small hole [הנקב הקטון] which is on the second corner of the square, at the corner where the second [end of the] alidade [מעצר השנית] is.

When you have done this, see at how many degrees the head of the alidade stands. Begin to count from the eastern edge — and thus is the altitude of the star. You can also know the altitude of the sun if you know its place on the sphere [גלגל], even by its appearance [reflected]. The sight of the eye was not the swift true [reading]; rather it was as though hidden, on account of the clouds that concealed it. You may set it [for measurement] as [you would] the star, and you will know its altitude.

The Third Gate [השער השלישי]: On knowing the equation [שיווי] of the sun from the circles [העגולות] that are on the back [of the plate].

When you wish to know this, learn first which day of the month it is now between Christians [הנוצרים], and how many days into the month, and set the alidade [המעצר] so that its head lies upon the sign [המזל]; and the degree of the sign [המזל...מן המזל] in which the sun then is. You will arrive at [knowing] which day of the month it is, if you know the place of the sun. When you set the alidade upon the degree, behold it will show you the day, just as [a sundial] shows you the degrees.

Even if you do not have the circles [העגולות], you can know the equation of the sun [השיווי...השמש], for the sun enters the sign [מזל] on the 14th day [ביום י"ד] of

[the Christian] March [מ'מארסו], and from the 14th of March into [the new sign]. Give a degree [מעלה] for each day, and behold: near the end of each month the sun enters at the head of each sign [בראש כל מזל]. But this is not precise to exactness, for at times the journey of the sun is longer, as I will explain at greater length in the [Book of] Nativities [ספר המולדות].

The Fourth Gate [השער הרביעי]: On knowing the true place [הרשת] of the sun from the rete [מקום אמיתת].

When you wish to know this, it requires that there be a rider [רוכב] upon your alidade [המעצר]. Take the altitude of the sun [גובה השמש] at midday [בחצי היום], if you wish to know its place. Know in which quarter of the year [רביעית השנה] that day falls — the day you are seeking — and turn the circle of the signs [עגולות] in that quarter; and the degree [המעלה] which you find on the line of midheaven [קו חצי שמים] at the value [דמיון] of the sun's altitude — there is the true place of the sun [מקום השמש נאמת].

The reason it is known by the quarter [is this]: from near the middle of March [מ'מחצי מארסו] until near the end of June [קצי יוניא], the sun is in the north [בצפון] and is ascending in it; it is then in the sign of Aries, Taurus, Gemini [טלה שור] [תאומים]. From the middle of June until the end of September [קצי שטאבי = septembris], the sun descends in the north; it is then in the sign of Cancer, Leo, Virgo [סרטן אריה בתולה]. From the middle of September until the end of December [קצי דיקטבר = december], the sun descends [recte: is in the south] and is in Libra, Scorpio, Sagittarius [מאזנים עקרב קשת]. From the middle of December until the middle of March [מ'חצי מארסו], the sun ascends in the south, and is in the sign of Capricorn, Aquarius, Pisces [גדי דלי דגים].

Behold, twice in the year the hours of the day are equal. The reason: by it [these points] the altitude of the sun at midday [גובה השמש בחצי היום] — there is no difference between [them]. In every place its altitude is one [the same]: from the head of Capricorn [ראש גדי] to the head of Cancer [ראש סרטן] in its ascent, and from the head of Cancer to the head of Capricorn in its descent. So when it is at the head of Cancer — which is the limit of the north [סוף הצפון] — there is no day in the year that attains its altitude. Likewise, when it is at the head of Capricorn — which is the limit of the south [סוף הדרום] — no day [other than that one] attains the altitude of the day [whose altitude] is one of the days of the year. So when you know the quarter of the year, the day opposite it will not be confused for you.

The Fifth Gate [השער החמישי]: On knowing the place opposite the sun [מקום נוכח השמש = the nadir].

When you wish to know this, strike off [count] from the place of the sun until the completion of six signs — which are one hundred and eighty [180 = ק"פ] degrees of the sphere [הגלגל]. And the place where 180 degrees [ק"פ מעלות] are completed [recte: see note] — that is the opposite point [הנוכחי = the nadir]. You can also arrive at knowing the opposite point [המכח] thus: when you set the place of the sun on the line of equality [נקו השוה], the degree which you find opposite it on the line of equality [נקו השוה] — that is the opposite point [הנוכחי]. The reason: taking the opposite point is like taking the [point] opposite the degrees of the sun [בעלות השמש].

The Sixth Gate [השער השישי]: On knowing how many hours of the day have passed, of the seasonal hours [השעות המעוותות = unequal/temporal hours].

When you wish to know this, take the altitude of the sun [גובה השמש] at whatever time you wish. Take the place of the sun and set it upon the value of the altitude [דמיון הגונה]. If the sun was, at the time of taking its altitude, eastern [מזרחי], set it among the eastern [bodies; bodies in the east]; and if the sun was western [מערבי] at your taking of its altitude, set it among the western bodies. Look at the [point] opposite the sun [מכח השמש = nadir], at how many hours, of all the seasonal hours [המעוותות] — and so [you know] how many seasonal hours have passed.

If [you wish to find] the [point] opposite [the sun] at the middle of the hour [באמצע השעה], and you wish to know what part of the hour it is: set a marker [סימן] with the head of Capricorn [ראש גדי]. When you set the place of the sun upon the altitude, the marker opposite the sun [מכח השמש] [marks] upon the altitude [על הגונה]; this is called the middle marker [סימן אמצעי]. The opposite point [הנוכחי], at the head of Capricorn [ראש גדי] — mark also [וסמן ג"כ = gam ken, "likewise"] there at the head of Capricorn; this is called the first marker [סימן ראשון]. And mark also [וסמן ג"כ] upon the sun at the start of the hour [תחילת השעה]; and mark also [וסמן ג"כ] the place of the sun at the end of the hour [סוף השעה]. And mark also [וסמן ג"כ] this...

it will be called the last marker [סימן]. See how many degrees lie between the first marker and the last, and observe how far the middle marker stands from the first. Reduce all those degrees to the [appropriate] part, and you will know what fraction of an hour has elapsed [?]; these are called seasonal hours [שעות מעוותות],

"unequal hours"], since each day is divided into twelve seasonal hours, and that division changes daily — every day.

Gate 7. On knowing how many hours of the night have elapsed by the seasonal hours.

Take the altitude of one of the visible stars among those set on the rete [רשת], and place it at its [proper] altitude on the degrees [the scale of degrees]. If the star was eastern at the time you took its altitude, set it on the eastern degrees; and if it was western, set it on the western degrees. Then examine the place of the sun [the solar point on the rete], to learn how many [seasonal] hours have elapsed — just as I described for the seasonal hours. In this way you will know how many of the seasonal hours of the night have elapsed.

Gate 8. On knowing how many hours of the day or night have elapsed by the equal hours [שעות הישרות].

When you wish to know this, take the altitude of the sun on any day you wish, and place the place of the sun upon its altitude in degrees. If the sun was eastern at the time of taking [the altitude], set it on the eastern degrees; and if it was western, set it on the western degrees. Then, just as you did when you set a marker [סימן] with the head of Capricorn [ראש גדי], so too place the place of the sun, until you set it on the first eastern bridge [the eastern edge of the bridge — the alidade/rule]. Mark also [ג"כ = gam ken] with the head of Capricorn, and count the number of degrees between the two markers; divide them by fifteen [ט"ו] — fifteen. What results from the division is the number of equal hours of the sun's degrees that have elapsed.

And if you wish to know how many hours remain until sunset: after you have set the place of the sun, fix the place of the sun until you set it on the first western edge, and mark also [ג"כ] with [the head of] Capricorn. Then count the degrees, and divide them between the two markers by fifteen — fifteen. What comes out in the division is the number of [equal] hours that remain until night.

Gate 9. On knowing how many hours of the night have elapsed by the equal hours.

When you wish to know this, take the altitude of one of the fixed stars [הכוכבים המוכחים, "the [fixed] stars"], and place it on its altitude in degrees. If it was eastern at the time of taking its altitude, set it on the eastern degrees; and if it was western, set it on the western degrees. Then, when you have set the star upon its altitude, set a marker [סימן] with the head of Capricorn, and fix the place of the

sun [the solar point] until you set it on the first western edge, and make a marker [סימן]. Mark also [ג"כ] with the head of Capricorn, and count the degrees between the two markers. Divide them by fifteen — fifteen, and what comes out in the division is the number of [equal] hours of the night that have elapsed.

And if you wish to know how many equal hours remain until sunrise [עלות השמש]: after you have set the star upon its altitude, set a marker and fix the place of the sun until you set it on the first eastern edge, and mark also [ג"כ] with the head of Capricorn, and count the degrees between the two markers. Divide them by fifteen — fifteen, and what comes out in the division is the number of [equal] hours that remain of the night until sunrise.

Gate 10. On knowing how many equal hours there are in the day or night — which is called the arc of the day [קשת היום] or the arc of the night [קשת הלילה].

When you wish to know this, place the place of the sun on the first eastern edge, and make a marker with the head of Capricorn; fix the place of the sun until you set it on the first eastern edge, and mark [סמן] with the head of Capricorn, and count the degrees between the two markers — this is the arc of the day [קשת היום]. Whatever remains from there — the degrees that are [the total of] all the degrees of the sphere — is the arc of the night [קשת הלילה]. And if you divide the arc of the day or the arc of the night by fifteen — fifteen, you will find how many equal hours there are in the day or in the night.

And if you wish to extract the arc of the night: before you extract the arc of the day, place the place of the sun on the first eastern edge and mark with the head of Capricorn; then fix the place of the sun upon the first western edge, and mark also [ג"כ] with the head of Capricorn [?]

until you set it on the first eastern edge, and count the degrees between the two markers — this is the arc of the night. Whatever remains from there in degrees is the arc of the day.

Gate 11. On knowing the equal hours from the seasonal ones, in the day or the night.

When you wish to know this, find the place of the sun for that day [מקום השמש ליום ההוא], and set the altitude of the sun [נוכח השמש, "the sun[']s position"] on the first western edge if it is day, and mark with the head of Capricorn. Then fix the altitude of the sun [נוכח השמש] according to [the count of] the seasonal hour you wish to convert, and mark also [ג"כ] with the head of Capricorn, and count the

degrees that are between the two markers; divide them by fifteen — fifteen, and what results from the division is the equal hours.

And if you wish to know this at night, perform this same operation with the degrees of the nadir [נוכחו, "its opposite point"] — not [the degrees] of the sun [itself].

Gate 12. On knowing the seasonal hours from the equal ones.

Find the place of the sun for that day, set the altitude of the sun [מכה השמש] on the first western edge, and mark with the head of Capricorn. Then, regarding the equal hours you wish to convert — all of them into degrees — count them out at fifteen by fifteen [ט"ו ט"ו], and reach the head of Capricorn with the number of those degrees. You will then see at the sun's altitude how many hours, out of all of them, are seasonal — and this is how many seasonal hours have elapsed.

And if you wish to know this at night, place the degrees of the sun on the first western edge, as I have mentioned.

Gate 13. On knowing the altitude of any degree you wish of the circles of the signs [מעגולות המזלות].

When you wish to know this, find which degree you wish, set it on the line of midday [קו חצי היום, "the meridian"], and see how many degrees it stands at; that is how high the sun will be when it is at that degree. And the degree whose distance from the head of the [solstitial] descent [ראש ההפוך, "the head of the turning-point" — the solstice] equals the distance of this degree — that is the degree whose altitude is the same as the altitude of this degree.

Gate 14. On knowing the declination [נטייה] of any degree you wish, or of any star you wish.

When you wish to know this, set the degree you wish on the line of midday [the meridian], and see how much lies between that degree and the point of the circle of the head of Aries [ראש טלה] and Libra [מאזנים], which is the equator [עגולת היום, "the circle of the equalizer of the day"]; that is the declination of that degree. If it is in the northern signs [המזלות הצפוניים], the declination is also northern; and if it is in the southern signs [המזלות הדרומיים], the declination is also southern.

And if you wish to know the declination of a star, set the star on the line of the middle of the heavens [קו חצי שמים, "the meridian"], and see how much distance lies between the star and the equator [עגולת משה היום] — that is the declination

of the star. If the star's degrees are greater than the degrees of the equator, the declination is northern; and if the star's degrees are less than the degrees of the equator, the declination is southern.

Gate 15. On knowing any degree you wish of the signs [המזלות], or any star you wish — whether it rises by day or by night.

When you wish to know this, place the degree you wish, or the star you wish, on the first eastern edge, and examine the altitude of the sun [מעלה השמש] to see whether the horizon [האופק] rises in degrees — then it is day. Know how many hours it will be: double the nadir [הנוכח] from it upon the [seasonal] hour. And if [the degree falls below] all the degrees of the sun, [so that it is] beneath the horizon, then it is night. Know how many hours it is: double the degrees of the sun itself upon the [seasonal] hour.

So too you shall do when you wish to know the time of setting [השקיעה] — when a degree you wish, or a star you wish, will set: then set that degree or the star on the first western edge, and so do it. So too you shall do when you wish to know the time at which [a body] will be in mid-heaven [אמצע השמים], or beneath the earth [תחת הארץ] — set it on the line of mid-heaven [קו חצי שמים], or on the line of the remaining earth [קו יתר הארץ, the lower meridian], and do exactly as I mentioned above for the degree.

Gate 16. On knowing the rising and setting degree [המעלה הצומחת] [והשוקעת]...

[continuation of Gate 16, On knowing the rising and setting degree]

and so the heaven [נהלי השמים] and the lower earth [נחמלע הארץ, the lower meridian] will be. At any moment you wish — whether by day or by night — you may know this. To know the present altitude of the sun, set the alidade [בריח] over the sun's place, just as I described for the altitude in degrees. If the sun lay to the east, set the place of the sun in the eastern degrees; if it lay to the west, set its place in the western degrees. Then look: the degree you find on the rete [רשת] at the eastern end of the first [degree-line] is the rising degree [המעלה הצומחת], to the east; and the degree you find at the western end of the first is the setting degree [השוקעת]. * The degree that lies on the line of mid-heaven [קו חצי שמים] is the degree at mid-heaven [באמצע השמים]; and the degree that lies on the line of the remaining earth [קו יתר הארץ, the lower meridian] is the degree beneath the earth [באמצע הארץ]. And if you wish to know this by night, take the altitude of one of the fixed stars set in the rete and proceed in everything just as I

mentioned for the place of the sun. From it you will learn the rising and setting degrees, and likewise what is at mid-heaven and at the lower earth.

Gate 17. On knowing how many degrees each sign causes to rise upon the line of equality [קו השווה].

When you wish to know this, set the head of the sign in question [ראש המזל] upon the line of equality, and mark the place of the head of Capricorn [ראש גדי] under [the alidade]. * Then set the end of that sign [סוף המזל] likewise [ג"כ] upon the line of equality, and mark the place of the head of Capricorn under [the alidade]. * Count the degrees lying between the two marks: that is how many degrees the sign in question causes to rise upon the line of equality.

Gate 18. On knowing how many degrees each sign causes to rise in your own land [בארצך].

When you wish to know this, set the head of the sign in question at the first degree-line at the eastern end [בקצה ראשון מזרח], and mark the place of the head of Capricorn under [the alidade]. Then set the end of that sign at the first degree-line at the eastern end, and mark the place under [the alidade] likewise. * See how many [degrees] lie between the two marks: that is how many degrees the sign in question causes to rise in your land. *

Gate 19. On knowing the two twilights [נשפים]: the day's twilight and the night's twilight.

The twilight [נשף / הכשף] is the light of the sun that you see among the clouds before you see the body of the sun, and likewise the light you see while the body of the sun is hidden after sunset. Now the day's twilight [נשף היום] is the light of the sun that you see among the clouds before you see the body of the sun. When you wish to know how many hours this is — if you wish to know it — set the altitude of the sun at eighteen degrees on the western side [שמונה עשר גשרים] [מערביים]. * Then read off the place of the sun: from it [you learn] how many hours of unequal [seasonal] hours [שעות המעוותות] there are, and that is how long the twilight lasts. And if you wish to know the night's twilight [נשף הלילה] — which is the light of the sun that you see [as] the body of the sun first hides itself — set the altitude of the sun at eighteen degrees on the eastern side [שמונה עשר] [גשרים מזרחיים], and read off the place of the sun: from it [you learn] how many unequal hours, and that is how long the twilight lasts.

Gate 20. On knowing the two shadows: the reversed shadow [צל הפוך] and the straight shadow [צל הישר].

Know that every shadow has a magnitude — whether less than [the gnomon] or more than it. * And know that the shadow that is less than [the gnomon] is called the straight shadow [צל הישר], while the shadow that is more than it is called the reversed shadow [צל ההפוך]. * When you wish to know how great this is — that is, the [altitude] of the sun from which it arises [the gnomon-to-shadow ratio] — at any moment you wish: if the sun's altitude is forty-five degrees [מ"ה מעלות], then every shadow equals its object [the gnomon], neither added to nor diminished. * But if the altitudes are greater than forty-five degrees [יותר ממ"ה מעלות], the alidade will always fall upon the fingers [אצבעות] of the straight shadow. Examine how many fingers [it falls upon] out of the [total] fingers of the straight shadow: that is the number of fingers. * And if the altitude is less than forty-five degrees [פחות ממ"ה מעלות], the alidade will always fall upon the fingers of the reversed shadow. Examine how many fingers out of the [total] fingers of the reversed shadow [it falls upon]: that is the [number of] fingers of the reversed shadow. *

And if the alidade falls in the middle of the [shadow] fingers [נפל הבריה באמצע], and you wish to know what fraction of a finger [שברי האצבע] there is, mark opposite the point of the alidade [נגד סמן האצבע] — which is the eastern-southern [point] [מזרחי דרומי] — in the half-degrees [בחצי במעלות הל], i.e. the graduated half-degrees of the alidade's quadrant [ברביע של בריח], where the altitude [גובה] is taken. * Then set the alidade over the beginning of [that] finger [תחילת האצבע], and mark likewise [ג"כ] upon the [graduated] quadrant of the alidade, up to the side of the alidade in that quadrant [עד צדו של בריח ברביע ההוא]. Set the alidade [ג"כ] over the end of the finger, and mark likewise upon that quadrant. * And know how many degrees there are between the first mark and the last; and know how far the middle [point] is distant from the first; and relate it [ותיחסהו] to the whole distance [כל המרחק]: that is the fraction of the finger [שברי האצבע].

[The bow and the shadow] I shall explain as a diagram so that you may compare them, for it is a bow [קשת]. * And to know the size of the finger — when you divide each thing into thirty parts [על ל' חלקי] — this requires no fine precision [אינו בדקדוק יפה], for at sunrise or sunset there is no [proper] comparison for the reversed shadow [אין ערוך לצל ההפוך]. But when the sun rises some degrees, then the measure will fall [yield a result] [אז יפיל המדה]; and this varies from city to city and from land to land, and one must take care of it before one comes to know it [וצריך לנסותו קודם שתגיע לידיעתו].

Gate 21. On knowing the altitude [גובה] from [a given] shadow [הצל], once you have known the shadow.

When you wish to know the altitude, set the alidade upon the number of fingers of the shadow [מספר אצבעות הצל] — whether the straight [shadow] or the reversed [shadow] — that there were at that time. * And when you have done this, look at the upper end of the alidade [למעלה בראש הבריה], on the quadrant [ברביע] where the altitude is taken: [see] how many degrees it falls upon — that is the altitude of the sun at that time. *

Gate 22. On knowing the latitude [רוחב] of any city.

Know that the latitude [הרוחב] is the distance of its place from the line of equality [קו השווה] toward the north [לצד צפון]. * When you wish to know this: if you are in [the period] from the 14th day of the month of March [יום י"ד לחודש מרסו = March] until the 16th day of the month of September [יום י"ו לחודש שטנברי = September], take the altitude of the sun at midday [לחצי היום] on that day. This altitude is called the meridian altitude of the head of Aries and of Libra [גנהות ראש טלה] [ומאזנים]. It is also called [גי"כ] the meridian of the equator of that day [גנהות משוה]. Subtract it from ninety [תחסרהו מתשעים], and the remainder is the latitude of that place [רוחב המקום ההוא]. *

And if you are in [the period] from the 15th day of the month of June [יום ט"ו לחודש יוניא = June], take the altitude of the sun at midday of that day, and subtract from it twenty-four degrees [כ"ד מעלות]; the remainder is the meridian altitude of the equator of that day [גנהות משוה היום]. Subtract that from ninety, and the remainder is the latitude of the place. *

And if you are in [the period] from the 17th day of the month of December [יום י"ז לחודש דוקאברי = December], take the altitude of the sun at midday of that day, and add to it twenty-four degrees [כ"ד מעלות]; the sum [והמקובץ] is the meridian altitude of the equator of that day. Subtract from ninety, and the remainder is the latitude of the place. *

As for the adding and subtracting of twenty-four [degrees] [הוספת וגרעת כ"ד]: this is because the [solar] declination [שהנטיה] is twenty-four degrees [הרב הוא כ"ד] [מעלות], according to the view of Ptolemy [לדעת בטאלמיס]. * And if you were in the remaining days of the year, not among these four well-known days [ימים הידועים], and you wish to know the latitude of the place: take the altitude of the sun

at midday of that day. Know also [ג"כ] the declination [נטות] of the sun for that day. * If the [solar] declination is southern [דרומית], add it to the altitude [תוסיף]; * and if it is northern [צפונית], subtract [it from the altitude] [תחסר]. * What comes out, after the addition or subtraction [אחר התוספת והמגרעת], is the meridian altitude of the head of Aries and of Libra [גנהות ראש טלה ומאזנים], which is the meridian of the equator of the day [גנהות משוה היום]. Subtract it from ninety [תחסרהו מתשעים], and the remainder is the latitude of the place. To arrive at knowing the declination [לידיעת הנטיה], proceed as I set out earlier in Gate 14 [בשער הי"ד]: set the place of the sun on the line of midday [בקו חצי היום], and see which degree, between the circles [לבין עגולות, the parallel-of-declination circles], that degree falls upon — that is the meridian of the equator of the day, and that is the declination [והיא הנטיה]. * Thus too you will know [ג"כ תדע] whether the declination is northern or southern, as I mentioned. And you can likewise [ג"כ] determine the latitude of the place from the stars that are near the [meridian] line and do not set beneath the earth [שאינם נשקעים תחת הארץ]: if you can recognize one of them, take its altitude — the greatest it ever reaches, which is what you see when, as it ascends, it can rise no higher [שאינ יכול לעלות יותר] and begins to descend [ומתחיל לרדת]; take that altitude. And take also [ג"כ] its lowest point [שפליותו] — the least it ever reaches, which is what you see when, as it descends, it can descend no further [שאינו יכול לרדת יותר] and begins to ascend [ומתחיל לעלות]; take that lowest point. Add the two together — its rising and its setting [העליה והשפלות] — and the half of their sum [וחצי המחובר] is the latitude of the place. * And to know it from the sun is more reliable [מהשמש הוא יותר נכון]. *

Gate 23. On knowing the moon, and on knowing the place of the five wandering stars [חמשה כוכבי הנבוכה, the five planets].

When you wish to know their place in the sphere of the signs [בגלגל המזלות] approximately [על דרך קרובה]: take their altitude [קח גובהם], and take also [ג"כ] the altitude of one star [גובה כוכב א] of the [fixed] stars set in the rete; and let this be at one moment [ב'עת א], so that the altitude does not change [שלא יתחלף]. Set that fixed star upon [the scale] according to its altitude [על דמיון גובהו] in degrees: if it was eastern at the [time] of taking [the altitude], set it in the eastern degrees [בגשרים המזרחיים]; and if [the stars] were western [מערביים], set it in the western degrees, and the degree you find [there] will tell you [the position]. * Set [the moon or planet] according to its altitude — the altitude of the moon or of the wandering star [הכבוך, the planet], and that is its place [מקומו]. * And take care, for if you found the moon or the planet [הכבוך] toward the eastern side, you must seek [it accordingly] [למזרח בצד תבקש]...

on the analogy of its altitude in the east. And if you found it on the western side, set the degree on the analogy of its altitude in the west. Then you will be able to know its place approximately. To learn whether the moon [is at] 30 degrees from the place [of] the sun, take its altitude as well [ג"כ = כן ג]. And do all that I have mentioned — when you have taken its altitude, take the altitude of the sun as well, and do everything I have mentioned, provided that you take the two altitudes at one [and the same] time.

The Twenty-Fourth Gate — on knowing whether a star is round or straight [i.e. circular or upright].

When you wish to learn this, take its altitude and mark it; and take the altitude of one of the fixed stars [lit. a star that is at rest] as well, and mark it too. And when, after two or three nights, you again [take] the altitude of the fixed star on the analogy of the altitude you marked when you first took its altitude — if it was in the east, it will still be [in] the east; and if it was in the west, it will still be [in] the west now. And afterward, at that same time, take the altitude of the wandering star [planet], and you will find the second altitude either less than the first — then it is straight [upright]; or greater — then it is round [circular]. And if the star's degree was on the western side, [reckon] it the reverse; for this is the rule: if the second altitude is greater than the first, then it is straight; and if less, then it is round.

The Twenty-Fifth Gate — on knowing the concealment of the moon and its appearing.

The explanation of the moon's concealment: if you see it in the last part [of the night], before the sun rises, then it is near to conjoining [in conjunction] with the sun. And the explanation of the moon's appearing: if you see it at dusk, after the sun has set, [it is] after the conjunction with the sun.

When you wish to learn this — whether the concealment [is at] the place where you set the moon on the first bridge [degree-scale] at the eastern end, mark [it] together with the head of Capricorn [ראש גדי, "head of the Goat"] — set the place of the sun at the eastern end as well, and mark [it] together with the head of Capricorn — and see how many degrees there are between the two marks. If there are twenty degrees between them, you will see the moon. And if there are [fewer]... * if there are fewer than 13 degrees between them, you will not see the moon at all. This rule is called the "arc of vision" [קשת המראה]. All this is correct provided that the moon has no [latitude].

For instance, if the moon is near to the head of Aries [ראש טלה] or the head of Libra [ראש מאזניים]: if it has northern latitude, take two thirds of [the value of] vision and add them to the degrees between the two marks — that is what is called the "arc of vision." And if [the latitude is] southern, take two thirds of [the value of] vision and subtract them from the arc. Then, after the addition or subtraction, you will see whether the arc of vision reached 13 degrees — [if so] you will see the moon; and if it did not reach 13, you will not see [it] at all.

And if you wish to learn the appearing of the moon — that is, whether you will see it at dusk, after sunset, when it has separated from the sun — set the place of the moon on the first bridge at the western end as well, set the place of the sun at the western end, and mark always together with the head of Capricorn, and proceed in all that I have mentioned.

The Twenty-Sixth Gate — on knowing the place of the moon's mansion [station].

Know that the ancients divided the sphere into 28 parts and called them "mansions" [manazil; מחנות]. And know that the judgment [of astrology] concerning the moon varies according to the mansion in which it is — this is its [proper] name. For this is something that does not apply to the other five wandering stars [planets], the moon alone, as I will explain in the Book of Judgments [Sefer Mishpatim]. I will now write the [names of the] mansions in the language of Kedar [Arabic]; and they are also rendered [glossed] in the language of Kedar [i.e. transliterated]. And [know] that to each sign [of the zodiac] there belong two and a third mansions.

The beginning of the mansions is called:

אלנטח — א [al-Naḥ = al-Sharaṭān]. Its translation: "the youth" [recte: "the butter," cf. Aramaic נטח]; for it is the horn of Aries, and they are 3 stars. אלבטן — ב [al-Buṭayn]. Its translation: "the belly," and they are, as it were, three stars. — ג אלגדיאה [al-Thurayyā = the Pleiades]. It is Kimah [the Pleiades], and it is two stars. אלדבראן — ד [al-Dabarān = Aldebaran]. Its translation: "the follower," and it is one red star, and above it [are] small stars. אלמיסאן — ה [al-Maysān = al-Haq'a]. Its translation: "the spoon," and they are 3 small stars between 2 bright ones. — ו אלתמי [al-Tahāyī / al-Han'a]. Its translation: "the quiet" — one bright star. — ז אלדרסין [al-Dirā'ayn / al-Dhirā' = the Two Arms]. Its translation: "the arms," and they are two bright stars. אלנתרה — ח [al-Nathra]. Its translation: "the scattered" — 2 small stars, and between them [something] like the form of a cloud. — ט אלטרף [al-Ṭarf]. Its translation: "the eye," and they are 3 stars, and it is forever

hidden [from view]. אלגבהה — י [al-Jabha]. Its translation: "the forehead," and they are 4 stars. אלכותאין — יא [al-Khartān / al-Zubra]. Its translation: "the thighs" — one star. אלעזר — יב [al-ʿAwwāʾ]. Its translation: "the slaughter," they are 4 stars, and the uppermost is bright. אלסמאן — יג [al-Simāk]. Its translation: "the red" — one large star. אלכפאר — יד [al-Ghafr]. Its translation: "the covered," and they are three small stars. אלזבאן — טו [al-Zubānā]. Its translation: "the net" (and accordingly [a] rete [שבכה/רשת]) — two bright [stars]. אלמעליל — טז [al-Iklīl]. Its translation: "the crown" — five bright stars. קלב — יז [Qalb = Antares]. Its translation: "the heart," and they are three stars. אלשולא — יח [al-Shawla]. Its translation: "the tail," and they are eleven stars, and the [last] two are bright. — יט אלנטיים [al-Naʿā'im]. Its translation: "the beams [logs]," and they are nine stars, and the ninth is bright. אלבדלא — כ [al-Balda]. Its translation: "a bow," for it is like a bow; and there is no star there, and it is covered [empty]. אלדבה — כא [al-Saʿd al-Dhābiḥ?]. Its translation: "the onyx," and they are three stars. אלשער — כב [al-Saʿd]. Its translation: "the good" — they are two hidden stars. שער אלשער — כג [Saʿd al-Suʿūd]. Its translation: "the best of the good," and they are two stars, and one is bright. אלכוכי — כד [al-Akhbiya]. Its translation: "the mutes [the dumb]," and they are two stars. אלבוזכר — כה [al-Fargh al-Muqaddam]. Its translation: "the back," for it is the rear of the tent, and they are four stars. אלפרגל — כו [al-Fargh al-Awwal?]. Its translation: "the bucket [Aquarius's water-jar]," and they are two bright stars. אלפרגל מאוסר — כז [al-Fargh al-Muʾakhkhar]. Its translation: "the latter bucket," and they are two middling stars. אלחות — כח [Baṭn al-Ḥūt]. Its translation: "the belly of the fishes," and they are ten stars.

And if you wish to know correctly in which mansion the moon is: if you know the place of the moon, you can determine the mansion by [the rule] that you assign to each sign two mansions and a third of a mansion. But if you do not know the place of the moon, and you wish to know in which mansion it is — begin from the mansion in which the sun is on the day of the new moon [molad], and assign one mansion to each day. This is not exact enough to be fine, for there is a great mansion [and] also a small mansion. And it may be that the molad falls in the middle of the mansion or at the end of the mansion.

The Twenty-Seventh Gate — on knowing the rising of the twelve [signs] of the heavens, upon which the [astrological] judgment depends. Know that every moment...

the sphere is divided into thirty-two parts. Twelve of them are called the "houses of the heavens," and the [other] four of them are called "cardinal points" (יתדות).

And the [remaining] eight of them are called "succedent" (סמוכות) — that is, the supports.

When you wish to set up the twelve houses, take the altitude of the Sun at any moment you like, and place the [marker for] the position of the Sun on the [astrolabe] in the manner of its altitude. For example: if the Sun was on the eastern side at the moment you took the altitude, place the marker for it in the degrees [on the eastern side]; and if it was on the western side, place the marker for them in the western degrees. And if you wish to set up the houses by night, take the altitude of one of the fixed stars from the stars set into the rete, and place it [as a marker] in the manner of its altitude, in the way I mentioned regarding the Sun. *

Then look: the degree you find on the left, at the first cardinal point — that is the beginning of the first house, and it is the **ascending degree** (the ascendant), and that cardinal point is called the eastern [one]. * Look also: the degree you find on the line of the meridian — that is the beginning of the tenth house, and that cardinal point is called the **upper** [one]. * Look also: the degree you find on the left, at the first western point, which is the **setting degree** — that is the beginning of the fourth house, and that cardinal point is called the **lower** [one]. *

Now there is no doubt concerning the four cardinal points, for there are conclusive proofs for them. It is only in the determination of the four [other] houses, the rest of them, that there is doubt and disagreement among the sages. The four [in question] are the second, the third, the fifth, and the sixth. There is no need to cite the words of Ptolemy and of those who dispute him concerning this — only [to follow] the way of truth.

After you have placed the marker for the position of the Sun upon its altitude, or [the marker for] the place of the star upon its altitude, look at the degree you find at the beginning of the eleventh hour — that is the beginning of the second house. * Look also at the degree you find at the beginning of the ninth hour — that is the beginning of the third house. * Look also at the degree [you find] at the beginning of the fifth hour — that is the beginning of the fifth house. Look also at the degree you find at the beginning of the third hour — that is the beginning of the sixth house. * And here there is no doubt, for the eighth house is opposite the second house, and the ninth house is opposite the third house. * And we have already said that the tenth house is the upper

cardinal point, and it is opposite the fourth house, which is the lower cardinal point. The eleventh house is opposite the fifth house. The twelfth house is opposite the sixth house. *

So now you have the procedure for the twelve houses. Moreover, you must know the place of the seven stars [the planets], in order to set them and correct their markers, as I shall explain. Know that the "equal house" (הבית הישר) is thirty degrees. * However, there is a house both larger and smaller [than thirty]. Know that all this is brought before you by God, for the judgment varies. When a star is in a large house, its power grows from what it [otherwise] would be — and this is the "equal [house]," which is called the **House of Spirit** (בית רוח). And when it is in a small house, its power likewise varies, and this is called the **House of Constriction** (בית דחוק), as I have explained in the *Sefer ha-Mishpatim* [Book of Judgments]. And here I shall draw for you the figure of the houses.*)

*) The figure of the houses is on a special plate at the end of the pamphlet. [Footnote, source p. 29.]

The Twenty-Eighth Gate — on knowing the aspects (המבטים) [cast] by the seven stars [planets].

Know that there is a great disagreement between the sages of Greece and the sages of India and Persia. The sages of India and Persia have a book of their own concerning them. * When you wish to know the aspects, [first] know the positions of the seven stars. * Know that if the star was below the earth, its aspect is downward, and it is called a **right aspect** (מבט ימיני). And if it was above the earth, its aspect is upward, and it is called a **left aspect** (מבט שמאלי).

Now the star which is at the beginning of a degree — its **ascending sextile** aspect (מבטו בשישית) is at the beginning of the third house; and you need not be concerned that it should be at the beginning of the second or the fourth house. Its **trine** aspect (מבטו בשלישית), which is at the beginning of the fifth house — and you need not be concerned that it should be at the beginning of the house of the sign of the quartile (the fourth-house relation). These aspects are left[-side] [aspects]. The star which is at the seventh house — its **opposition** aspect (מבט נוכח, opposite-aspect) is

[its] aspect, and it is the equal aspect (המבט הישר) which

the right aspects. The star which is at the beginning of the third house casts a trine aspect; * the star which is at the beginning of the ninth house casts an aspect upon the degree of the sixth [house] — its trine. * When the aspects do not

fall upon a house, neither a large house nor a small one in the [house-]aspects, the procedure of the aspects is as I have explained. * Furthermore, in the [house-]aspects there is the matter of whether the houses are wide (broad) or constricted, and all this is by an easy method. *

If the star was at the beginning of a house, then its [trine] is the half of the house. And if the star which casts a left aspect was [reckoned] from the beginning of the fifth hour, [the value is] **230 [ר"ל]** — that is, the half of the house. Or if the star which casts a right aspect [was reckoned] from the degree above, upon the beginning of an hour, [the value is] **230 [ר"ל]** — that, indeed, is the half of the house. And likewise the rest of the left aspects, if they were within the house. As for the right aspects: the aspect of the right [stars] from the degree which is at the beginning of [the] hour — [the value is] **230 [ר"ל]**, which is the half of the house, and you find the degree which is at the half of the left house too; this is no labor. But the rising-arc (הגיעה): if it [the star] was not at the beginning of the house nor at the half of the house, then perform the aspects as I have explained. So you shall do: know the degrees of the house in which the first star is, and the degrees of the house in which the second star is. And if the houses are equal in their degrees, then [the rule] is even for them, for all houses which are at the midpoint of the aspect-instrument [are equal].

And if you must enlarge the intermediate houses or reduce them, do so, and perform the aspect as it is. And if the houses are not equal, take the excess between the two of them, divide it in half, add it to the small house and on that procedure proceed; reconcile the aspects and perform the aspect as it is. And in the *Sefer ha-Mishpatim* [Book of Judgments] I shall explain the powers of the aspects.

The Twenty-Ninth Gate — on knowing the place of the great stars that are in the zodiacal sphere.

Here I shall write down for you their positions as they were in the year **4,606 of the Creation of the world** [4606 = 6 + 400 + 4000 = ד' אלפים ות' מאות ושיש = AM; 4606 - 3760 = 846 CE].

Know that every star moves from its place one degree in every seventy years. Thus it moves, in each year, **fifty-one seconds and twenty-six thirds** [נ"א שניי' 26" 51" = [ועשרים וששה שלישיי']. Add that to the place of the star as it is written [in the catalog]. And if you wish to know its place at a past time, take for each year **twenty-one seconds and twenty-six thirds** [כ"א שניי' וששה ועשרים שלישיי' =

26"], and subtract them from the place of the star as it is written; then you will find its place.

Behold, I shall write down for you their positions. And further, I shall give you a way to recognize them in the sphere [rete]. I have already informed you that they place in the rete of the astrolabe only stars of the first or the second magnitude. The star which is of the first magnitude — I shall name it; and every star concerning which I do not mention which magnitude it is, know that it is of the second magnitude.

The left eye of the Bull (עין שור השמאלי): it is the one called **אלדבראן** [al-Dabarān = Aldebaran]. It is in the sign of Taurus, [longitude] 27 degrees 50 minutes; its latitude is 5 degrees 10 minutes, north; and it is of the first magnitude, and it is northern.

The foot of the Dog (רגל הכלב): it is the one called **אלגוזא** [al-Jawzā'; = a star of Orion/Gemini]. It is in the sign of Gemini, [longitude] 4 degrees 58 minutes; its latitude is 31 degrees 51 minutes, and it is southern.

Gate 29 — Catalog of the bright stars (continued)

The shoulder of the Champion, called 'Alyūq [al-'Ayyūq = Capella]: first magnitude; in Gemini [literally "the Twins"], 7°58'; latitude 16°30', southern.

The shoulder of the Champion, called Manjib al-Jabbār [Manqib al-Jabbār = the shoulder of Orion]: in the sign of Gemini, 28°28'; latitude 20° even [?]; southern.

The shoulder of the Champion, called al-Shi'rā al-'abūr [al-Shi'rā al-'Abūr = Sirius]: of the first magnitude; in Cancer, 20°44'; latitude 34°10'; southern.

The lesser dog [literally "his small eye," al-kalb al-aṣghar], called al-Shi'rā al-Ghumayṣā [al-Shi'rā al-Ghumaiṣā' = Procyon]: of the first magnitude; in Cancer, 4°18'; latitude 16°10'; southern.

The heart of the Lion, called Qalb al-Asad [Qalb al-Asad = Regulus]: of the first magnitude; in Leo, 17°31'; latitude 16°10'; southern.

The tail of the Lion, called al-Ṣarfa [al-Ṣarfa = Denebola]: in the sign of Virgo, [?] °38'[?] [the longitude region inks ארבעים מעלות שלושים ושמונה ("forty degrees, thirty-eight"), a value exceeding 30° within a single sign — genuinely inked on one full-width line, not a column-split artifact; degrees flagged [?]]; latitude 11°20'; northern; and of the first magnitude.

The Champion, without a spear, called al-Simāk al-Aʿzal [al-Simāk al-Aʿzal = Spica]: of the first magnitude; in the sign of Libra, 11°48'; latitude 40' [?]; southern.

And he [the other Simāk], the Champion, the spear-bearer, called [Simāk al-Rāmiḥ = Arcturus]: of the first magnitude; in the sign of Libra, 27°2'; latitude 31°1'; northern.

The falling Eagle [al-nasr al-wāqiʿ], called al-Nasr al-Wāqiʿ [al-Nasr al-Wāqiʿ = Vega]: of the first magnitude; in the sign of Capricorn, [?]°25' [?] ...

[Footnote marker at foot of column:]

[Gloss (footnote, marked *):] [Yiddish/Hebrew abbreviations:] בנ"א הגבוה — "in another reading [it is], the higher"; בכ"ב הגבוה — "in another copy, the latitudes [?];" וע"ד כאשר כתבתי — "and according to this [reading] as I have written."

latitude 36°10'; northern..]

The mouth of the Fish, called Fum al-Ḥūt [Fam al-Ḥūt = Fomalhaut]: in the sign of Aquarius, 24°10'; latitude 23°13' [?]; northern [?]. Latitude minutes partly faint.]

The head of the Woman, called Ra's al-Mar'a [Ra's al-Mar'a = β Andromedae / Mirach]: in the sign of Aries, 2°38'; latitude 12°8' [?]; northern.

The head of the Crab [Cancer], called Ra's al-Ghūl [Ra's al-Ghūl = Algol]: in the sign of Taurus, 44°48' [the longitude inks שור ארבעים וארבעה מעלות ארבעים ושמונה ודקים ("Taurus, forty-four degrees, forty-eight minutes"), intact on one full-width line — a genuinely inked >30° intra-sign value, not a column-split artifact; flagged [?]]; latitude 23°20' [?]; northern.

The carrier [literally "the bearer," 'ashā], head of the Crab, called Ras al-Ghūl [a second Ra's al-Ghūl entry]: in the sign of Taurus, 20°39'; latitude 30' [?]; northern.

The left shoulder of the Champion, called Manjib al-Jabbār [Manqib al-Jabbār = Bellatrix / γ Orionis]: in the sign of Gemini, [2?]5°28'; latitude 17°30'; southern..]

Samm [the venom-gland?], the bridle-curb [ʿaşr al-rasan], called Mamsak al-ʿInān [Mumsik al-ʿInān = ζ Aurigae / the rein-holder]: in the sign of Gemini [literally "the Twins"], 17°28'; latitude 20° even; northern.

The head of the foremost Twin [al-ta'm al-muqaddam], called Ra's al-Taw'am [Ra's al-Taw'am al-Muqaddam = Castor]: in the sign of Cancer, 11°48'; latitude 30°15'; northern.

The head of the hindmost Twin [al-ta'm al-mu'akhkhar], called Ra's al-Taw'am [Ra's al-Taw'am al-Mu'akhkhar = Pollux]: in Cancer, 25°48'; latitude 30°51'; northern.

The bright star in the neck of the Lion, called al-Mārib al-Dīb [?] ...

2 **

‘unuq [= the neck of the Lion]: in Leo, 17°7' [?]; latitude 18°... "

latitude 8°30'; northern.

The crupper [al-'arūs] which is in the neck of the Lion, called al-Dunbī al-'unuq [?] [al-Dhanab? = a tail-region star of Leo]: in Leo, 30°28' [recte: "thirty degrees, twenty-eight minutes" exceeds the 30° limit — [?] flagged]; latitude 20°; [magnitude not stated → second].

The heart of the Scorpion [aqrab], in the scorpion, called Qalb al-'Aqrab [Qalb al-'Aqrab = Antares / Cor Scorpīi]: of the first magnitude; in the Scorpion, 26°6' [?]; latitude 45°5' [?]; southern. degrees, five" — high southern latitude flagged.]

The knee of the Bow [Sagittarius], from the left, called al-Rāqīb [al-Rā'ī / al-Rakba?] [?]: in Capricorn, 28°8' [?]; latitude 18°10'; northern.

The ankle of the Bow [Sagittarius], called Arqūb al-Dāmī [‘Urqūb? al-Rāmī = of the Archer]: in Capricorn, 23°3' [?]; latitude 53°3' [?]; southern. minutes, three"; flagged.]

The flying Eagle [al-nasr al-ṭā'ir], called al-Nasr al-Ṭā'ir [al-Nasr al-Ṭā'ir = Altair]: of the first magnitude; in Capricorn, 18° even; latitude 29°[?]; northern.."]

The tail of the Hen [al-dajāja], called the Prophet [?], called 'alā Ṭij [al-Dhanab? / Deneb]: of the first magnitude; in Aquarius, 24°28'; latitude 18° [?]; southern.. Lemma זנביא ("the Prophet") is a transmitted garble — flagged.]

The heart of the Fish [al-ḥūt], called Qalb al-Ḥūt [Qalb al-Ḥūt]: in Aries, 9° even [?]; latitude 26°26' [?]; northern.

The shoulder of the Horse [al-faras], called Manjib al-Faras [Manqib al-Faras = β Pegasi / Scheat], among the Fishes: in the Fishes [Pisces], 7°... "; latitude 31°20'; northern. Longitude degrees compounded/abraded — flagged.]

latitude 31°20'; northern.

The foot of the Woman, the left, called Rijl al-Mar'a [Rijl al-Mar'a al-Yusrā = γ Andromedae / Almach]: in Taurus, 20° even; latitude 28°20' [?]; northern.."]

The ankle of the Twin [al-ta'm], called 'Urqūb al-Jawzā' ['Urqūb al-Jawzā'], in the Twins [Gemini]: 18°... "; latitude 24° even [?]; northern. Longitude degrees compounded — flagged.]

latitude 24° even [?]; northern.

The point [al-nuqṭa] between the two points, in the Scorpion, 28°9' [?]; latitude 60°40' [recte: a latitude exceeding 60° is anomalous — [?] flagged]. minutes; latitude sixty degrees, forty minutes." See Numerical impossibles.]

The hindmost [point], in the Scorpion, 7°19'; latitude 35°...

latitude 35° even.

The head which has no power [literally "head that has nothing in it," Caput algol/the demon-head], in the Bow [Sagittarius], called al-Ra's [al-Rāmī? / Rukbat al-Rāmī = α Sagittarii]: in the Bow, 26°6'; latitude 32°2' [?]; northern.

The neck of the Horse, in Aquarius [al-faras]: 20°21' [?]; latitude 44°34' [recte: a 44° latitude with the high-minute value is anomalously large — [?] flagged]; southern.

The tip of the tail of the star Qayṭūs [Cetus], [in] 20° [of its sign]: 20°...; latitude 22°5' [?]; southern.; latitude twenty-two degrees, five[?] minutes." Sign of longitude not legibly stated — flagged.]

[Gate 30 — Determining a star's place on the rete]

When you wish to recognize, by means of an instrument, on which degree a given star sits — the star fixed in the rete [shavkha / reshet] — and to know how great its breadth is from the great circle [literally "the line of mid-heaven," qaw chatzi ha-shamayim] — then observe the degree found on the rete, sitting on the great circle. There the star is set in your astrolabe. The degrees lying between the star and the great circle: if the degrees of the star [its latitude] are more than the degrees of the rete, the star is southern; and if the degrees of the star are more than the degrees of the rete, it is southern, and this is called the breadth [latitude, marchav] of the star. And if the degrees of the rete are more than the degrees of the star, it is northern; this is called the breadth of the star. [recte: the source repeats the comparison clause; transcribed as printed —]

Now, when it [the star] inclines [from] the circle of the celestial equator [ma'agolat moshveh ha-yom], it is then called the bending-aside [neṭiyot] of the star — as I made known to you in Gate 14. And if you recognize one star and wish to know its place, and afterward you know likewise its breadth [latitude], take its altitude when it is at mid-heaven [chatzi ha-shamayim] — that is, observe it rising until it can rise no higher and begins to descend; for then it is at mid-heaven. Take the altitude, and you will know the breadth [latitude]. If it is northern, subtract the breadth from the altitude; and if it is southern, add the breadth to the altitude. The remainder, which is lacking, turn the circle of the signs in that quadrant, and you will arrive at knowledge of ...

the fourth [point] at the place of the sun, and the [resulting] degree will be the meridian line [קו חצי שמים]. Then count off on the number of the altitude after the addition or the subtraction, and there is its place.

You can also determine the place of revolving stars [planets] when they conjoin with the fixed stars [המשרתים], and you will know the place of the servant-stars [planets] from the [fixed] stars accompanying them; this too is by means of the star that conjoins with it.

By this method you can recognize the stars if you do not [already] know them. For consider the great star that appears to you as one of those known to you, and take its altitude when it is at mid-heaven [chatzi shamayim], and place the rete so that the star which you have set [on the instrument] reaches that altitude — and that is the [true] star [you sought], in truth. And if you should recognize another star [by it], you can [then] recognize still others. This is done by taking the altitude of the star that you recognize and placing the star [you wish to identify] at [its corresponding] altitude in degrees. If the star was eastern, take its altitude when it is in the eastern degree; and if it was western, take its altitude when it is in the western degree, upon the western degree. Take the altitude of one star known to you, which is among the great [bright] ones, and you will see that if you find no star at all upon that same altitude, it is the [identified] star itself — provided that you take the two altitudes at one [and the same] hour, so that the altitude does not change.

Gate 30 [השער השלושים]: Knowing at which degree a star will rise above the earth [horizon]

When you wish to know this, place the star you have set [on the rete] upon the first degree at the eastern edge [of the horizon], and the degree that you find on the rete at the eastern edge, together with it that star will rise.

Gate 31 [השער השלושים ואחד]: Knowing at which degree a star will set

Place the star you have set on the first degree at the western edge, and the degree that you find on the rete at the western edge — with it that star will set.

Gate 32 [השער השלושים ושנים]: Knowing the day-arc of a star and its night-arc

That is to say, the duration of its visibility above the earth, and the duration of its concealment beneath [the earth]. When you wish to know this, place the star you have set on the first degree at the eastern edge, and note, together with the head of Capricorn [ראש גדי], the degree [it marks]; and turn back the star you have set to the western edge, and note, together with the head of Capricorn, [its degree], and see how much lies between the two markings — that is the day-arc of the star.

If you subtract this from all the degrees of the [whole] circle, you will find its night-arc. If you divide the day-arc and the night-arc by fifteen [ל"ט"], you will find how many equal hours are in its day-arc and its night-arc. And if you wish to derive its night-arc before you have derived its day-arc: place the star you have set on the first degree at the western edge, and note [the degree]; likewise place [it] also on the first degree at the eastern edge, and note [the degree]; and whatever lies between the two markings is its night-arc. If you subtract this from all the degrees of the circle, you will find its day-arc.

Gate 33 [השער השלושים ושלושה]: Knowing the height of any tower or tree

When you wish to know the height of any elevated thing, set the alidade [המעצר] upon the forty-five degrees of the quadrant [רביע] at which its height is to be taken. Approach and withdraw with respect to the tower you wish to measure, and proceed along a straight line by way of the [two] sighting-holes [נקבים], until you see its top. This is done when you close one eye, and when you have seen the top of the tower, measure from the standpoint of your foot up to the base [foot] of the tower, and add to it the height of your stature, which is [the distance] from your eyes to the ground — and that is the height of the tower.

But if you do not wish to measure [along the ground] up to the foot of the tower, [proceed thus:] when you have seen the top of the tower, set the diametral rule

[הבריה] upon the fourth [degree-mark] — which is the eastern one, as appears [on the instrument] — on the forty-five degrees, and proceed along the way of the sighting-holes; for in this case you stand in your [own] place, only that you turn about in your eye, and the place that appears [marked] on the ground — mark it, and from that mark measure up to the base of the tower, and that is the height.

But if you can neither withdraw nor approach this much, [then] stand in one place, lower or raise [the alidade], and use your understanding, until you see its top up to the base; thus measure up to the base of the tower, and add to it the height of your stature from your eyes to the ground — and that [is what] comes out: it is the height of the tower. And always you add the height of your stature, from your eyes to the ground.

But if you cannot measure up to the base of the tower, and you wish to know its height: stand in one place and sight along the way of the sighting-holes until you see the top of the tower, and see at how many digits [אצבעות] of the diametral rule [the line of sight falls], and mark the place where you stood. Then go to another place, forward or backward, and sight a second time upon its top, and see at how many digits of the diametral rule [it falls], and likewise note the place where you stood there [too]. Measure the distance that lies between the one standpoint and the second, and apply it to those digits [the shadow-ratios] — and whatever comes out is the height of the tower.

And if you wish to know the height of the tower without measuring [on the ground] at all: aim the top of the tower [in the sights] and see at how many degrees the standpoint stands on the quadrant at which the height is to be taken, and note there the degrees, or [note] the place on the rest of the instrument opposite the edge of the diametral rule. Then lower the diametral rule on the fourth [mark] — which is the eastern one, as before — and stand in your place; lower and depress the alidade [המעצר] until you see the root [foot] of the tower. Set the alidade to stand in its place, and go to another place opposite another wall, and withdraw and approach with respect to it until you see the base of that wall by way of the sighting-holes, the alidade remaining fixed in its place. When you see the sun [or target], stand in your place and raise the alidade up to the mark which you have set on the quadrant, at which the height is to be taken — opposite the edge of the diametral rule. And when you raise it up to that mark, sight along the way of the sighting-holes [to] the place of the wall, and the place that you see — mark it — and from there measure...

Gate 34 [השער השלושים וארבעה]: Knowing the height of any thing that is below your standpoint, or the depth of any thing

When you wish to know the height of any thing that is below your standpoint, set the alidade [המעצור] on the quadrant of the eastern [side], as before, and sight along the way of the sighting-holes; raise and lower the alidade until you see its top. Measure from the standpoint of your foot up to the base of that thing, and subtract it from your stature — and the remainder is the height of that thing.

And if you wish to know a depth — [as] from the top of a roof down to below — set a mark [סימן]. And if you have no measure of the shadows [no shadow-scale] on that quadrant, hang the instrument on your left [side]; and if you do have a measure of the shadows on that quadrant, hang it on your right, and sight upon the mark you have set, and see at how many digits of the diametral rule [the sight falls], and note the place where you stood. Go forward and backward, and sight a second time upon the mark, and see at how many digits of the diametral rule [it falls], and likewise note the place where you stood. Measure the distance that lies between the first standpoint and the second, and apply them to the digits; and whatever comes out of the ratio is the depth — only that you subtract from it the height of your stature.

And if you were upon the top of a column [pillar], so that you cannot go up higher, and you wish to know its height: set a mark on the ground, and hang the instrument on your right if you have a measure of the shadows on the eastern quadrant; and if you have no measure of the shadows, hang it on your left, and stand upon the top of the column. Sight along the way of the two sighting-holes, and raise and lower the alidade until you see that mark which you have set [on the ground]. And when you see the mark, see at how many digits of the diametral rule [it falls], and set yet another mark on the ground, and raise and lower the alidade again until you see that mark, and likewise see at how many digits of the diametral rule [it falls], and measure the distance...

on the basis of the number of shadow-digits for the last [reading], and the ratio of the distance to the number of shadow-digits for the last mark — between it and the instrument. So is the height [determined], and so is it correct.

And if you wish to suspend the instrument from your right hand, you may do so — provided you do not have a quadrant of shadows graven on the eastern [back of the] instrument. Likewise, after you have seen what you wish to see, look at the head of the alidade, [to find] over how many degrees [it falls] out of all the ninety degrees of that quadrant, and place the alidade upon the corresponding degrees

of those degrees that are in the western part of the quadrant of shadows. And behold, the edge of the alidade will show you the shadow-digits. In this manner you may always perform your work.

To know the depth of a pit: stand at the edge of the pit, and sight along the sighting-holes until you see the surface of the water from the other [side] of the well. Note over how many shadow-digits [the alidade falls] out of all the [degrees of] the alidade, and measure the diameter of the pit. Then the ratio to it of the shadow-digits — so will be the depth.

To know the breadth of a river: stand at the bank of the river on one side, and sight through the sighting-holes until you see the other side. Set the alidade in its place, and stand at a level place and sight through the sighting-holes, and measure from your standpoint to the place where you sighted with your foot — and so is the breadth of the river.

*** The thirty-fifth Gate.** Everything I have mentioned in all the operations — you may perform all of it upon a tablet whose breadth is the breadth of your land [i.e. your latitude]. And if you do not have a tablet for the breadth of your land, and you wish to perform one of the operations: take a tablet whose [breadth] is less than the breadth of your land, and perform upon it the operation you wished to perform; then also take a tablet whose [breadth] is greater than the breadth of your land, and perform that same operation upon it as well, and see what difference there is between the two breadths. And know how far your place is distant from the lesser tablet, and add the like of that ratio onto it — and so will that operation come out for your land.

Example: We wished to know the rising degree [the ascendant] at latitude 36 degrees. You have a tablet for latitude 33 degrees, and you also have a tablet for latitude 39 degrees. The degree that rose on the tablet whose breadth is 33 — let the head of Aries — and its breadth that rose on [the tablet] whose breadth is 39 was 6 degrees. We saw that the difference between the two breadths was 6 degrees. And so, the proportional part for each degree out of the [latitude] difference [comes to] one degree from the [zodiacal] sign. Now our place is distant from the lesser tablet by 3 degrees: we take 3 degrees from the sign and add them onto the rising [degree] on the lesser tablet — which had been the head of Aries — and in our land the rising [degree] will be 3 degrees [of Aries]. So too with all the rest of the operations.

Only this: if you wished to know the place of the sun, you can know it from one tablet alone, [whether its latitude is] less or more [than yours]. This is how: take a

tablet whose breadth is greater than the breadth of your land, and [find] the [difference of] degrees between the tablet and your land — relative to the altitude of the sun — and from the remainder you derive the place of the sun. Or: take a tablet whose breadth is less than the breadth of your land, and add the degrees between the tablet and your land onto the altitude of the sun; and from the sum you derive the place of the sun.

Example of this: We wished to know the place of the sun at latitude 36, and we have a tablet whose breadth is 33; and the altitude of the sun was forty degrees. We added 3 degrees onto it, turned the rete, and the degree we found on the half-heaven line at degree 43 — there is the sun. And if our tablet had been one whose breadth is 39: we subtracted three degrees from the altitude of the sun, turned the rete, and the degree we found on the half-heaven line at degree 37 — there is the sun.

The thirty-sixth Gate. Everything I have mentioned concerning the working of the instrument, I mentioned only for a complete instrument, one upon which you can find a degree-line for every degree of altitude. But if you have an incomplete instrument and you wish to perform one of the operations, and you cannot find a degree-line for the [required] altitude: place the degree that you wish — taken from the [ecliptic] circle, or the tooth of the star [pointer] — upon the degree-line that has [just] passed, and set [it] with the head of Capricorn. Then place that same degree, or the tooth of the star, upon the degree-line that comes [next], and likewise set [it] with the head of Capricorn. And you will see how much [lies] between the two degree-lines. Then take the ratio of [your] altitude to the first [interval].

Here I shall give you an example for each [case], for it is a [matter of] arc. If you wished to know the place of the sun by a sixth-part instrument [an incomplete one], and the altitude of the sun was 45 degrees, but you have no degree-line on the sixth-part instrument except [for] 43 and 45: we turned the rete on the degree-line that has passed, and there were 24 degrees of the sign of Libra. We also turned the rete on the degree-line that comes [next], and we set it constantly with the head of Capricorn. We saw the distance — how much there was between the two marks — and it was 5 degrees. And behold, we reasoned thus, because our altitude was 45, which is the midpoint between 43 and 45.

And if the sign that rose was the head of Capricorn [running] up to the end of Gemini: add the half [of that interval] onto the first place, and you will find the place of the sun. And if the sign that rose was the head of Cancer up to [the end

of] arc [Sagittarius]: subtract that [half] from the first place, and you will find the place of the sun.

And behold, we took 4 degrees, and subtracted them from the place [at the degree-line] on which we found that there were 24 degrees of the sign of Libra; and the place of the sun is 20 degrees of the sign of Libra. And if you wished to know [the place] by the degree-line: we set the head of Capricorn [advancing] through 4 degrees with the head of Capricorn, and the rising degree that you will find on the half-heaven line of the zodiac is the place of the sun. And [there] is the degree-line of 45. Likewise, if you wished to know the rising degree [the ascendant], do it in this way.

Example of this: We wished to know the rising degree, [working] by a sixth-part instrument, and the altitude of the sun was 45 degrees. And behold, we have no degree-line; we set the place of the sun on degree-line 43 and made a mark with beta; and we also saw the ascendant, which is the head of Aquarius. We turned the rete [to set] the place of the sun on degree-line 45 and made another mark with beta, and there were 5 degrees between the two marks; we took the half of them. And if the sun was in the east, add it [the half] onto the first ascendant, and you will find the ascendant. And if the sun was in the west, subtract it from the first ascendant, and you will find the true ascendant.

And behold, in truth, the sun was in the west [and] we subtracted [it], and we set the head of Capricorn upon the place [the degree-line] of degree 43; and the ascendant was 4 degrees of Aquarius. And if you find the star-pointer at the head of Capricorn [advancing] through 4 degrees with beta, then sight the ascendant, and you will find it in truth. And the whole [matter] is one — whichever way you wish. So too is every other operation of the instrument's working, if you have no degree-line for the required altitude.

And all this that I have mentioned [is performed] easily with an instrument upon which the zodiac circle is divided into [all] 360 degrees, as with the complete instrument. But if you have no complete instrument, and you do not find a line for the required degree on the [zodiac] circle: take a small [pair of dividers], set [the legs] with beta, and take 22 [degrees], and take the required ratio. And behold, I shall give you an example.

We wished to know the place of the sun, and behold, we set the rete on the [zodiac] circle, but we found no line for the exact required degree of the [zodiac] circle — only a line "before," of six degrees of the sign of Aries, and after it was line 13. We made a mark with the head of Capricorn, with beta, and we set the

half-heaven line of the [zodiac] circle's belt that passed upon the half-heaven line, and made another mark — this is called the "first mark." Again we set [a mark] upon the half-heaven line, with the head of Capricorn — and we made another mark also with beta, with the head of Capricorn — this is called the "last mark." And we saw that between the first mark and the last there were 4 degrees. The [middle] mark was distant from the first by 30 degrees. These are a quarter of all the distance. We took from line 6 to line 13 of the [zodiac] circle's belt — and they are 1 degree and 30 minutes. We added them onto the line of six degrees, which is 6 degrees of the sign of Aries — and they are 7 degrees and 30 minutes; and there is the place of the sun.

And if you wish [to know] the rising degree [the ascendant], do likewise in this way. And behold, I shall give you an example. We wished to know the rising degree, and the altitude of the sun was...

[Conclusion of the worked example — operating an instrument whose zodiac circle is divided into all 360°]

47° and some minutes, and the sun's place was 9 degrees in Libra [Moznayim]. Now behold, there is for it no fixed line on the rotating circle of the zodiac signs answering to nine degrees in Libra, but only lines for every 6 degrees. So there is for it a line at 6 degrees and a line at 12 degrees. We therefore took the 6-degree line and set it upon the altitude, and we made a mark there [at the head of Capricorn — ראש גדי].

We made the altitude [reading] and set it upon the 12-degree line; we set [the rete] again upon 12. Then we made [a second] mark upon the altitude, with the head of Capricorn [ראש גדי] [against] the [other] mark, and there were between the two marks 5 degrees [?]. We took from these the half — that is, two-and-a-half degrees [?] — and added them to the [reading], and set [it] upon the first altitude that we had marked, and that which results [from the interpolation] is the [true] altitude.

And if you wish the rising degree [the ascendant], do the like by the way of the head of Capricorn [the index], [proceeding by] 4 degrees [?], and you will arrive at the altitude — and that is the altitude at that time. And do likewise for the rest of the operations of the instrument, if your instrument should be an imperfect instrument; but [if] the instrument is a perfect one, then it is the best of all instruments.

[Colophon]

This book was completed in the year של"ג [333 of the minor reckoning,) = לפ"ק 333(5 AM; (5)333 - 5000 = 333, i.e. 1572/73 CE] [Hebrew: = 3ג + 30ל + 300ש 333], on the eve of [the night of day] 4-into-5 [נליל ד' ה' — Wednesday night into Thursday], [in the month of] Ḥeshvan [חשן, final letter abraded] [?], on [the Sabbath portion] Lekh Lekha.

I am the scribe [הסופר] — "a cluster of henna" [אשכול הכופר, Song of Songs 1:14, a humble rhymed flourish, not a name] — who sets down the words of the book [נותן אמרי ספר]. I [am the one] who completes this book. To the God, Creator of the world [לא אל בורא עולם]. Thus says Shemuel [Samuel], son of the chief [האלוף], the exalted one [המרומם], our honored teacher and master [כמהור"ר] Moshe [Moses] Sofer [משה סופר], of the holy congregation [ק"ק] of Prague [פראג].

Diagram, upper figure. A square astrological chart (the standard twelve-house "square horoscope" layout): an outer square crossed by its two diagonals and by lines joining the midpoints of its sides, dividing the field into twelve triangular cells around a central diamond. The chart runs counterclockwise from the central diamond (house א, the ascendant) in the conventional Hebrew order. Each cell carries a single Hebrew letter (a house/position index, א-יב). The structure and most house letters are recovered at native resolution; a few cell letters remain at the abrasion floor.

- Center diamond: א [1st / ascendant]
- Top center: ט [9th]
- Upper-right: יא [11th]
- Right-upper: י [10th] [?]
- Left-upper: ח [8th] [?]
- Lower-left: ב [2nd] [?]
- Lower center: ג [3rd]
- Right-lower: ד [4th]
- Bottom: ה [5th]
- Remaining cells (ו [6th], ז [7th], יב [12th]) fall at the tile seams and are not separately legible — [?]; the intended single-letter sequence is א-יב.

` at tile seams/abrasion.]

Diagram, lower figure. A second square twelve-house chart, same construction, but with the four cardinal directions written outside the four sides and each house-cell labeled with a single letter plus a short caption (a zodiac degree-and-

sign or a brief descriptive phrase). The four recovered zodiac captions run Sagittarius → Capricorn → Aquarius around the top with Cancer at the bottom, confirming a real zodiac-ordered house diagram. Direction labels (outside the square):

- Right side (running vertically): מזרח [East]
- Below the bottom side: דרום [South]
- Above the top side: [North — abraded direction abbreviation] [?]
- Left side (running vertically): מערב [West] [?]

Central title-cell: כלי בתקונו ["the instrument in its array/order"] — a self-referential title, not a house number; final letter [?].

Cell labels (letter + caption), reading counterclockwise around the chart:

- ט [9th] — ט"ו/ל בקשת [15° in Keshet / Sagittarius]
- י [10th] — י"ב בגדי [12° in Gedi / Capricorn]
- יא [11th] — ט' בדלי [9° in Deli / Aquarius]
- ד [4th] — ע"ג [73] נסרטן [in Sartan / Cancer]
- ה [5th] — ס' נקריה [?] (the ה and ס' legible; נקריה abraded)
- יב [12th] — [caption abraded: מצרים / חצרים] [?]
- ח [8th] — [caption abraded] [?]
- ז [7th] — [caption abraded] [?]
- ו [6th] — [caption abraded] [?]
- ב [2nd] — [caption abraded] [?]

Parsing notes: the structure, the house letters ג, ד, ה, י, יא, ט, and the four zodiac captions (Sagittarius/Capricorn/Aquarius/Cancer) plus directions East/South are firm at native resolution. The remaining ≈6 cell captions (houses ב, ח, ז, ו; the חצרים / נקריה tokens) and the 2 cardinal-direction abbreviations (north, west) are at the abrasion floor — genuinely abraded, not resolution-limited — and are left [?] rather than guessed.

` at the abrasion floor.]

לוח הטעות — Table of Errata

The errata table reads right-to-left in the source; the logical column order (page → line → printed error → correction) is preserved below. Page and line numbers are Hebrew numerals.

דף (Page)	שורה (Line)	שגיאה (Error, as printed)	תקן (Correction)
[7] ז	[50] נ	"ת	ת"י
[6] ו	[6] ו	קששה	חששה
[15] טו	[22] כב	ב	בו
[70] ע	[3] ג	כרצוכו	כרצונו
[15] טו	[14] יד	—	חסר אחר תבת היום מלת מן ["after the word היום the word מן is missing"]
[18] יח [?]	—	בגשמים	בגשרים
[25] כה	—	וסמכ	וסמן
[7] ז	—	וסימן	וסימן
[18] יח [?]	[23] כג	לוחה	[?] לוחה

Parsing notes:

- The table has four logical columns; in several rows the line-number cell is blank (em-dash in source) and only a page number is given.
- Row "ת"י / ת" / נ / ז": the error/correction lemmas ("ת → ת"י) read cleanly at native resolution. The line-number (50=) נ is read off the tile and is unusually large for a line number but is what is printed; transcribed as-is.
- Row "ו" / ו": printed קששה (kuf) corrected to חששה (ḥet) — a kuf/ḥet confusion.
- Row "יח / —": printed בגשמים (mem) corrected to בגשרים (resh) — a mem/resh confusion, exactly the kind the closing note describes. The page-number cell (18=) יח carries a worn second glyph that reads ambiguously between ḥet and final-nun — flagged [?].
- Last row (page יח / line כג): the printed error and the correction both read לוחה on the tile; the intended single-letter distinction is not legible — [?] retained on the correction only. (The pair was misread as אותה/אותה in the prior pass.)
- Several lemma pairs differ by a single confusable letter (ן/ן, ש/ר, כ/ג), consistent with the closing note below.

[Closing note to the errata]

[Note, below the table:] The abbreviation ז"ו [recte ז"ו / ת"ר?] [?] — in several places [מ"כ] the [marks of] reference-letters [ת"ר, "initial-letters / siglum"] became interchanged: in the table, two words at the beginning [are] to come [in place of the proper reading]; likewise at the end of one word [there is confusion]. And so, whatever the reader perceives [as out of place] — he will set it right [as he reads], and there is no pressing need to point them all out [individually].

[The closing note is small-type and partly abraded; the technical sense — that the corrigenda chiefly concern transposed/confused single letters and that the attentive reader can self-correct — is given, with the uncertain tokens flagged [?].]

[End of the treatise. The book closes here with the colophon and errata; no further text follows.]