NOMOGRAMS FOR GEOLOGICAL PROBLEMS

WITH

PORTFOLIO OF PLATES

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l'hommage de l'auteur

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PROEFSCHRIFT

TER VERKRIJGING VAN DE GRAAD VAN DOCTOR IN DE WIS- EN NATUURKUNDE AAN DE RIJKSUNIVERSITEIT TE UTRECHT OP GEZAG VAN DE RECTOR MAGNIFICUS Dr. H. W. OBBINK, HOOGLERAAR IN DE FACULTEIT DER GODGELEERDHEID, VOLGENS BESLUIT VAN DE SENAAT DER UNIVERSITEIT TEGEN DE BEDENKINGEN VAN DE FACULTEIT DER WIS- EN NATUURKUNDE TE VERDEDIGEN OP MAANDAG 20 MEI 1957 DES NAMIDDAGS TE 13.30 UUR PRECIES

DOOR

JOANNES EMMANUEL JOSEPH MARIA VAN LANDEWIJK
GEBOREN TE TILBURG

1957

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PROMOTOR: PROF. DR. W. NIEUWENKAMP

Aan mijn ouders

Aan mijn vrouw

Het is niet meer dan natuurlijk om mijn proefschrift te beginnen met een woord van oprechte dank tot allen, die mij op mijn weg door de academische wereld tot dus ver hebben geleid.

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CONTENTS.

"There is no more common error than to assume that, because prolonged mathematical calculations have been made, the application of the result to some fact of nature is absolutely certain".

A. N. Whitehead.

SAMENVATTING.

Uit verzamelde metingen moet men vaak niet gemeten grootheden bepalen. Dit kan onder andere gedaan worden met nomogrammen. Een nomogram is een geometrische uitdrukking van een afhankelijkheid; hoe die afhankelijkheid gegeven is, is alleen van belang voor de vorm van het nomogram.

Een nomogram behoort eenvoudiger en sneller te zijn dan berekening of constructie en is vooral aan te raden, als eenzelfde probleem meermalen voorkomt.

De nauwkeurigheid moet vooral bepaald worden door de nauwkeurigheid van de waarnemingen.

Voor verschillende problemen zijn speciaal nomogrammen vervaardigd.

SUMMARY.

Non-measured data must often be determined from collected data. It can be done among others with nomograms. A nomogram is a geometric expression of a relation; how this relation is given, is only of importance for the form of the nomogram.

A nomogram must be simpler and swifter than calculation and construction, and is especially recommended, if the same problem arises frequently.

The exactness must be determined above all by the exactness of the collected data.

Special nomograms are constructed for different problems.

A. INTRODUCTION.

The geological data which are collected must be brought in a space - and time-relationship to each other. Desired data must therefore be derived from given ones.

This derivation and the analysis of data can be done by construction and by calculation (tables included) and in general also by the use of the stereographic projection or another special, ready made nomogram.

Which method will be preferable, depends on the relation between given and required data, the exactness and the range of the data, the available time and apparatus, and the frequency of the problem.

If nomograms are to be used, it is very often a drawback that the construction of nomograms usually takes much time. The nomogram once constructed is profitable because of the swiftness and simplicity in the solution of the problem.

The following nomograms are made, because the problems which can be solved with them, do often enough appear in the geological work, although many not often enough in a certain work to justify the construction of the special nomogram by each geologist individually.

A nomogram is a geometric expression of a relation between variables. A nomogram can be constructed from formulae, empirically found data and directly from a geometric relation.

The variables are represented by lines and points on a nomogram in such a way that there will be a simple geometric relation between the independent and the dependent variables. Study of figures 1 a, b, c and d will explain this and will also illustrate some of the terminology.

The form of a nomogram depends on the given relation (cf. plate 17 and 18), the exactness and the range of the data, the acceptable length and so on. From the same functional relation one can make different nomograms each with its own drawbacks and advantages. Compare e.g. plate 2, 3 and 4; plate 2 and 3 are for different ranges, plate 4 can also be used for a range to about 88°. See also plate 2 and 12; in plate 2 the range till abt. 80° can easily be read, plate 12 is not so exact in application but there is no limit in the range and it is more easily understood and visualized.

B. TOPOGRAPHICAL AND CARTOGRAPHICAL NOMOGRAMS.

1. *Sections with exaggerated vertical scale.*

If angles in a section with an exaggerated vertical scale must be drawn or read, the scale difference has to be corrected for. It will be clear that the tg of angle α will be $\frac{na}{b}$ at a n times exaggeration, if the tg α is $\frac{a}{b}$.

The exaggeration factor is plotted on scale I, the true angle on scale II and the section angle will be found on scale III. To convert section angles to true angles one plots of course on scale III and reads on scale II. See fig. 2, plate I.

2. *The determination of the slope from the horizontal contour distance, the interval and the scale.*

The formula which must be represented, is tg $\alpha = \frac{n\,i}{h_k s}$, wherein α is the slope, i the interval, h_k the map contour distance and s the denominator of the scale fraction. $h_k s = h_t$ (actual horizontal contour distance). See fig. 3.

In connection with the required exactness two nomograms are constructed, one nomogram for vertical differences smaller than 100 m and large slope angles (fig. 4, plate 2) and one for the other cases (fig. 5, plate 3).

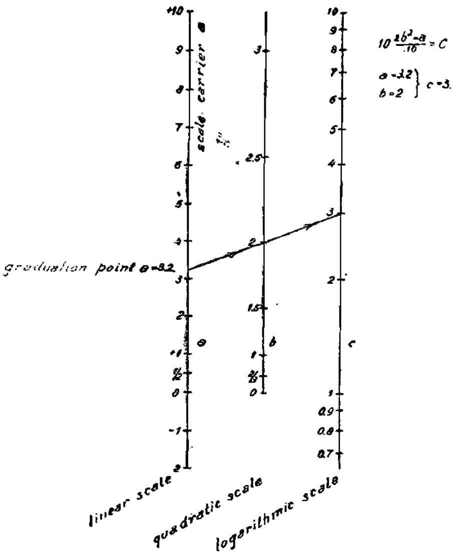
The same problem can be solved by plate 2 and 3 (see A and Bl). In fig. 4 the distance is plotted on scale I and the vertical difference on scale II (both true or map size). Both marked points are connected by a straight line and thus the slope is found on scale III.

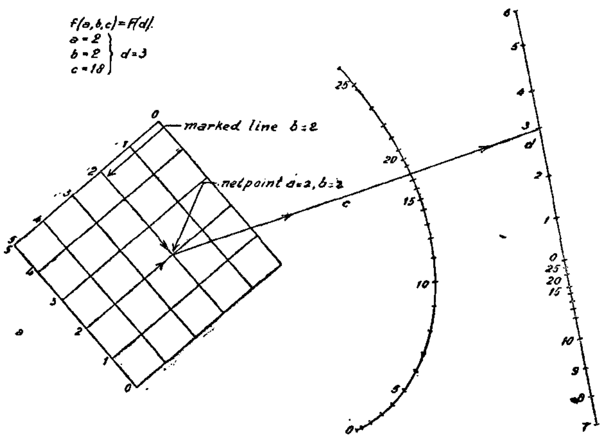
In fig. 5 one can find the horizontal field distance on scale V with the map distance on scale I and the scale denominator on scale II with a perpendicular angle. There is no need to read this horizontal true distance. The slope can be read on scale IV with a perpendicular angle and with the aid of the elevation difference plotted on scale III. In the case of distances smaller than 100 m and small slope angles the right hand scales III and IV are used, otherwise the left hand ones.

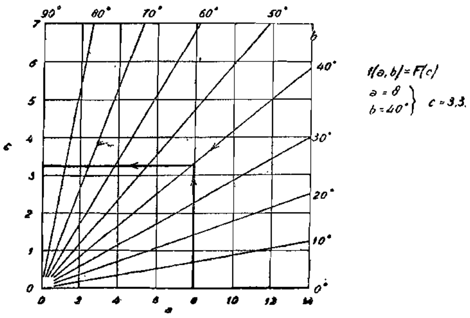
In fig. 6, plate 4, another nomogram for the same problem is drawn to demonstrate a possible other form. The converted formula used for this form is: $\log \operatorname{tg} \alpha = \log ni - \log s - \log h_k$ and $\log h_t = \log s + \log h_k . h_t$ is a turning scale, there is no need to read this line.

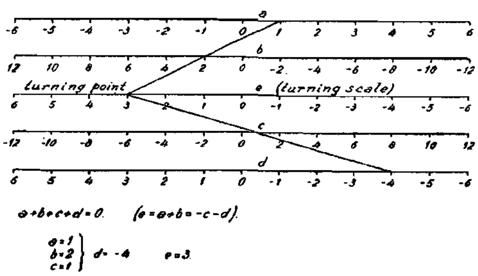
3. *The determination of the horizontal distance and the vertical (height) difference in triangulation.*

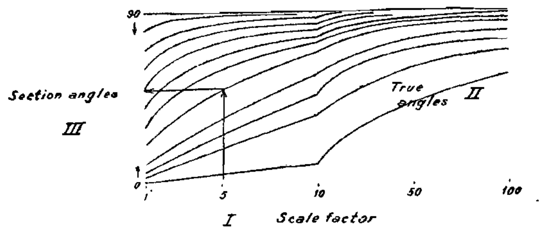
In fig. 7 A represents station 1 and B station 2. The base line of the measurement is b. If A and

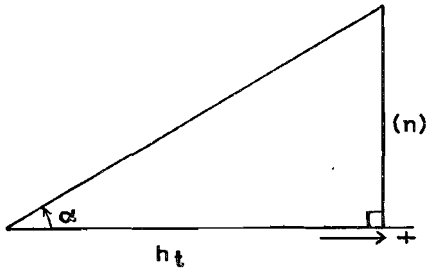


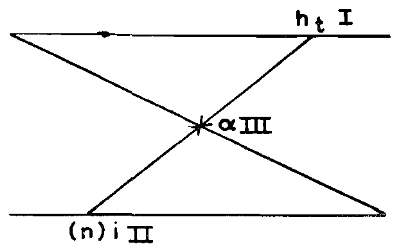


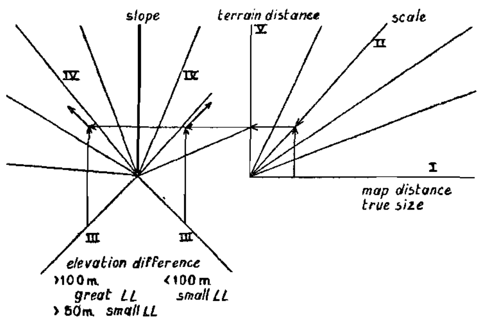












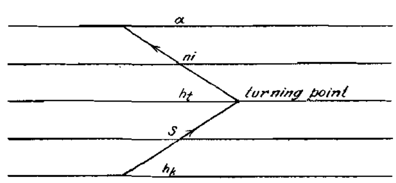
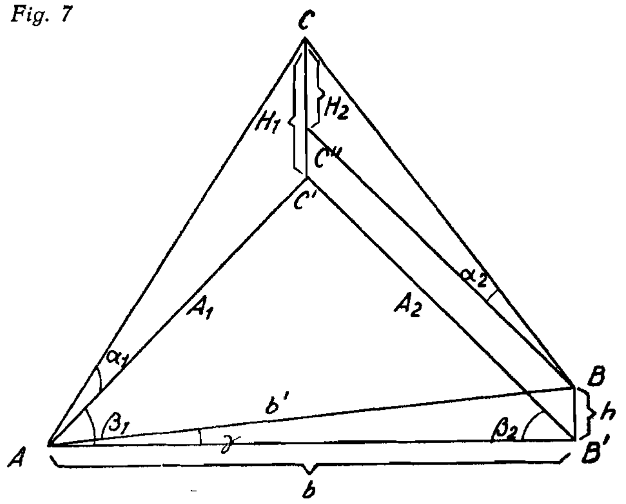


Fig. 1a
Fig. 1b
Fig. 1c
Fig. 1d

Fig. 2
Fig. 3
Fig. 4
Fig. 5
Fig. 6

Fig. 7



B are not situated on the same elevation, b and h must be determined from b′ (the non horizontal distance AB) and γ (the slope angle). This can be done with nomogram fig. 8, plate 5.

The formulae AB′ = AB $\cos\gamma$ applies to the distance and h = AB $\sin\gamma$ to the vertical difference. On scale I AB = b′ is plotted and encircled to the marked line of γ found on scale II. On scale III AB′ is found as one perpendicular coördinate of the determined point and h as the other perpendicular coördinate on scale IV.

In triangulation the given data (fig. 7) are: b′, h, β, β_2 and α_1 (or α_2), the required ones are A_1 and H_1 (or A_2 and H_2). The relation is

$$b = \frac{A_1 \sin(\beta_1+\beta_2)}{\sin\beta_2} \text{ and } H_1 = A_1 \operatorname{tg} \alpha_1.$$

In the nomogram fig. 9, plate 6, β_1 is plotted on scale I and β_2 on scale II and the ray which functions as a turning scale is found. With this turning scale and b plotted on scale III the required A_1 is found on scale IV. This can be checked by changing β_1 and β_2 and finding A_2 instead of A_1.

The height difference H_1 is found with the nomogram fig. 8, plate 5, scale III is A_1, scale II is α_1 and scale IV is H_1. The check is: scale III is A_2, scale II is α_2 and scale IV is H_2.

4. *The determination of distance and elevation difference when reading the vertical stadia rod.*

In fig. 10 DE is the topographical elevation with regard to the instrument I, DC is the part of the stadia rod that is read. In the determination one must take into account the distance DP and the elevation of I above the 0 surface whereas the point P is determined with regard to I.

IE and EP are determined from CD and γ. Angle PAC is virtually equal to 90° (AB ⊥ IP). AB = CD $\cos\gamma$, IE = IP $\cos\gamma$ and EP = IP $\sin\gamma$. In the case that the visual angle (AIB) is 10 mils, IP = 100 AB, whence follows: IP = 100 CD $\cos\gamma$ and therefore IE = 100 CD $\cos^2\gamma$ and EP = 100 CD $\sin\gamma\cos\gamma$.

In the nomogram the stadia rod reading is plotted on scale I, the angle γ on scale IIa for the distance determination, on scale IIb for the elevation determination, and respectively the distance or the elevation difference is found on scale III. See fig. 11 and 12, plate 7 and 8.

5. *Temperature correction with altimeter-barometer reading.*

Because the air pressure is not dependent only on the altitude (elevation), but also on the temperature, first of all the barometer reading should be corrected for the temperature. An altimeter is calibrated to give the exact absolute elevation at one given calibration temperature (often 50° F). The difference that must be corrected is ·2 % of the read elevation difference for each degree difference between the reading temperature and the calibration temperature. The reading temperature is the mean temperature of the measurements at station 1 and 2. t_1 and t_2 are the temperatures at station 1 and 2.

The elevation difference is thus: reading $\pm \left(\frac{t_1 + t_2 + 900}{1000}\right) \times$ reading = the elevation difference, corrected for the temperature.

It should be noted here that one of the stations should be taken at a known altitude (or already corrected). The correction effects all readings.

In nomogram fig. 13, plate 9, the measured elevation difference is plotted on scale I, the sum of the temperatures of the two readings on scale II, the elevation difference corrected for temperature (at a callibration temperature of 50° F) is found on scale III.

6. *Conversion scales for measurements.*

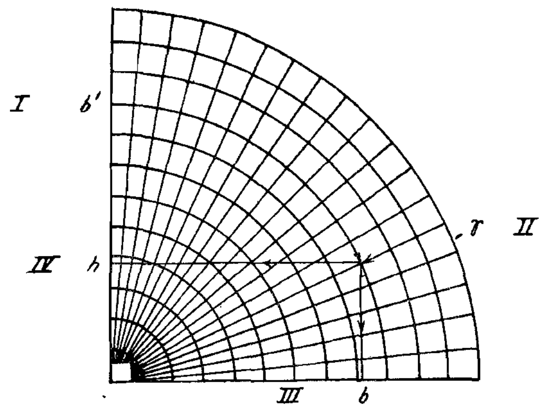
Some double-scales are made in nomogram plate 10 to convert different measurements in each other. These nomograms are self-explanatory.

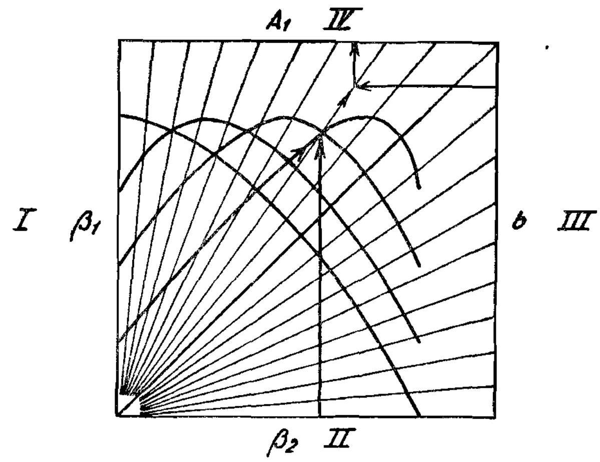
C. DETERMINATION OF THE ORIENTATION OF PLANES AND LINES.

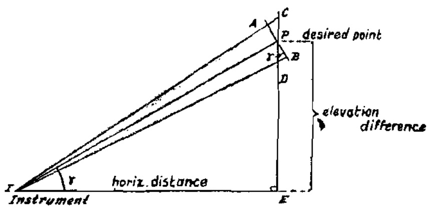
A horizontal direction is indicated by stating the azimuth, that is: the angle which the direction makes with the direction to the north, measured to the right from the north direction, see fig. 14.

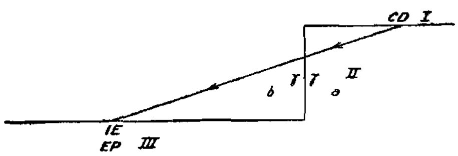
A line is indicated by stating the azimuth of its projection on a horizontal plane in the direction in which it descends, see fig. 15, and by its dip.

A plane is indicated by stating the strike and dip. The strike is the direction of a horizontal line in the plane, the dip is the dihedral angle of the









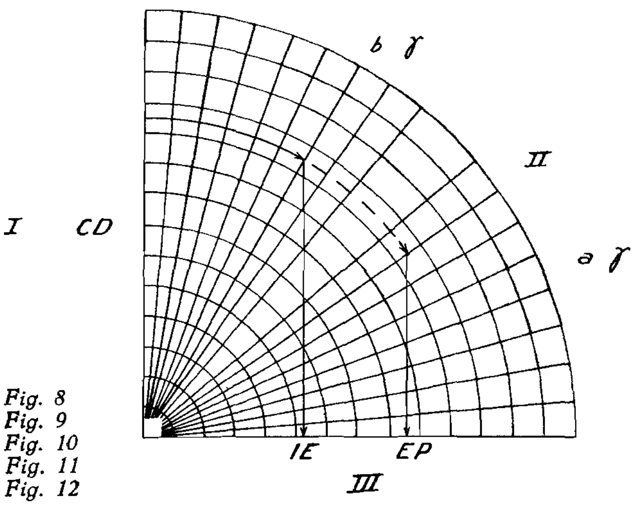
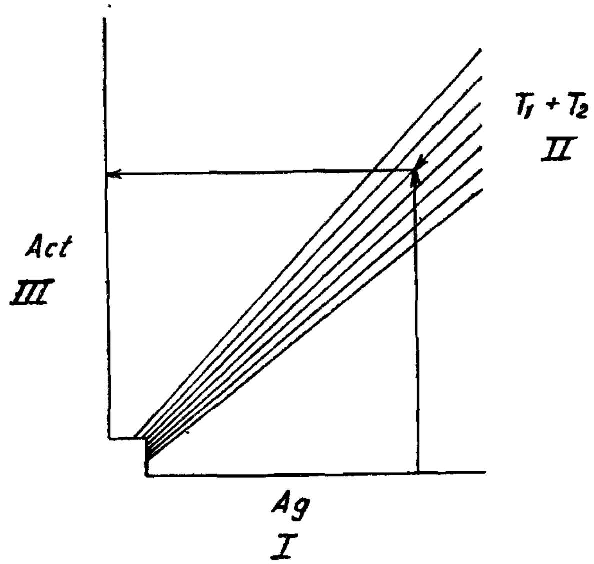
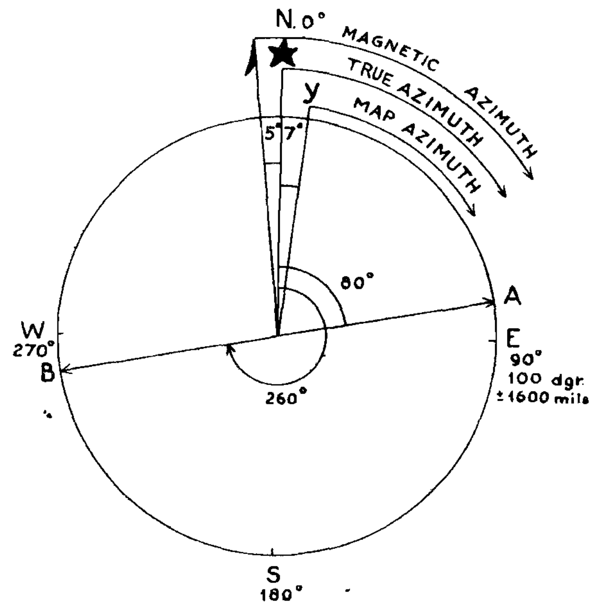


Fig. 8
Fig. 9
Fig. 10
Fig. 11
Fig. 12





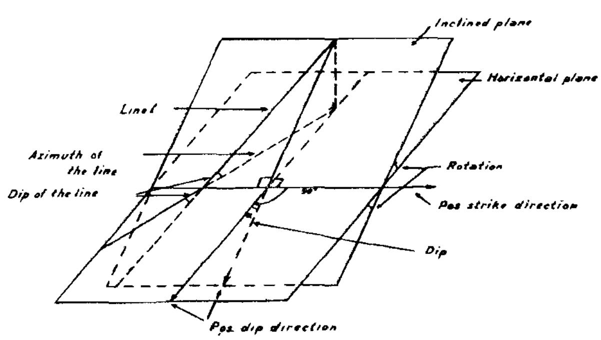


Fig. 13
Fig. 14
Fig. 15

plane with the horizontal plane. The direction of the strike goes 90° behind the direction of the dip. Strike and rotation (and dip direction) form a to-the-right system (corkscrew), see fig. 16.

I. Determination of the orientation of a plane.

1. *Strike and dip determination from two lines in the plane.*

Figure 17 gives a representation of this case. α_1, α_2 and γ are given; β_1 (or β_2) and α are required. The formula is:

$$\operatorname{cotg} \beta_1 = \frac{\operatorname{cotg} \alpha_1 \operatorname{tg} \alpha_2 - \cos \gamma}{\sin \gamma} \text{ and } \operatorname{cotg} \alpha = \operatorname{cotg} \alpha_1 \sin \beta_1.$$

The nomogram fig. 18, plate 11, represents this relation. α_1 and α_2 are plotted on scale I and II respectively and the turning point P is found on the vertical 0-line. γ on scale III (the angle between the azimuth of the two lines) is connected with this point P and the angle β_1 is found on scale IV. The line β_1 of scale IV to α_1 of scale I touches on the marked point of the dip α of scale V.

For $\beta_1 > 90°$ one takes $\beta'_1 = 180° - \beta_1$ and determinates α at the usual manner.

For $\gamma > 90°$ one takes α_1 on the left hand side and reads on the upper scale.

The solution can be checked with this nomogram by changing α_1 and α_2 and getting β_2 in stead of β_1.

2. *Strike and dip determination from three points in a plane.*

First two lines are determined which are defined by the three points and use is made of the above mentioned nomogram.

For this determination nomogram fig. 19, plate 12, can be consulted; see also fig. 4 and 5, plate 2 and 3.

The horizontal distance is plotted on scale I, the elevation difference on scale II and the dip of the line is read on scale III. The azimuth of the line is the azimuth from the highest point to the lowest of the two.

A check is possible by taking another combination of three points.

II. Indirect determination of the dip of a line with a known azimuth.

1. *Indirect determination of the dip of a line from a great distance and in a direction not perpendicular to the azimuth.*

At a suitable station, from which the line is seen in a direction not perpendicular to the azimuth of the line, one measures the sight line, and afterwards the apparent dip of the line with the vertical clinometer.

In fig. 20 is known: azimuth l, the apparent dip α_1' and the azimuth of the sight line. α_1 is required.

The formula reads: $\operatorname{tg} \alpha_1 = \operatorname{tg} \alpha_1' \sin \gamma$.

γ is the angle between the azimuth of l and the sight line measured to the right (clockwise).

γ is plotted on scale I of the nomogram fig. 21, plate 13, the apparent dip α_1' on scale II.

The required α_1 is found on scale III on the same rectilinear as the two points.

Remarks: In the case $\gamma = 0$ α_1 is indetermined (one looks in the azimuth of the line). In the case $\alpha_1' = 0$ or 90 α_1 is also 0 or 90 respectivelly.

Another nomogram for the same problem is fig. 48, plate 24.

2. *Indirect determination of the dip of a line from short distance and in a direction not perpendicular to the azimuth.*

A point A on the line of outcrop or its production is sighted with the horizontal compass. The azimuth OA is determined. Next the azimuth and the dip of another sight line OB is determined. See fig. 22.

Azimuth OA, azimuth OB, azimuth l and the angle φ are known, the angle α_1 is required. The formula is: $\operatorname{tg} \alpha_1 \sin \gamma = \operatorname{tg} \varphi \sin \delta$.

In nomogram fig. 23, plate 14, δ is plotted on scale I and φ on scale II and the turning point P is found on scale III. With this point and γ plotted on scale IV α_1 is found on scale V.

In the case of high values of φ φ is plotted on scale V and α_1 is found on scale II.

3. *The strike and the slope of the topographical surface comprising the line, is known.*

In fig. 24 ABC′ is the topographical surface, of which strike AC′ and slope φ are known. Besides the azimuth of l is known.

The formula is: $\log \operatorname{tg} \alpha_1 = \log \operatorname{tg} \varphi + \log \sin \gamma$. In the nomogram fig. 25, plate 13, (the same nomogram as for 1) the angle γ is plotted on scale I. γ is the angle from the strike of the topographical surface to the azimuth of the line measured clockwise. The angle φ is plotted on scale II. The required α_1 is found on scale III by connecting point I and II by a rectilinear.

III. Indirect determination of the azimuth and dip of a line in a known topographical surface.

1. *Indirect determination of the azimuth and dip of a line from a great distance.*

One stations oneself such that the sight lines

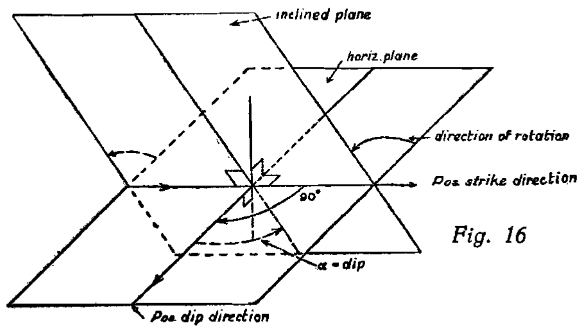
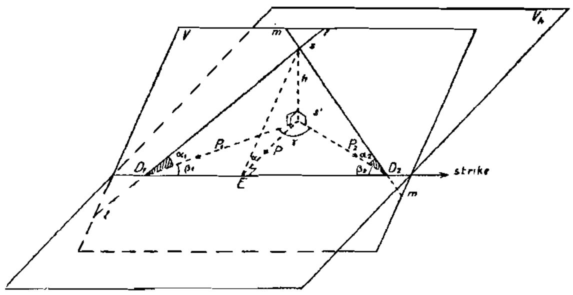
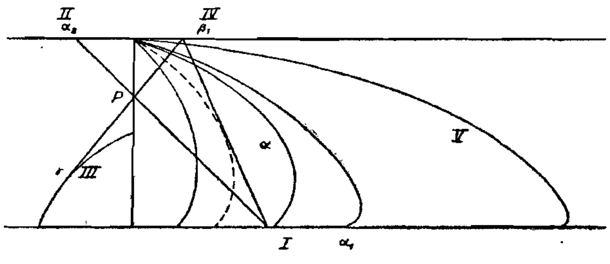
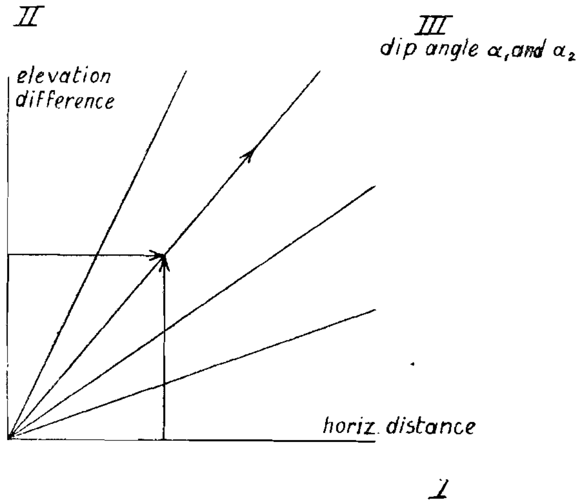
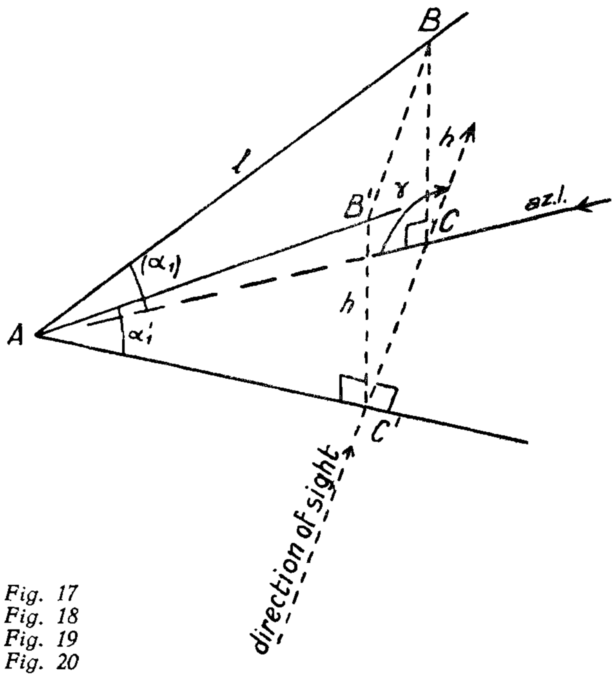


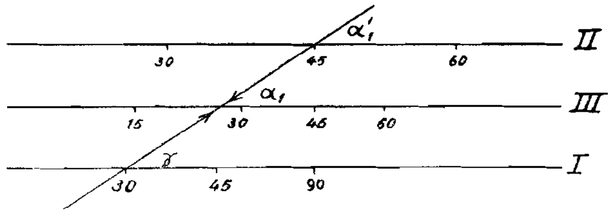
Fig. 16

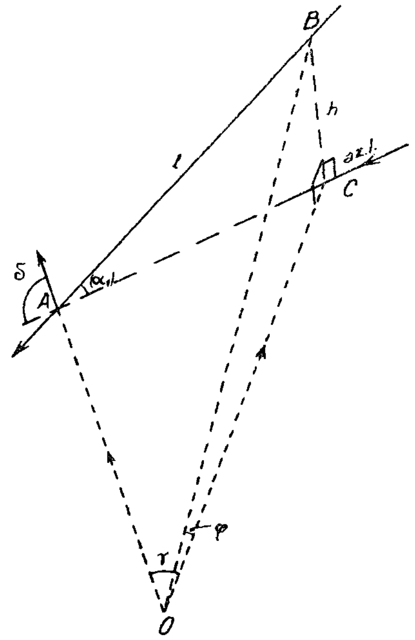


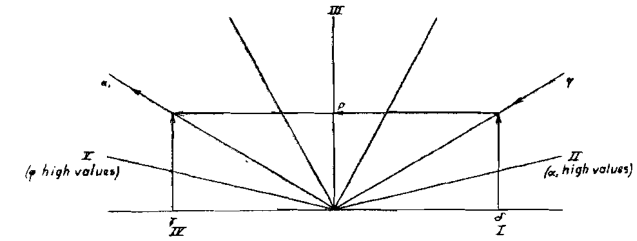


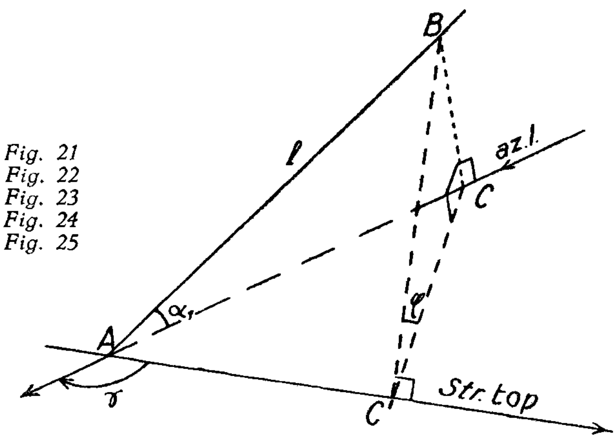












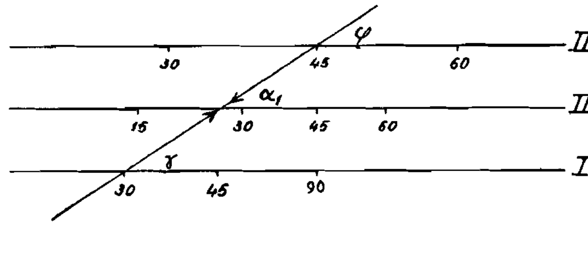
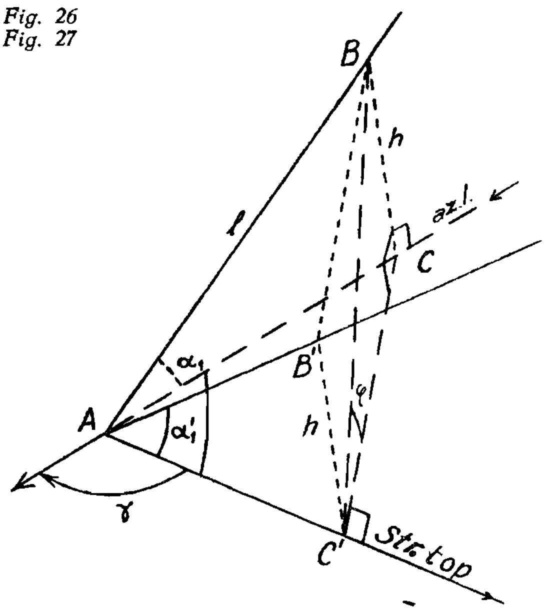
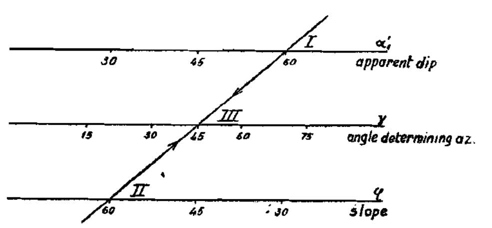


Fig. 17
Fig. 18
Fig. 19
Fig. 20

Fig. 21
Fig. 22
Fig. 23
Fig. 24
Fig. 25

Fig. 26
Fig. 27





which are considered parallel, are perpendicular to the strike of the topographical surface. The apparent dip α_1' is measured. Further φ and the azimuth AC′ are known, see fig. 26. The formula for the determination of the azimuth of the line $1: \mathrm{tg}\,\gamma = \mathrm{tg}\,\alpha_1' \,\mathrm{cotg}\,\varphi$. γ is the clockwise measured angle between strike and the azimuth of l. For the dip applies: $\log\,\mathrm{tg}\alpha_1 = \log\,\mathrm{tg}\,\varphi + \log\,\sin\gamma$.

The nomogram to determine the azimuth is fig. 27, plate 15. The apparent dip α_1' is plotted on scale I, the slope on scale II. The connecting line of those points indicates the value of γ on scale III.

For the dip see fig. 25, plate 13.

2. *Indirect determination of the azimuth and dip of a line from a short distance.*

The station is chosen such that the sight line to the point B of the line, not at eye altitude, is perpendicular to the strike of the topography (fig. 28). Measured are the direction OA (A is a point of the line at the same elevation as the eye O), the dip OB and the topography.

The formula for the azimuth determination is: $\mathrm{cotg}\,\gamma = (\mathrm{cotg}\,\psi\;\mathrm{tg}\,\varphi - 1)\;\mathrm{tg}\,\delta$ and for the dip: $\mathrm{tg}\,\alpha_1 = \mathrm{tg}\,\varphi\;\sin\gamma$.

γ is again the clockwise measured angle from the topographical strike to the azimuth of the line, δ is the angle from the horizontal sight line to the azimuth of the non-horizontal sight line.

For the azimuth determination δ is plotted on scale I in nomogram fig. 29, plate 16, ψ on scale II and φ on scale III. The angle γ is found on scale IV.

For the dip see fig. 25, plate 13.

3. *Indirect determination of the azimuth and dip of a line from two theodolite readings from one point.*

This case is comparable with the preceding, there is no need now to choose one of the sight lines horizontal. In practice the sight lines are measured to two different points of the same line of outcrop, if two lines are determined by this method, the strike and dip of the plane can be obtained.

In fig. 30 the angles δ_1, χ, ψ, η and φ_1 (φ_1 follows from the slope and η, for instance with nomogram fig. 25, plate 13, or fig. 48, plate 21) are known. The angle γ is required.

First the plane EOB is determined from the two lines OA and OB with monogram fig. 18, plate 11. The angle δ_2 will follow from this determination.

The formula that is represented in fig. 31, plate 17, is:

$$\frac{\sin\gamma\,\sin\delta}{\sin\,(\eta-\gamma)\,\sin\,(\eta+\delta)} = \frac{\sin\psi\,\cos\varphi}{\sin\,(\varphi-\psi)}$$

With φ on scale I and ψ on scale IIa the turning point is found on scale III. With this turning point and a point on scale IIb found with δ on scale IV and η on scale V, a point is found on scale VI. From this last point the required γ on scale VIII follows with η on scale VII.

The dip can be found with the aid of nomogram fig. 25, plate 13.

IV. Indirect determination of the azimuth and dip of a line from four theodolite readings in pairs from two points.

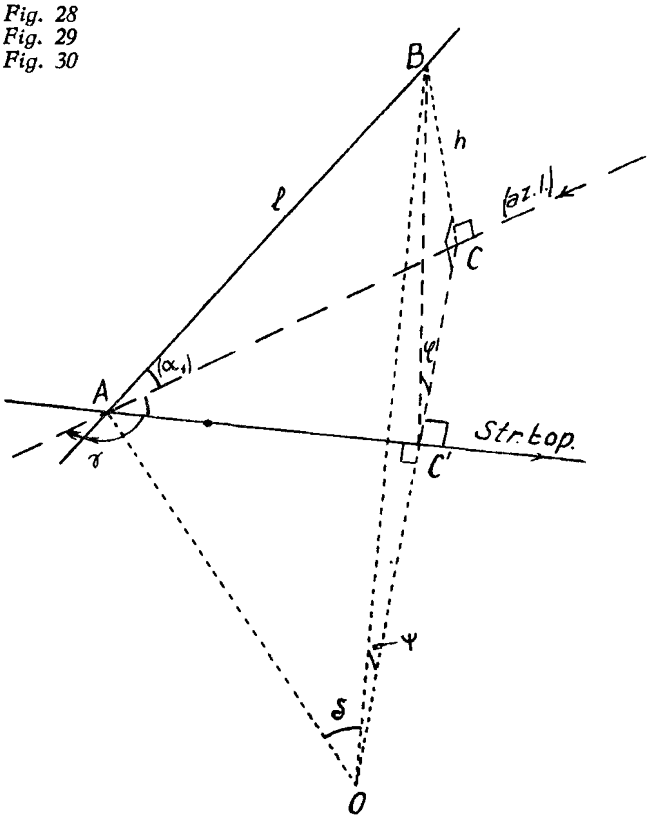
If a line at a distance must be determined and the topographical surface cannot be measured, one can take readings with the theodolite as in III 2, but then twice. The four points may be the same two and two, but this is a special case of the general one. This problem will often arise in high mountains.

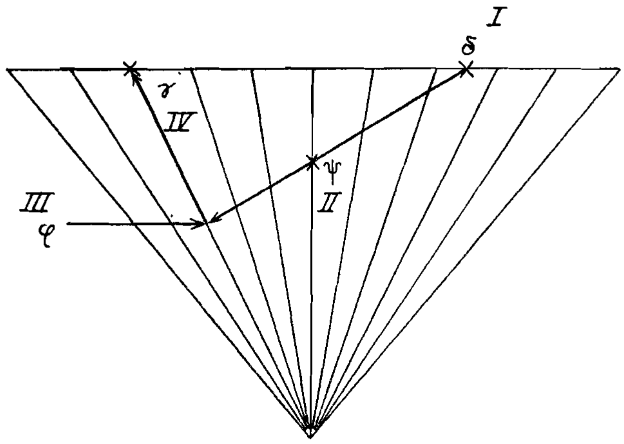
If a line is given by measurements of the sight lines to two points of the line from one station and then from another station, the nomogram fig. 18, plate 11, can be applied, to determine the plane through a and b and the plane through c and d (fig. 32).

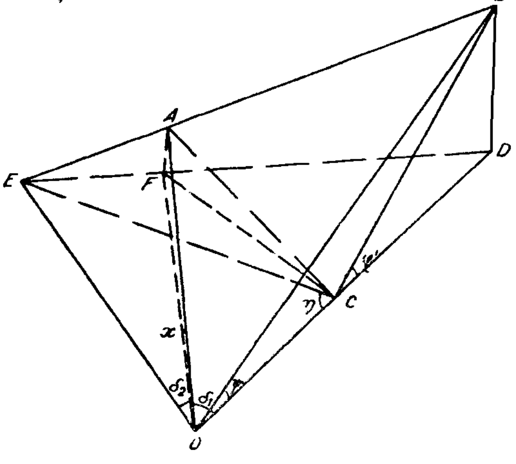
Next azimuth and dip of l will be determined with the aid of the nomogram fig. 33, plate 18. l is the intersecting line of the planes above determined (see fig. 34).

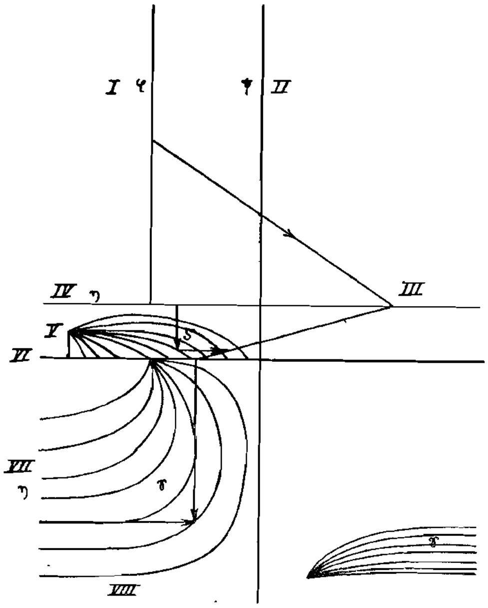
α is plotted on scale I and φ on scale II and the ray is found on scale III. A point is found on scale III with η on scale IV, with it δ is read on scale V. A second ray with δ is obtained on scale V and the fixed line on scale IV. In this second ray a point is found by conveying φ horizontally on scale II. The found horizontal coördinate can be read as γ on scale I.

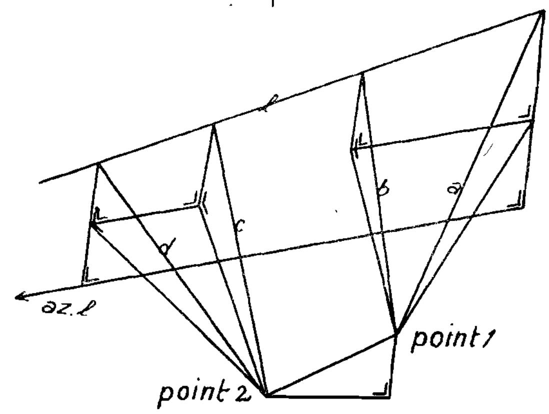
Fig. 28
Fig. 29
Fig. 30

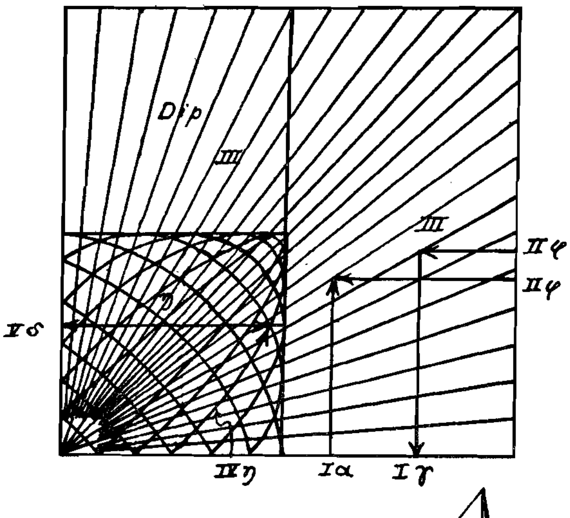












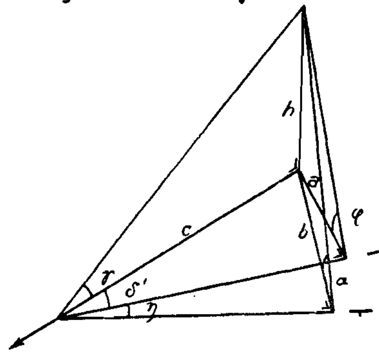


Fig. 31
Fig. 32
Fig. 33
Fig. 34

D. STRATUM THICKNESS AND WIDTH OF OUTCROP (HANGING WALL AND FOOTWALL ARE PARALLEL FLAT PLANES, THE SLOPE IS CONSTANT).

a. Examination of given and desired data.

In the practice of surveying one will often measure the distance between hanging wall and footwall of a stratum or strata in an arbitrary direction at the topographical surface. One will mostly want to know map outcrop width, the thickness of the stratum and the vertical distance between hanging wall and footwall. It can also be of importance to know the shortest horizontal distance between hanging wall and footwall.

In map studies and studies of data from bore holes and from galleries these data will often be transposed into each other.

b. Definitions and notation.

The used data are demonstrated in fig. 35 and 36.

D is a line in the topographical surface between the line of outcrop of hanging wall and footwall.
H is the map projection of D.
d is the thickness of the stratum or strata.
PT is a horizontal distance between hanging wall and footwall.
B is any stratum width, not perpendicular to hanging wall and footwall, not in the topographical surface, not horizontal.
α is the dip of the stratum.
φ is the slope of the topography.
β is the slope, which is measured not perpendicular to the contours. (Taken positive, if the direction, in a general sense, is the same as α's and vice versa).
δ is the angle between the strike of the stratum and the azimuth of a line.
ω is the angle of a line with the vertical.
The index w means arbitrary.
The index n means normal (perpendicular) to the line of outcrop.
The index s means perpendicular to the strike of the stratum.
The index φ means perpendicular to the contours.
The index v means vertical.

1. *The relation in terrain measurements.*

D_w, strike and dip of the stratum (δ and α) and the topography (φ and the direction of φ, thus also the β's) are known. (Instead of β_w sometimes ω_w can be given; $\omega_w = 90 \pm \beta_w$).

The formula for d-determination is: $d = D_w (\sin\alpha \sin\delta_w \cos\beta_w - \cos\alpha \sin\beta_w)$.

In fig. 37, plate 19, δ_w is plotted on scale I, β_w on scale II and α on scale III (scale II and scale III give a net point). The turning scale is found on scale IV. Scale VI gives the required d with this turning scale and D_w on scale V.

Remark: The representation of the line $\alpha = 90$ is the vertical line, of $\beta_w = 90$ is the horizontal line, of $\alpha = 0$ is the horizontal and of $\beta_w = 0$ is the vertical line.

B_v can be determined with the same nomogram, see fig. 38. B_v is considered as a vertical D_w, not in the topography. β_w is 90, δ_w is indefinite and there is no need to use it. The netpoint lies on the horizontal turning scale and B_v is read on scale V with the first determined d.

In the same way one reads D_s ($\delta_w = 90$) and PT_n ($\beta_n = 0$).

The nomogram fig. 39, plate 5, can be used for the relation H_w, H_s and H_n. In this one the formula that is represented, is:

$$D_w = \frac{H_w}{\cos\beta_w} \text{ and } B_v = \frac{d}{\cos\alpha}$$

D_w (B_v) is plotted on scale I and β_w (α) on scale II and H_w (d) is found on scale III and vice versa.

Remark: It is clear, that H_s, etc. can be read on this nomogram, if all w-indices are changed in s-indices, etc.

It appears useful to give a nomogram for the relation between β_w and φ to be able to find the used β_w easily in the above mentioned nomograms.

Nomogram fig. 40, plate 20, gives the relation: $\operatorname{tg}\beta_w : \operatorname{tg}\varphi = \cos(\delta_w \pm \delta\varphi)$. This is the relation between the slope and the slope in the w-direction in dependence of the angle between the slope-direction and the w-direction. Compare also nomograms fig. 25, plate 13 and fig. 48, plate 24.

δ_w is plotted on scale I and $\delta\varphi$ on scale II from scale II going up, if the slope has the same direction as α, otherwise going down. The turning point is found on scale III and with φ on scale IV β_w is found on scale V.

2. *The relation in map studies.*

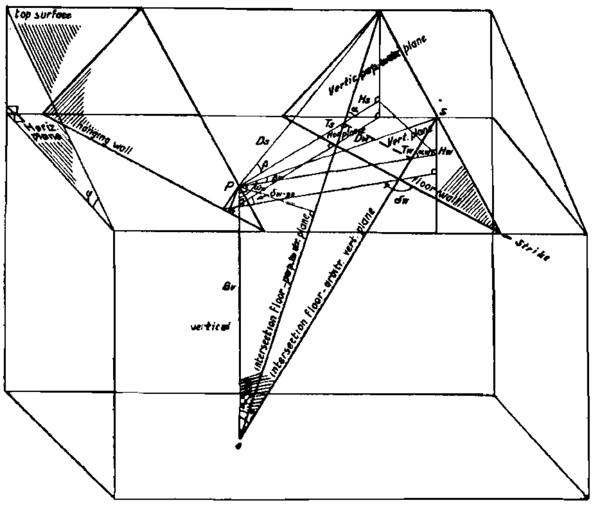
The above mentioned nomograms can be used. One can also start from the direct formula:

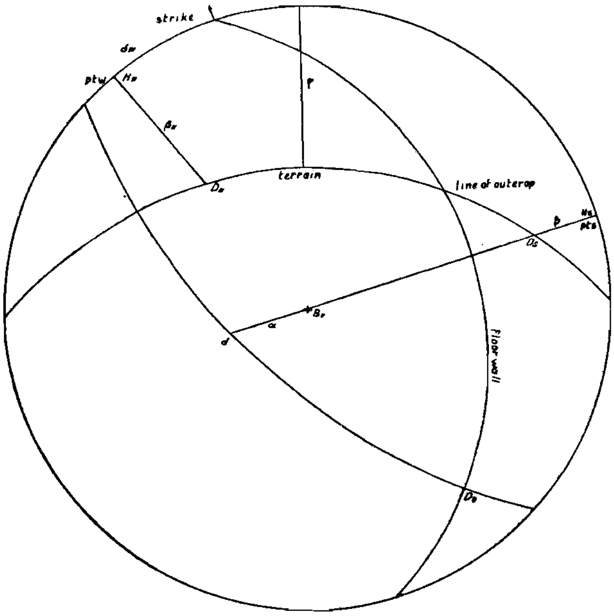
$$H_w = \frac{d}{\sin\alpha \sin\delta_w - \operatorname{tg}\beta_w \cos\alpha}$$

In that case the nomogram fig. 41, plate 21, is obtained. α is plotted on scale I and β_w on scale II and the accessory netpoint is found. With this netpoint and δ_w on scale III one finds the turning point on scale II. With this turning point and H_w on scale IV d is found on one of the V-scales.

3. *The relation in bore holes and galleries.*

In bore holes and galleries in general a B_w is given. This B_w can be considered as a D_w, not lying in the topographical surface. Thus one of the above mentioned nomograms can be applied to find d, B_v, etc.





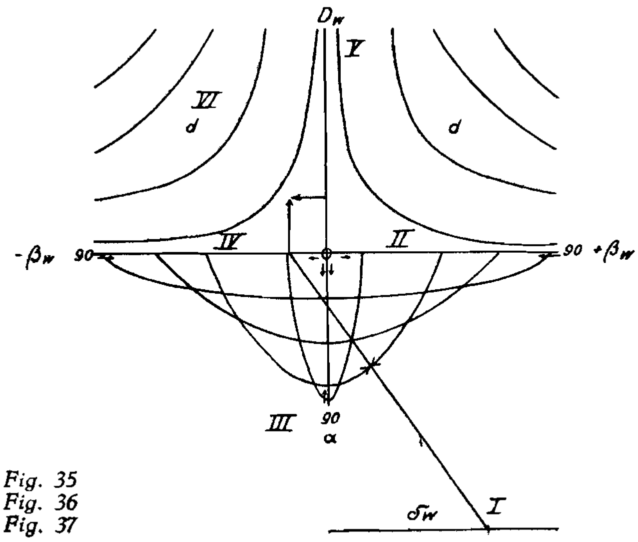
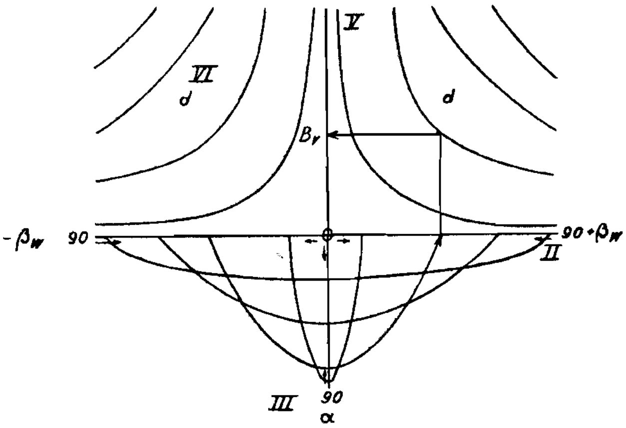
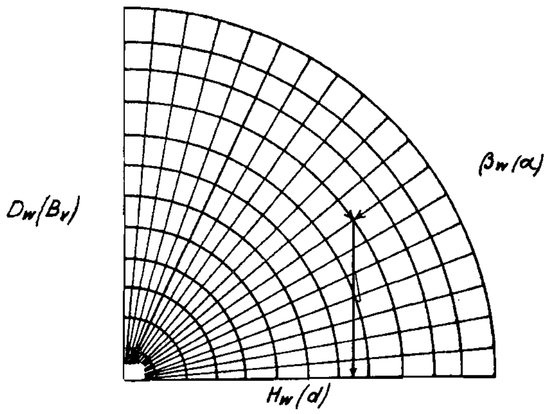
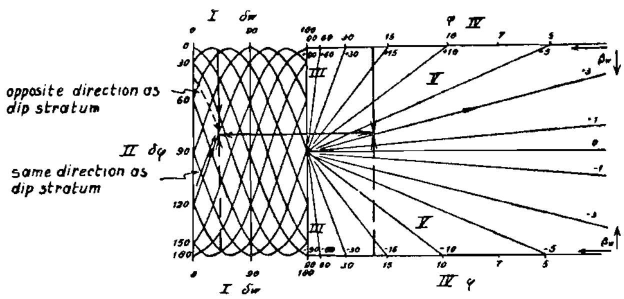


Fig. 35
Fig. 36
Fig. 37







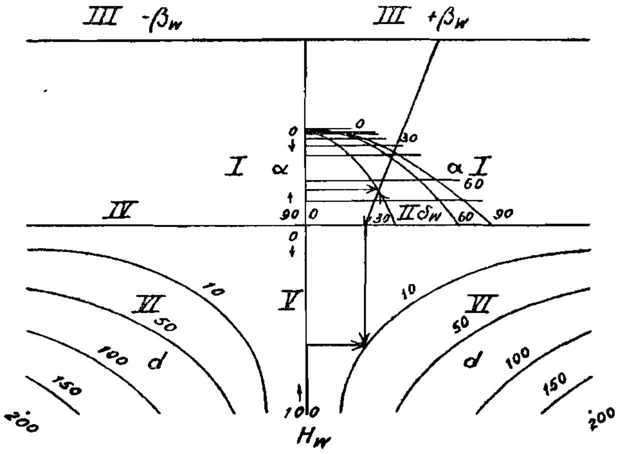


Fig. 38
Fig. 39
Fig. 40
Fig. 41

E. THE FAULTS.

a. Consideration.

The constructed nomograms are concerned with fault problems whose results can be attained by sheer translation along a non-curved plane. Some terms are explained in fig. 42.

It is clear, that a displacement of a fault is determined with respect to size and direction, if two formerly adjacent points can be indicated on both sides of the fault plane. Such a point will mostly be determined as the intersection point of the intersecting line of two planes V_1 and V_2 with the fault plane B, see fig. 43.

As a convention we will assume, that the footwall has remained fixed, the hanging wall has been displaced. In the case of a downthrow fault PQ is directed downwards, in the case of an upthrow fault, upwards.

In most cases the following data will be known: strike and dip of two displaced planes and of the fault plane and the distance of the intersection point of the non-displaced line of outcrop of V_1 and V_2 with the line of outcrop of the fault plane to the intersection point of the displaced line of outcrop of V_1 and V_2 with the line of outcrop of the fault plane, measured along the line of outcrop of the fault plane.

These measurements will be made, after the displaced lines of outcrop are moved to one point on the line of outcrop of the fault plane. Thus P_vv_1 and P_vv_1 are known. The whole representation of the lines of outcrop is constructed as an intersection with a horizontal plane, see fig. 43.

1. *Determination of the displacement in size and direction.*

I. Determination of η_1 and ω_1.

η_1 and ω_1 must be determined first so as to be able to handle the problem by nomograms (η_1 is $\angle Pv_2T$ and ω_1 is $\angle Pv_1T$), see fig. 44. These are the dips of V_2 and V_1 measured in the fault plane.

Here are known: the dip of the fault plane φ, the dip of the displaced plane V_2 β or of V_1 α and the angle between the line outcrop of V_2 or V_1 and of the fault plane η or ω ($\angle Uv_2T$ or $\angle Uvv_1T$).

A netpoint is found with η on scale I and φ on scale II in the nomogram fig. 45, plate 22. Through this obtained netpoint and α on scale III a rectilinear is determined, which intersection point with scale IV is the required η_1 m.m. ω_1.

II. Determination of the size and the direction of the displacement PP_v.

In nomogram fig. 46, plate 23, ω_1 is plotted on scale I and η_1 scale II. The seperate scale III and IV is placed such that the distance v_1v_2 (scale III) is between the legs a and b while the distance v_2P_v is plotted on scale IV. The obtained point P_v is connected with the point P and the size of PP_v is read on scale V.

At the same time ψ_1 can be read on scale II (PP_vT). With this angle and the angle φ on scale VI the direction angle ψ can be read on scale VII.

If one circles ψ_1 from scale VI on PP_v in oblique position, one finds ϱ again on scale VI (dip of PP_v) with a perpendicular.

2. *Determination of other data in respect to the faults.*

The different other data can be found with the nomogram for the determination of thickness, fig. 37, 39, 40 and 41 and the plates 19, 20, 21 and 5. One has a topography which is horizontal (or one takes the fault configuration from the map without transformation to a horizontal plane) and considers the half-plane at one side of the fault plane as the hanging wall and at the other side as the footwall of a stratum. Then D_w and B_w can be determined with the mentioned nomograms in every direction (e.g. perpendicular on V or B).

3. *The determination of sole strike-slip or sole dip-slip.*

If there is only one displaced plane, it may be useful to determine how large a sole strike-slip or a sole dip-slip must be to result in the observed vP_v, see fig. 47.

In the case of sole strike-slip the size and the direction is vP_v.

In the case of sole dip-slip η_1 or ω_1 is determined in the usual manner and the required displacement size (in length) is found on scale VII, if the length of vP_v is plotted on scale VI (fig. 46, plate 20).

4. *Relation between ϱ, φ, ψ and ψ_1.*

The relation between ϱ, the dip of the displacement, φ, the dip of the fault plane, ψ, the acute angle between the azimuth of the displacement and the strike of the fault, and ψ_1, the acute angle between displacement and the strike of the fault, is analogous to the relation mentioned in F (see plate 24).

In nomogram fig. 48, plate 24, φ is plotted on scale I and ψ on scale II and ϱ is found on scale III as the curve through the intersection point of the arc of a circle φ and the radius ψ. The scale IV ψ_1 passes through the same point.

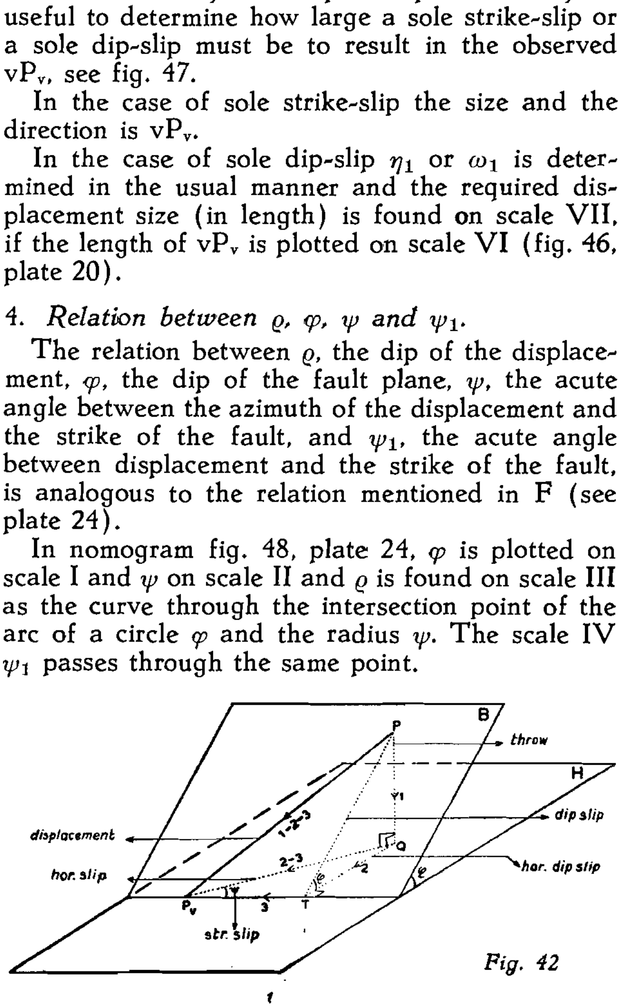
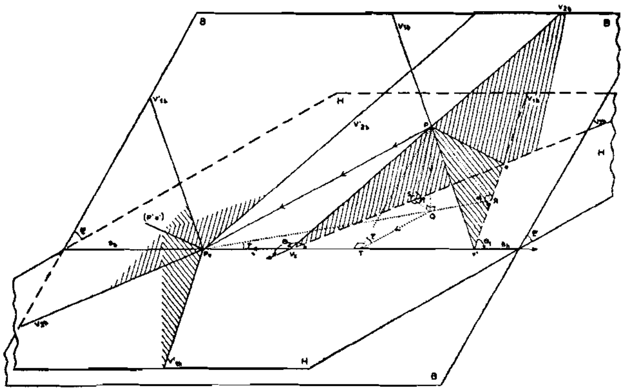
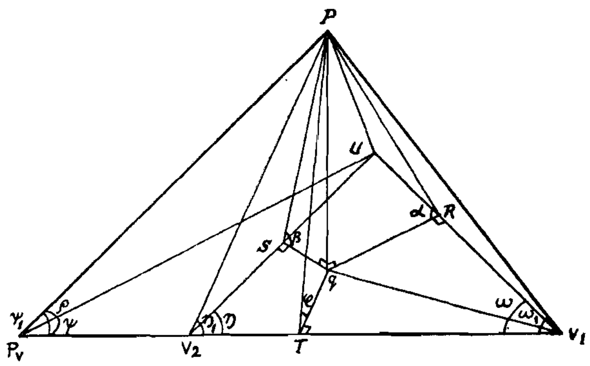
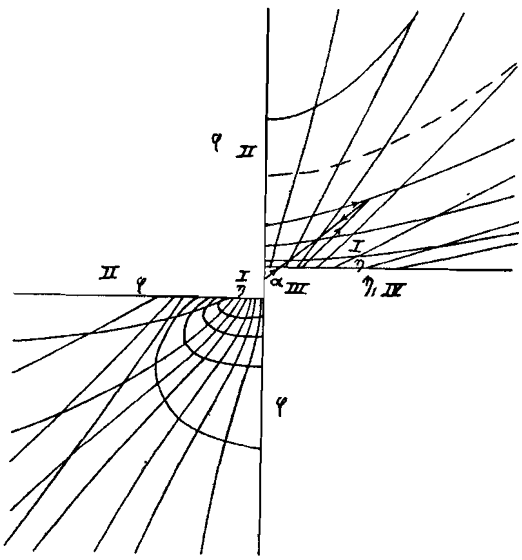


Fig. 42







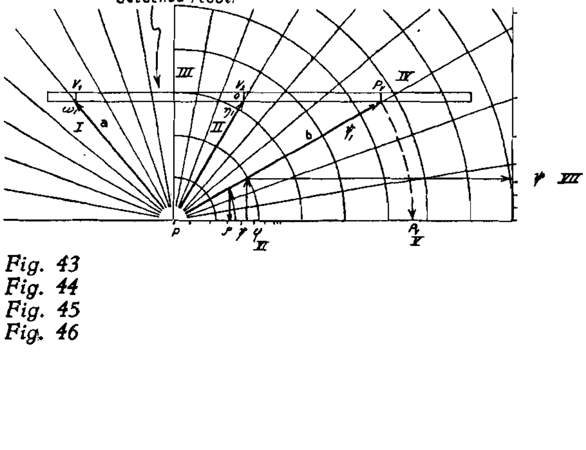
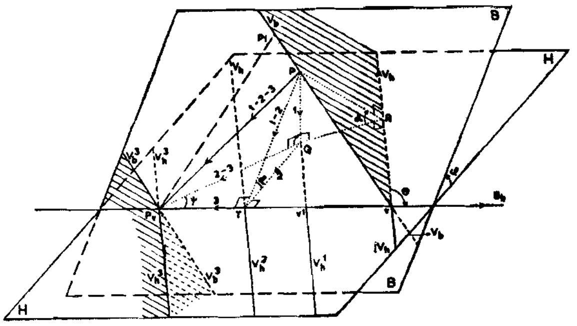
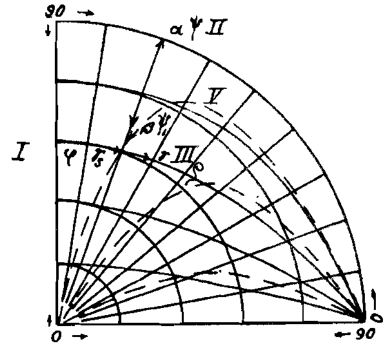
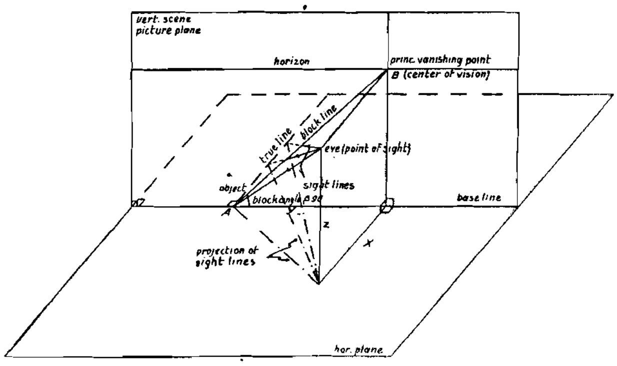


Fig. 43
Fig. 44
Fig. 45
Fig. 46







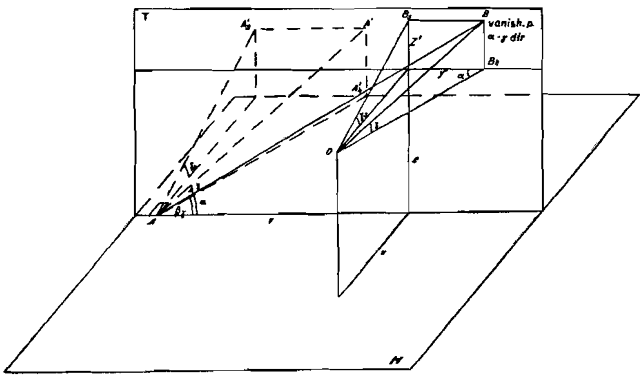


Fig. 47
Fig. 48
Fig. 49
Fig. 50

F. THE REDUCED DIP IN THE CONSTRUCTION OF SECTIONS.

The formula that is represented by the nomogram fig. 48, plate 24, is: $\mathrm{tg}\,\gamma = \mathrm{tg}\,\gamma_s \sin\alpha$, in which γ_s is the true dip, γ the reduced dip and α the acute angle between the strike of the plane and the direction of the section.

γ_s is plotted on scale I and α on scale II and γ is found as the curve through the arc γ_s and the radius α on scale III. See for this problem also nomogram plate 13.

G. BLOCKDIAGRAMS.

I. The central-perspective blockdiagram.

a. *Definitions.*

In a central-perspective blockdiagram all projecting lines (sight lines or visual rays) come from one centrum (the eye or point of sight) that lies on a finite distance from the object to be projected. The scene (drawing plane of picture plane) is vertical before the object, the eye is before the scene. See fig. 49 and 50.

Some definitions are contained in the table below.

Eye	the projection centrum, the point of sight
scene	the (vertical) drawing plane or picture plane
level of the object	an important horizontal plane of the object, may be the base-plane
base-line	the intersection line of level and scene
the coördinates:	x the distance of the eye before the scene
	y the distance along the base-line from the projection of the eye to A. A being a point of the object on the base-line. Therefore y is the length of the projection of OA on the base-line.
	z height of the eye above the base-plane (z is variable with the level of the object)
true line	the line of the object
true angle	the angle in the object or the angle of a line of the object with a line in the scene
block line	the representation of a true line in the scene, a line of the blockdiagram
block angle	the representation of a true angle in the scene
vanishing point	the point of intersection of block lines with the same true direction
principal vanishing point	the perpendicular projection of the eye on the scene, it is the vanishing point of the lines that are perpendicular to the scene, the center of vision
horizon	the horizontal line through the principal vanishing point, it is the locus of the vanishing points of all horizontal lines.

The representation of an object is the intersection line(s) of the plane of sight lines with the scene.

The angle between the base-line and the direction of a line backward from the scene is α, the dip of a line is γ, the dip reduced in the direction perpendicular to the scene is γ_s. The angle between the blockline and the base-line is β, if necessary with indices.

b. *Examination.*

The popular distinction between one-, two- and three-point perspective is not essential, the representation of a point, etc. is identical, see fig. 51.

The size of the block angle is represented by:

$$\mathrm{tg}\beta_{\alpha\gamma} = \frac{z + x\,\mathrm{tg}\,\gamma_s}{y + x\,\mathrm{cotg}\,\alpha} \text{ or } \mathrm{tg}\,\beta_{\alpha\gamma} = \frac{z\sin\alpha + x\,\mathrm{tg}\,\gamma}{y\sin\alpha + x\cos\alpha}$$

For the length of a line applies:

$$\left(a + \frac{x}{\sin\alpha\cos\gamma}\right) : AB = a : AD,$$

a is the true length of the line (measured from the scene), AD is the length of the line in the blockdiagram and

$$AB = \sqrt{\left\{\left(z + \frac{x\,\mathrm{tg}\,\gamma}{\sin\alpha}\right)^2 + (y + x\,\mathrm{cotg}\,\alpha)^2\right\}}.$$

1. *Template nomogram for the determination of the block.*

A simple template nomogram is represented in

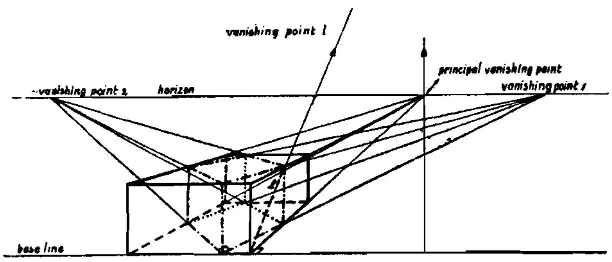


Fig. 51

fig. 52 and 53. This template must be constructed on transparant mm material with x, y and z on map scale (if another scale is used, lengths must be measured with a graphic scale or such a graphic scale must be plotted along the margin). The template can also be constructed as a rule with a movable leg and plate. The plate may be rotated around the horizontal.

The template is placed on the desired line on the map, the required y's are found with the known x (fig. 52).

y_1 is the y of the lower right hand corner of the map,

y_2 is the y of the intersection point of the line with the base-line to the corner of the map,

y_3 is the extra y caused by the direction angle α ($x \cot g\ \alpha$).

The total y is now known.

Next the template is adjusted on the drawing paper with the intersection point of the pencil of rays on the base-line and at a distance y_{total} from the $y = 0$ index or at a distance $y_{total}—a$ from the index $y = a$.

In most cases it will be correct to plot all lengths on a small scale to construct the enveloping block. This block can be enlarged and the different data may be drawn without the use of the vanishing points (y total).

The desired block angle is found with the known z. The line can be drawn as with a normal protractor without reading the angle.

The above mentioned applies to horizontal lines. In practice this is nearly always sufficient for drawing the block, see the commercially obtainable special protractors for the so-called isometric blocks.

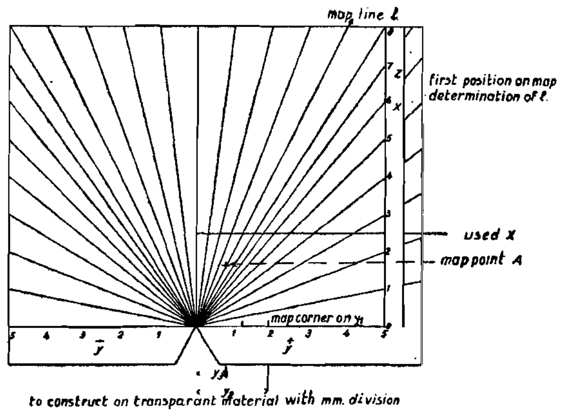
If the block angle of a dipping line is to be determined, this can be done with the same template. The oblique line of the triangle, formed by y_3 and x is circled around on the horizontal in the first position of the template, the dip angle is plotted and the vertical distance thus determined is read. This vertical distance is added to the z in the second position. For this extended application one must provide the template with concentric arcs of circles and with a degrees-division.

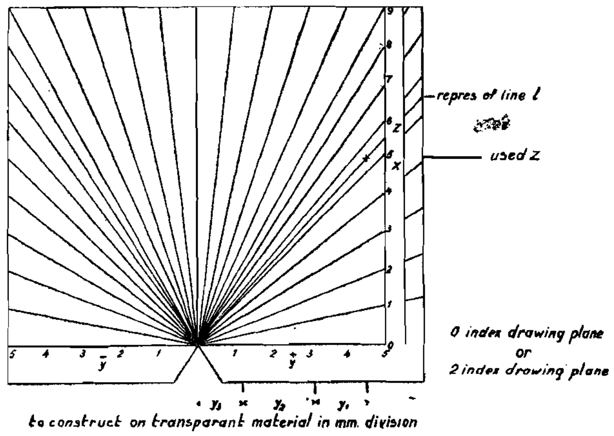
To determine a point on a line or the length of a line one determines first the representation of the line as above mentioned and next the template is again placed on the map, now with the $y = 0$ line on the desired point. Thus the required y_2 is found (fig. 54).

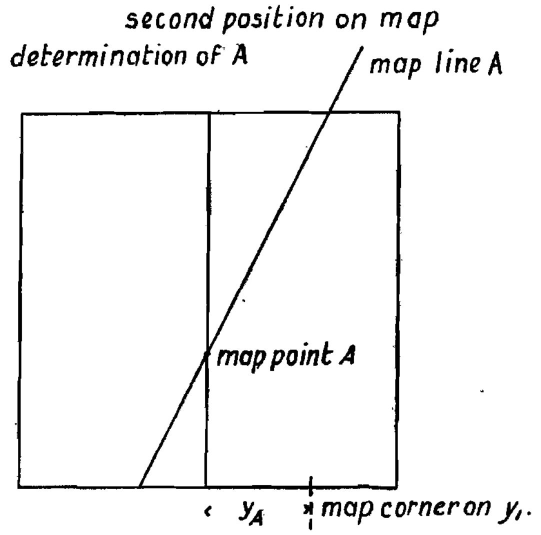
After placing the template on the drawing paper in the right place ($y_1 + y_2$ on the 0-index) an intersection line with the representation of l is found with the z. The intersection point is the desired point (fig. 55).

Remark: The intersection line is a representation of a line perpendicular to the scene.

Points are drawn by drawing arbitrary lines through the points following the above mentioned procedure.







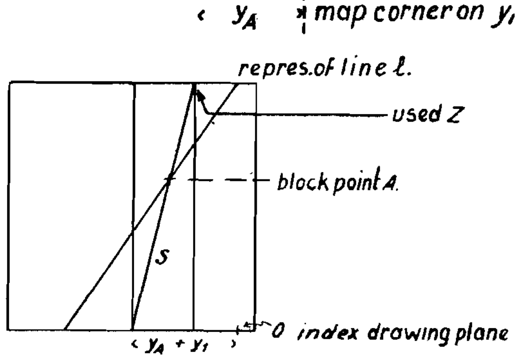


Fig. 52 Fig. 54
Fig. 53 Fig. 55

2. *Normal nomogram for the determination of a block.*

If the numerical value of the block angle β must be determined from x, y, z, α and γ, use can be made of a nomogram constructed from the formula.

In fig. 56, plate 25, one finds a netpoint by plotting γ on scale I and α on scale II. One finds a second netpoint by plotting $\frac{z}{x}$ on scale III and $\frac{y}{x}$ on scale IV. A straight line goes through the two netpoints and the desired β on scale V.

This method cannot be used, if α is 90°.

α is positive, if the line back of the scene lies on the eye side of the x-direction.

γ is positive, if the line back of the scene, goes upwards.

β is positive, if the vanishing point lies above the base-line.

If α is 90°, the detached pointer is used (fig. 57). The pointer with the index 0 is put on the netpoint $\frac{z}{x}$, $\frac{y}{x}$ and the desired β is found on scale V as the intersection point of the scale V with scale VI (γ).

With the same nomogram one can determine $\frac{y}{x}$ and $\frac{z}{x}$ y or z is plotted on scale A (fig. 58) and x on scale B and $\frac{y}{x}$ and $\frac{z}{x}$ are found respectively on scale III.

Lengths can be determined by a graphic scale along one block x-direction or by intersecting lines.

3. *Relation between γ, α and γ_s.*

The conversion of γ into γ_s appears to be important considering the above mentioned formulae. This is the problem of reduction of dips, see nomogram plate 13.

Nomogram fig. 59, plate 24, given in F, is also applicable to this problem. One plots γ on scale I and α on scale II. The distance from 0 to the netpoint found is measured as γ_s on scale III by circling around 0.

II. The parallel-perspective blockdiagram.

a. *Definitions.*

One observes the block (object) from an infinite far distance in the parallel-perspective case, but the blockdiagram has yet "measurable" dimensions.

The sight lines are parallel to each other, y is finite, but of no significance. The ratio between x and z is important (x and z are, however, infinitely great). $\frac{z}{x} = \text{tg}\,\omega$, ω is the angle of vision, that is the dip of the sight lines, see fig. 60.

The block lines of parallel lines are parallel.

b. *Examination.*

The block angle of an arbitrary line is:

$$\text{tg}\,\beta = \frac{\frac{z}{x} + \text{tg}\,\gamma_s}{\frac{y}{x} + \text{cotg}\,\alpha}$$

and, if z and x are infinite and $\frac{z}{x} = \text{tg}\,\omega$, $\text{tg}\,\beta = \text{tg}\,\omega\ \text{tg}\,\alpha + \text{tg}\,\gamma_s\,\text{tg}\alpha$ (for other definitions see I).

In the parallel-perspective case — see fig. 61 the standard cube — is thus EF $\|$ AD $\|$ CB, GE $\|$ CA $\|$ BD and CG $\|$ AE $\|$ FD. This implies that the same scales s_1 can be applied to EF, AD and CB (and to all lines parallel to those), just as to all lines parallel to GE the scale s_2, and to all lines parallel to GC the scale s_3.

If the true angle FEH is 45° and the true angle FEG is 90°, then $s_1 = s_2$. How great the angle FEH = angle GEH′ is, will depend on the angle of vision. The scale s_3 depends on the angle of vision and on the position of AE.

In special cases $s_1 = s_2 = s_3$, those cases must be called the isometric cases because of the similar scales of the three coördinate axes.

In constructing a parallel-perspective blockdiagram one mostly draws the enveloping cube so as to use the coördinate axes in the drawing of the different data. It is therefore of special importance to know the block cube angle (FEH) which follows from the formula: $\text{tg}\,\beta = \text{tg}\,\omega\ \text{tg}\,\alpha$.

c. *Isometry.*

If AE is vertical in reality and lies in the scene, the isometric case will be called the vertical-isometric case.

The usual method is to take the scene perpendicular to the sight line. This case will be called the normal-isometric case; this case is usually called the isometric case.

The isometric cases with dipping scene and dipping AE, not in the scene, will be called the dipping-isometric cases. This is the general case.

d. *The angle of vision, the block cube angle and the scale ratio $s_{12} : s_3$ with vertical scene.*

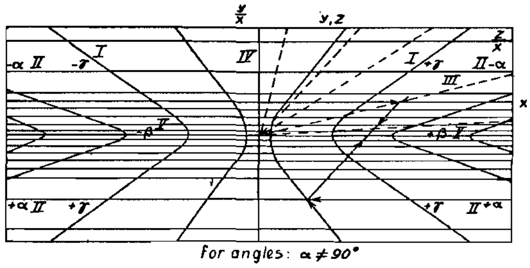
(We will designate the true lines with ′, if necessary.) AE = AE′ and take CD = CD′ (one of the drawing methods), see fig. 62. The formula with $\alpha = 45°$ is: $\text{tg}\,\beta = \text{tg}\,\omega$. AB′ $\text{tg}\,\omega$ = AB; AD′ = ½ AB′ $\sqrt{2}$; AD = ½ AB′ $\sec\omega$, thus AD = AD′ in the case of $\omega = 45°$, that is the vertical-isometric case.

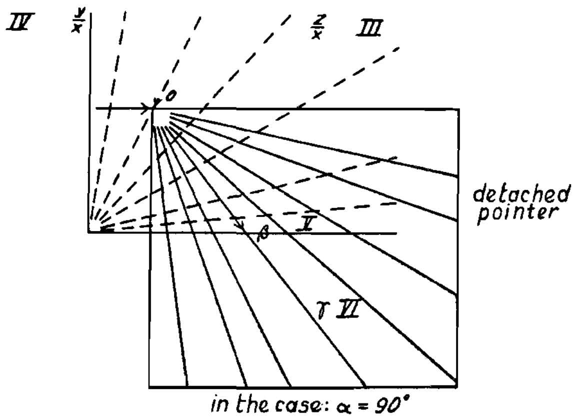
With F′EH = α is not 45° applies: AD : AD′ = $\cos\alpha : \cos\beta$; $\text{tg}\,\beta = \text{tg}\,\omega\ \text{tg}\,\alpha$.

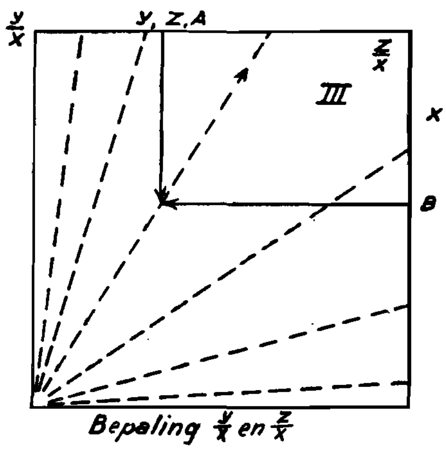
1. *A nomogram for the determination of the block cube angle and the scale ratio $s_{12} : s_3$ with vertical scene.*

The formula $\log\text{tg}\,\beta = \log\text{tg}\,\alpha + \log\text{tg}\,\omega$ is represented in fig. 63, plate 26. α is plotted on scale I, ω on scale II. The desired β is found on scale III (the block angle of a horizontal line).

The formula $\log \text{AD} = \log\cos\alpha - \log\cos\beta$ and the formula $\log \text{AD} = -\log\cos\omega - \frac{1}{2}\log 2$ for







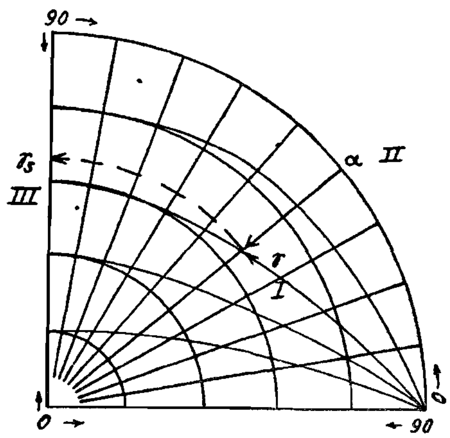
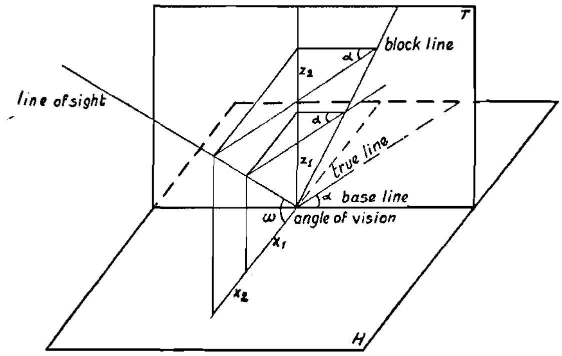
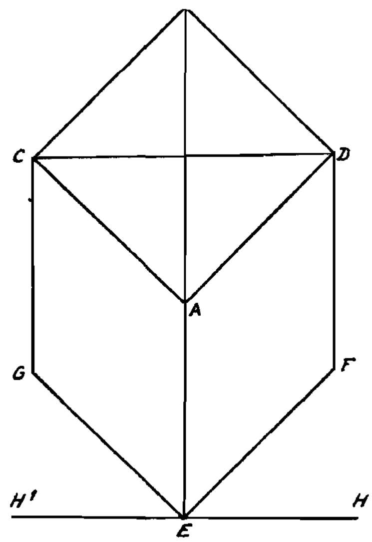
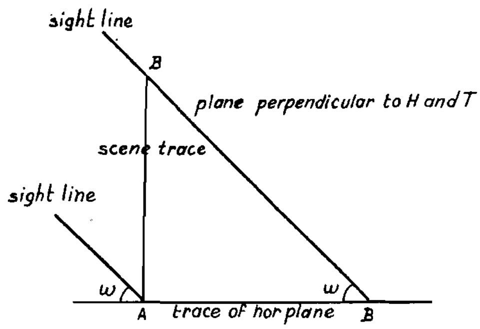


Fig. 56
Fig. 57
Fig. 58
Fig. 59







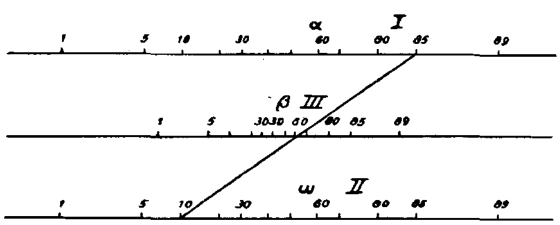


Fig. 60
Fig. 61
Fig. 62
Fig. 63

the 45° case are solved with the nomogram fig. 64, plate 27.

In these formulae AD stands for the ratio AD : AD′, in which the unit is taken for AD′.

β (respectively ω) is plotted on scale I and α (respectively the point 2 is used) on scale II and the scale factor of AD is found on scale III (if AD = 0.1, then the scale of AD is 1 : 10 with respect to the scale of AD′).

e. *The visual angle, the block cube angle and the scale ratio $s_{12} : s_3$ with scene perpendicular to the sight line.*

In the 45° case apply (fig. 65): AE = AE′ cos ω, AB = AB′ sin ω, AD′ = $\frac{1}{2}$ AB′ $\sqrt{2}$ and AD = $\frac{1}{2}$ AB′ $\sqrt{(\sin\omega^2 + 1)}$. Hence the scale factors follow with variable ω. AE : AE′ = cos ω : 1 and AD : AD′ = $\sqrt{(\sin\omega^2 + 1)} : \sqrt{2}$.

The normal-isometric case has as ω an angle of 35°15′54″, that is the dip of the cube diagonal.

For the nomogram see 2 and 3.

f. *The angle of vision, the block cube angle and the scale ratio $s_{12} : s_3$ with a scene dipping in respect to the sight line and to AE′.*

See fig. 66. $a = \dfrac{e}{\operatorname{tg}\alpha}$; $\operatorname{tg}\alpha' = \dfrac{d}{a} = \dfrac{\operatorname{tg}\alpha}{\cos\gamma_s}$; with $\alpha' = 45°$ thus $\operatorname{tg}\alpha = \cos\gamma_s$ (in which γ_s is also the angle, which AE′ makes with the vertical).

The formula for the true dip angle of AD′ is: $\cos\alpha \cos\gamma = \cos\alpha'$, with $\alpha' = 45°$; $\cos\alpha \cos\gamma = 0.707$. The block cube angle will follow from the above given formula. In fig. 67 is shown: AE : AE′ = $\cos(\omega+\gamma_s) : \cos\omega$; AB : AB′ = $\sin(\omega+\gamma_s) : \cos\omega$; AD′ = $\frac{1}{2}$ AB′ $\sqrt{2}$ and

$$AD = \frac{AB'}{2\cos\omega}\sqrt{\{\sin^2(\omega+\gamma_s) + \cos^2\omega\}}.$$

The dipping-isometric cases fulfil the relation: $3\cos^2(\omega+\gamma_s) - 1 = \cos^2\omega$.

For a nomogram see 2 and 3.

g. *True angles and true lengths.*

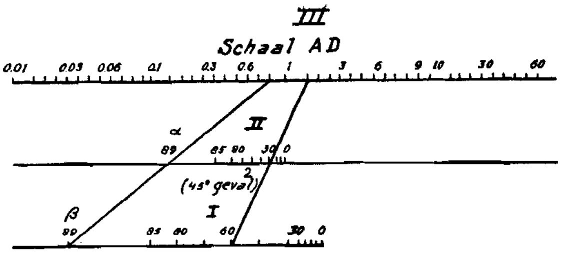
Block coördinates can be used to convert true angles and true lengths into block angles and block lengths. In fig. 68 b, c and a is identical to the true length times the scale denominator of the block in the isometric case or b and c times s_1 and a times s_3. The true M′N′ = $\sqrt{(a^2 + b^2 + c^2)}$, the block line can be drawn by plotting a, b and c along the coördinate axes.

α is the block direction angle, γ the block dip angle (tg true direction angle $= \dfrac{b}{c}$, the tg of the true dip angle $= \dfrac{a}{\sqrt{(b^2 + c^2)}}$).

One may also consider lines lying in the upper face as follows (fig. 69):

$$\operatorname{cotg}\alpha = \frac{\sin(CAB + \beta)}{\sin\beta} \text{ and } \frac{CB}{DB} = \frac{\sin CAB \ \sin\alpha}{\sin\beta}$$

In the side face applies (if AE has a scale 1 : s in respect to AB) : $\operatorname{tg}\alpha = \dfrac{AB}{s.\,AE}$ and the scale of EB is $\dfrac{s.\sin CAB.\sin\alpha}{\sin\beta}$



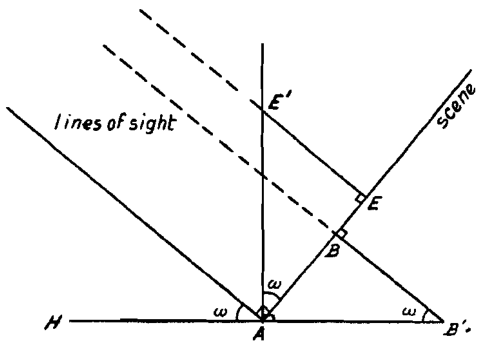


Fig. 64
Fig. 65

From this it follows that special protractors can be made for isometric cases and special protractors for upper and side face in the non-isometric cases.

2. *A nomogram for the true length, the true angle, the block angle and the block length in a rectangular coördinate system.*

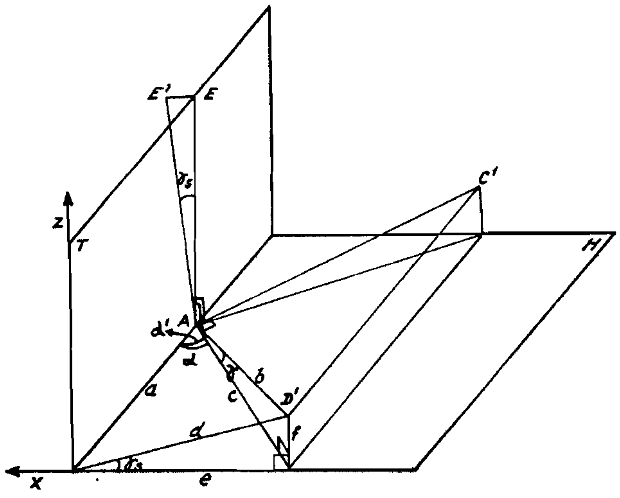
c (fig. 68) is plotted on scale I in nomogram fig. 70, plate 20, and b on scale II and the direction angle with AC (fig. 61) is found on scale IV. On scale III the inter-point is found that is transported on scale I without reading. Then a is plotted on scale II, if necessary multiplied by the scale denominator in respect to b and c, and the length of the line is read on scale III and the dip angle on scale V.

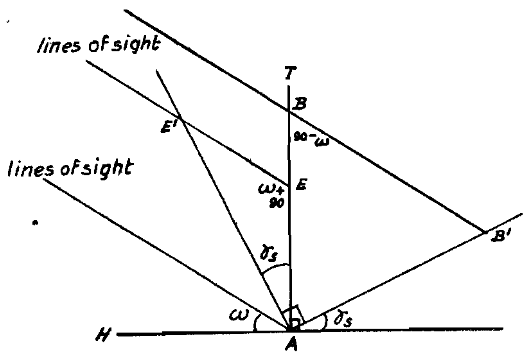
This nomogram can also be used the other way round. If one wants to know the block length (mostly useless) a must be given in respect to the interlength, and b and c in respect to each other with the correct angle at 0. The nomogram must sometimes be enlarged to the left hand side.

3. *A nomogram for the general relation between angles in parallel-perspective blockdiagrams.*

The formula: $\operatorname{tg}\beta = \operatorname{tg}\omega \operatorname{tg}\alpha + \operatorname{tg}\gamma_s \operatorname{tg}\alpha$ is represented in fig. 71, plate 28.

ω is plotted on scale I and α on scale II and a netpoint is found. β is found on scale IV with this netpoint and γ_s plotted on scale III. In this nomogram as in any nomogram one may interchange the knowns and the desired.





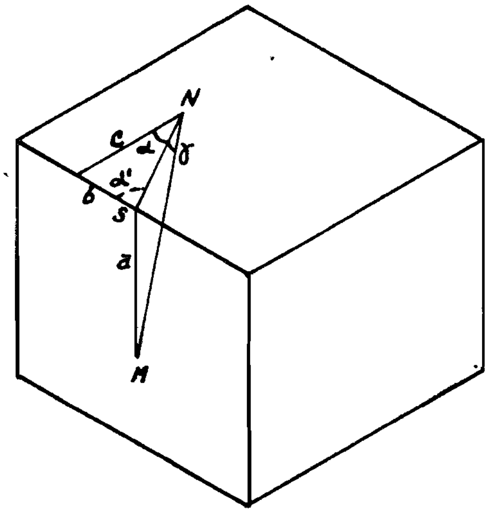
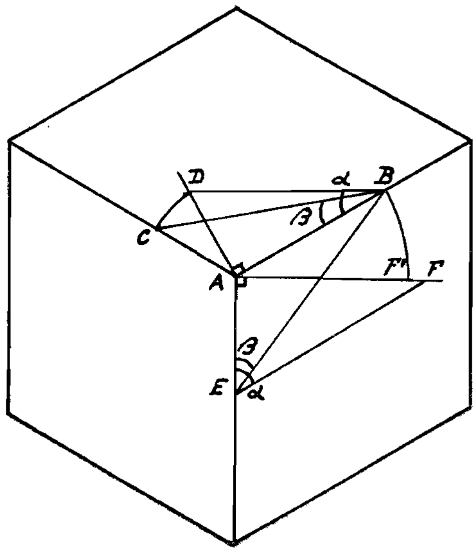
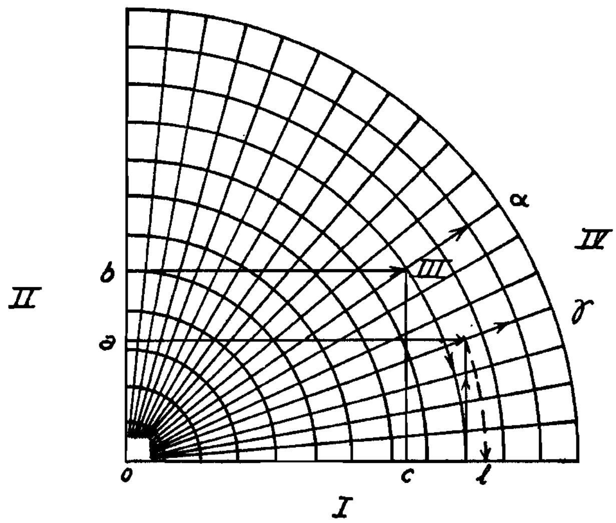


Fig. 66
Fig. 67
Fig. 68





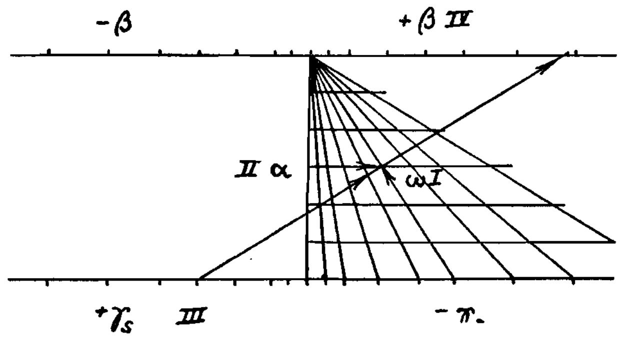


Fig. 69
Fig. 70
Fig. 71

H. VECTOR NOMOGRAM (AMONG OTHERS FOR THE DETERMINATION OF THE MAGNETIC POLE).

If the perpendicular coördinates (A, B and C) of a vector R (fig. 72) are known, R can be determined in size and direction (angle d and i). Of course in this problem also different data can be taken as given and required.

B is plotted on scale I and C on scale II in nomogram fig. 73, plate 20. The direction angle d is read on scale III. The netpoint is circled around 0 on scale II and with this netpoint on scale II and A plotted on scale I i is found on scale III (the angle with the vertical).

The distance from the second netpoint to 0 is the size of $|R|$ and can be read on scale II (or scale I) after circling around 0.

I. DETERMINATION OF THE AZIMUTH AND DIP OF A LINE FROM MEASUREMENT OF THE OBLIQUE ANGLE BETWEEN THE LINE AND THE STRIKE OF THE KNOWN PLANE COMPRISING THE LINE (E.G. STRIAE MEASUREMENTS).

The angles δ and φ are known in fig. 74, the angles α' and γ are required. The angle γ is the clockwise measured angle from the strike of the plane to the azimuth of the line. The formula for the azimuth is: $\operatorname{tg} \gamma = \cos \varphi \; \operatorname{tg} \delta$. The dip is as mentioned in part C, nomogram 13.

In nomogram fig. 75, plate 29, the angle δ is plotted on scale I and the dip φ on scale II. The intersection point of the two perpendiculars through those two lines give the required angle γ on scale III.

J. CONVERSION OF MEASUREMENTS OF NON-VERTICAL BORE HOLES.

1. *Nomogram of a formula from practice.*

The formula is: $\cos \vartheta = \cos \gamma \cos \varphi \pm \sin \gamma \sin \varphi \cos \psi$. φ is the true dip, γ is the angle between the bore hole and the vertical, ψ is the difference between the azimuth of the dip and the azimuth of the bore hole, ϑ is the apparent dip in the bore hole.

In nomogram fig. 76, plate 30, ϑ is plotted on scale I and ψ on scale II and these two points are connected by a straight line. A netpoint on the straight line is found with γ on scale III, of which φ can be read on scale IV.

2. *Nomogram for the formal case.*

In fig. 77 β is the measured apparent dip and ϑ the dip of the plane perpendicular to the bore hole, i.e. the angle which the bore hole makes with the vertical. With the above mentioned nomograms ϑ is transformed in ϑ_1. η is the clockwise measured angle between the apparent dip direction and the dip direction of the perpendicular plane, δ is the angle, which the apparent dip direction makes with the true dip direction (the angle with the strike direction is therefore $\delta - 90$).

The formula for the dip direction is:

$$\operatorname{cotg} \delta = \frac{\operatorname{cotg} \eta \sin (\vartheta_1 - \beta) \cos \vartheta_1}{\sin (\vartheta_1 - \beta) \cos \vartheta_1 + \sin \beta}\text{; for the true}$$

$$\text{dip } \alpha\text{: } \operatorname{tg} \alpha \cos \delta = \frac{\sin \vartheta_1 \sin (\vartheta_1 - \beta)}{\sin (\vartheta_1 - \beta) \cos \vartheta_1 + \sin \beta}$$

In fig. 78, plate 31, ϑ_1 is plotted on scale I and β on scale II. A netpoint is found. With this netpoint and η plotted on scale III the required δ is found on scale IV.

In fig. 79, plate 32, ϑ_1 is plotted on scale I and β on scale II and a point is found on a turning scale III. With this turning scale and δ plotted on scale IV the required α is found on scale V.

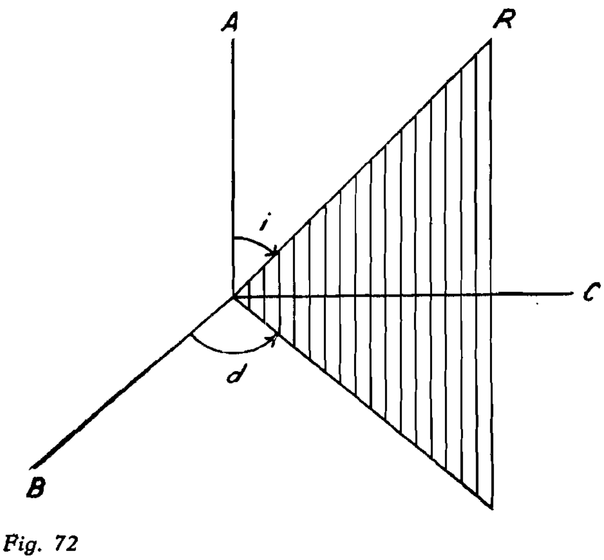
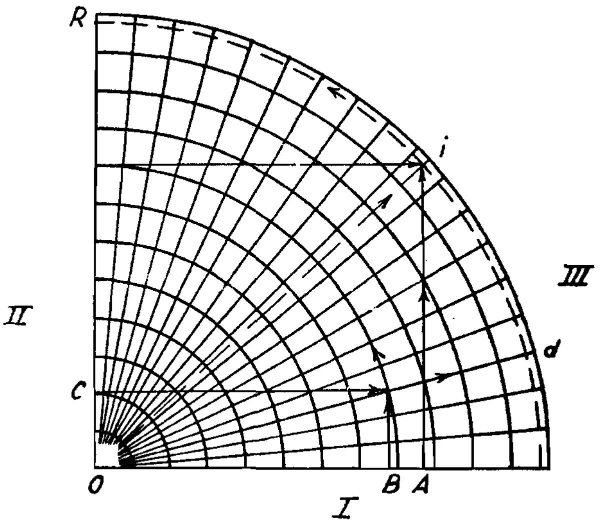
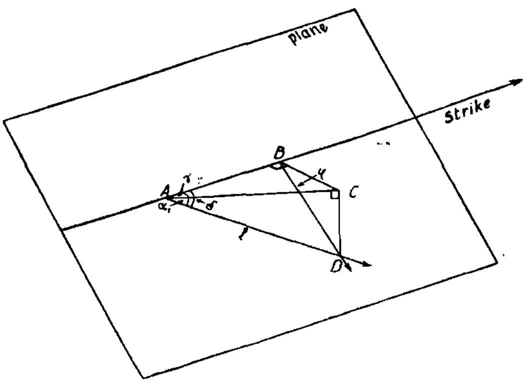


Fig. 72





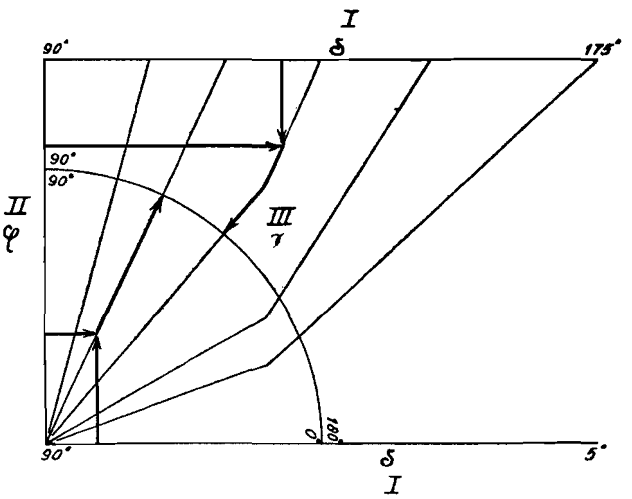
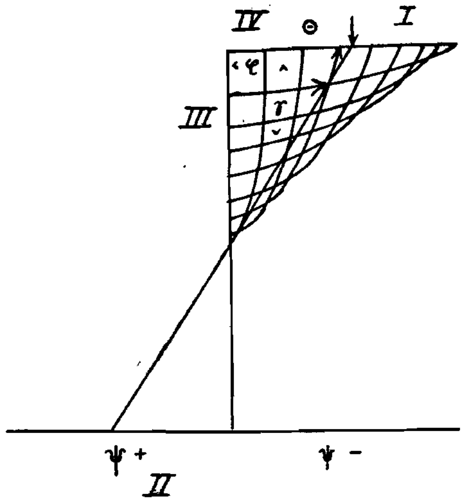
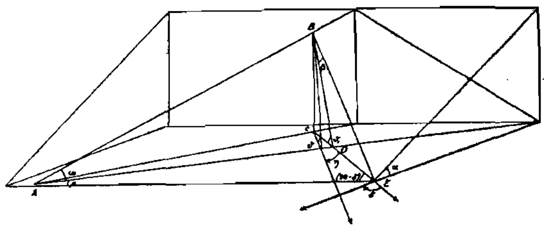


Fig. 73
Fig. 74
Fig. 75





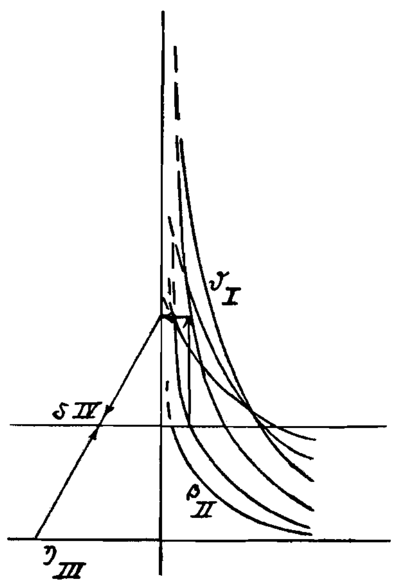


Fig. 76
Fig. 77
Fig. 78

K. STRIKE AND DIP RELATION AT TWO PLANES OF REFERENCE.

If, for instance, a line or a plane has been measured in regard to the actual horizontal plane as is normally done and one wants to convert measured strike and dip (or in the case of a line, direction and dip) into strike and dip in regard to another, now non-horizontal plane, one has the situation of fig. 80 (for the line one can take the strike + 90°).

α is the dip of the required plane in regard to the actual first reference plane.

β is the dip of the second reference plane.

γ is the clockwise measured angle between the positive strike of the required plane and the positive strike of the second reference plane.

δ is the clockwise measured angle between the positive strike of the second reference plane and the positive strike of the plane in regard to the second reference plane.

ω is the dip of the plane in regard to the second reference plane.

(To get the "old" situation the plane AFE must be rotated around AF till it lies in H.)

The formula for the strike in regard to the second reference plane is: $\operatorname{cotg} \delta \ \sin \gamma = \sin \beta \operatorname{cotg} \alpha + \cos \beta \cos \gamma$. In fig. 81, plate 33, β is plotted on scale I and γ on scale II. The required δ is found on scale IV with the obtained netpoint and α on scale III.

The formula for the dip in regard to the second reference plane is: $\operatorname{cotg} \omega \sqrt{(1 - \cos^2\delta \ \cos^2\beta)} = \operatorname{cotg} \delta \cos \beta \sin \delta + \operatorname{cotg} \gamma \sin \delta$.

In fig. 82, plate 34, β is plotted on scale I and δ on scale II and a netpoint is found. With this netpoint and γ on scale III the required ω is found on scale IV.

L. FINAL REMARKS.

I. Applicability and efficiency.

Nomograms can be constructed for many geological problems (including mineralogical, geophysical ones, etc.). (Many nomograms are already in use, e.g. for the calculation of Niggli values). They have the advantage that unskilled people can solve the problems and that the operation is quicker than by construction or calculation. A nomogram of wide application is the Wulffs'grid in stereographic projection. This grid is a rival to the particular nomograms, especially for the determination of angles, but the grid has the limitation that it gives angles only and not lengths, and that some skill is needed for its use.

Some nomograms as plates 22 and 23 are rather complicated, but the solution of the problem by construction or calculation is appreciably more time consuming.

If a nomogram must be used several times, it will of course be useful to put first the known data in ordered columns.

For the comparison of different possible forms of nomograms for the same problem see e.g. plate 1, 2 and 3 and plate 13 and 24 and also the introduction.

For an explanation of the problems see S. G. Trooster and J. E. J. M. van Landewijk in Inleiding in de Geologische Metingen en Constructies, Geological Mineralogical Institute, State University Utrecht, 1957.

The remark may be made that the nomograms here constructed for special problems, can be used for more general problems like nomogram fig. 31, plate 17, (C III 3) and fig. 33, plate 18, (C IV) for the determination of the intersecting line of two planes from different knowns. Many are applicable to sphere measurements and to projective transformations.

Nothing will be said here about the possibility of determining the functional relation from the nomogram constructed from empirical data.

II. The exactness.

With regard to the exactness in respect to the technical execution and the properties of the paper we will suffice with the remark that the deviation can be checked by a ruler along two perpendicular axes and by interpolation.

The interval of different data is generally chosen such that no larger mistakes are made as can be justified in respect to the reading error of the known data. The interval chosen is of course also dependent on the range of the data and the length of the nomogram.

The possiblity of transforming the nomograms found directly by projection has in most cases been abandoned.

Interpolation can be made at sight or with a self made interpolator.

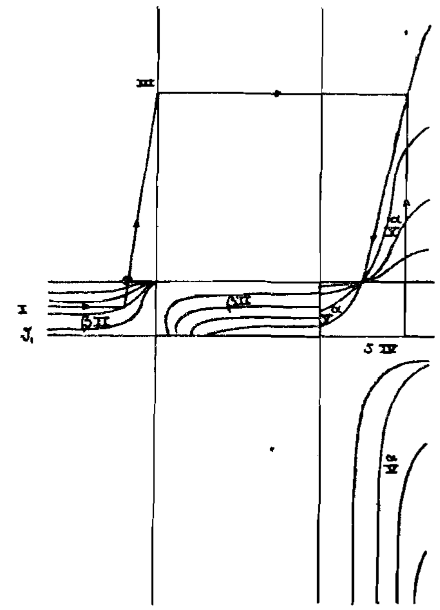
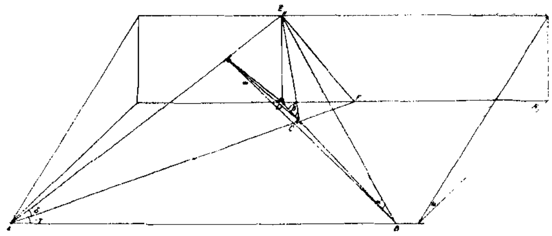
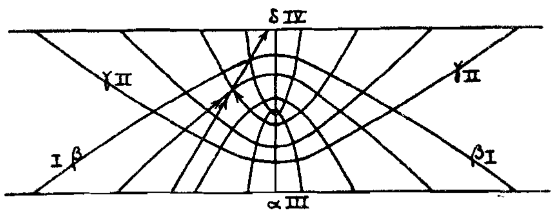


Fig. 79





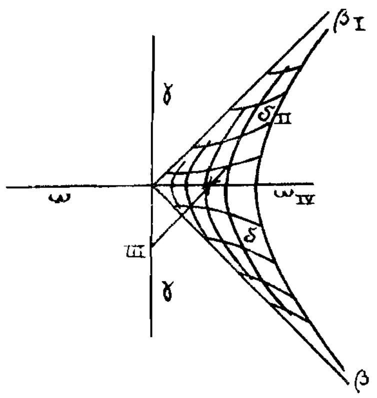


Fig. 80
Fig. 81
Fig. 82

LITERATURE.

Nomography: J. C. G. Nottrot, Leerboek der Nomografie, P. Noordhoff N.V., Groningen, 1930.
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J. E. J. M. VAN LANDEWIJK

20 mei 1957

STELLINGEN

1. Voor de bepaling van het boorgatafwijkingsverschil ("hole-curvature" of "dogleg severity") tussen twee bepalingen verdient het nomogram, uit de exacte formule en met grote nauwkeurigheid over het gehele bereik geconstrueerd met toepassing van de stelling van Pythagoras, aanbeveling boven het benaderde nomogram van Arthur Lubinski.
Arthur Lubinski: How Severe is that Dogleg, World Oil, Febr. 1, 1957.

2. Het verdient aanbeveling om bij strekkings- en hellingsbepaling uit scheveboringengegevens uit te gaan van de algemene formules:

$$\operatorname{cotg} \delta = \frac{\operatorname{cotg} \eta \sin(\vartheta_1 - \beta) \cos \vartheta_1}{\sin(\vartheta_1 - \beta) \cos \vartheta_1 + \sin \beta} \text{ en } \operatorname{tg} \alpha \cos \delta = \frac{\sin \vartheta_1 \sin(\vartheta_1 - \beta)}{\sin(\vartheta_1 - \beta) \cos \vartheta_1 + \sin \beta}$$

δ rechtsom gemeten hoek tussen schijnbare hellingsrichting en werkelijke hellingsrichting;
η rechtsom gemeten hoek tussen schijnbare hellingsrichting en hellingsrichting van normaalvlak op boring;
ϑ_1 in schijnbare hellingsrichting gereduceerde hoek van afwijking van boorgat van verticaal;
β schijnbare helling;
α echte helling;

in plaats van de gebruikelijke formule voor de helling:

$$\cos \vartheta = \cos \gamma \cos \varphi \pm \sin \gamma \sin \varphi \cos \psi.$$

ϑ schijnbare helling; γ hoek tussen boorgat en verticaal; φ echte helling;
ψ verschil tussen azimuth helling en azimuth boorgat.)

3. Bij de oplossing van tectonische problemen kunnen de conclusies uit stroomrichtingsindicaties in troebelingsstroomafzettingen belangrijk zijn.
E. ten Haaf: Tectonic utility of oriented resedimentation structures, Geologie en Mijnbouw, no. 2, Febr. 1957.

4. Bij het parallel-perspectief is elk geval, dat voldoet aan de betrekking: $3 \cos^2 (\omega + \gamma_s) - 1 = \cos^2 \omega$ een isometrisch geval (ω gezichtshoek; γ_s helling tafereel). Uit deze beschouwing volgt, dat men meerdere mogelijkheden in gezichtshoek- en tafereelhellingskeuze heeft.
Trooster en v. Landewijk: Inleiding in de Geologische Metingen en Constructies, Min. Geol. Instituut, Utrecht, 1957.

5. Werkelijke op- en afschuiving kan men in het algemeen slechts na een geometrische beschouwing van de gegevens vaststellen en zeker niet uit de aard van de schijnbare verschuiving in het standvlak van het verschuivingsvlak. Een interpretatie volgens de Geologische Nomenclator van 1929 (o.a. pag. 82 en 83) is onhoudbaar.
Geologische nomenclator, afd. Tectonische Geologie, G. A. F. Molengraaff, 1929.
Trooster en v. Landewijk: Inleiding in de Geologische Metingen en Constructies, Min. Geol. Instituut, Utrecht, 1957.

6. De graniet van Panticosa is een deel van de graniet van Cauterets en daarvan gescheiden door een breuk, waarlangs de graniet van Panticosa een relatief lagere ligging heeft gekregen dan de graniet van Cauterets.

7. Zwaartekrachtsprofielen over ontsloten en over vermoede a- en post-tectonische granieten wijzen op een magmatische oorsprong met instorting (stoping) als voornaamste plaatsingsproces (mise en place) ofwel naar een metasomatische oorsprong met diffusie van de zware bestanddelen naar beneden. Deze twee processen zullen elkaar gewoonlijk aanvullen.
M. H. P. Bott: A Geophysical Study of the Granite Problem, The Quarterly Journal of the Geological Society of London, vol. CXII, part 1, no. 445, aug. 1956.

8. Het domineren, in granitisch tot granodioritisch gesteente, van pseudo-homogene perthiet en perthiet, waarvan de plagioklaas-lamellae niet evenwijdig aan de a-as zijn, is een sterke indicatie voor een gesmolten (liquid) geweest zijn van het gesteente.

9. Voor statistisch gebruik in de paleontologie moeten ratio's aan bepaalde voorwaarden voldoen.
Alan B. Shaw: Quantitative trilobite studies I, Journal of Paleontology, vol. 30, Sept. '56, no. 5.

10. Voor de bepaling van plagioklasen is het dienstig gebruik te maken van de scheve belichtingsmethode. Men kan cylinderprojecties van de uitdovingshoeken bij recht en bij scheef invallend licht onder elkaar zetten. Bij bepaling aan tweelingen dient men dit te verdubbelen, bij bepaling aan eenlingen zou men nog gebruik kunnen maken van de dubbelbreking.

11. Het is ter handhaving van het zelfbeschikkingsrecht en van de rechten van de mens als omschreven in het Handvest noodzakelijk, om bij de Verenigde Naties de met voorzorgen omklede mogelijkheid van gehoor (hearing) in te stellen voor personen en groepen.

12. Gezien de ontwikkeling van de wapens, transportmiddelen en de logistiek moet men in de toekomst bij landingen vanuit zee uitgaan van de compagnie als kleinste zelfstandige taktische eenheid. Opleiding en organisatie, vooral uit logistisch oogpunt, moet men naar dit principe inrichten. De verzorgingseenheden dient men drastisch in te krimpen.

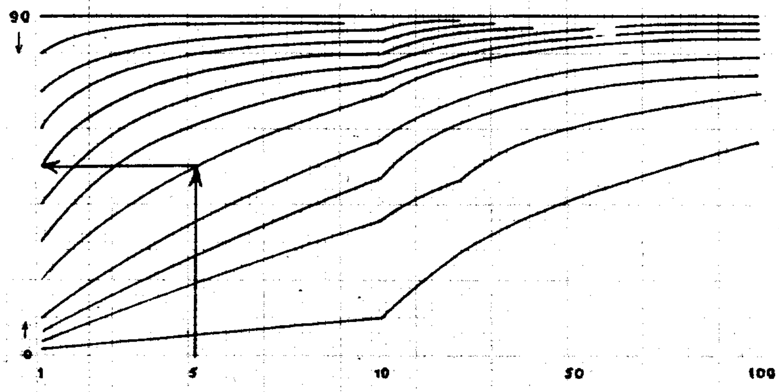
13. De Utrechtse en landelijke studentenvertegenwoordiging is ondemocratisch en ontoereikend. Een betere begrenzing van werkgebieden van de studentenorganisaties en een vertegenwoordiging via bestaande algemene lichamen is een dringende noodzaak. Het is wenselijk, dat zowel de studentenorganisaties als de Academische Senaat in deze richting zouden werken.

Plaat 1. Hoeken bij overdreven hoogteschaal

Plate 1. Angles with exaggerated vertical scale

VOORSCHRIFT

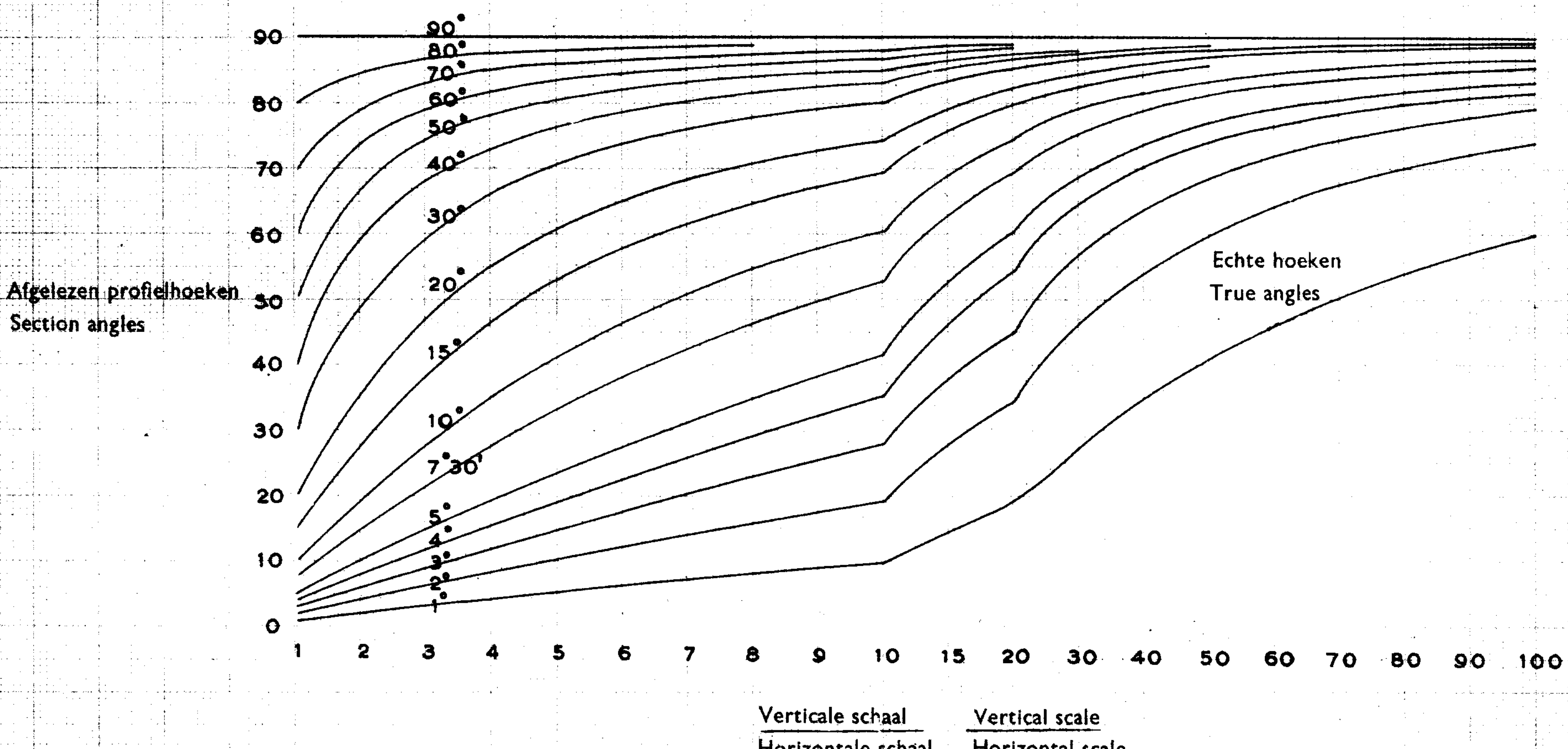
INSTRUCTION



Formule

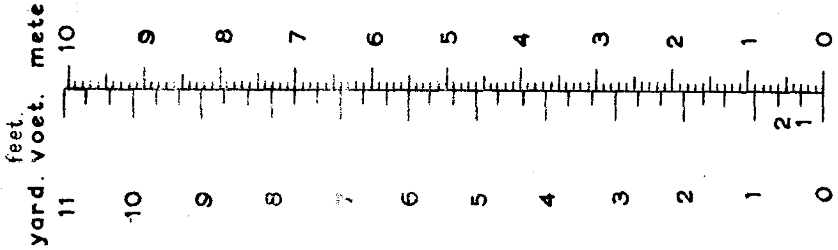
Formula

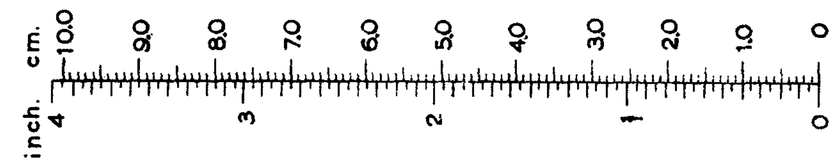
$$tg\,\alpha = \frac{na}{b}$$

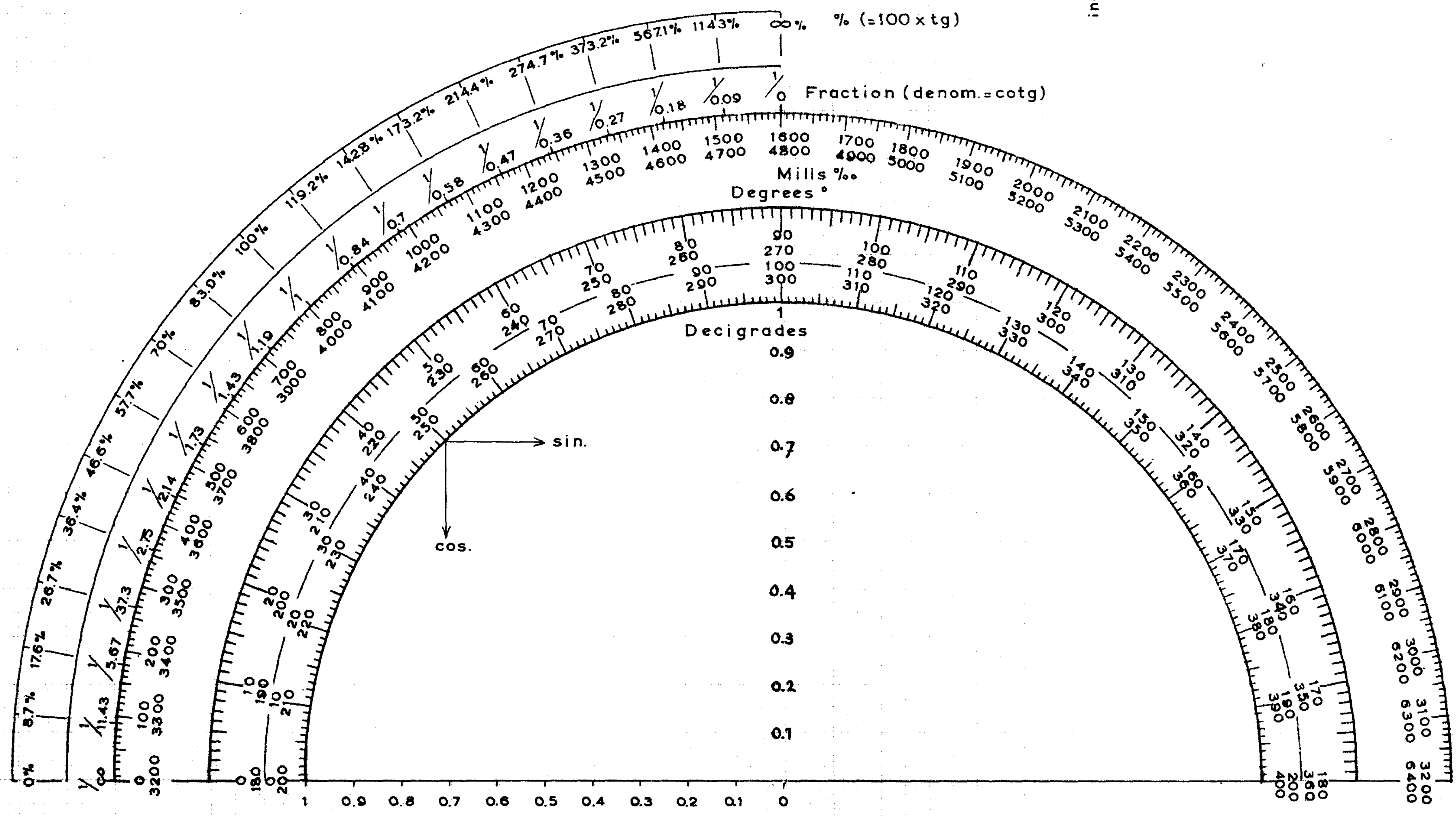


Plaat 10. Conversie-dubbelschalen voor hoek en lengtenmaten

Plate 10. Conversionscales for angle and length units







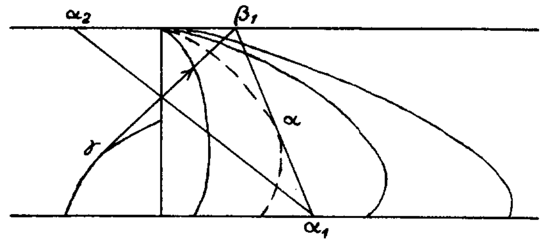
Curves α: if $\beta_1 > 90°$:
take $180° - \beta_1$ instead of β_1
and determine α.

For $\gamma > 90°$
take α_1 on left hand part
and read β_1 on upper scale

Strike and dip of a plane from two lines

α_1. Dip of line 1
α_2. Dip of line 2
γ. Azimuth difference between the two lines
β_1. Azimuth difference between strike and azimuth line 1
α. Dip of the plane

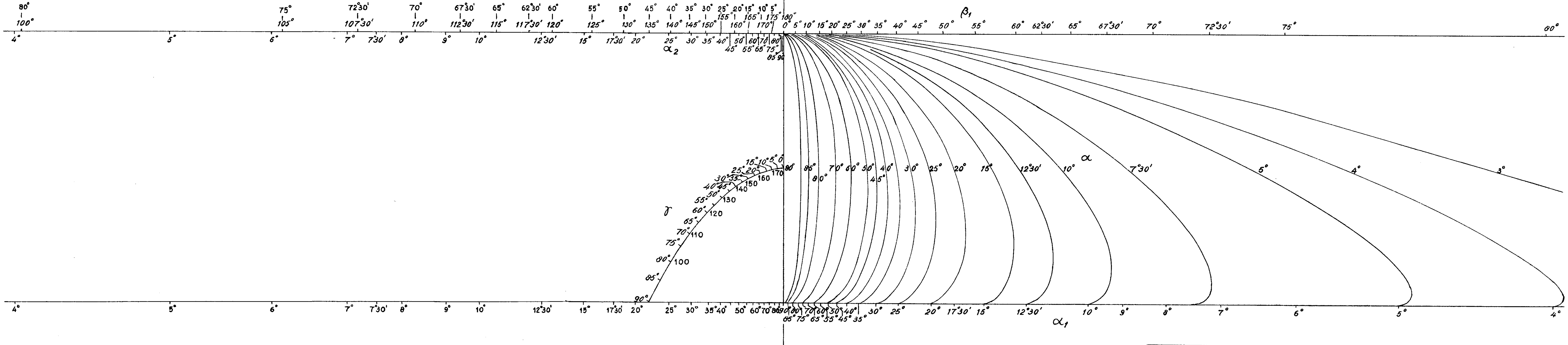
Instruction



Formula:

$$\sin\gamma \,\mathrm{cotg}\,\beta_1 + \cos\gamma - \mathrm{cotg}\,\alpha_1 \,\mathrm{tg}\,\alpha_2 = 0.$$

$$\mathrm{cotg}\,\alpha = \mathrm{cotg}\,\alpha_1 \sin\beta_1$$



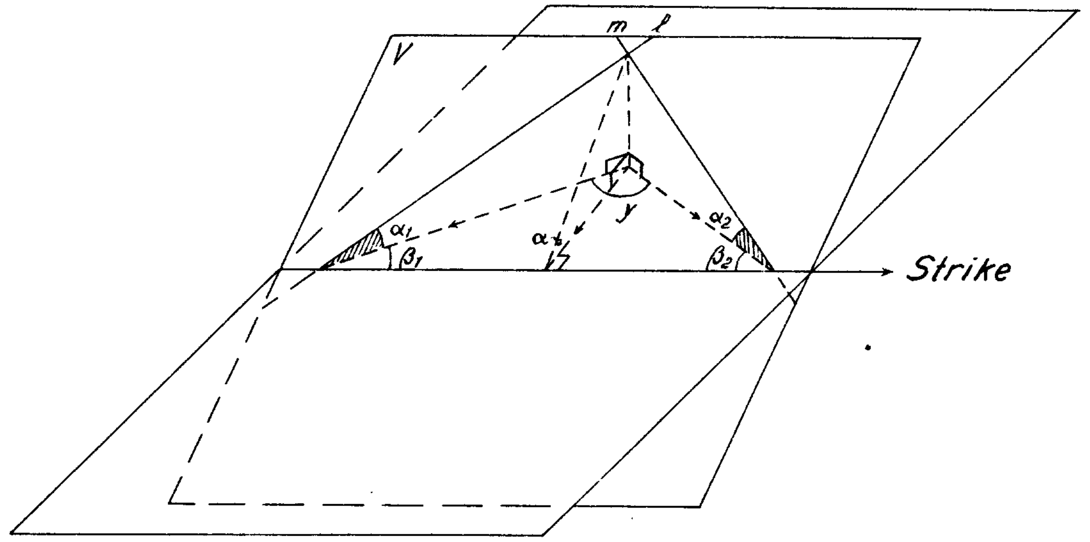
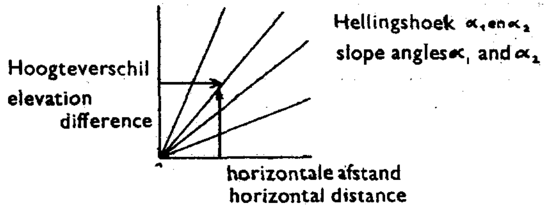


Plate 11

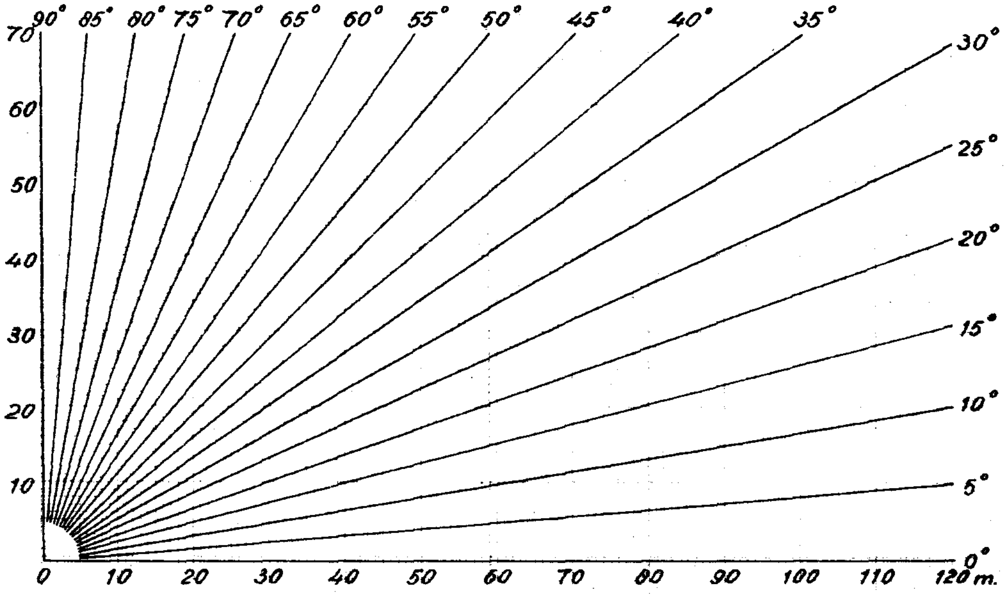
NOMOGRAMVOORSCHRIFT

INSTRUCTION



Plaat 7a.
Plate 12.

Hoogteverschil in meters
Elevation difference



Horizontale afstand
horizontal distance

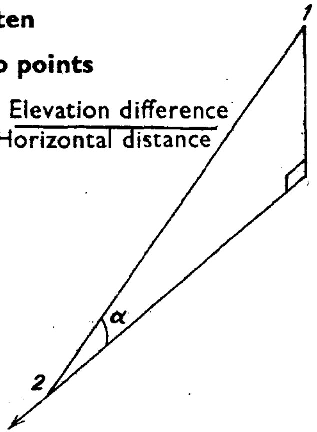
Hellingshoek α_1 en α_2

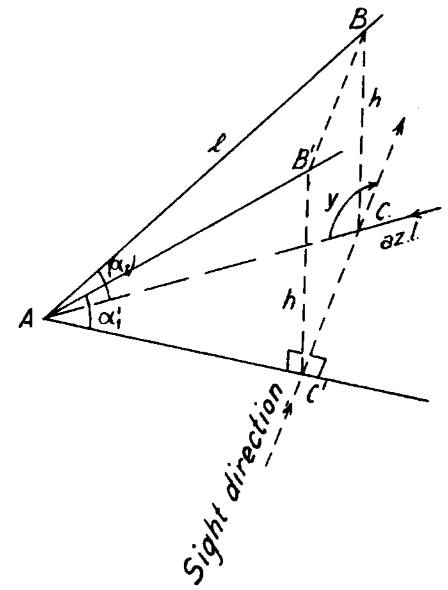
Slope angles α_1 and α_2

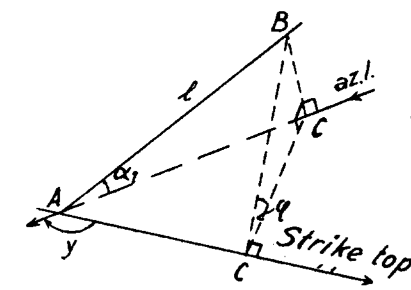
Lijn uit 2 punten

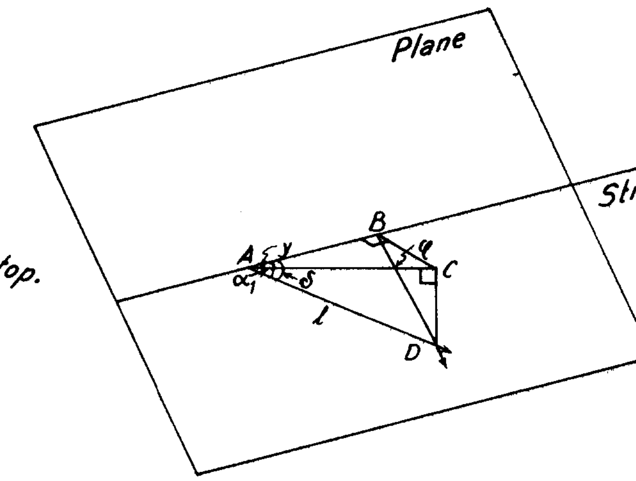
Line from two points

$$tg\,\alpha = \frac{\text{Hoogteverschil}}{\text{horizontale afstand}} \quad \frac{\text{Elevation difference}}{\text{Horizontal distance}}$$





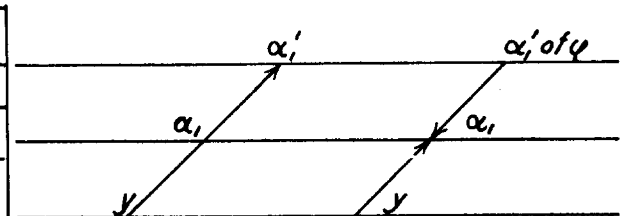




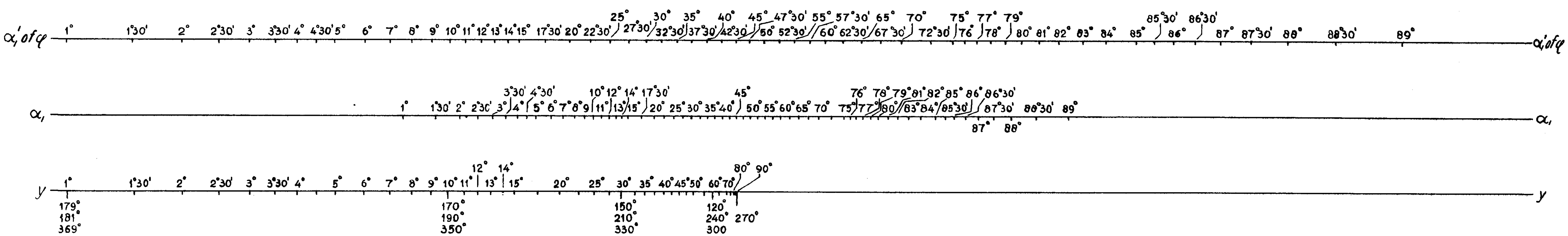
<u>Formulae:</u> $tg\alpha_1 = tg\alpha_1' \sin\gamma$
$tg\alpha_1 = tg\varphi \sin\gamma$

Instruction

Reduced (section) dip
true dip
reduced dip
Clockwise measured angle from strike to section-direction (in reduced dip direction)

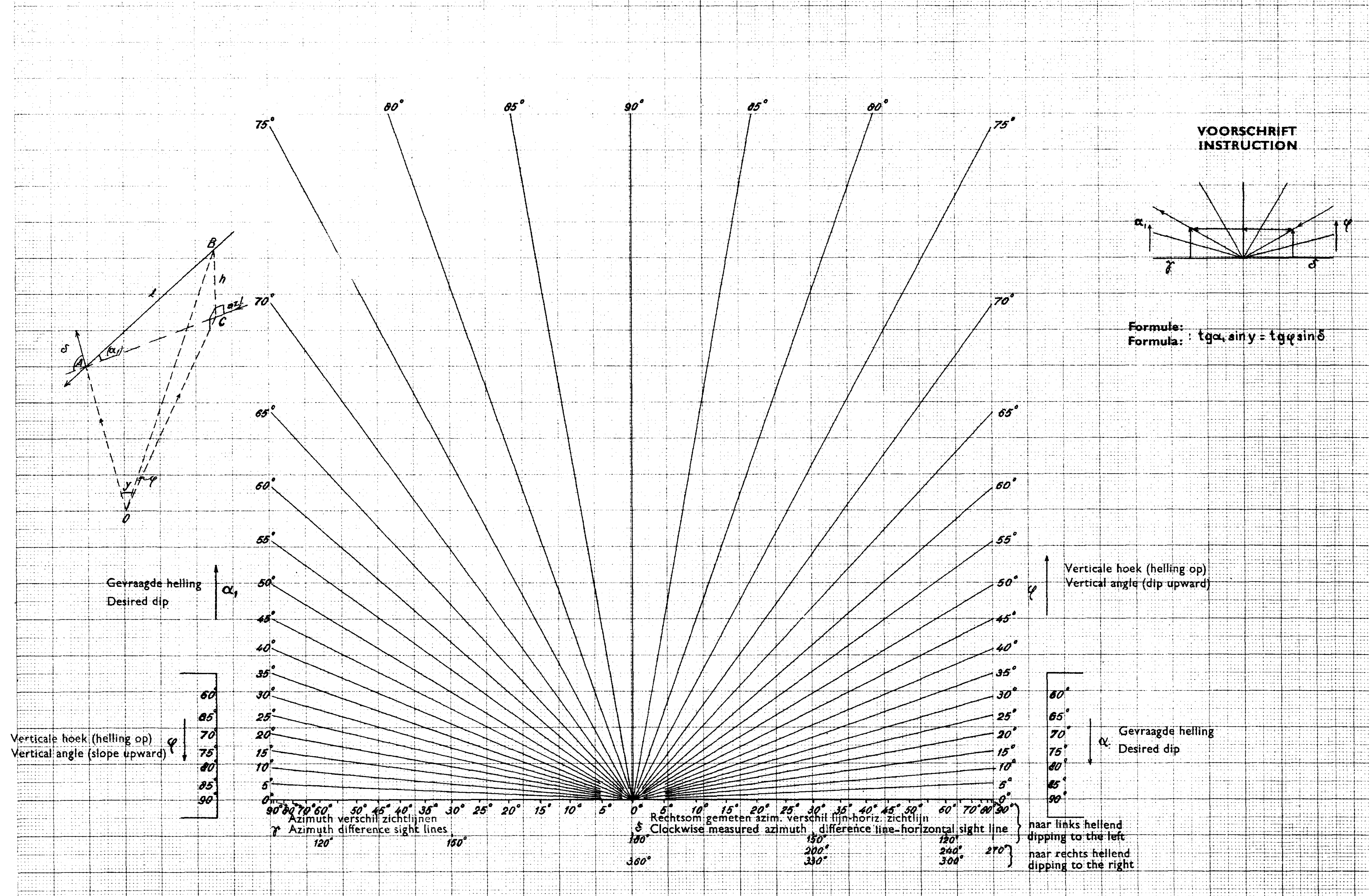


Indirect determination of the dip of a line:		
with known azimuth at a great distance	with known slope	with known strike and dip of a plane through the line
α_1' apparent dip	φ slope	φ dip of the plane
α_1 true (desired) dip		
Clockwise measured angle from		
γ azimuth of the line to azimuth sight line	strike topography to azimuth of the line	strike plane to azimuth of the line

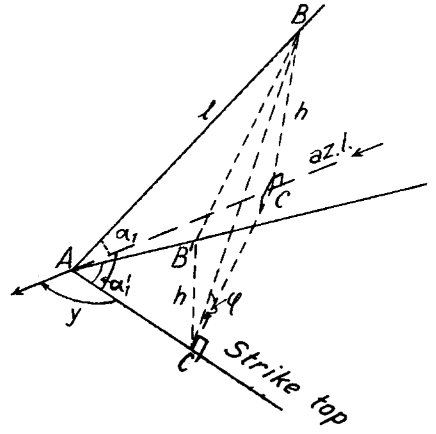


Plaat 9. Indirecte meting van de helling van een lijn op korte afstand

Plate 14 Indirect determination of the dip of a line from a short distance

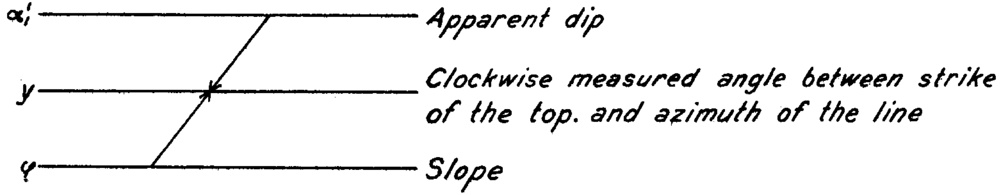


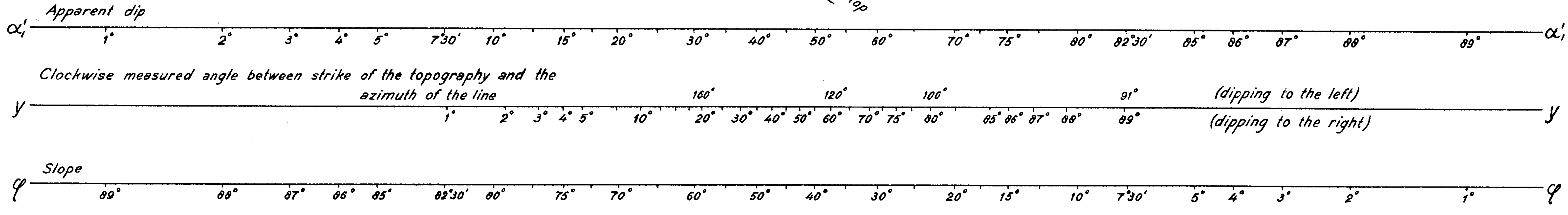
Indirect determination of the azimuth of a line in a known topography and with a known apparent dip from a great distance.



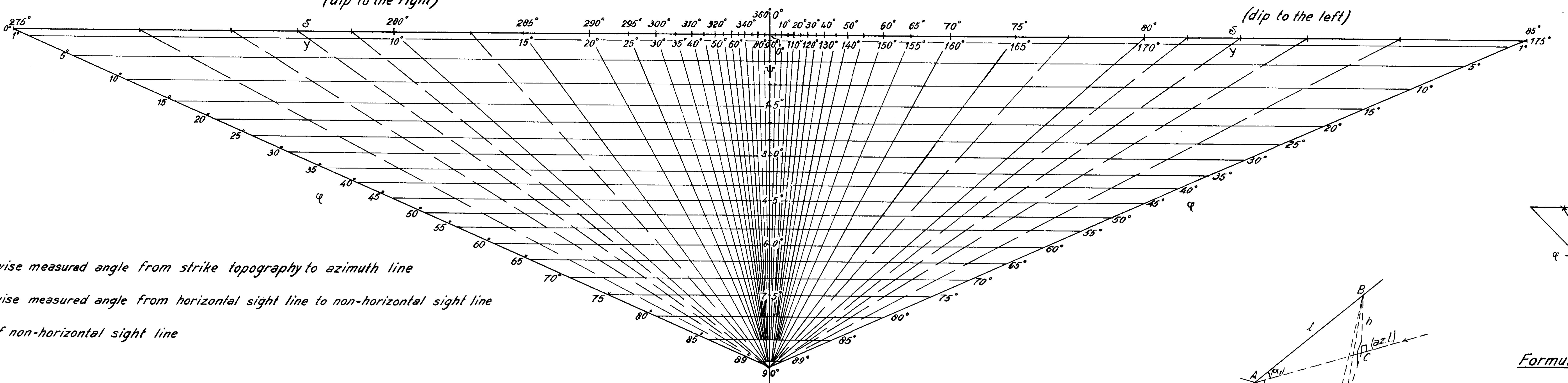
Formula: $\log tg\alpha_1' + \log cotg\varphi - \log tg y' = 0$

Instruction





Indirect determination of the azimuth of a line with known topography from a close point

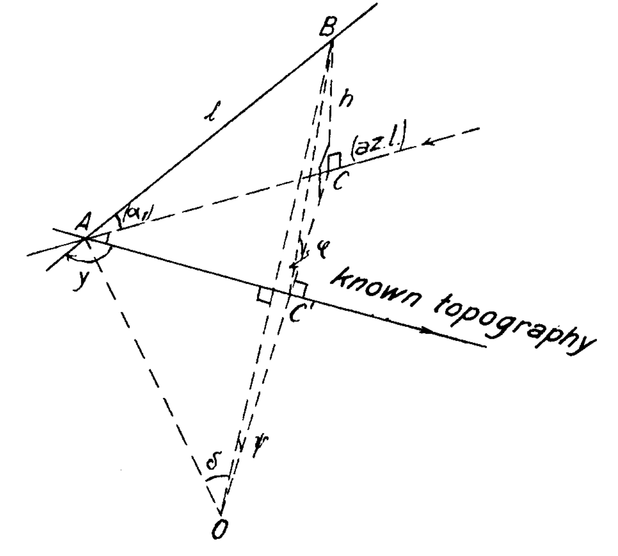


γ. Clockwise measured angle from strike topography to azimuth line

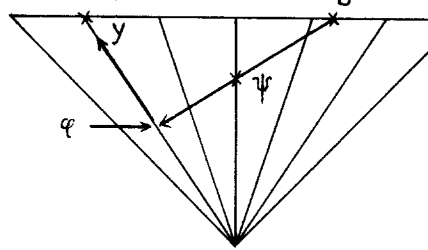
δ. Clockwise measured angle from horizontal sight line to non-horizontal sight line

ψ Dip of non-horizontal sight line

φ Slope

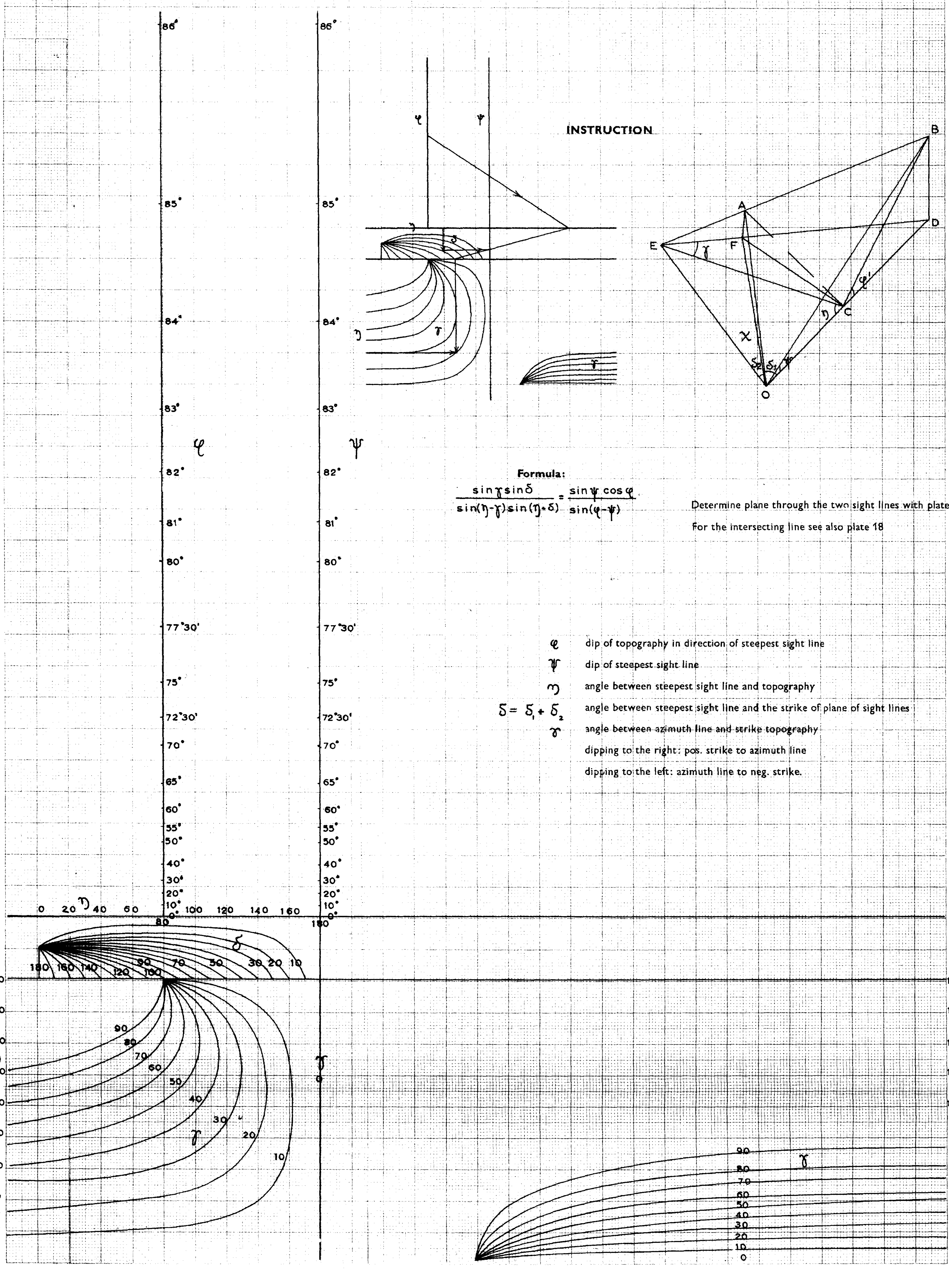


Instruction



Formula: $\cot g\,\gamma = (\cot g\,\psi \; tg\,\varphi - 1)\, tg\,\delta$.

Plate 17. Indirect determination of the azimuth of a line from two theodolite readings from one point (intersecting line of two planes)



Formula:

$$\frac{\sin\gamma\sin\delta}{\sin(\eta-\gamma)\sin(\eta+\delta)} = \frac{\sin\psi\cos\varphi}{\sin(\varphi-\psi)}$$

Determine plane through the two sight lines with plate 11

For the intersecting line see also plate 18

φ dip of topography in direction of steepest sight line

ψ dip of steepest sight line

η angle between steepest sight line and topography

$\delta = \delta_1 + \delta_2$ angle between steepest sight line and the strike of plane of sight lines

γ angle between azimuth line and strike topography

dipping to the right: pos. strike to azimuth line

dipping to the left: azimuth line to neg. strike.

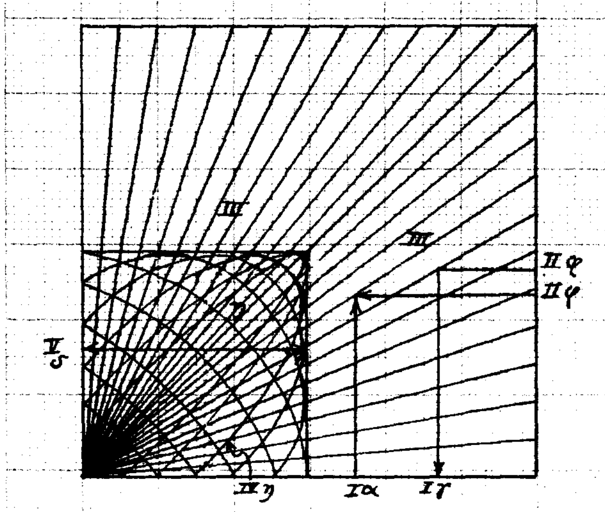
Plate 18. Indirect determination of the azimuth and dip of a line from theodolite readings in pairs from two points (intersecting line of two planes)

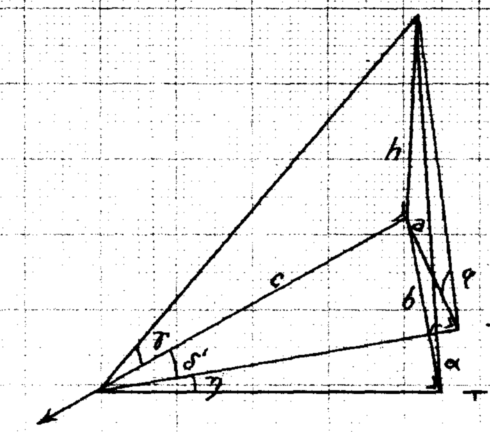
INSTRUCTION

Determine the plane through the two sightlines of station 1 and the plane through the two sightlines of station 2.

η clockwise measured angle (in the dip direction of both planes) from the strike of plane 1 to the strike of plane 2
δ clockwise measured angle from the strike of plane 1 to the azimuth of the line
φ dip of plane 1
α dip of plane 2
γ dip of the line

INSTRUCTION

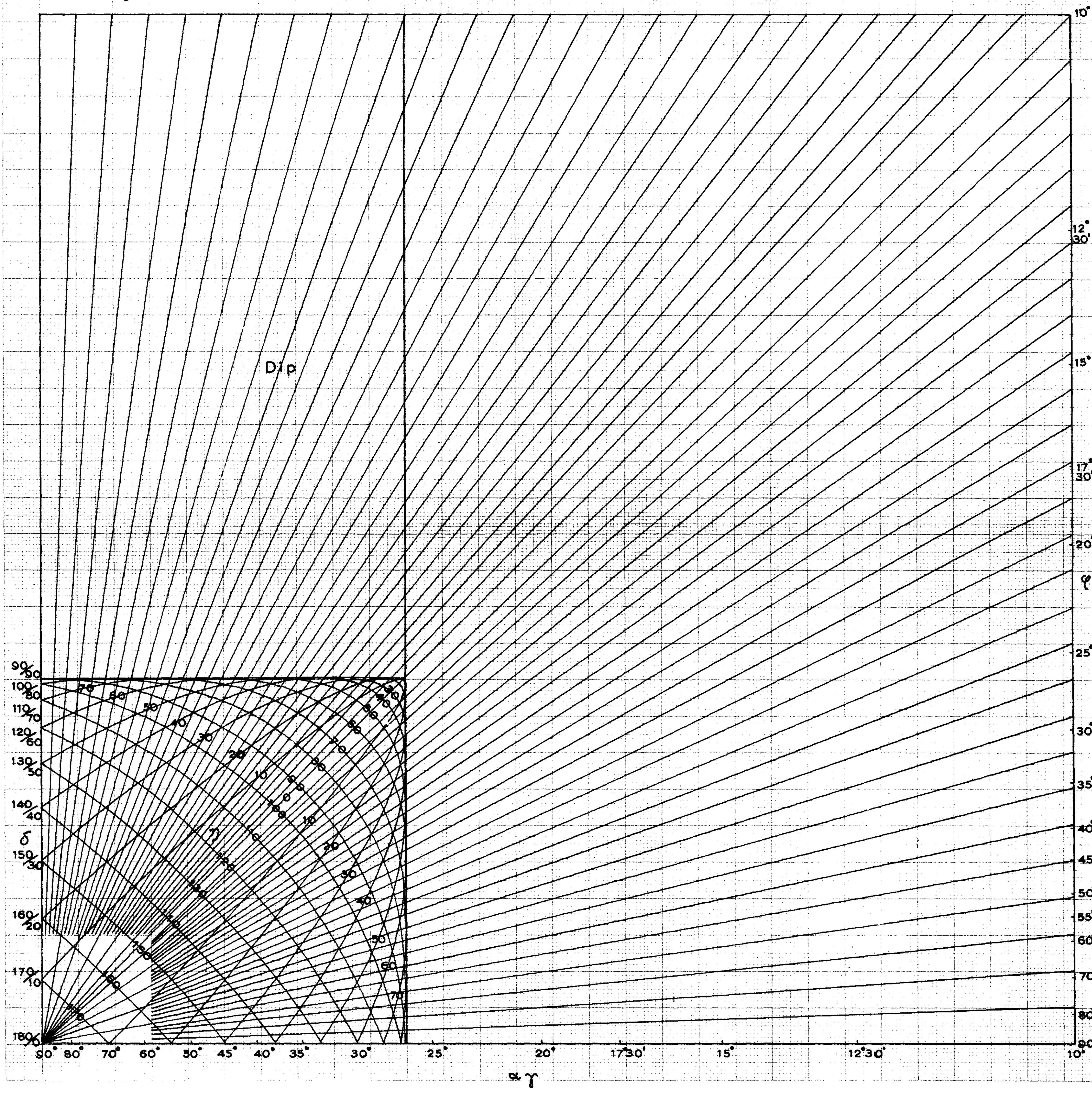




Formula

$$\frac{\text{cotg}\,\alpha}{\text{cotg}\,\varphi} = \frac{\sin(\delta-\eta)}{\sin\delta}$$

$$\frac{1}{\sin\delta} = \frac{\text{cotg}\,\gamma}{\text{cotg}\,\varphi}$$



Plaat 17a. Diktebepaling uit veldgegevens

Plate 19. Determination of the thickness from field data

D_w. Breedte in willekeurige richting
Arbitrary line between a point of hanging wall and a point of footwall

δ_w Hoek tussen de strekking van de laag en azimuth van D_w
Angle between strike of stratum and azimuth D_w

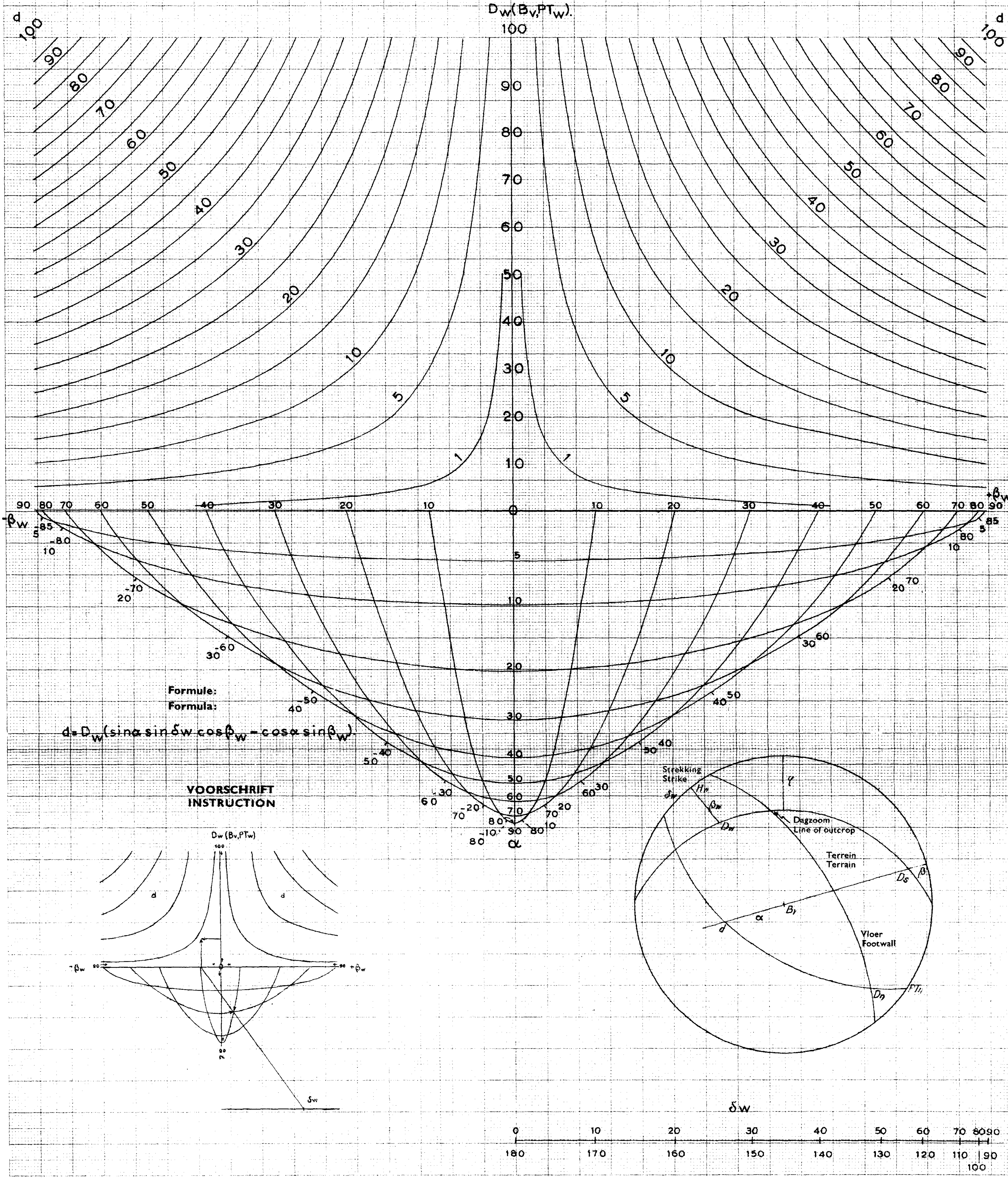
α. Helling van de laag
Dip of the stratum

β_w. Helling van D_w (+ in dezelfde richting als α, — tegengestelde aan α).
Dip of D_w (+ in the same direction of α, — in the other direction as α,)

d. Dikte
Thickness

B_v. Verticale afstand van dak en vloer
Vertical distance between hanging wall and footwall

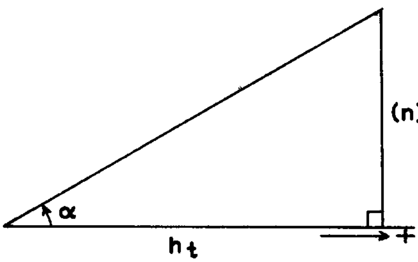
PT_w Horizontale afstand van dak en vloer in willekeurige richting
Horizontal distance between hanging wall and footwall in an arbitrary direction



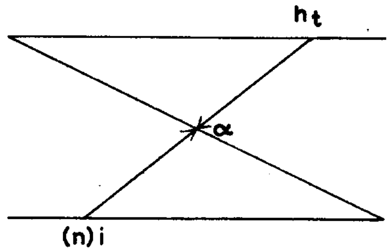
Slope from interval and distance
ni < 100 m. great LL

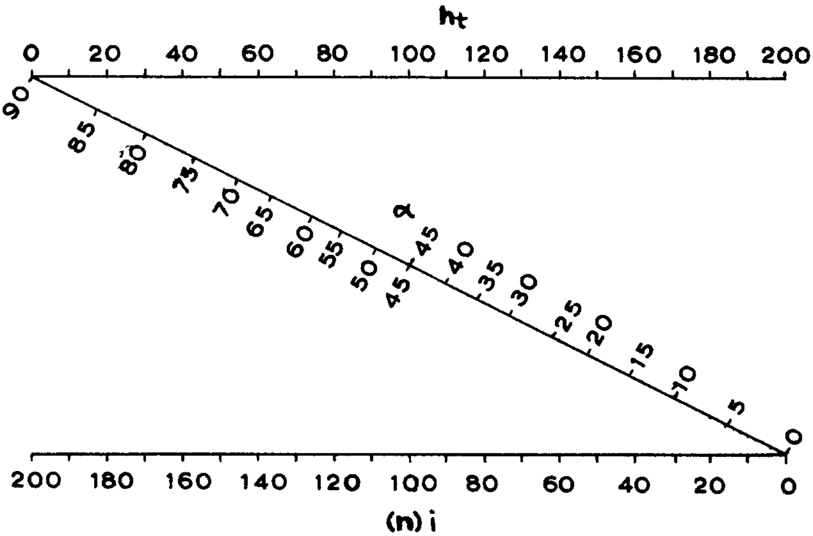
Formula:

$$tg\,\alpha = \frac{ni}{h_t}$$



Instruction

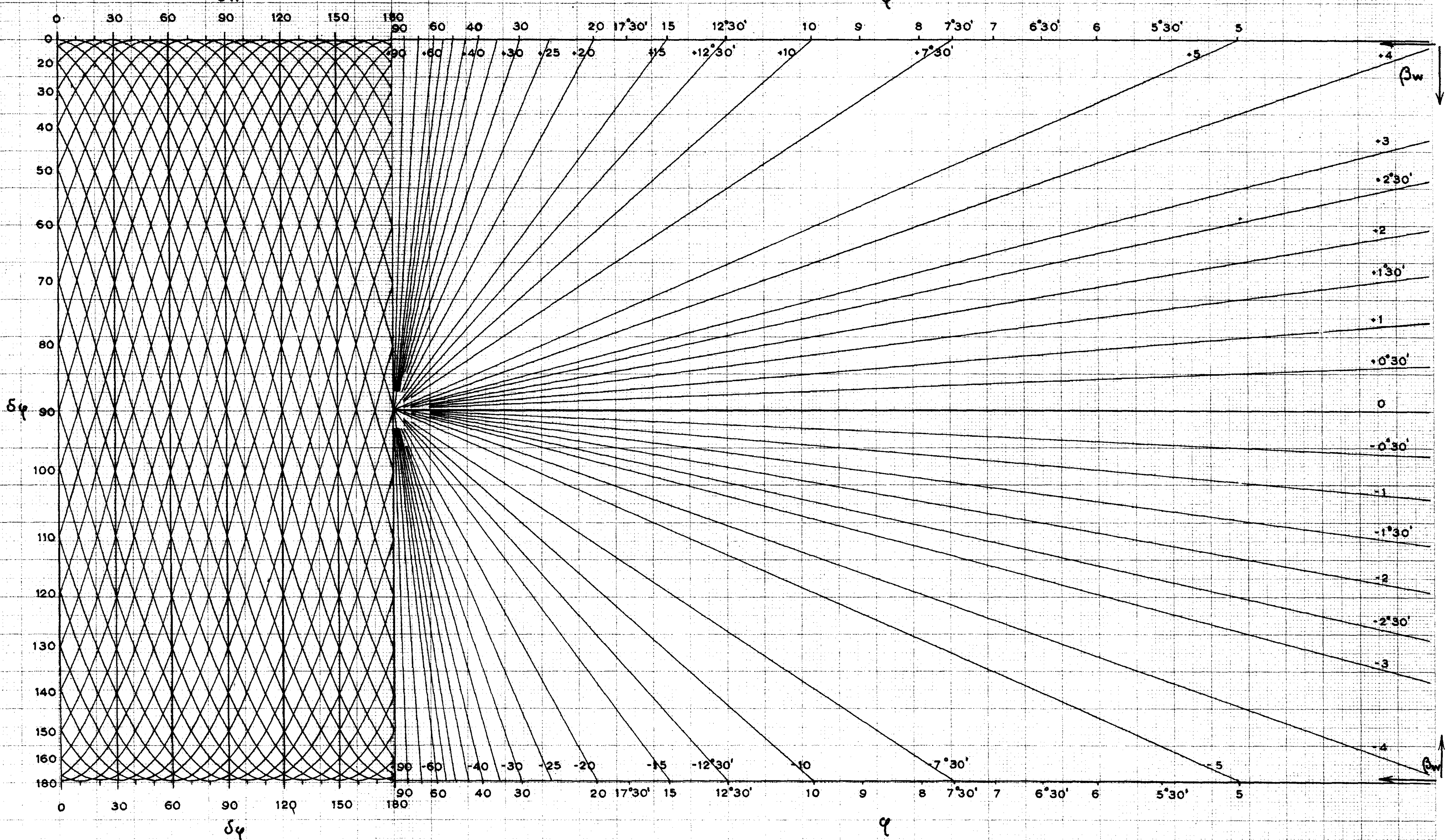




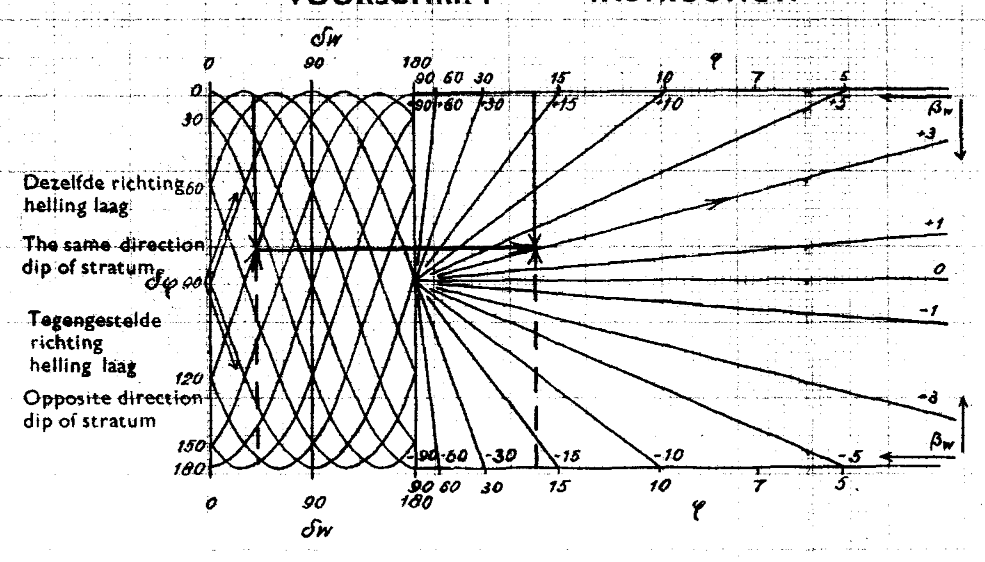
h_t. Horizontal distance
α. Topographical slope
ni. Elevation difference

Plaat 17c. Verband tussen $\delta w, \delta\varphi, \varphi$ en βw.

Plate 20. Relation between $\delta w, \delta\varphi, \varphi$ and βw.



VOORSCHRIFT INSTRUCTION



Formule Formula

$$\frac{tg\beta_w}{tg\varphi} = \cos(\delta w - \delta\varphi),$$

glooiing in dezelfde richting als de helling van de laag (vanuit $\delta\varphi$ omhoog)
slope in the same direction as the dip of the stratum (from $\delta\varphi$ upward)

$$\frac{tg\beta_w}{tg\varphi} = \cos(\delta w + \delta\varphi),$$

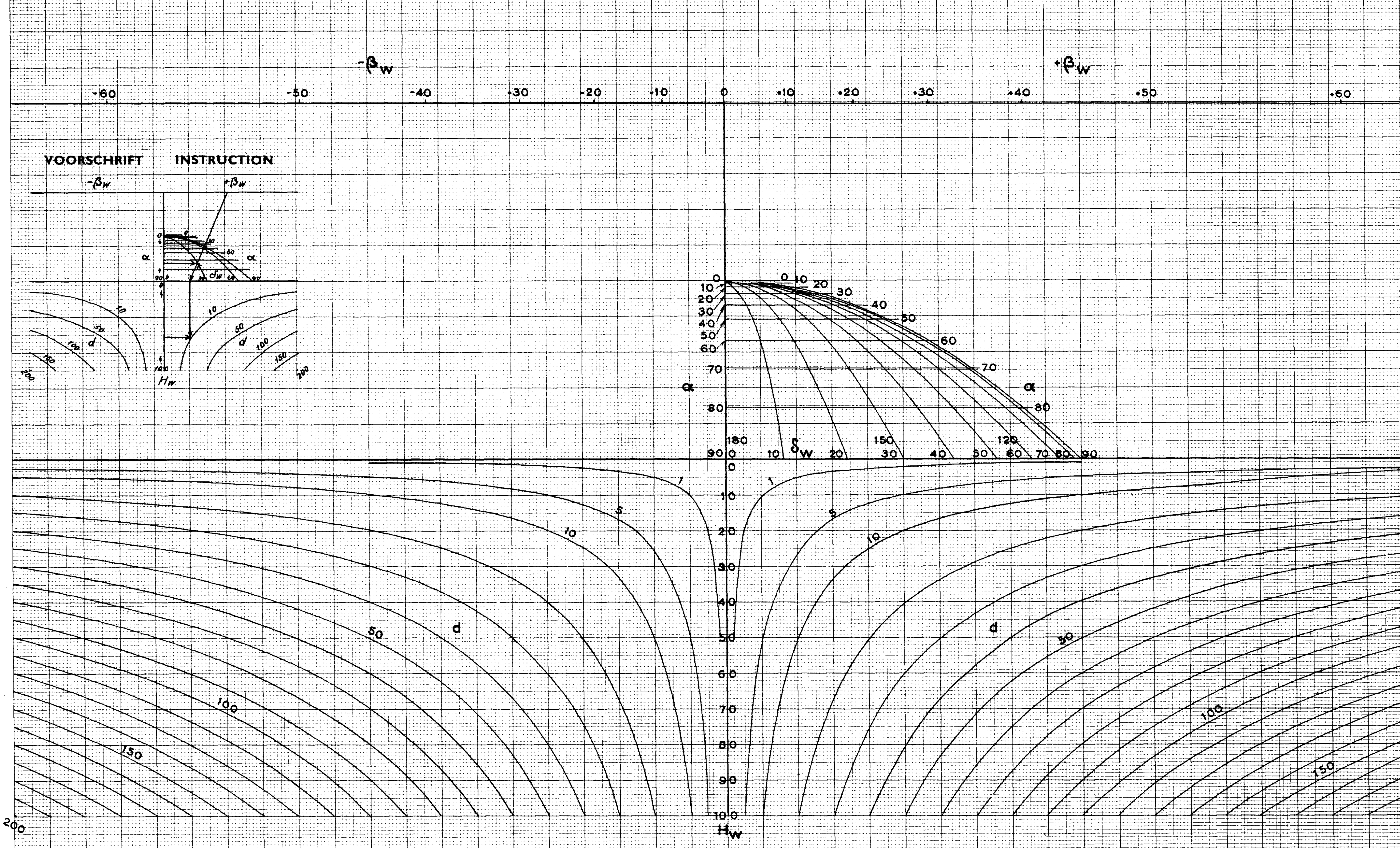
glooiing in tegengestelde richting als de helling van de laag (vanuit $\delta\varphi$ omlaag)
slope in the opposite direction as the dip of the stratum (from $\delta\varphi$ downward)

δw.	Hoek tussen strekking van de laag en azimuth D_w	Angle between strike of the stratum and the azimuth of D_w
$\delta\varphi$.	Hoek tussen strekking van de laag en azimuth glooiing	Angle between strike of the stratum and the azimuth of the slop
φ.	Glooiing	Slope
βw.	Helling D_w	Dip of D_w

Situatieschets zie plaat 17a

Situation see plate 19

Plaat 18. Kaartafstand en dikte van een pakket **Plate21. Map distance and thickness of a stratum**



α.	Helling van de laag	Dip of stratum	β_w.	Helling van H_w Dip of H_w
H_w.	Kaartafstand van dak en vloer	Map distance from hanging wall to footwall	d.	Dikte van de laag Thickness of stratum
δ_w.	Hoek tussen strekking van de laag en azimuth van H_w	Angle between strike of stratum and azimuth of H_w		

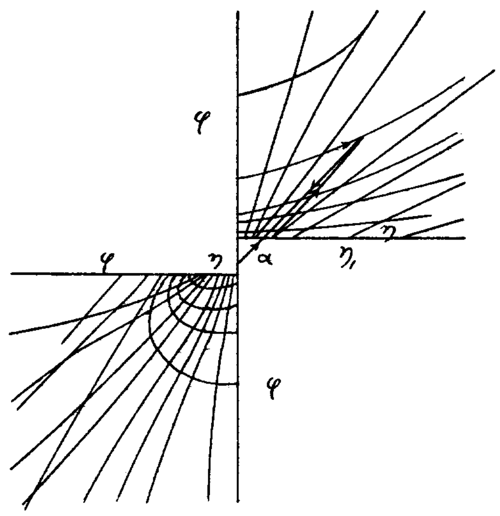
Situatieschets zie plaat 17b **Situation see plate 5**

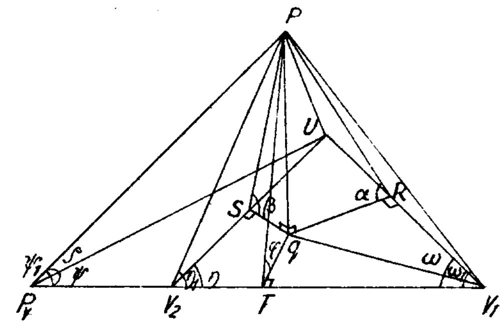
Formule **Formula**

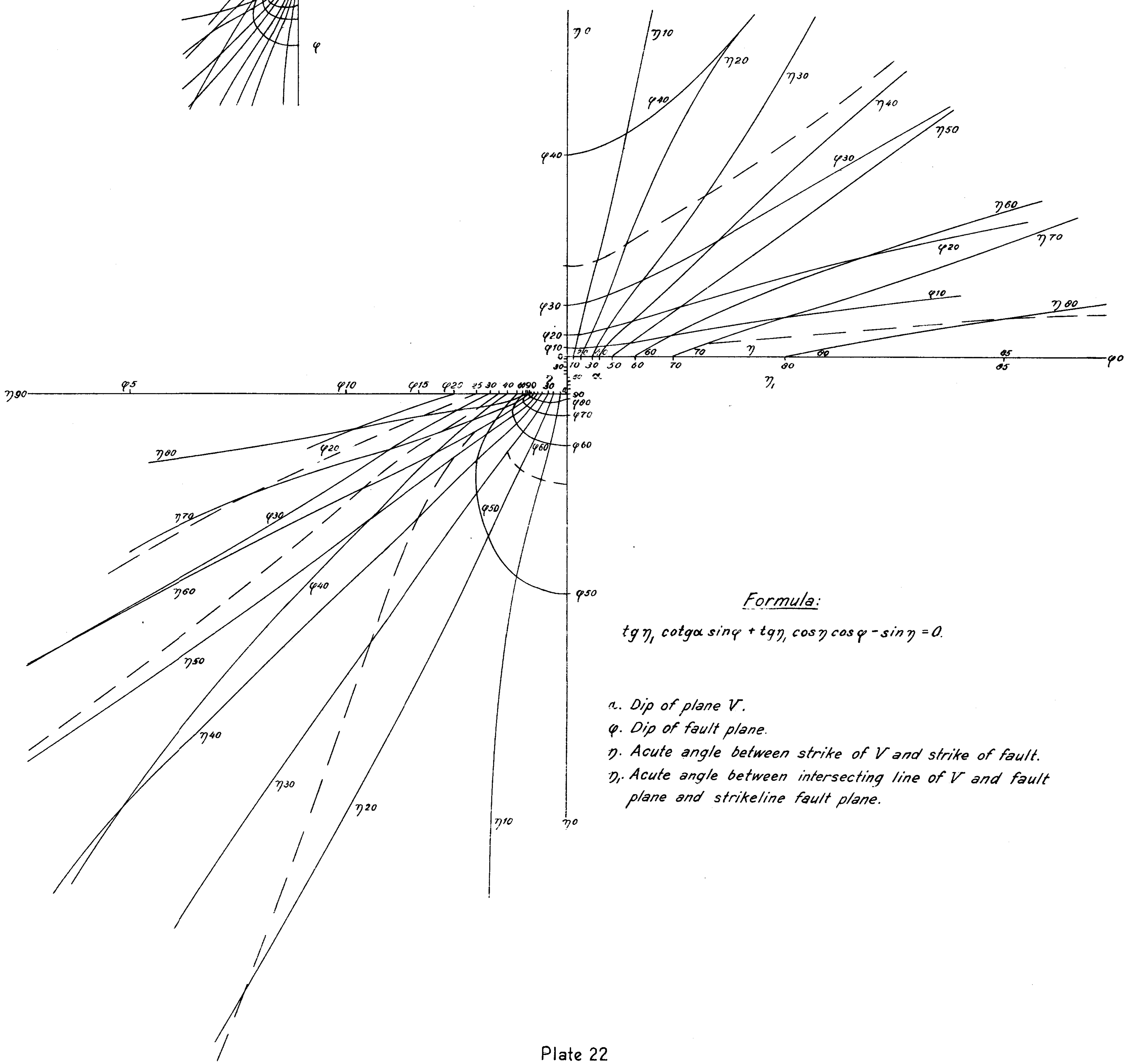
$$H_w(\sin\alpha\sin\delta_w + \operatorname{tg}\beta_w\cos\alpha) = d.$$

Determination of auxillary data in faultproblems.

Instruction







Formula:

$$tg\,\eta_1\,\cot g\,\alpha\,\sin\varphi + tg\,\eta_1\cos\eta\cos\varphi - \sin\eta = 0.$$

α. Dip of plane V.

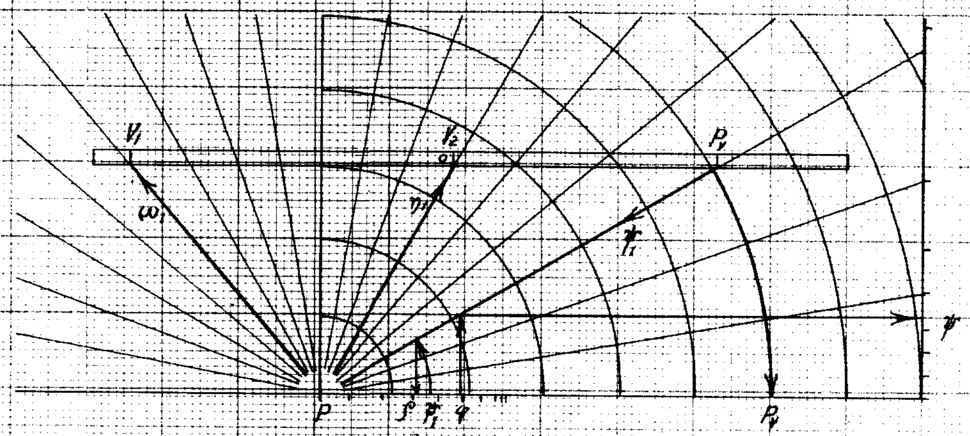
φ. Dip of fault plane.

η. Acute angle between strike of V and strike of fault.

η_1. Acute angle between intersecting line of V and fault plane and strikeline fault plane.

Plaat 23b. Breukbedrag (grootte en richting) bepaling **Plate 23 Fault displacement determination (size and direction)**

VOORSCHRIFT **INSTRUCTION**



η_1. Hulpconstanten van de breuk vlak V_1 (= hoek tussen doorgang vlak V_1 en strekking breuk) — Auxiliary datum of fault plane and plane V_1 (angle between intersecting line of plane V_1 and strike fault plane)

ω_1. Hulpconstanten van de breuk vlak V_2 (= hoek tussen doorgang vlak V_2 en strekking breuk) — auxiliary datum of fault plane and plane V_2 (angle between intersecting line of plane V_2 and strike fault plane)

PP_v. Grootte breukbedrag — Size fault displacement

ψ. Hoek tussen richting bedrag en strekking breuk — Angle between direction of displacement and strike fault

ψ_1. Hoek tussen bedrag en strekkingslijn breuk — Angle between displacement and strike fault

ρ. Helling PP_v. — Dip PP_v.

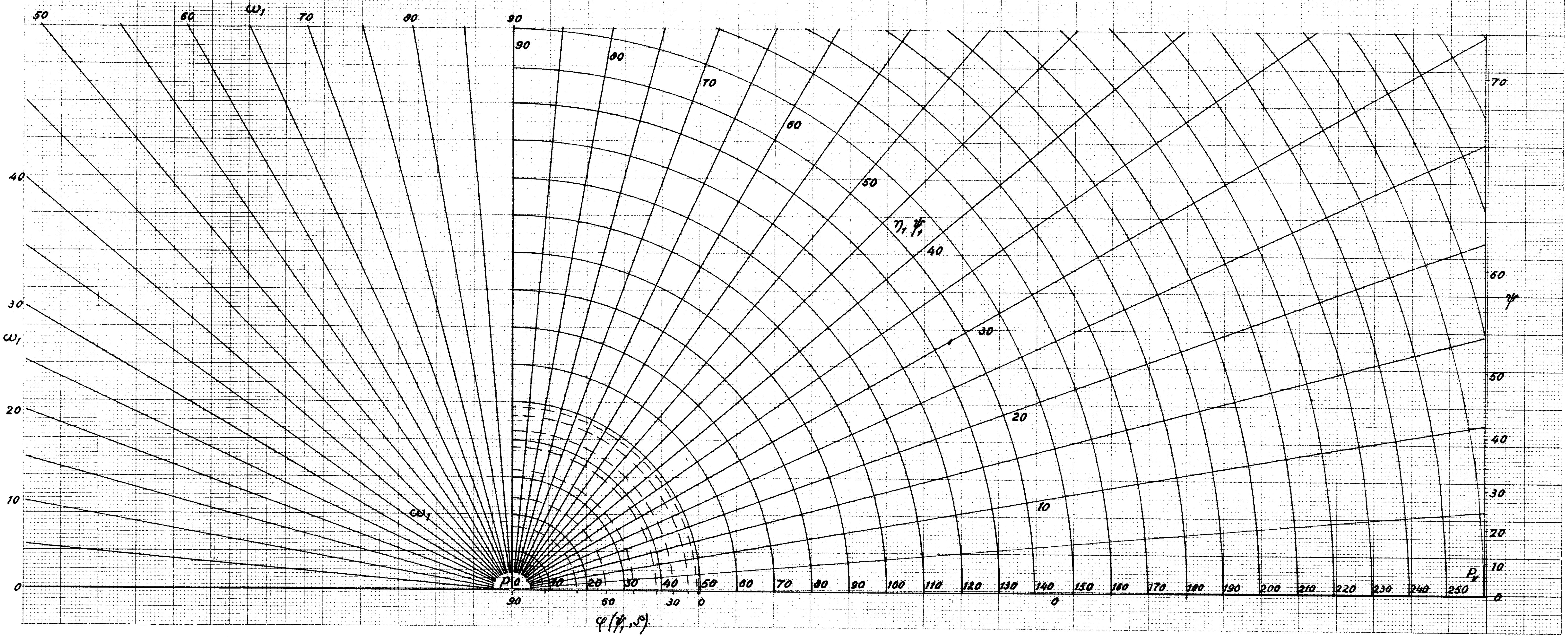
Formule **Formulae**

$\Delta PP_v V_1$ en $\Delta PP_v V_2$.

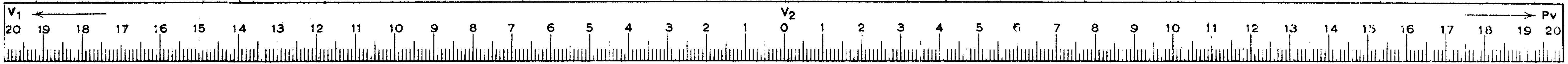
$$tg\,\psi_1 = \frac{tg\,\psi}{\cos\varphi}$$

$$\cos\psi_1 = \frac{\cos\rho}{\cos\psi}$$

Situatieschets zie plaat 23a **Situation see plate 22**



READER OF PLATE 23



Reduced dip and oblique angle

Determination reduced dip

γ reduced dip

γ_s true dip

α acute angle between strike and section direction

β acute angle between intersection line of the reduced angle and plane (oblique angle)

In fault problems (see plate 23)

= ρ dip of displacement

= φ dip of fault plane

= ψ acute angle between azimuth dispacement and strike fault plane

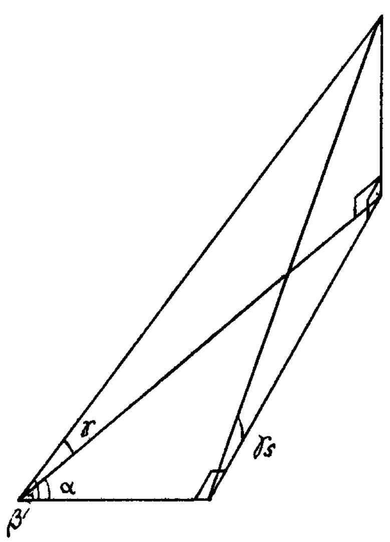
= ψ_1 acute angle between displacement and strike fault plane

In blockdiagrams problems

γ true dip of line

γ_s dip of line scene

α direction of line in respect to y-direction



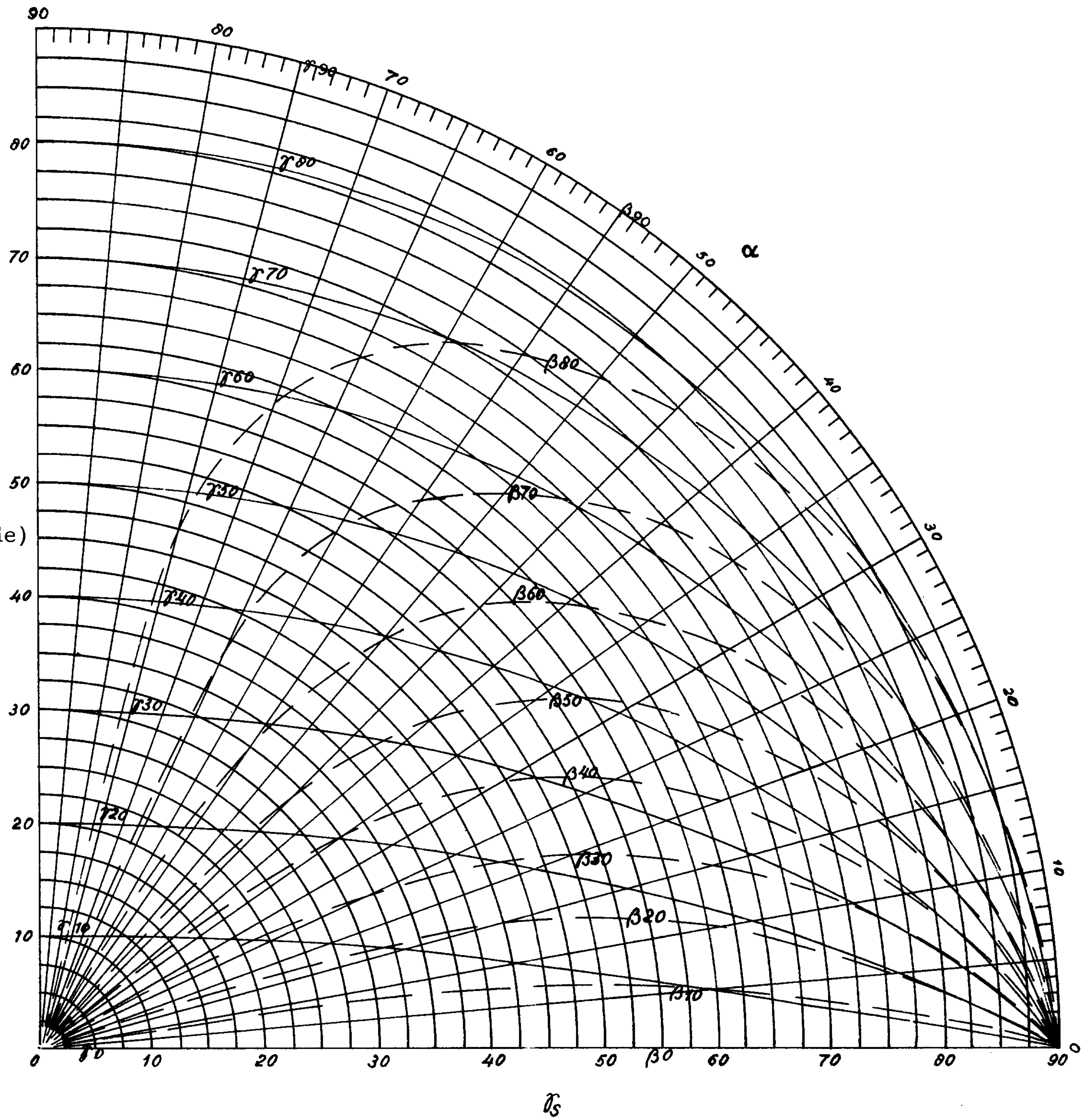
Formulae:

$$tg\,\gamma_s = \frac{tg\,\gamma}{\sin\alpha}$$

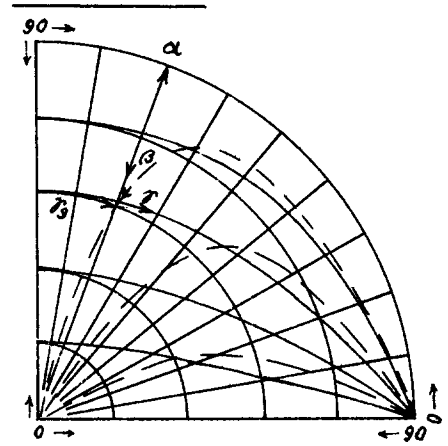
$$\cos\gamma_s = tg\,\alpha\, cotg\,\beta$$

γ_s (arcs of circle)

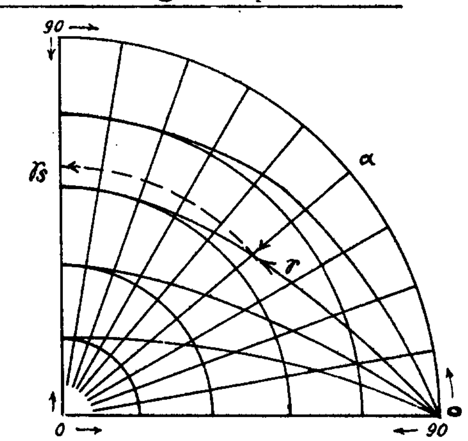
(γ curves to α = 0)



Instruction



For blockdiagram problems



Plaat 28. Bepaling van de centraal-perspectivische-blokdiagramhoek.
Plate 25. Determination of the blockdiagram angle in central-perspective.

x Oogcoördinaat ⊥ tafereel.
Eye coördinate ⊥ scene

y Oogcoördinaat, horizontaal in tafereel.
Eye coördinate, horizontal in scene

z Oogcoördinaat, verticaal in tafereel.
Eye coördinate, vertical in scene

Formule:
Formula
$$tg\beta = \frac{z + x\,\frac{tg\gamma}{\sin\alpha}}{y + x\,\cot g\alpha}$$

α. Horizontale richtingshoek t.o.v. y richting { + aan oogzijde van x richting / — aan de andere zijde. } van tafereel naar achteren.
Horizontal direction angle with respect to y-direction { + at eye-side of x-direction / — at other side of x-direction } from scene backward

γ. Hellingshoek { + van het oog af naar boven / — van het oog af naar beneden }
Dip angle { + from the eye up / — from the eye down }

β. Blokhoek { + van de horizontaal naar boven / — van de horizontaal naar beneden } richting van horizontaal naar horizon
block angle { + from horizontal up / — from horizontal down } from base to horizon

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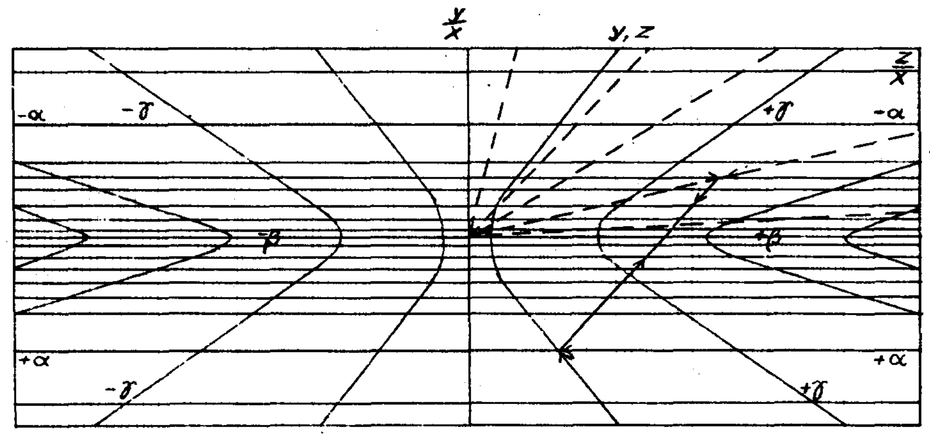
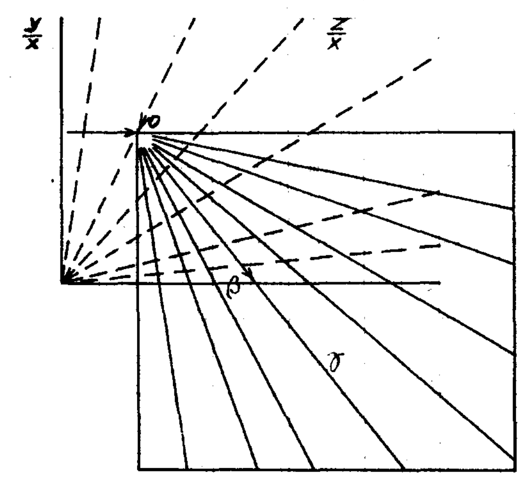
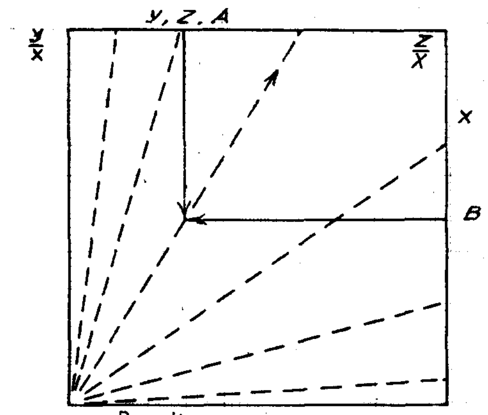


Voor hoek $\alpha \neq 90°$
for angle $\alpha \neq 90°$

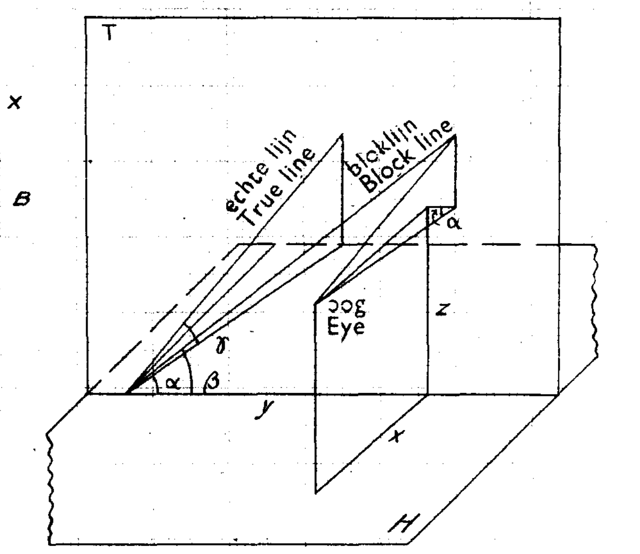


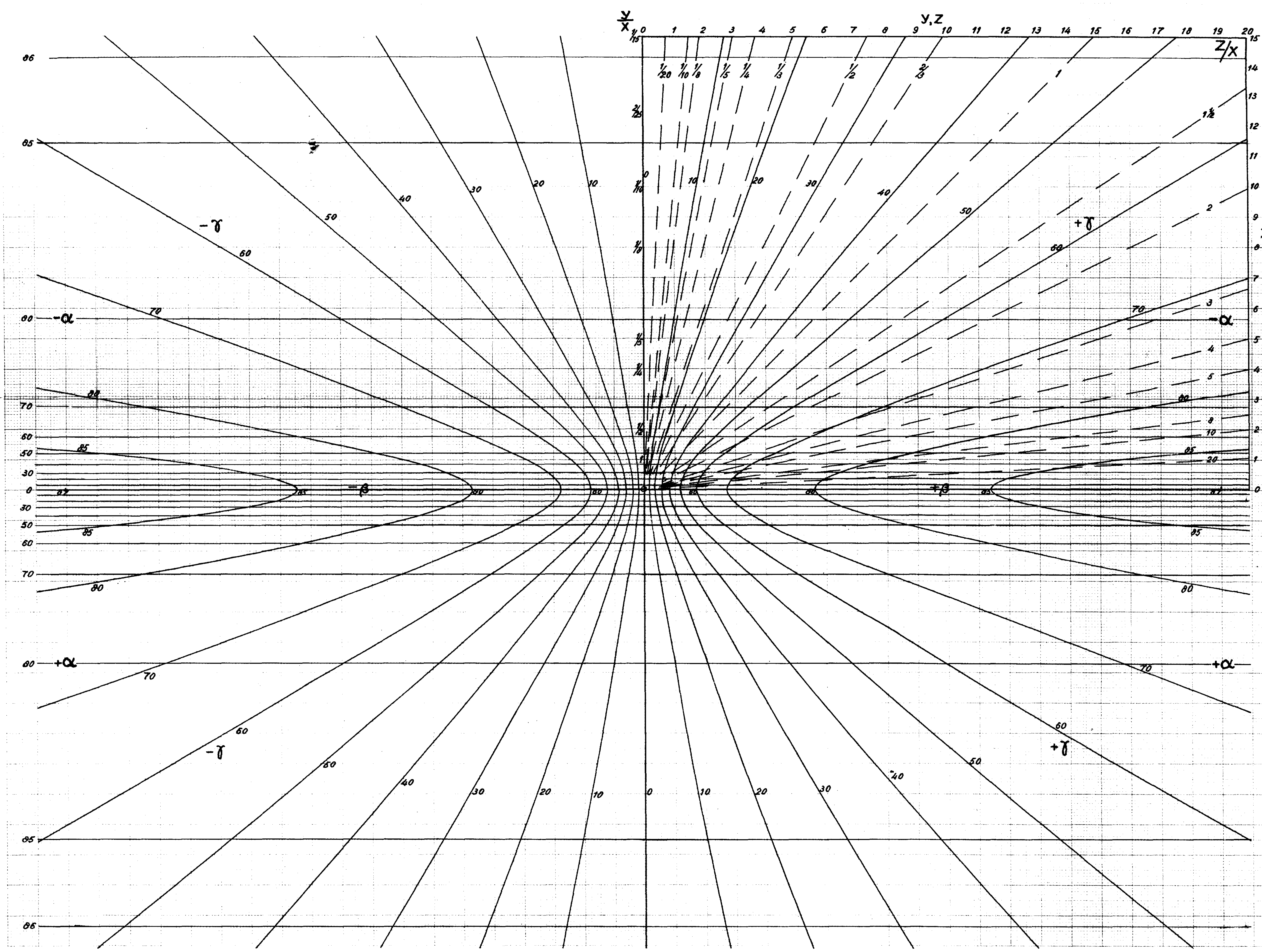
Losse wijzer
Detached pointer

Bepaling bij $\alpha = 90°$
Determination $\alpha = 90°$

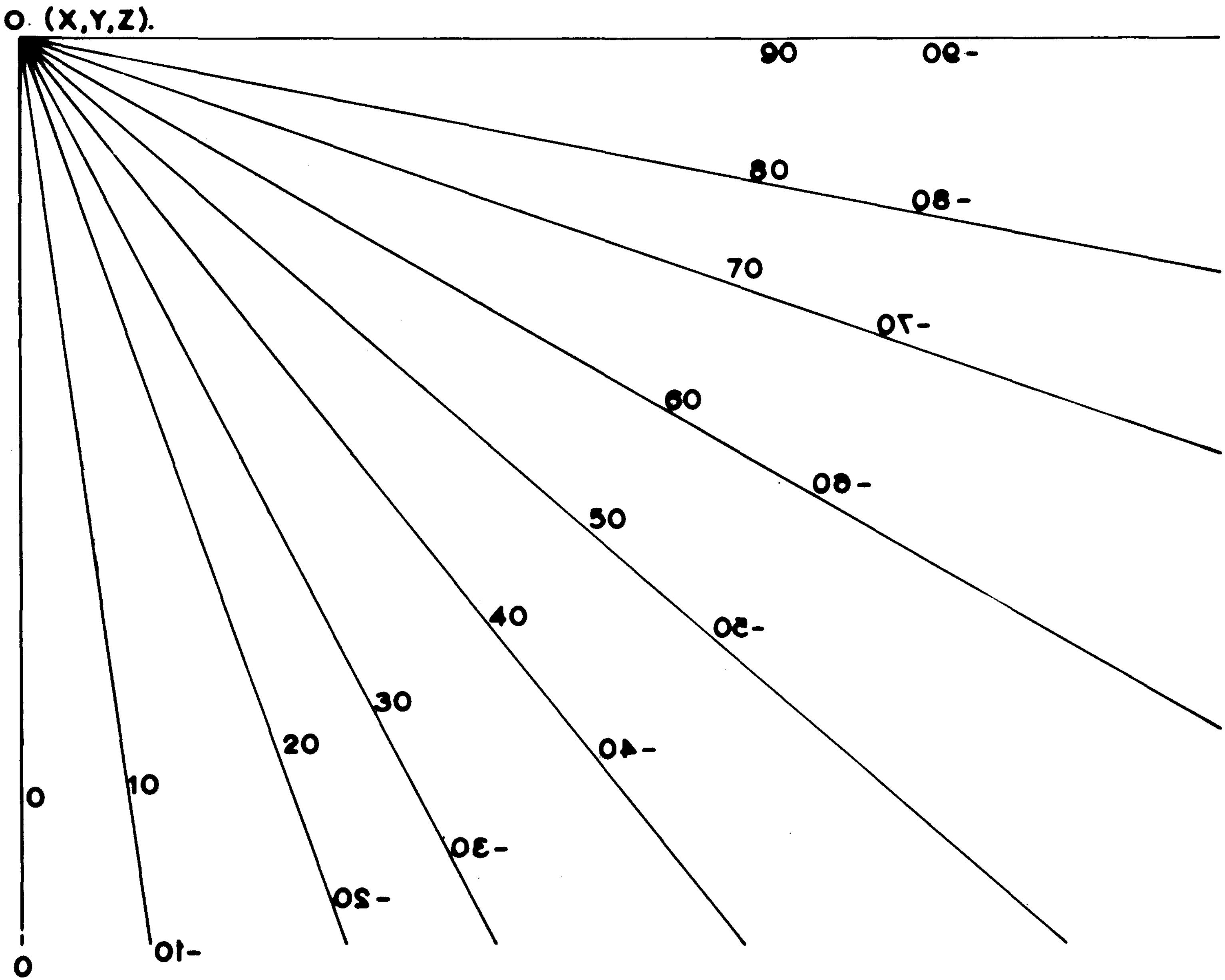


Bepaling
determination $\frac{y}{x}$ & $\frac{z}{x}$



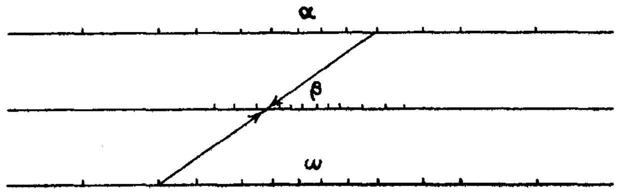


Detached pointer of plate 25 for $\alpha = 90°$, for negatieve γ turn pointer.



Determination of the block-angle in the „two points" parallel-perspective (vertical scene).

Instruction



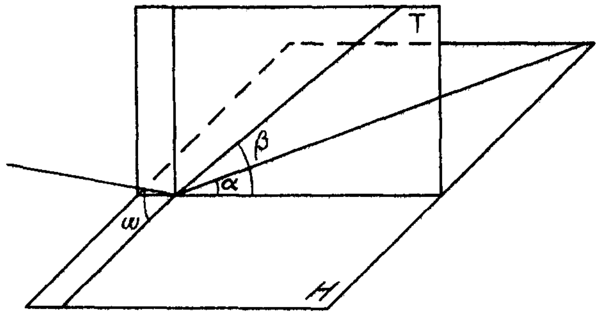
α. True direction angle (angle of the line with the base-line from scene backwards).

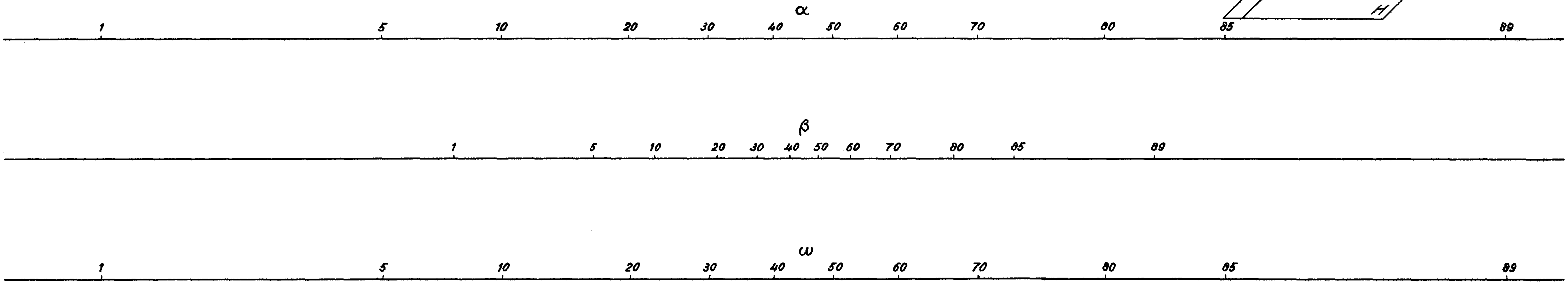
ω. Angle of vision.

β. Block angle (from base-line upwards)

Formula:

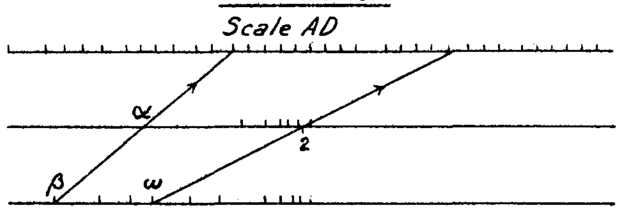
$$\log tg\beta = \log tg\alpha + \log tg\omega.$$

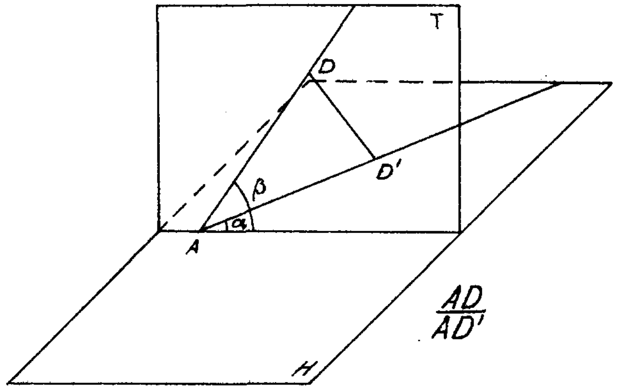




Determination of the scale of the side ribs in the „two points" parallel-perspective (vertical scene)

Instruction





α. Direction angle of the side rib with scene

β. Block angle (angle side rib with horizontal)

Scale AD. Ratio of block rib to true rib

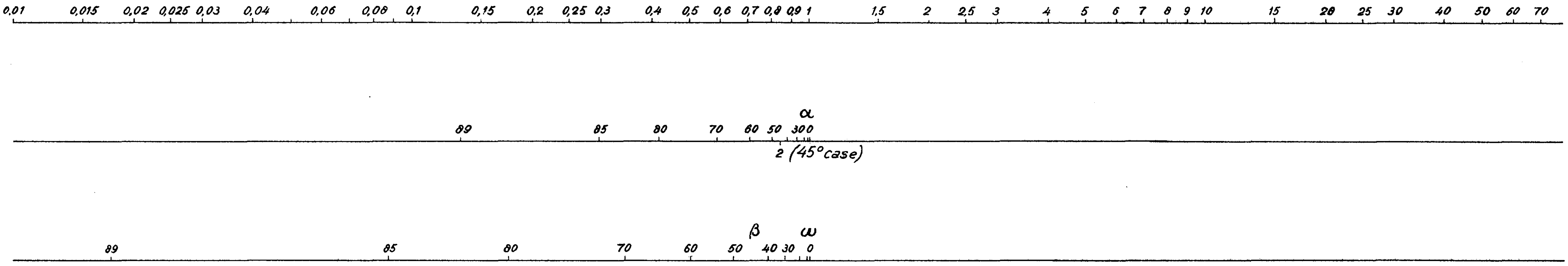
ω. Angle of vision

Formulae:

$\log AD = \log \cos\alpha - \log\cos\beta$

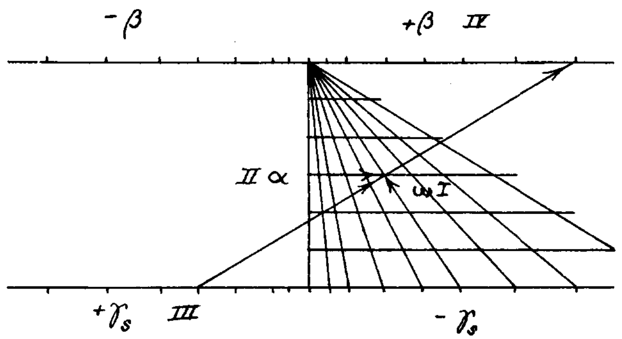
$\log AD = -\log\cos\omega - \tfrac{1}{2}\log 2$ (45° case)

Length true AD is 1



General relation between angles in parallel-perspective block diagrams

Instruction



Formula:

$$\operatorname{tg}\beta = \operatorname{tg}\omega \operatorname{tg}\alpha + \operatorname{tg}\gamma_s \operatorname{tg}\alpha$$

α. Direction angle of true line (from base line to the line behind the scene)

γ_s. The reduced dip of the line perpendicular to the scene

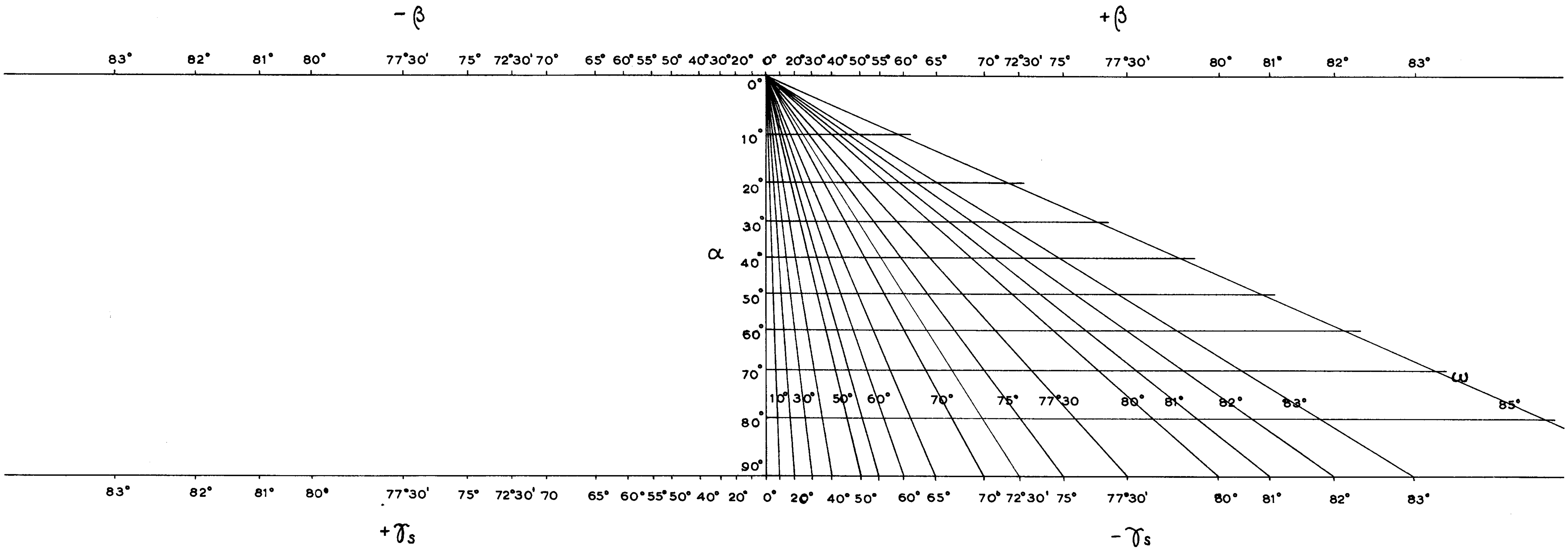
+ Backwards upwards

− Backwards downwards

ω. Angle of vision

β. Blockangle (dip of a line of the block) + from horizontal upwards

− from horizontal downwards



Plaat 12. Indirecte bepaling van het azimuth van een lijn bij bekende strekking en helling van een vlak door de lijn (bijv. striae)

Plate 29. Indirect determination of the azimuth of a line in a plane with known strike and dip (e.g. striae)

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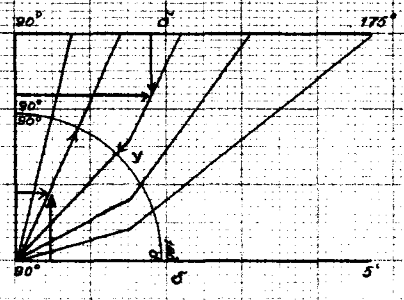
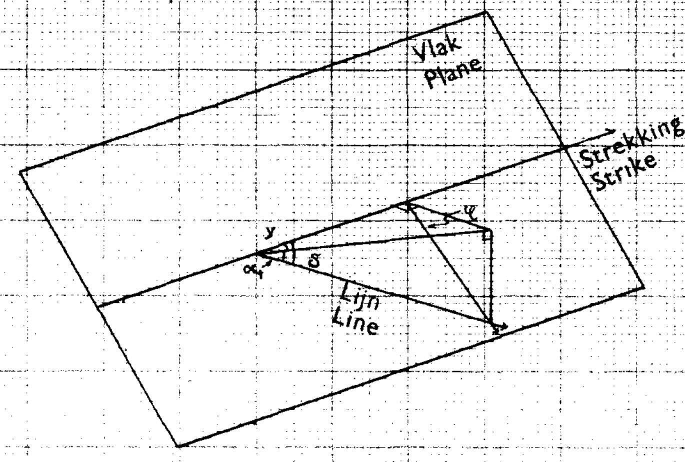
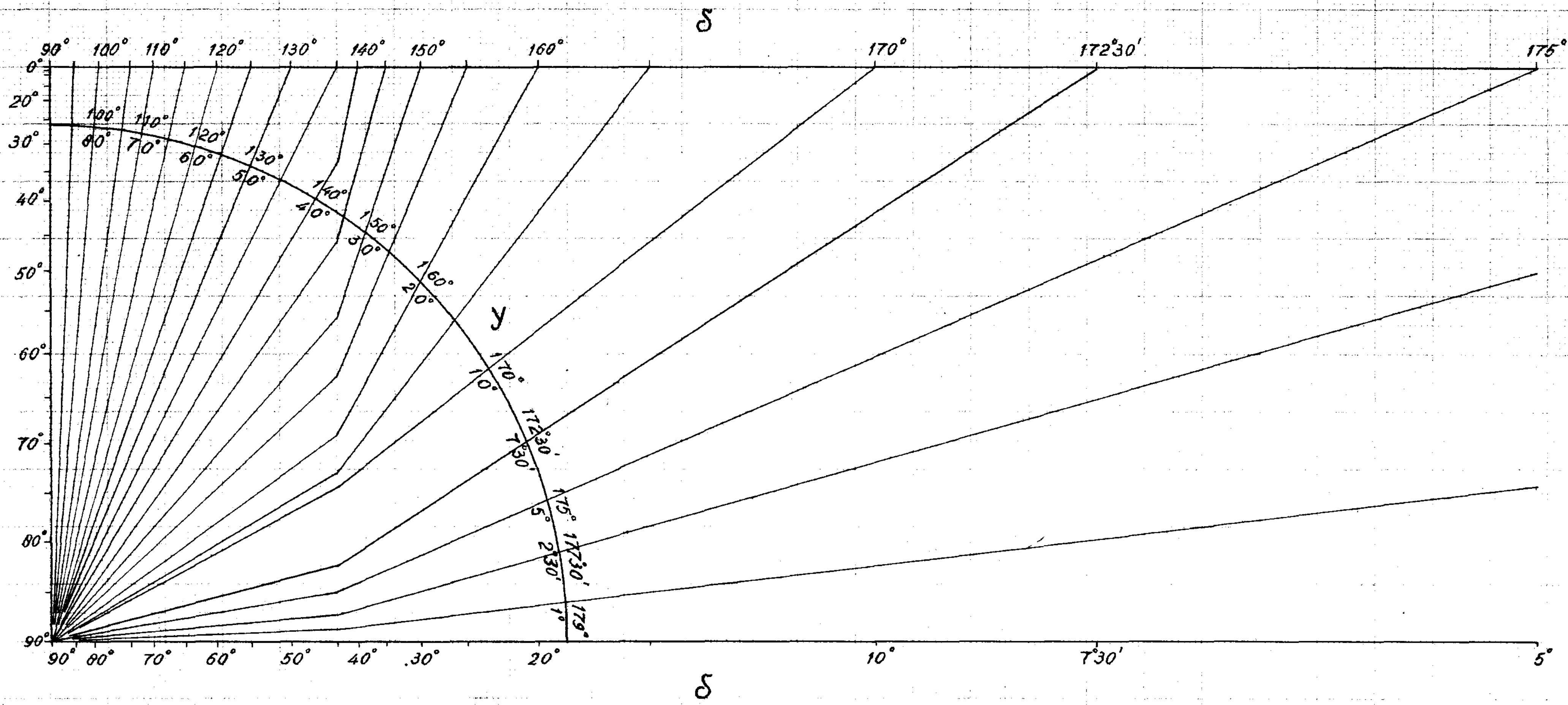
INSTRUCTION



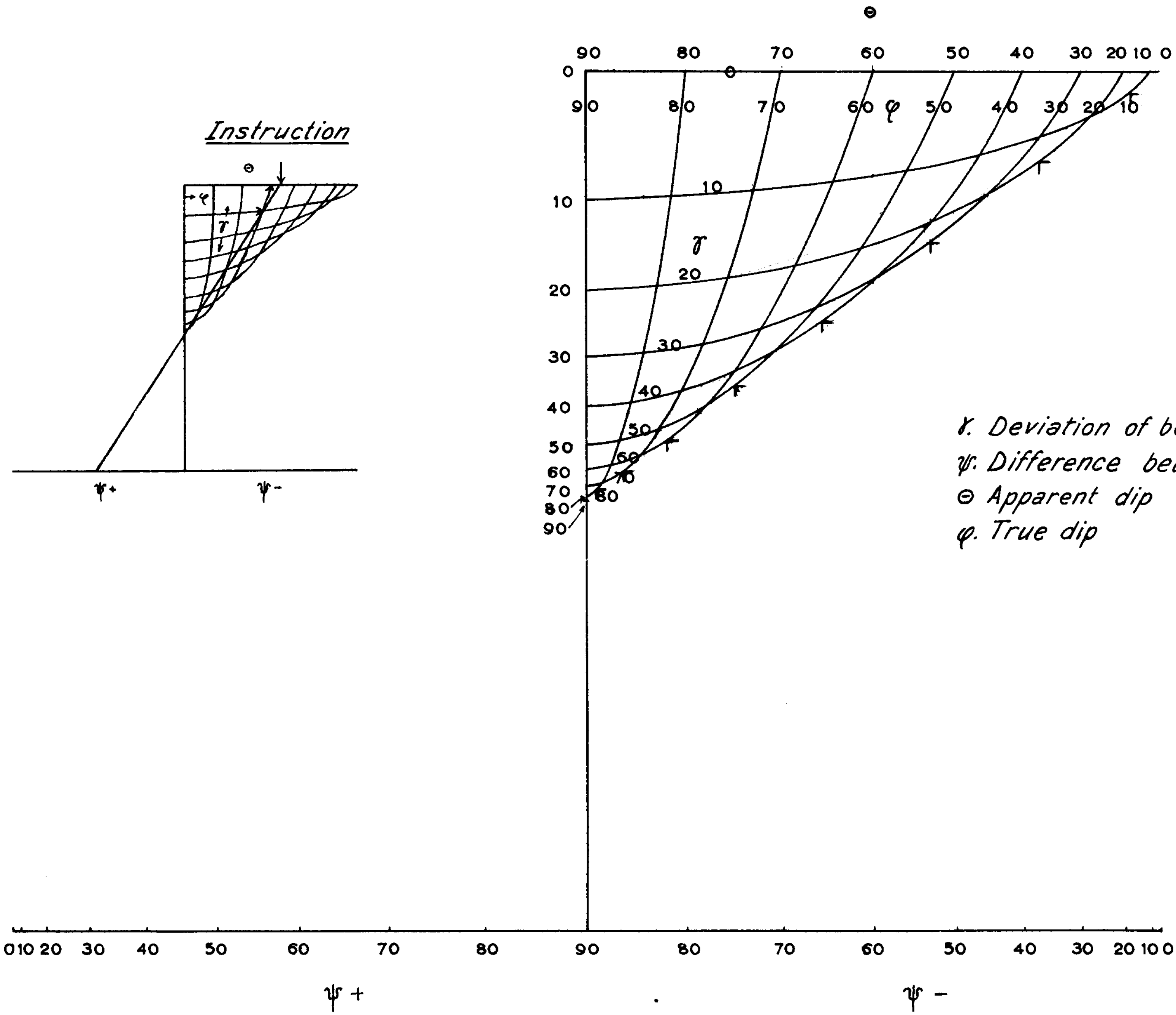


Formule
Formula $: tg\,y = \cos\varphi \cdot tg\,\delta$



δ. De rechtsom gemeten hoek **in** het vlak van de strekking naar de lijn	Clockwise measured angle **in** the plane from the strike to the line
φ. Helling van vlak	Dip of plane
y. De rechtsom gemeten hoek van de strekking van het vlak naar het azimuth van de lijn	Clockwise measured angle from the strike of the plane to the azimuth of the line

Dip determination in non-vertical bore holes (formula from practice)



Formula:

$$\cos\Theta = \cos\gamma\cos\varphi \pm \sin\gamma\sin\varphi\cos\psi.$$

+ Bore hole dips against dip of stratum

− Bore hole dip in the same directions as stratum

γ. Deviation of bore hole from vertical

ψ. Difference between azimuth of dip and azimuth of bore hole

Θ Apparent dip

φ. True dip

Plate 31. Determination of strike of plane measured in a non-vertical bore hole

(formal formula)

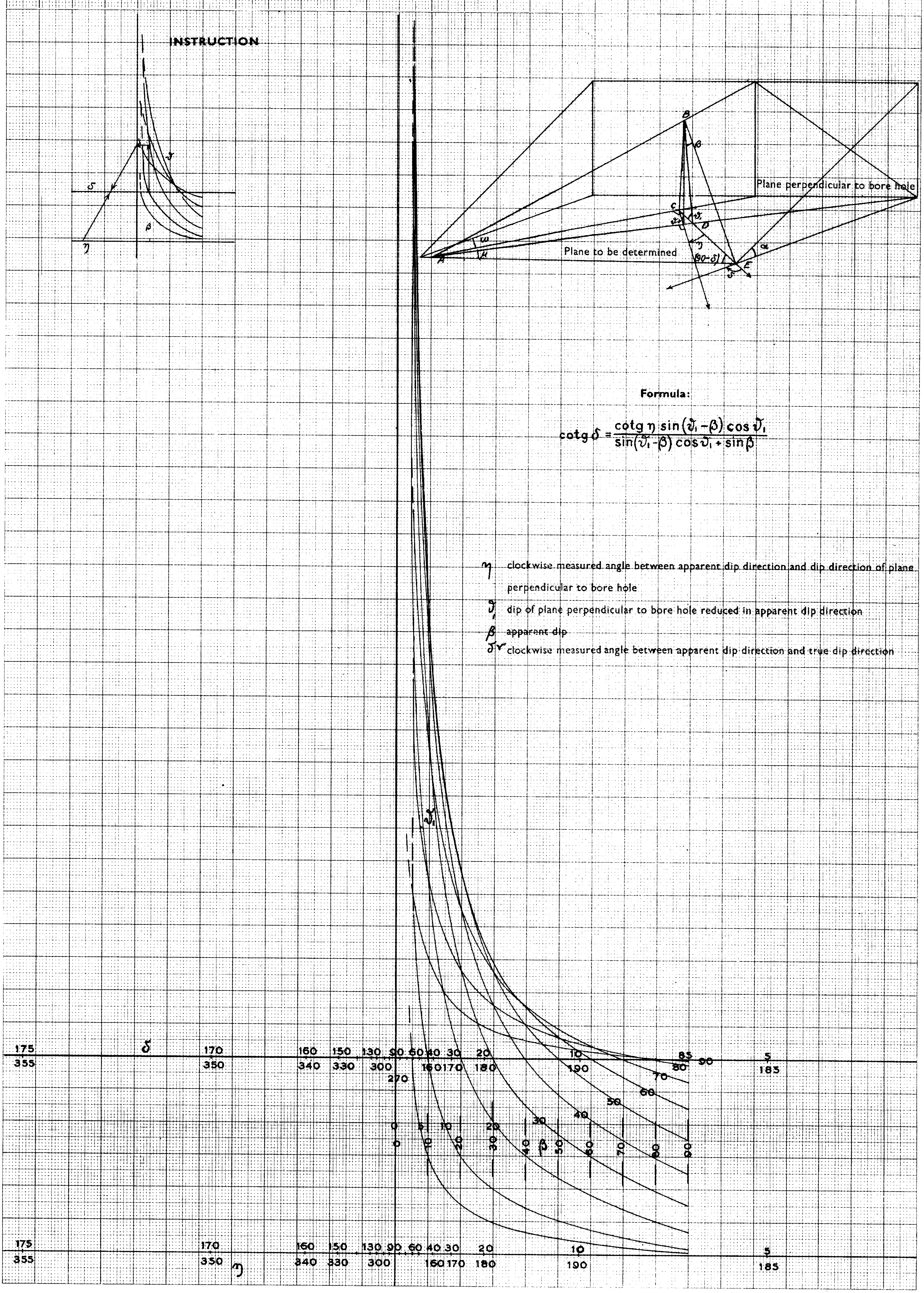


Plate 32. Determination of dip of plane measured in a non-vertical bore hole

(formal formula)

SITUATION see plate 31

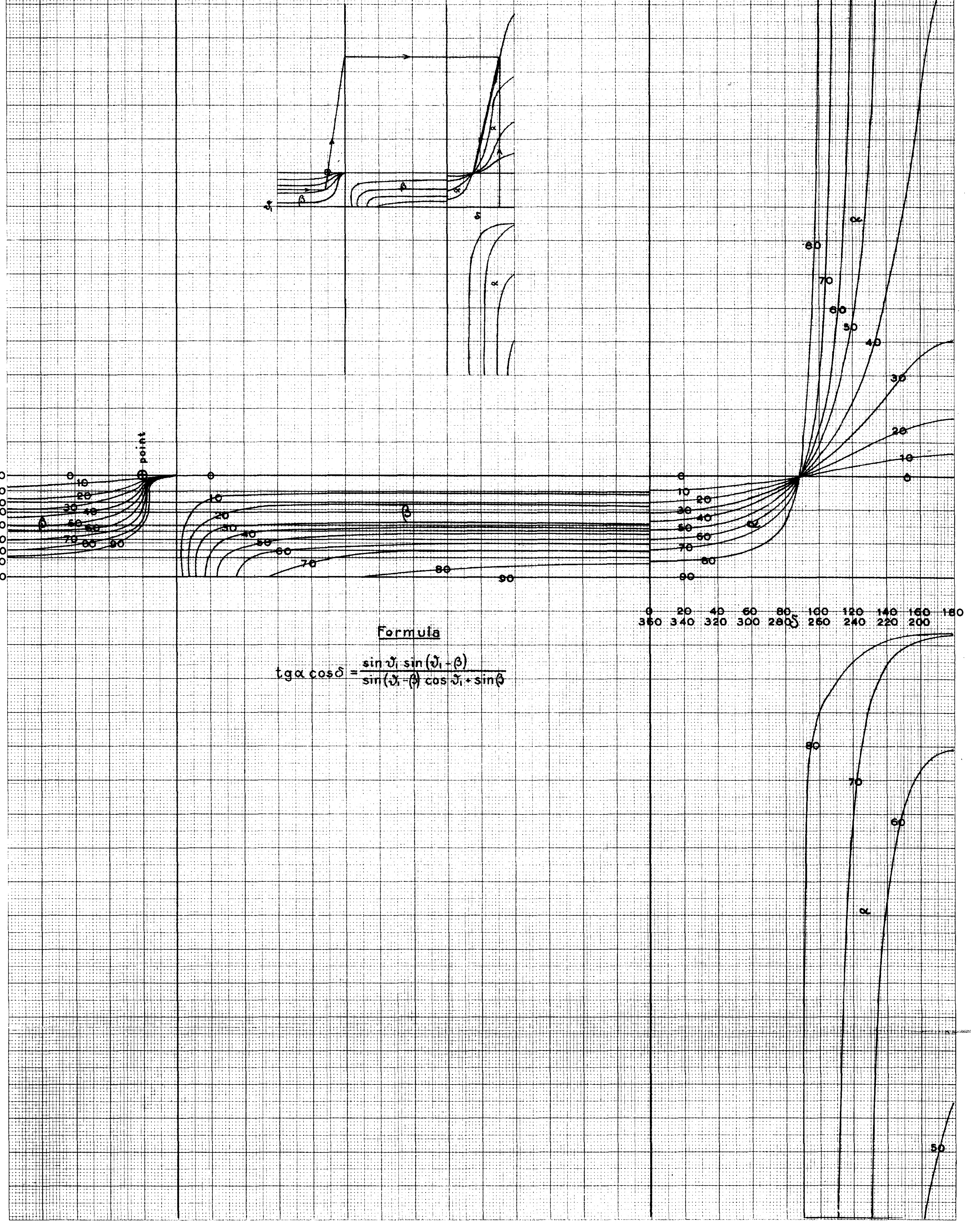
ϑ_1 dip of plane perpendicular on bore hole reduced in apparent dip direction

δ clockwise measured angle between apparent dip direction and true dip direction

β apparent dip

α true dip of stratum

INSTRUCTION



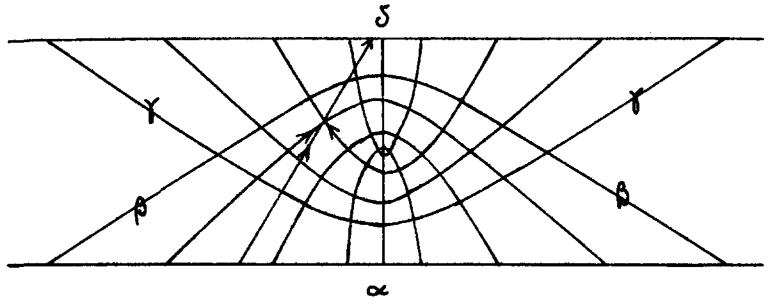
Formula

$$\mathrm{tg}\,\alpha\cos\delta = \frac{\sin\vartheta_1 \sin(\vartheta_1-\beta)}{\sin(\vartheta_1-\beta)\cos\vartheta_1+\sin\beta}$$

Strike and dip relations of two planes of reference

Strike determination

Instruction



Formula:

$$\operatorname{cotg}\delta \sin\gamma = \sin\beta \operatorname{cotg}\alpha + \cos\beta\cos\gamma$$

α. Dip of plane in respect to first reference plane

β. Dip of second reference plane in respect to first reference plane

γ. Clockwise measured angle between the positive strike of the first reference plane and the positive strike of the second reference plane, if greater than 180° the clockwise measured angle between the positive strike of the second ref. plane in respect to the strike of the first ref. plane

δ. Clockwise measured angle between pos. strike of second ref. plane to pos. strike of plane in respect to the second ref. plane

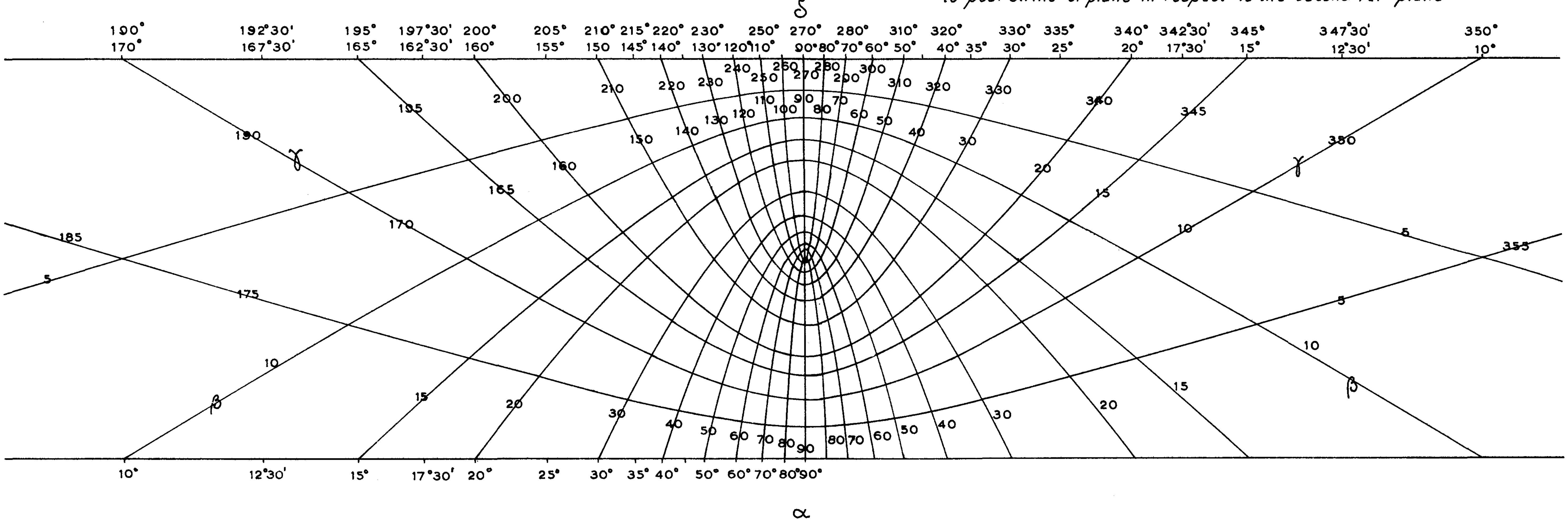
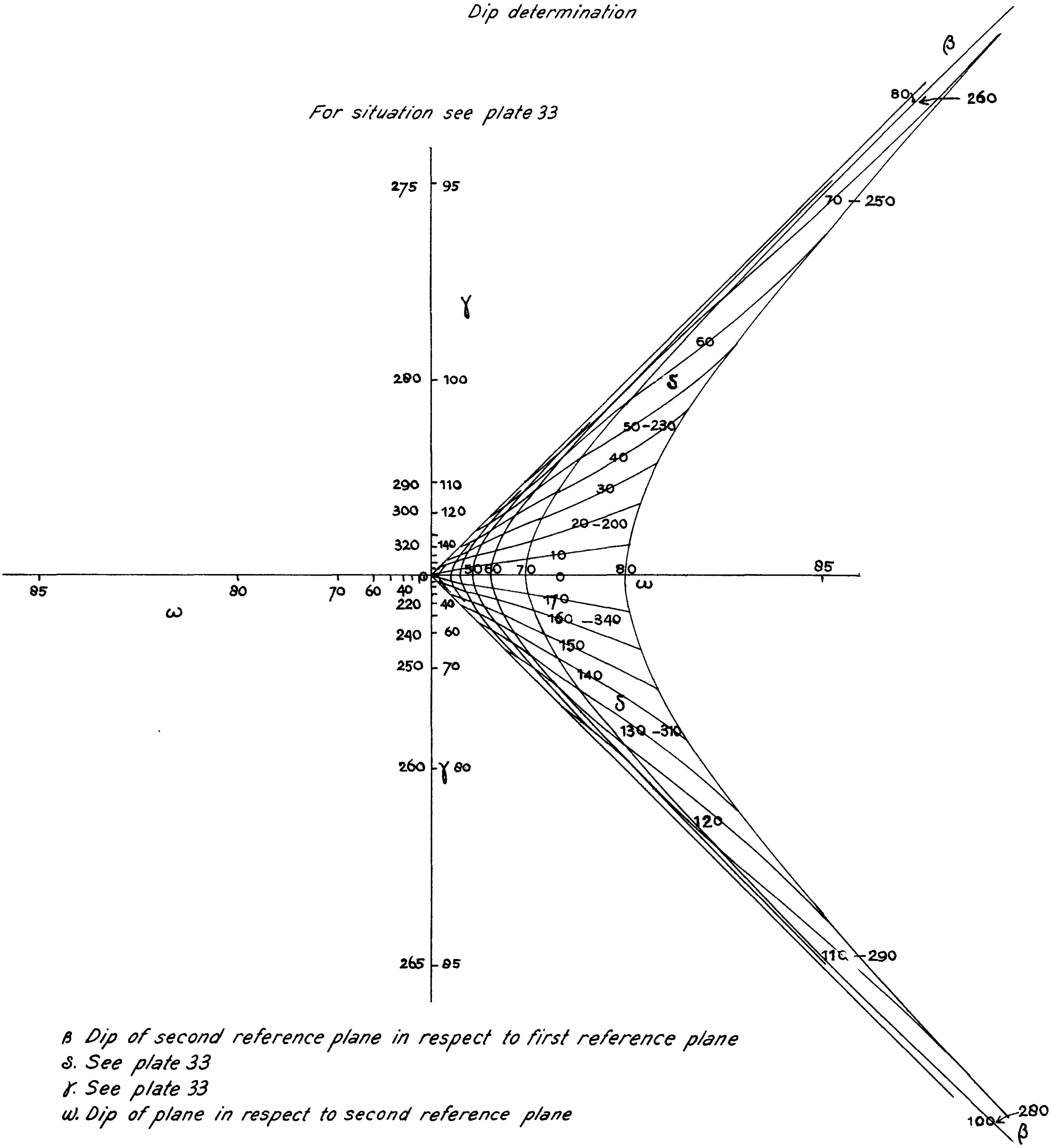


Plate 33

Strike and dip relations of two planes of reference

Dip determination

For situation see plate 33



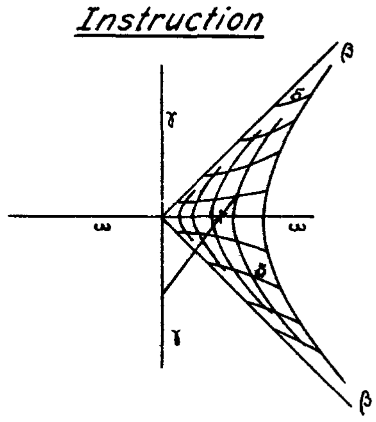
β Dip of second reference plane in respect to first reference plane

δ. See plate 33

γ. See plate 33

ω. Dip of plane in respect to second reference plane

Instruction



Formula:

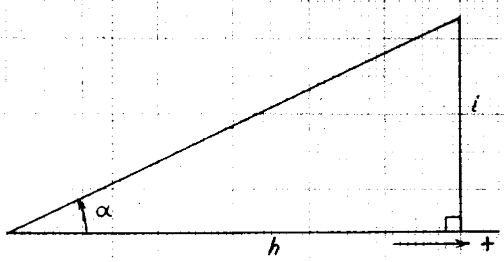
$$\frac{\cot g\,\omega}{\sin\delta}\sqrt{1-\cos^2\delta\cos^2\beta}-\cot g\,\delta\cos\beta-\cot g\,\gamma=0$$

Plaat 4a. Glooiing uit interval en afstand voor kleine glooiings∠∠ en grote glooiings∠∠ ni > 100 m

Plate 3 Slope from interval and contour distance for small slope angles and for large slope angles and ni > 100 m

$$tg\alpha = \frac{ni}{Sh_k}$$

$$Sh_k = h_t$$



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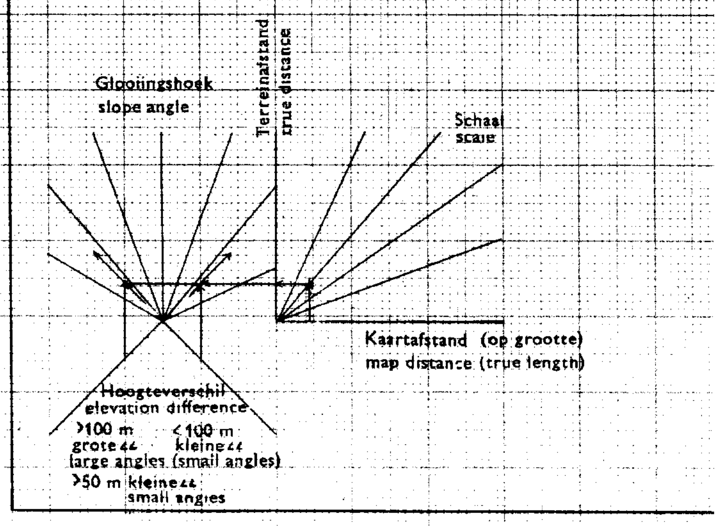
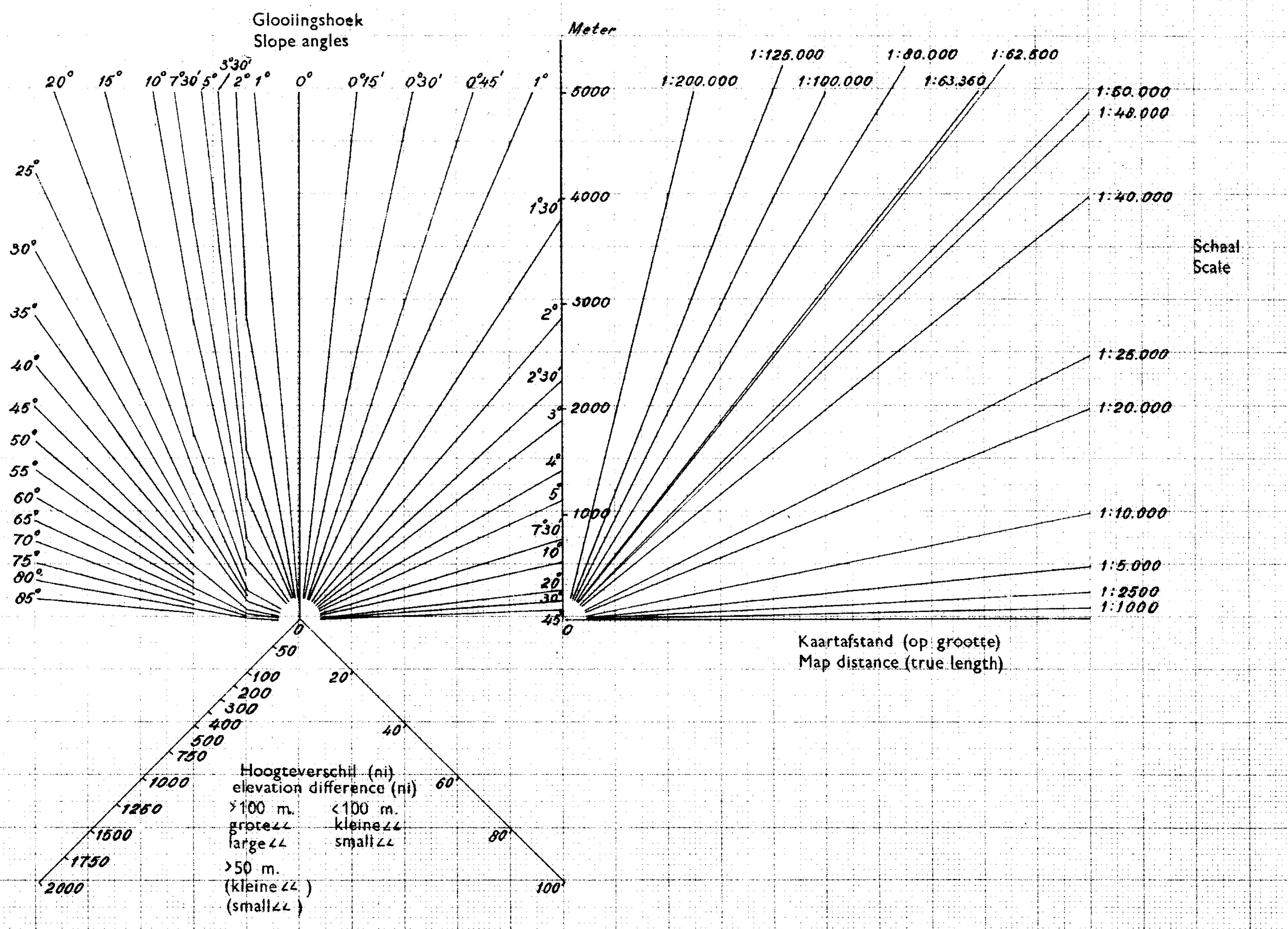
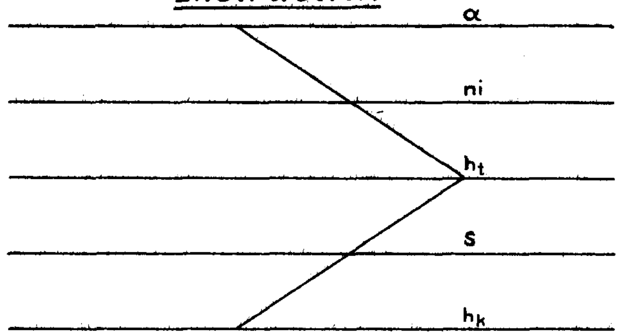
INSTRUCTION





The determination of the slope from the horizontal contour distance, the interval and the scale

Instruction



α. Slope
ni. Difference in elevation
h_t. Horizontal true distance
S. Denominator of scale fraction
h_k. Mapdistance

Formula:

$$\log tg\alpha = \log ni - \log S - \log h_k$$
$$\log h_t = \log S + \log h_k$$

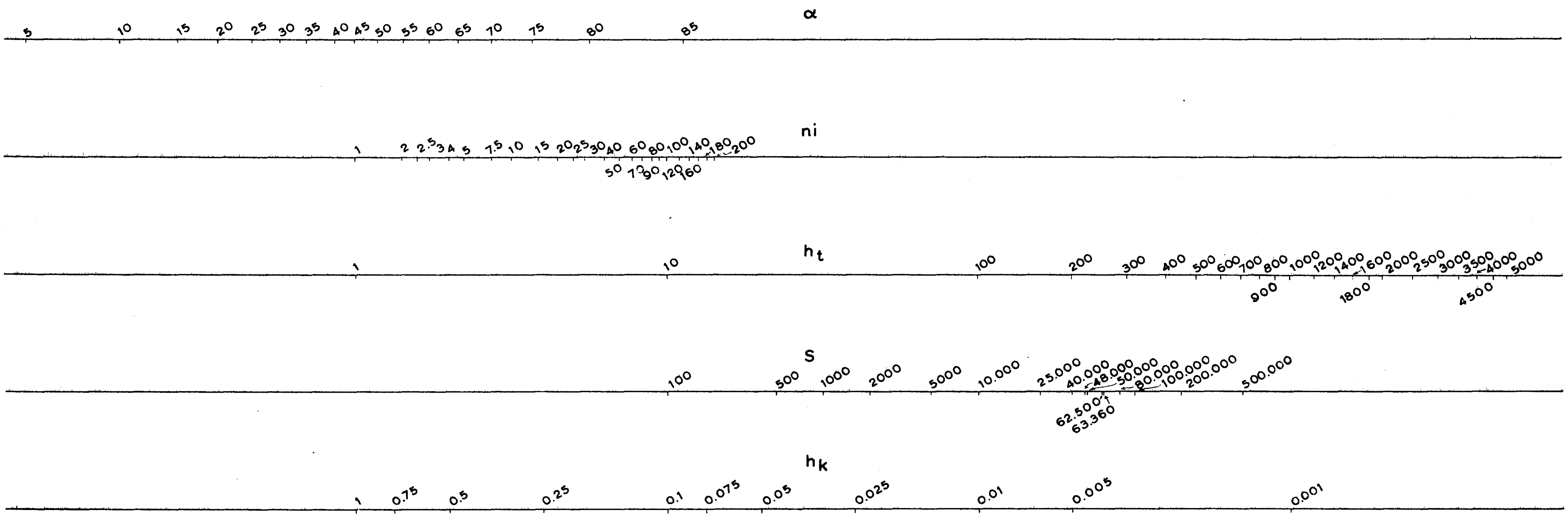
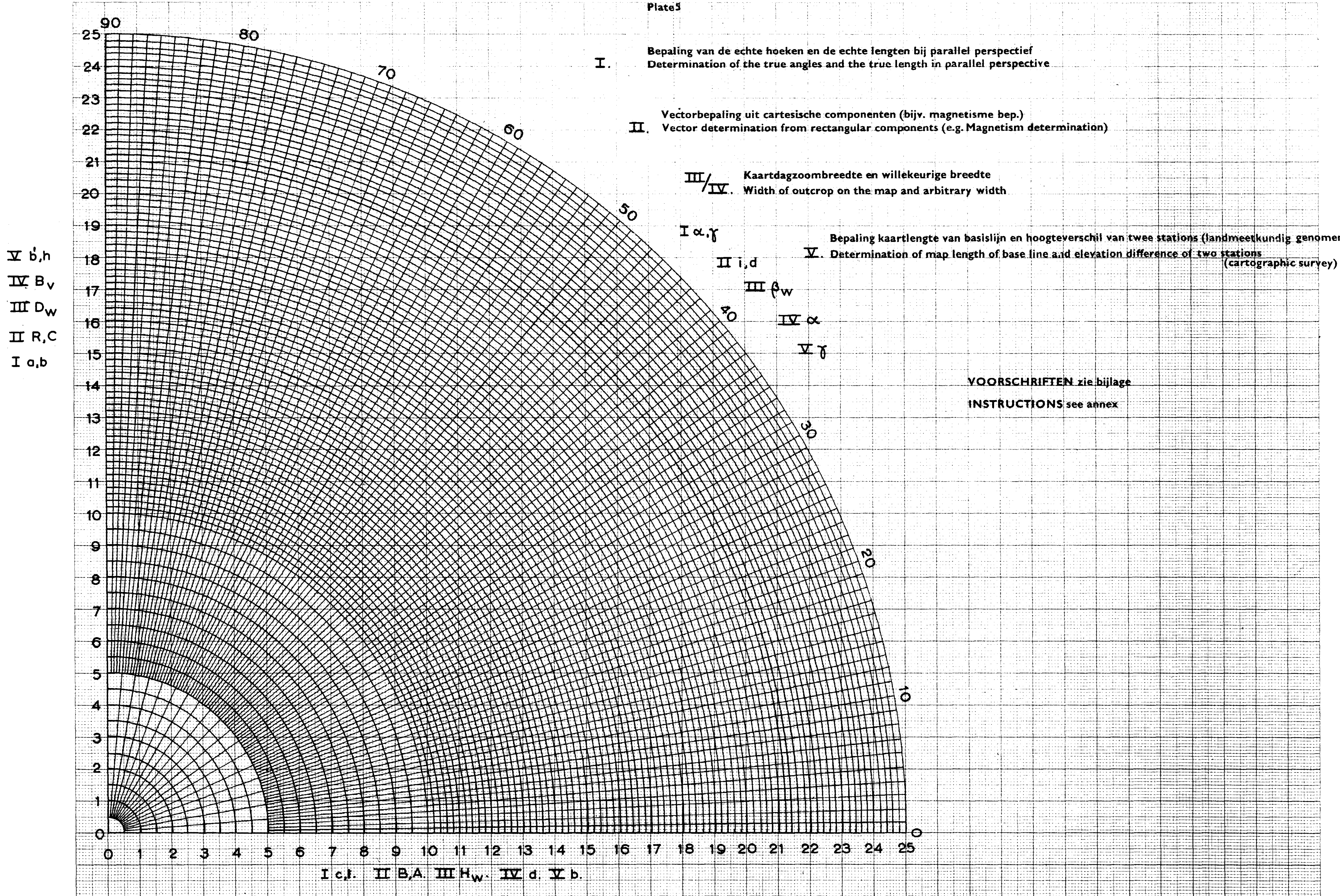


Plate 4

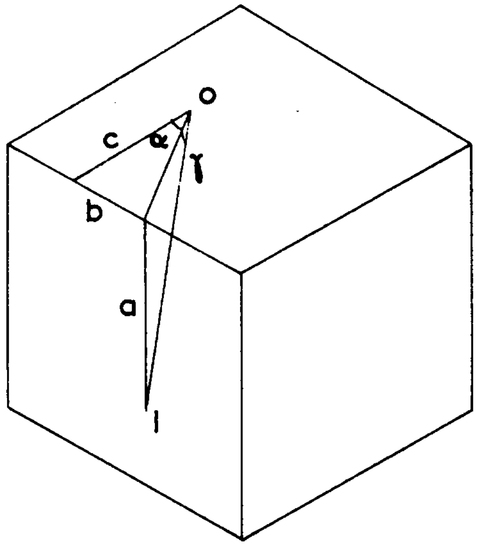
Plaat 17b.

Plate 5



I

Determination of the true angles and the true length in parallel perspective



a |vertical component|

b, c |horizontal components| (side ribs)

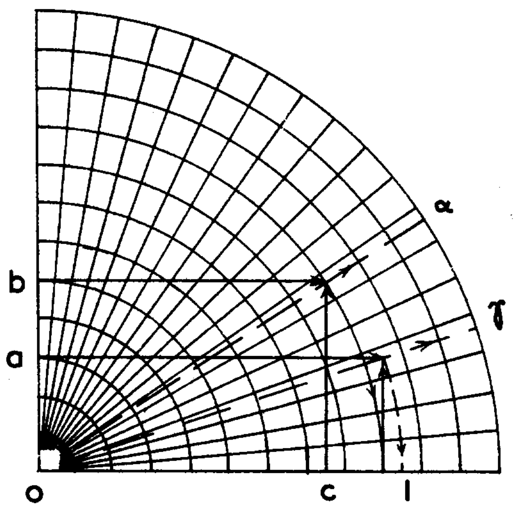
α direction angle between azimuth ol en c

γ dip

ol |true length|

Remark: scale a the correct length with respect to scale b and c.

Instruction



Formulae:

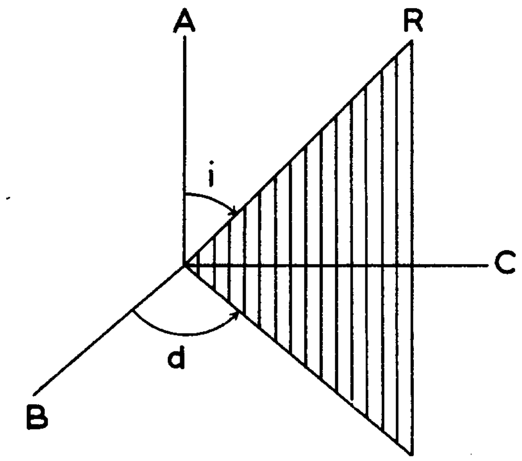
$$ol = \sqrt{a^2 + b^2 + c^2}.$$

$$tg\gamma = \frac{|a|}{\sqrt{b^2 + c^2}}$$

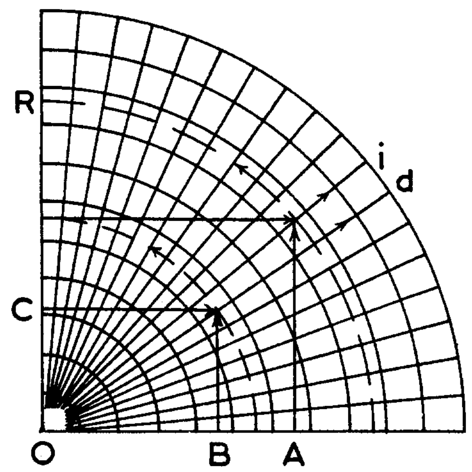
$$tg\alpha = \left|\frac{b}{c}\right|$$

II

Vector determination from rectangular components (e.g. magnetism determination)



Instruction



A |vertical component|

B, C |horizontal component|

R |length of vector|

i angle with vertical

d angle between azimuth R and |B| direction

Formulae:

$$R = \sqrt{A^2 + B^2 + C^2}.$$

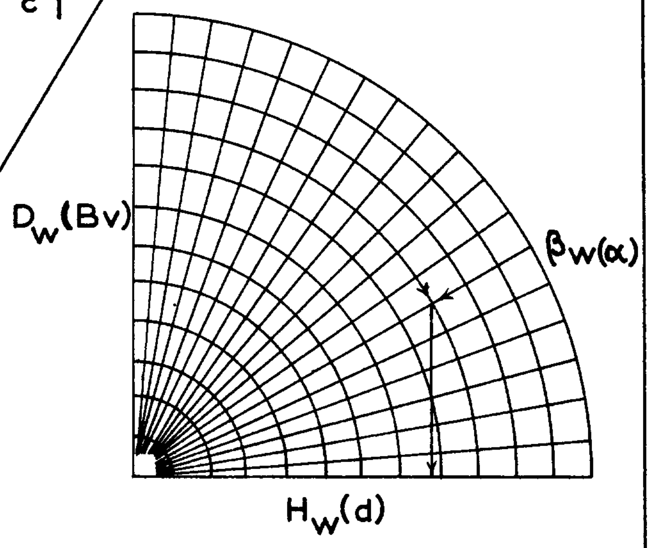
$$tg\, i = \frac{\sqrt{B^2 + C^2}}{|A|}$$

$$tg\, d = \left|\frac{C}{B}\right|$$

III/IV

Width of outcrop on the map and arbitrary width

Instruction



D_W arbitrary width

H_W width of outcrop on the map in an arbitrary direction

β_W dip of D_W

B_V vertical width

α dip of the stratum

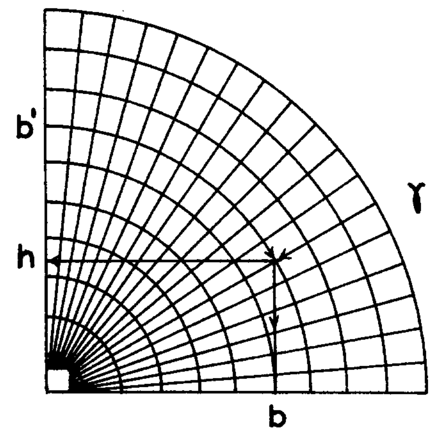
Formulae:

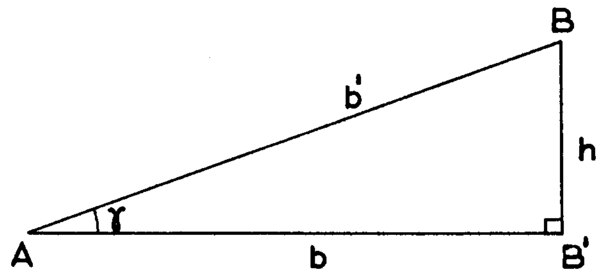
$$D_W = \frac{H_W}{\cos\beta_W} \qquad B_V = \frac{d}{\cos\alpha}$$

V

Determination of map length of the base line and elevation difference of two stations (cartographic survey)

Instruction





b' distance between two stations

γ |dip of the sightline from station A to station B|

b map distance between the stations

h |elevation difference between the stations|

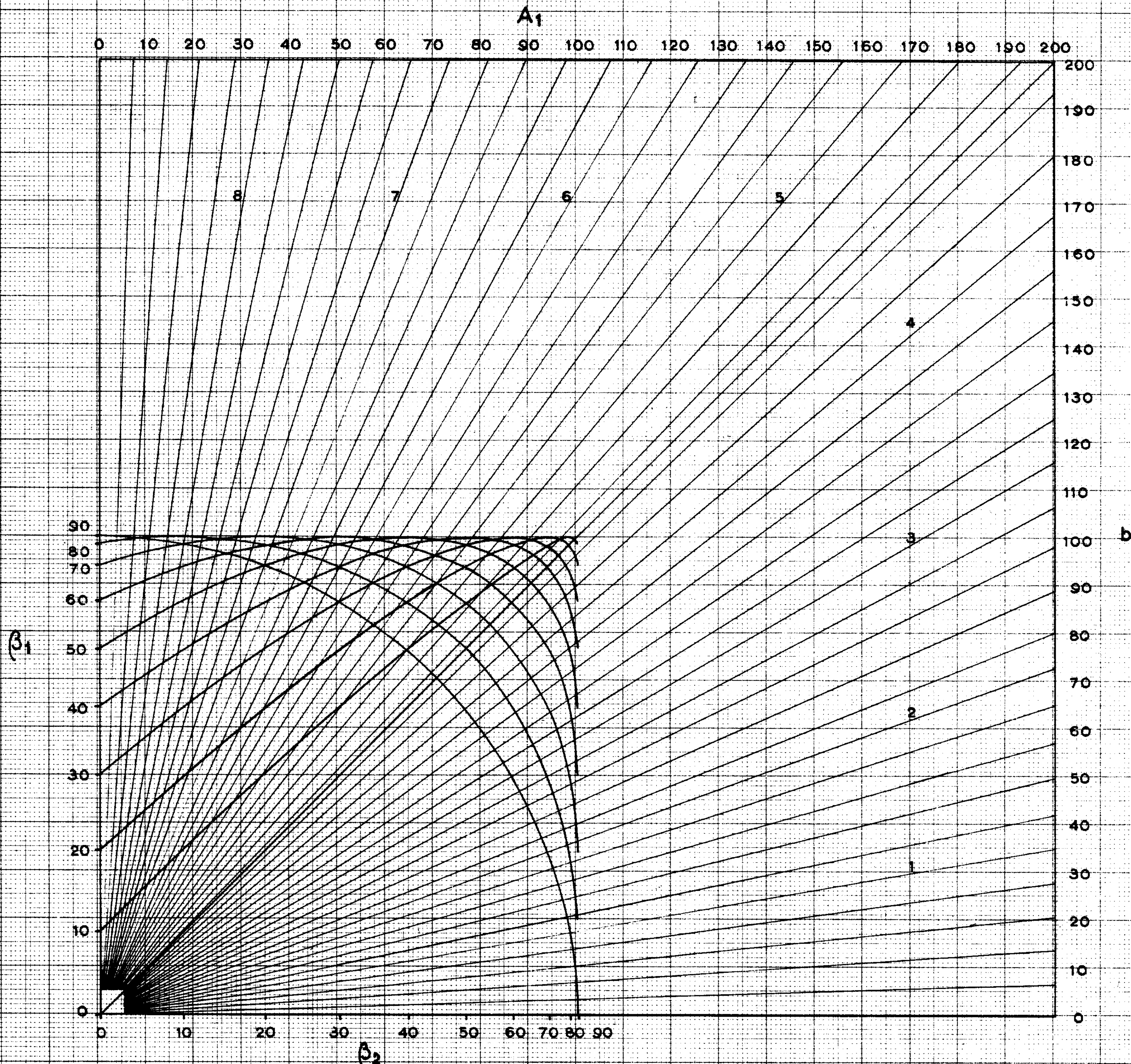
Formulae:

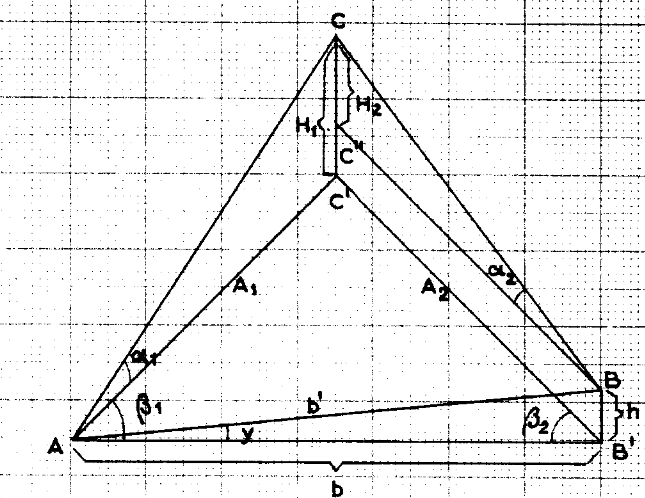
$$\frac{b}{b'} = \cos\gamma$$

$$\frac{h}{b'} = \sin\gamma$$

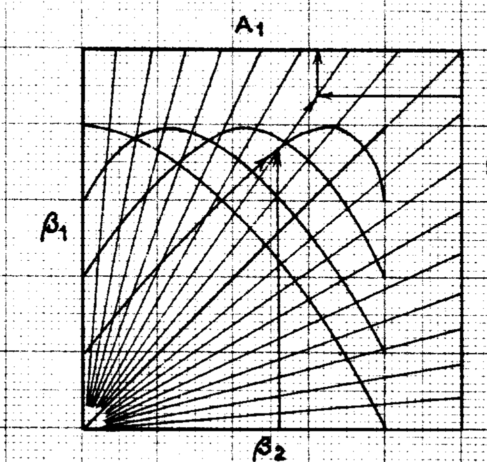
Plaat 30. Kartografisch nomogram voor afstandsbepaling bij driehoeksmeting
(voor hoogteverschil zie pl. 17b)

Plate 6. Cartographic nomogram for the determination of distance in triangulation
(for elevation difference see plate 5)





VOORSCHRIFT
INSTRUCTION



Formule:
Formula:

$$A_1 \sin(\beta_1 + \beta_2) = b \sin \beta_2$$

β_1 :	richtingshoek vanaf basislijn naar gezochte punt vanuit station 1	direction angle from base line to desired point from station 1
β_2 :	richtingshoek vanaf basislijn naar gezochte punt vanuit station 2	direction angle from base line to desired point from station 2
b :	horizontale lengte basislijn	horizontal length of base line
A_1 :	horizontale afstand van station 1 naar gezochte punt	horizontal distance from station 1 to desired point

Plate 7

Determination of distance and elevation difference from reading of the vertical stadia rod and dip (of instruments with an angle of vision of 10 mils

Distance determination $\gamma > 40$

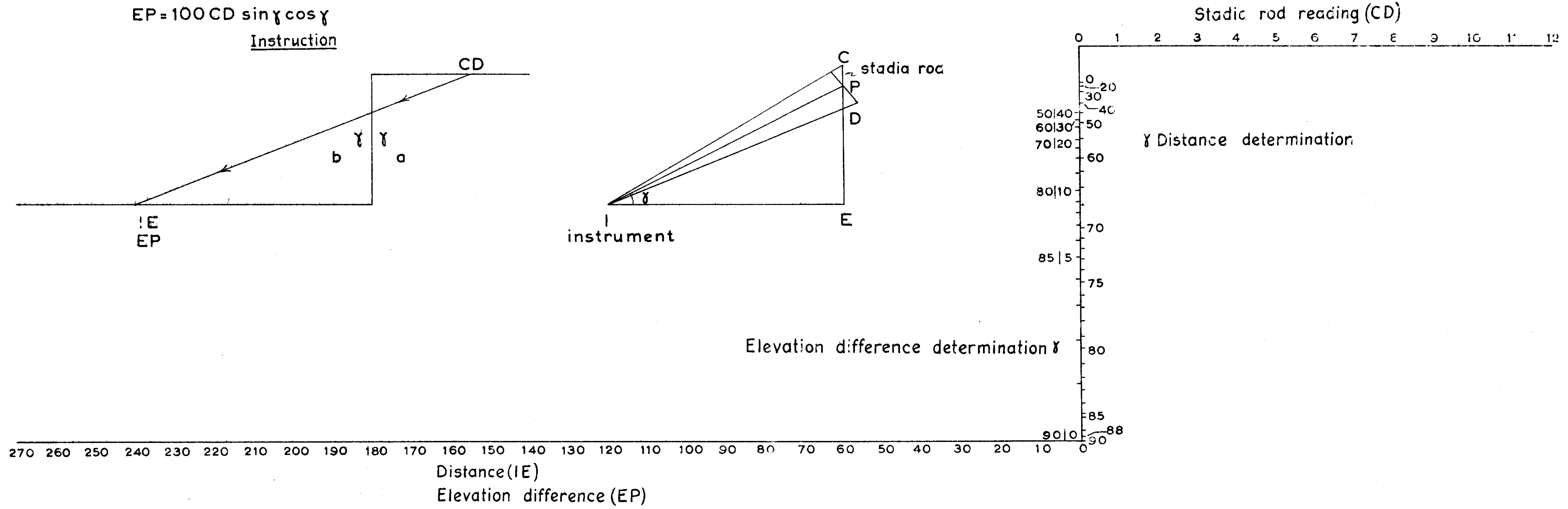
Elevation difference $\gamma \begin{cases} 0-20 \\ 70-90 \end{cases}$

Formula:

$IE = 100\,CD \cos^2\gamma$

$EP = 100\,CD \sin\gamma \cos\gamma$

Instruction



Plaat 31b. Bepaling van afstand en hoogteverschil uit verticale-baakaflezing en helling (bij instrument met gezichtshoek 10 mils)

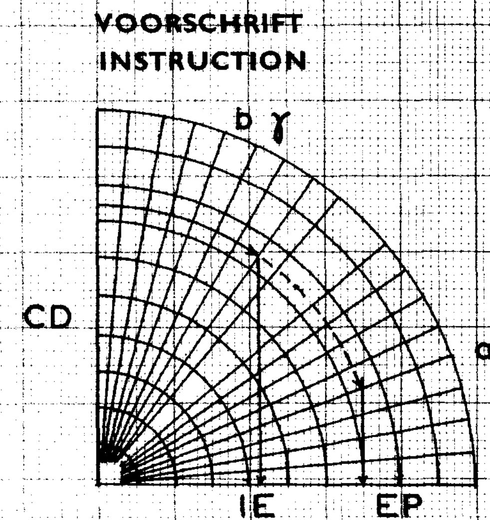
Plate 8. Determination of distance and elevation difference with reading of the vertical stadia rod and dip (of instrument with an angle of vision of 10 mils)

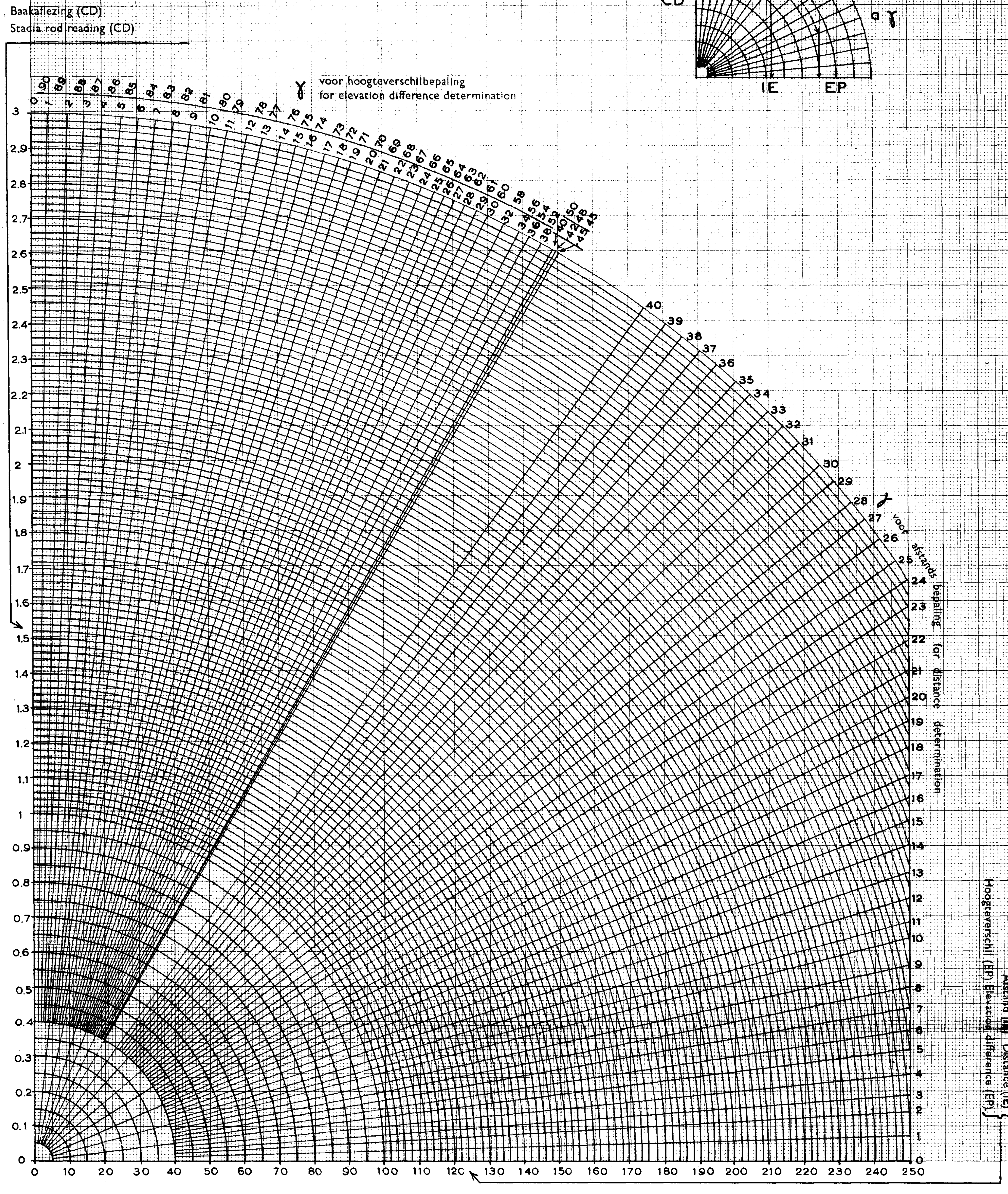
Afstandsbepaling
Distance determination $\gamma < 40$.

Situatietek. zie pl. 31a
Situation see plate 7

Formule
Formula

$$IE = 100\,CD\,\cos^2\gamma.$$
$$EP = 100\,CD\,\sin\gamma\,\cos\gamma.$$





Plaat 32. Hoogtemeter-Temperatuurcorrectie

A gemeten: gemeten hoogteverschil tussen station 1 en 2 (juiste hoogte van een der stations bekend)

A corr.t.: het in temperatuur gecorrigeerde hoogteverschil

T_1: temperatuur in ° F. van station 1

T_2: temperatuur in ° F. van station 2.

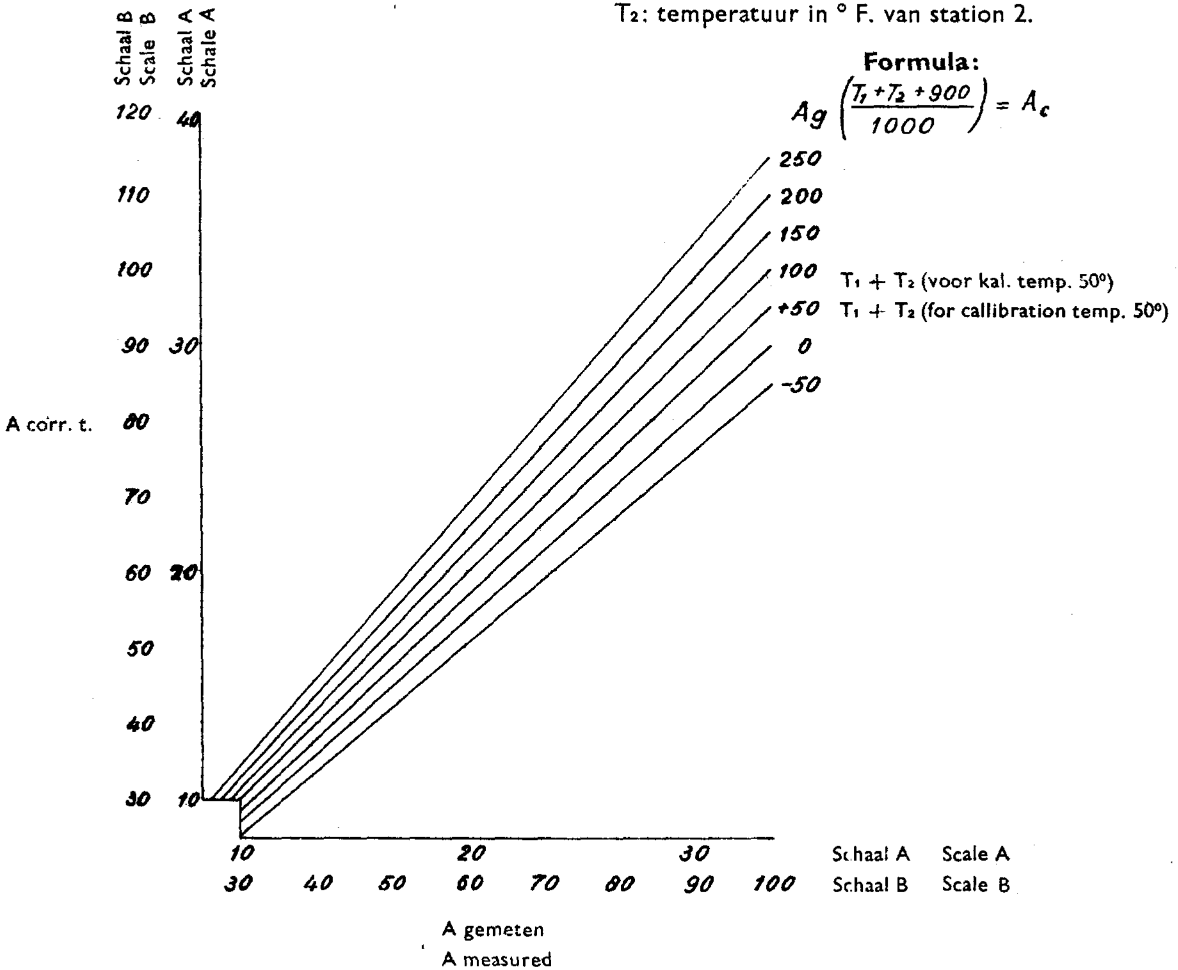
Plate 9. Altimeter temperature correction

A measured: measured elevation difference between station 1 and 2 (elevation of one station known)

A corr.t.: elevation difference corrected for temperature

T_1: temperature in F° station 1

T_2: temperature in F° station 2



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