Jan. 25, 1927. 1,615,510

W. F. GROTENDORST

TABULAR CALCULATING APPARATUS PARTICULARLY FOR USE IN THE LAYING OF ORDNANCE

Original Filed March 29 1926 3 Sheets-Sheet 1

Fig. 1.

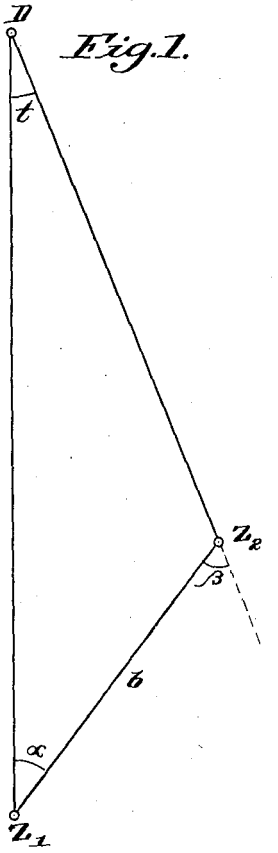
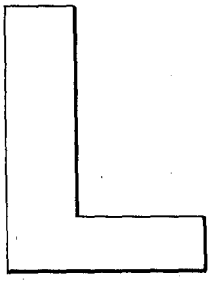


Fig. 5.



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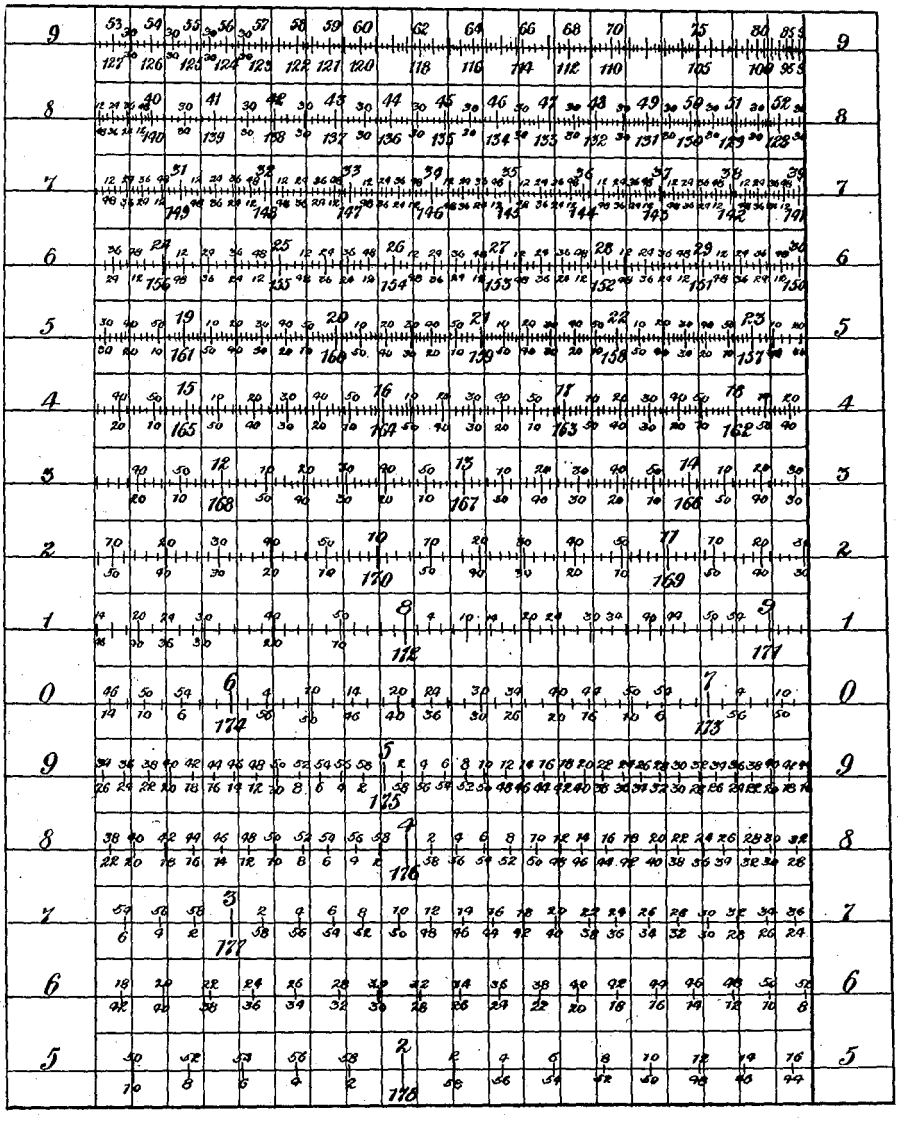
TABULAR CALCULATING APPARATUS PARTICULARLY FOR USE IN THE LAYING C^T ORDNANCE

Original Filed March 29, 1926 3 Sheets-Sheet 2

Fig. 2.



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Jan. 25, 1927. **1,615,510**

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TABULAR CALCULATING APPARATUS PARTICULARLY FOR USE IN THE LAYING OF ORDNANCE

Original Filed March 29. 1926 3 Sheets-Sheet 3

Fig. 3.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
6	39·3	40·0	40·0	40·0	40·1	40·1	40·1	40·2	40·2	40·2	40·3	40·3	41·0	41·0	41·1	41·1	41·1	41·2	41·2	41·2	41·3	41·3	41·3	42·0
7	50·0	50·1	50·1	50·2	50·2	50·2	50·3	51·0	51·0	51·0	51·1	51·1	51·2	51·2	51·3	51·3	52·0	52·0	52·1	52·2	52·2	52·2	52·3	53·0
8	63·0	63·1	63·1	63·2	63·3	63·3	64·0	64·0	64·1	64·1	64·2	64·3	65·0	65·0	65·1	65·2	65·2	65·3	65·3	66·0	66·1	66·1	66·2	66·3
9	79·2	79·2	79·3	80·0	80·0	80·1	80·2	80·3	81·0	81·0	81·1	81·2	81·3	81·3	82·0	82·1	82·2	82·2	82·3	83·0	83·1	83·1	83·2	83·3

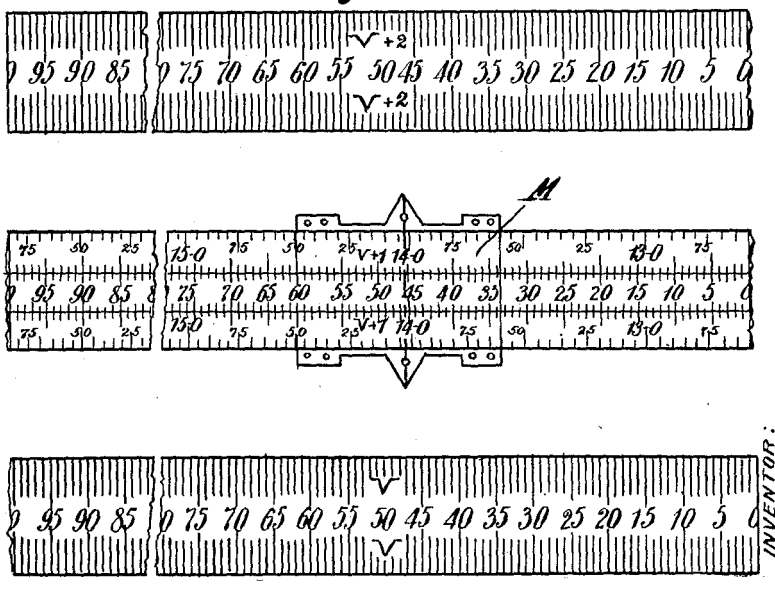
	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73
6	44·2	44·3	44·3	45·0	45·0	45·1	45·1	45·1	45·2	45·2	45·3	45·3	45·3	46·0	46·0	46·1	46·1	46·2	46·2	46·2	46·3	46·3	47·0	47·0
7	56·1	56·1	56·2	56·2	56·3	56·3	57·0	57·0	57·1	57·1	57·2	57·3	57·3	58·0	58·0	58·1	58·1	58·2	58·3	58·3	59·0	59·0	59·1	59·1
8	70·3	71·0	71·0	71·1	71·2	71·3	71·3	72·0	72·0	72·1	72·2	72·3	72·3	73·0	73·1	73·1	73·2	73·3	73·3	73·3	74·0	74·0	74·1	74·2
9	89·0	89·1	89·2	89·3	90·0	90·1	90·2	90·2	90·3	91·0	91·1	91·2	91·2	91·3	92·0	92·1	92·2	92·3	93·0	93·0	93·1	93·2	93·3	94·0

Fig. 3a.

24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
42·0	42·1	42·1	42·2	42·3	42·3	42·4	43·3	43·3	43·4	43·4	43·4	43·4	43·4	43·2	43·2	43·2	43·3	43·3	44·0	44·0	44·1	44·1	44·1	44·2	44·2
53·0	53·0	53·1	53·1	53·2	53·2	53·3	53·3	54·0	54·1	54·1	54·1	54·2	54·2	54·3	54·3	55·0	55·0	55·1	55·1	55·2	55·2	55·3	56·0	56·0	56·1
66·3	66·3	67·0	67·0	67·1	67·2	67·2	67·3	67·3	68·0	68·1	68·1	68·2	68·3	69·0	69·0	69·1	69·1	69·2	69·2	69·3	70·0	70·0	70·1	70·2	70·3
84·0	84·1	84·1	84·2	84·3	84·3	85·0	85·1	85·2	85·3	85·4	86·0	86·1	86·2	86·3	86·3	87·0	87·1	87·2	87·3	88·0	88·0	88·1	88·2	88·3	89·0

74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99
47·1	47·1	47·1	47·2	47·3	47·3	47·3	48·0	48·1	48·1	48·1	48·2	48·2	48·3	48·3	49·0	49·0	49·1	49·1	49·2	49·2	49·2	49·3	49·3	50·0	50·0
59·2	59·2	59·2	59·3	60·0	60·1	60·1	60·2	60·2	60·3	60·3	61·0	61·0	61·1	61·1	61·2	61·2	61·3	62·0	62·0	62·0	62·1	62·2	62·3	62·3	63·0
74·3	75·0	75·0	75·1	75·2	75·3	75·3	76·0	76·1	76·2	76·2	76·3	77·0	77·1	77·1	77·2	77·3	77·3	78·0	78·1	78·1	78·2	78·3	78·3	79·0	79·1
94·1	94·2	94·2	94·3	95·0	95·1	95·2	95·3	96·0	96·1	96·1	96·2	96·3	97·0	97·1	97·2	97·3	98·0	98·1	98·2	98·3	99·0	99·0	99·1	99·2	99·3

Fig. 4.



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Patented Jan. 25, 1927. 1,615,510

UNITED STATES PATENT OFFICE.

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TABULAR-CALCULATING APPARATUS PARTICULARLY FOR USE IN THE LAYING OF ORDNANCE.

Original application filed March 29, 1926, Serial No. 98,324, and in the Netherlands November 19, 1923. Divided and this application filed August 7, 1926. Serial No. 127,962.

This application is a division of my co-pending application Serial No. 98,324, filed March 29, 1926.

This invention relates to tabular calculating apparatus particularly for use in the laying of ordnance. The invention is particularly intended for use in conjunction with the device described in the specification of my co-pending patent application.

The main purpose of this invention is to provide a tabular device which shall permit of calculating the distance of an object or target from data obtained by simultaneous observations taken from each end of a known base line.

The present invention consists in an improved tabular calculating apparatus comprising a logarithmic scale constituted by a series of rows of equal lengths arranged one below the other, a ruler adapted to be used with said logarithmic scale three times the length of each of such rows and carrying an adjustable indicating mark and being uniformly graduated to indicate lengths in terms of the length of a row as a unit, and an anti-logarithm table for converting lengths read from the ruler into the data required, said table giving a plurality of answers for each fraction of a unit, so that when the answer is approximately known the ruler need only be read to the nearest two places of decimals in order to obtain an approximation corresponding to the use of three figure logarithms.

One form of the present invention is illustrated for the sake of example in the accompanying drawings in which:—

Fig. 1 indicates the positions of two observation posts and an object, and corresponds with part of the Fig. 1 of my above mentioned co-pending patent application.

Figs. 2 to 5 show the various elements of the apparatus, which are intended to be used in combination.

Fig. 2 shows a logarithmic chart indicating angles.

Figs. 3 and 3ª show an anti-logarithm table for converting logarithms into distances.

Fig. 4 shows a logarithmic rule with cursor.

Fig. 5 shows an indicating plate.

In Fig. 1, Z_1 and Z_2 represent two observation posts provided with angle measuring instruments, and D represents the position of an object or target. The distance $Z_1 Z_2 = b$. α is the bearing angle at which the object or target is seen from Z_1, and β is the supplement of the bearing angle at which the object or target is seen from Z_2. t is the so-called vertical angle.

The angles α and β are measured simultaneously at the posts Z_1 and Z_2.

From this we find

$$\angle\beta - \angle\alpha = \angle t.$$

In $\Delta Z_1 Z_2 D$ the following elements are now known:

$$Z_1Z_2 = b \quad \angle Z_1DZ_2 = \angle t \text{ and } \angle DZ_1Z_2 = \alpha$$

From this triangle may be obtained the equation Z_2D: Sin $\alpha = b$; sin t which reduces to

$$Z_2D = \frac{b \sin \alpha}{\sin t},$$

whence

$$\log. Z_2D = \log. b + \log \sin \alpha - \log \sin t. \quad (1)$$

From this formula the distance Z_2D can be calculated, which distance is necessary for determining certain data required for the indirect laying of ordnance, as described in the specification of my co-pending patent application.

The calculation of Z_2D according to the formula (1) would of course in practice require too much time and to facilitate rapid calculation of this distance Z_2D the apparatus which embodies the present invention is provided, the various details of which are illustrated in the Figures 2, 3, 4 and 5. By this calculating device a simple displacement of some parts, which may be done by unskilled hands, permits of immediately reading Z_2D. The usual table of logarithms works with numbers which must be added or subtracted. The principle of the calculating table constructed according to the invention is that it adds or subtracts lines, which lines, as regards their length, correspond with the logarithms. Keeping this in view the arrangement of the calculating device will be easily understood.

This calculating device consists of a table of angles (Fig. 2); three tables of distances

(one of which is shown in Figures 3 and 3a); four rulers with transparent slide (in Figure 4 one of them is shown); and a small transparent plate of special shape (Figure 5).

In the table of angles log. sin α and log. sin t are indicated, in the ruler log. b, and in the table of distances log. Z_2D. This is effected in the following way:—

The table of angles (Fig. 2) is constituted by a number of rows arranged under each other and provided with graduations showing degrees and minutes. The degrees and minutes are indicated by numbers under and above the marks, namely the degrees in large type and the minutes in small type. The numbers indicating angles greater than 90° are arranged under the corresponding rows, and those which indicate angles less than 90° are arranged above the rows. The mark indicating 90° is arranged at the top right-hand corner, so that proceeding from this point the rows run from the right to the left and then downward to the next row, etc., above the rows the angles decrease from 90° and under the rows the angles increase from 90°. Furthermore the numbers 9, 8, 7, 6, 5, 4, 3, 2, 1, 0, 9, 8, 7, 6, and 5 are arranged beside the rows. These numbers represent the first decimal of the log. sines, so that in the uppermost row are found all the angles of which the first decimal of the log. sin is 9; on the second row from the top are the angles of which the log. sin is 8, etc.: If for instance

$$\angle\alpha = 46° 30', \text{ log. sin } \alpha = 986056 - 10$$

and therefore $\angle 46° 30'$ will be found in the second row from the top, the first decimal of the log. sin being 8 and this number 8 being found opposite said second row.

The position of the angles in the row depends on the second and third decimal of the log. sines. It is sufficient to take the log. sines to three places of decimals. Again taking as example

$$\angle\alpha = 46° 30', \text{ log sin } \alpha \text{ being } 9.861 - 10.$$

The second and third decimal form the number 61. The angle 46° 30′ should therefore be 61/100ths of the length of a row from the left edge of the row.

Similarly log. sin 10° 20′ = 9.254—10.

The angle 10° 20′ is therefore found in the row opposite which 2 is placed, and 54/100ths of the length of a row from the left edge of the row.

By locating the indications of the angles in this way it follows that, in order to obtain log. sin a—log. sin t, the first decimal is obtained by subtracting the number at the end of that row in which angle t is found from the number at the end of that row in which angle a is found, and the second and third decimals are found by reading, by means of one of the rulers shown in Fig. 4, by what percentage of the length of a row the angle indications are separated laterally.

A ruler by which these lateral distances are determined is shown in Fig. 4, and comprises three portions each having a length equal to the length of a row in the table of angles, shown in Fig. 2, and each uniformly graduated from right to left into one hundred divisions with suitable indications for each five divisions. Above and below the graduations of the middle portion, other graduations are provided together with suitable indications of distance.

The last-mentioned graduations are made such that the distances given correspond with the logarithmic divisions in the middle portion of the ruler, i. e. each graduation of distances is placed opposite that mark of the logarithmic scale which denotes the second and third decimal of the logarithm of the distance concerned.

The distances indicated in the ruler shown in Fig. 4 are those from 1260 (the logarithm of which is 3.100) to 1585 (the logarithm of which is 3.200). It will be understood that a suitable number of rules is provided to cover any length of base line which it is desired to use. For instance, if another base line is established having a length of 3758 meters (or yards, or other unit in which it is desired to measure range) another rule would be provided on which 3162 (the logarithm of which is 3500) would be indicated at the right edge or zero of the center portion of the ruler, and 3981 (the logarithm of which is 3.600) would be indicated at the left edge or 100 mark of such center portion.

In order to adjust the ruler to a certain distance a transparent slide M, made for instance of mica and provided with two indicating points is provided. In order to adjust this slide to a given distance it is so set that the vertical line connecting the two indicating points coincides with the graduation showing the base line used. Adjacent their centers, each portion of each ruler such as shown in Fig. 4 bears an identifying indication, the left portion bearing the indication V+2, the central portion V+1 and the right portion V. The letter "V" is used, in using the apparatus, to indicate the difference between the first decimals of log sin a and log sin t, which is found in the table of angles (Fig. 2) by subtracting the numbers found at the ends of the rows in which the angles a and t occur. This difference usually constitutes the first decimal of the logarithm of the range Z_2D, but this first decimal will be one more if the left hand portion of the ruler must be used or one less if the right hand portion must be used.

By adjusting the slide upon the ruler to

the distance Z_1Z_2 and then placing the ruler itself with this indicating point opposite the angle α in the table of angles, and by further observing by the aid of the transparent plate shown in Figure 5 which number of the ruler is found in the same perpendicular with the angle t in the table of angles, there is only determined, strictly speaking, the second and third decimal of log Z_2D which is equal to log

$$b+(\log \sin \alpha - \log \sin t).$$

The first decimal of log Z_2D is indicated in the table of distances namely at the left opposite the rows of distances, while the numbers formed by the second and third decimal of log Z_2D are also shown in the table of distances, namely above the rows of distances. It is advisable that the second and third decimals of log Z_2D should be indicated both on the ruler and on the table of distances in red.

Three tables of distances are used, one for distances between 1 and 5 kilometres, one between 4 and 10 kilometres and one between 10 and 32 kilometres. By way of example the table 4—10 kilometres is shown in Figures 3 and 3^a. Each table of distances is provided with two rows of numbers preferably in red (from 0–49 inclusive and from 50–99 inclusive) which as stated above form the second and third decimals of log Z_2D. Under every red number we find under each other four members preferably in black, which indicate the distances corresponding to these logarithms. In the drawing the usual artillery notation is followed, in which the two numbers before the hyphen indicate hundred of metres, and the number after the hyphen so many times 25 metres, so that for instance the notation 66—3 represents a distance of 6675 metres.

In this way two groups each having four horizontal rows of distances are formed. Opposite each of these rows a number is placed which as stated above corresponds with V and therefore forms the first decimal of log Z_2D.

If the calculations are to be effected on the assumption that the base Z_1Z_2 is 1403 metres for example: then that ruler is taken on which said distance is found, and the indicator of the mica slide is adjusted as exactly as possible to 1403 metres (see Figure 4). The ruler is then ready for use. The table of angles (Fig. 2) is then placed ready for use and the table of distances (Figure 3) is attached on it for instance by means of clips. The choice of which table of distances to use depends on the distance at which a target may be expected. In the example assumed here this distance is between 4 kilometres and 10 kilometres. The table of distances referring thereto is indicated in Figures 3 and 3^a. The ruler which is arranged ready for use is laid in any place on the table of angles, parallel to the rows occurring on that table. Furthermore, a transparent indicating plate (Figure 5) is taken in the right hand, and the operator then waits until the angles α and t are determined.

For the sake of clearness a concrete example will be further worked out, and it will be assumed that

$$\angle\alpha = 41^\circ\,36' \text{ and } \angle t = \angle\beta - \angle\alpha = 8^\circ.$$

The operator looks up $\angle\alpha$ in the table of angles and finds it on the second row from the top, at one mark to the right from the 30 mark lying between 41° and 42°. The ruler is then displaced horizontally by the left hand over the table of angles until its indicating point is set vertically above or below the $\angle\alpha$ i. e. 41° 36′. He then ascertains by displacing by the right hand the transparent plate, which red number of the ruler is now vertically above the vertical angle i. e. above 8°. This appears to be about 26. Below the red number 26 on the table of distances the distance Z_2D is now found. However, four distances are found there namely 42—1, 53—1, 67—0 and 84—1. As a rule there is no doubt which of these four distances is the correct one, because from the previous measurement the distance is already known approximately. It may therefore only occur at the first calculation that it is not known which of the four distances is to be chosen. If the distance is measured by a range-finder there is no doubt possible, because although the measurement at large distances is very inaccurate, yet at any rate its accuracy is sufficient to indicate which of the given four distances is correct. If no range-finder is at hand, it is still possible by the construction of the calculating device to make the right choice at the first measurement. This may be done as follows:—Opposite the rows on which in the table of angles the angles α and t occur numbers are indicated. In the given examples these are the numbers 8 and 1. The difference V of these is taken, i. e. 7. Above the group of numbers to which the number read from the ruler (26) belongs is indicated V+1. Now from the four distances, that one must be chosen which belongs to the horizontal row opposite which is the number V+1, in the given case 7+1=8. The correct distance is therefore 67—0, i. e. 6700 m. In practice the use of the calculating device is very simple. It only consists in displacing with one hand the ruler and with the other hand the mica plate.

I claim:

A tabular calculating apparatus comprising a logarithmic scale having a series of rows of equal length and arranged one below the other, each row being indicated by a numeral, and having anti-logarithm indications each located in that row indicated

by the first decimal of its logarithm and spaced from the end of its row by the number of hundredths of the length of the row corresponding to the second and third decimals of its logarithm, and a ruler having a portion thereof of the same length as a row of said scale graduated into one hundred equal divisions adapted when an antilogarithm thereof representing a factor is adjacent the antilogarithm of another factor on a row of the tabular scale to determine on the rule certain logarithmic characteristics of the final factor by the intersection of a line projected from an antilogarithmic factor on another row of the tabular scale.

In testimony whereof I have signed my name to this specification.

WILLEM FREDERIK GROTENDORST.