PATENT SPECIFICATION

Application Date: Jan. 5, 1925. No. 28,557/25. **254,589**

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COMPLETE SPECIFICATION.

Improvements in or relating to Tabular Calculating Apparatus particularly for use in the Laying of Ordnance.

I, WILLEM FREDERIK GROTENDORST, of Koningstraat 4A, Helder, Holland, a subject of the Queen of Holland, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

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 No. 254,351.

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 observations taken from both ends 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 three times the length of a row carrying an adjustable indicating mark and uniformly graduated to indicate lengths in terms of the length of a row as a unit and adapted to be used in combination with said logarithmic scale, 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 Specification No. 254,351.

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

Figs. 2 and 2^a show portions of a logarithmic chart indicating angles.

Figs. 3 and 3^a 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 $\triangle Z_1 Z_2 D$ the following elements are now known: $Z_1 Z_2 = b$ $\angle Z_1 DZ_2 = \angle t$ and $\angle DZ_1 Z_2 = \alpha$.

From this triangle may be obtained the equation

$Z_2D : \text{Sin } \alpha = b ; \text{ sin } t$ which reduces to

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

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

From this formula the distance Z_2D can be calculated, which distance is necessary for determining certain data required for the indirect laying of ordn

ance, as described in the Specification No. 254,351.

The calculation of Z_2D according to the Formula (1) would of course in practice require too much time and therefore according to the invention a tabular calculating apparatus is used, 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 (Figures 2 and 2^a) three tables of distances (one of which is shown in Figures 3 and 3^a), 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 a 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 (Figures 2 and 2^a) 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 1—15. 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. sines is 9; on the second row from the top are the angles of which the log. sines is 8, etc.: If for instance $\angle a = 46° 30'$, log. sin $a = 0.86056 - 1$ and therefore $\angle 46° 30'$ will be found in the second row from the top, the first decimal of the log. sines 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 $\angle a = 46° 30'$, log sin a is taken $0.861 - 1$. The second and third decimal form the number 61. The angle 46° 30′ is now found at $2 \times 61 = 122^m/_m$. going to the right from the beginning of the row (the whole row being $200^m/_m$. long).

Similarly log sin 10° 20′ = $0.254 - 1$. The angle 10° 20′ is therefore found in the row opposite which 2 is placed, namely at $2 \times 54 = 108^m/_m$. to the right from the beginning of the row.

By setting the angles in this way in the rows it follows that the difference of the distances of two angles exactly constitutes the number which must be added to log b (i.e. log sin a − log sin t) in order to obtain log Z_2D. The rulers by which this difference is determined may be used at both sides and contain at each side three groups of numbers, each group running from 0—100. The subdivisions are such that said difference of distances may be read accurately to the nearest unit. Each group is as long as one row of the table of angles, so that the ruler has three times the length of such a row. The figures arranged opposite the marks are those which constitute the second and third decimal of the logarithm of a distance.

Above and underneath the middle group of numbers other graduations are provided on which the length of the base $Z_1 Z_2 = b$ at intervals of 5 metres (by the use of four rulers, for instance, it is possible to work with bases between 800 metres and 5000 metres).

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.

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 used bases. Furthermore above each group of numbers on the rulers the letter V occurs, whether or not followed by a number preceded by a plus or minus

mark. This letter V shows the difference between the first decimals of log sin α and log sin t, which first decimals are found in the table of angles opposite the rows of distances. This difference usually constitutes the first decimal of log Z_2D. However, it is possible that this first decimal of log Z_2D is one more or one less. For this purpose the indications V+1, V+2 etc., are used. If upon the middle group of the ruler V+1 is marked then the right part of the ruler must be marked V, and the left part of the ruler must be marked V+2.

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 obtained from the equation log b + (log sin α - 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 4 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 3a. Each table of distances is provided with two rows of preferably red numbers (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 preferably black numbers, 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 behind the hyphen so many times 25 metres, so that for instance the notation 39—3 represents a distance of 3975 metres.

In this way two times 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 (Figures 2 and 2a) is then placed ready for use and the table of distances (Figure 3) is attached to it for instance by means of clips. The choice of the table of distances 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 3a. 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 the concrete example will be further worked out, and it will be assumed that $\angle \alpha = 41^\circ 36'$ 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 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 a 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 both hands the ruler and the mica plate.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. An improved tabular calculating apparatus particularly for use in the laying of ordnance, comprising a logarithmic scale constituted by a series of rows of equal lengths arranged one below the other, a ruler three times the length of a row carrying an adjustable indicating mark and uniformly graduated to indicate lengths in terms of the length of a row as a unit and adapted to be used in combination with said logarithmic scale, 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.

2. A tabular calculating apparatus as claimed in Claim 1, comprising (*a*) a table of angles, (*b*) one or more tables of distances, (*c*) one or more rulers with a transparent slide belonging thereto, and (*d*) preferably a transparent indicating plate, the table of angles consisting of a number of rows arranged one below the other in which the angles from 0° to 90° are continuously marked off increasing from the lowest row upward, and those from 90° to 180° continuously increasing from the uppermost row downward in such a way that those angles, the first decimal of whose log sine is the same, are arranged in the same horizontal row, said first decimals being indicated opposite their corresponding rows and the angles being so marked out in the various rows that the distances from the beginning of the row are proportional to the fraction indicated by the second and third decimals of the log sine, the tables of distances being constituted by two times four horizontal rows of distances arranged one below the other, in which the distances, the first decimal of whose logarithm is the same, are arranged in the same horizontal row, said first decimals being indicated opposite their corresponding rows, while those distances, the second and third decimals of whose logarithms are the same, are arranged in the same vertical row, said second and third decimals being indicated above the row, the rulers being divided into three parts, of which each part is as long as a horizontal row of the table of angles and is provided with a scale graduated from 0—100, said graduations corresponding to the fraction formed by the second and third decimals of the logarithms of a distance, a second scale being provided on the central part, the graduations of which indicate distances and are set out in such a way that each distance of second scale corresponds to that point of the first-mentioned logarithmic division which indicates the fraction formed by the second and third decimals of the distance in question.

3. The improved tabular calculating apparatus substantially as hereinbefore described and illustrated in the accompanying drawings.

Dated this 12th day of November, 1925.

MARKS & CLERK.

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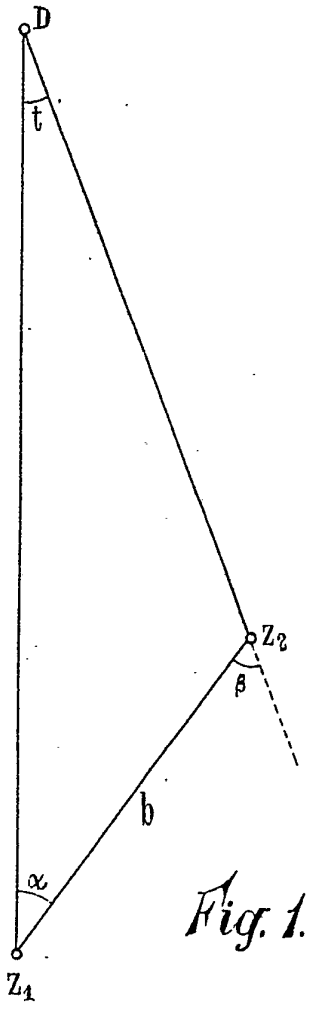


Fig. 1.

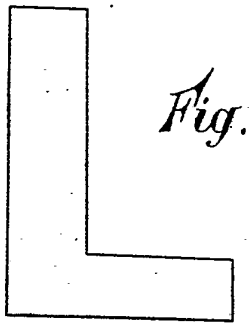
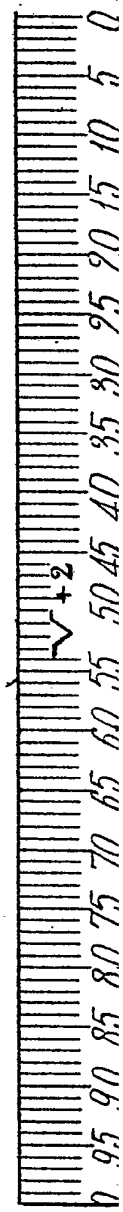
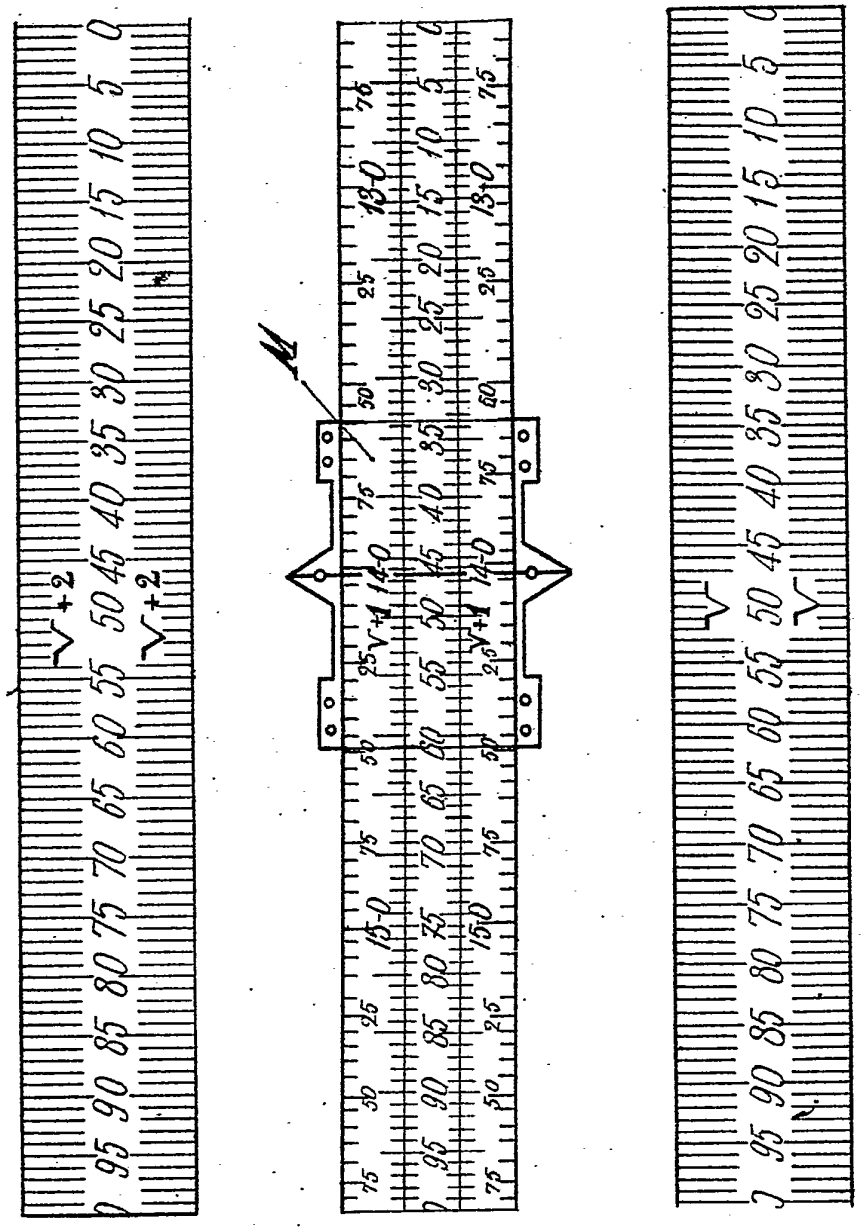


Fig. 5.



T 1

Fig. 4.



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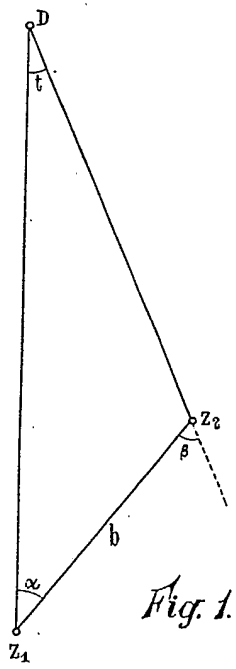


Fig. 1.

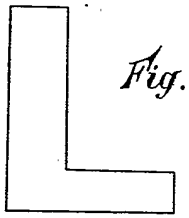
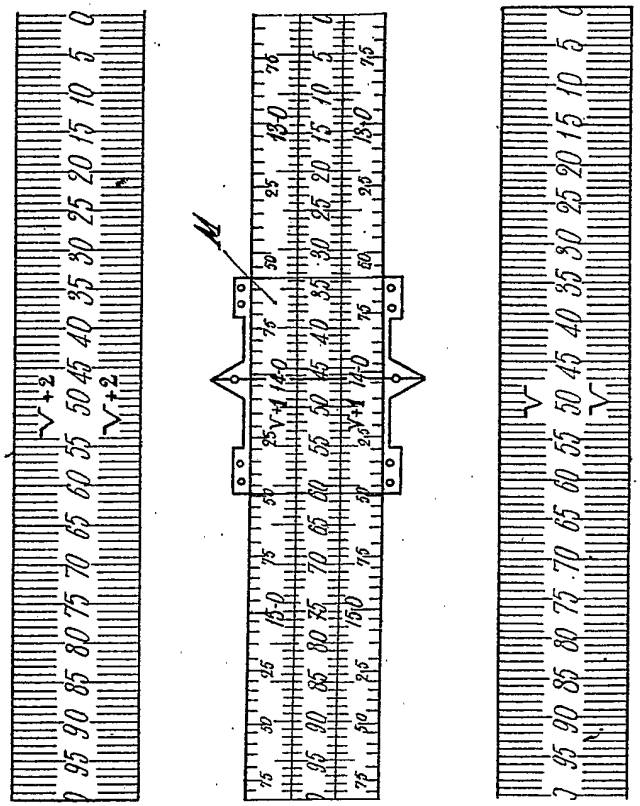


Fig. 5.

Fig. 4.



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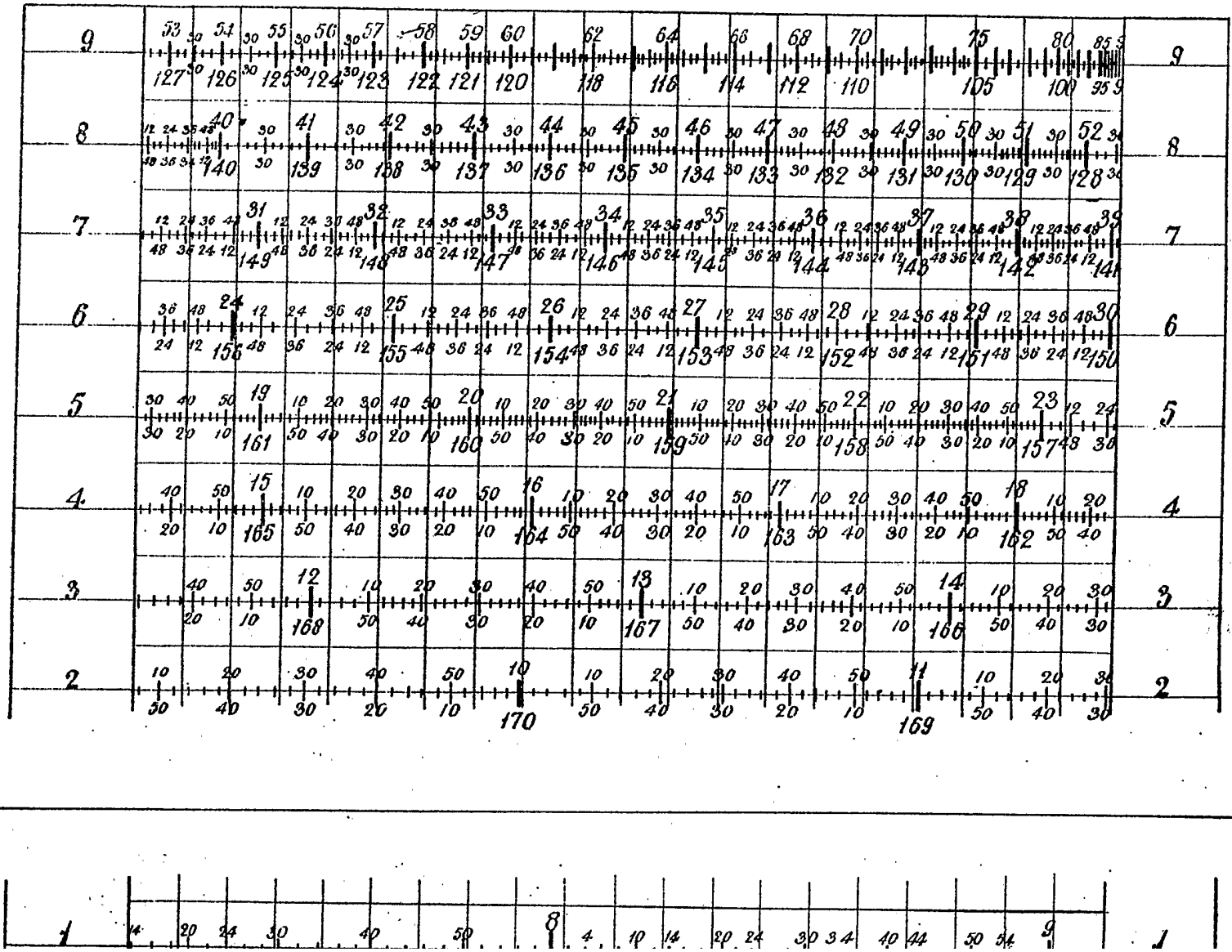

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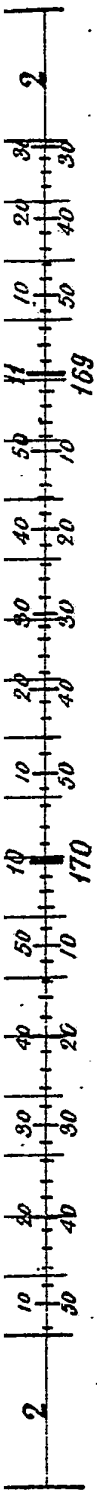
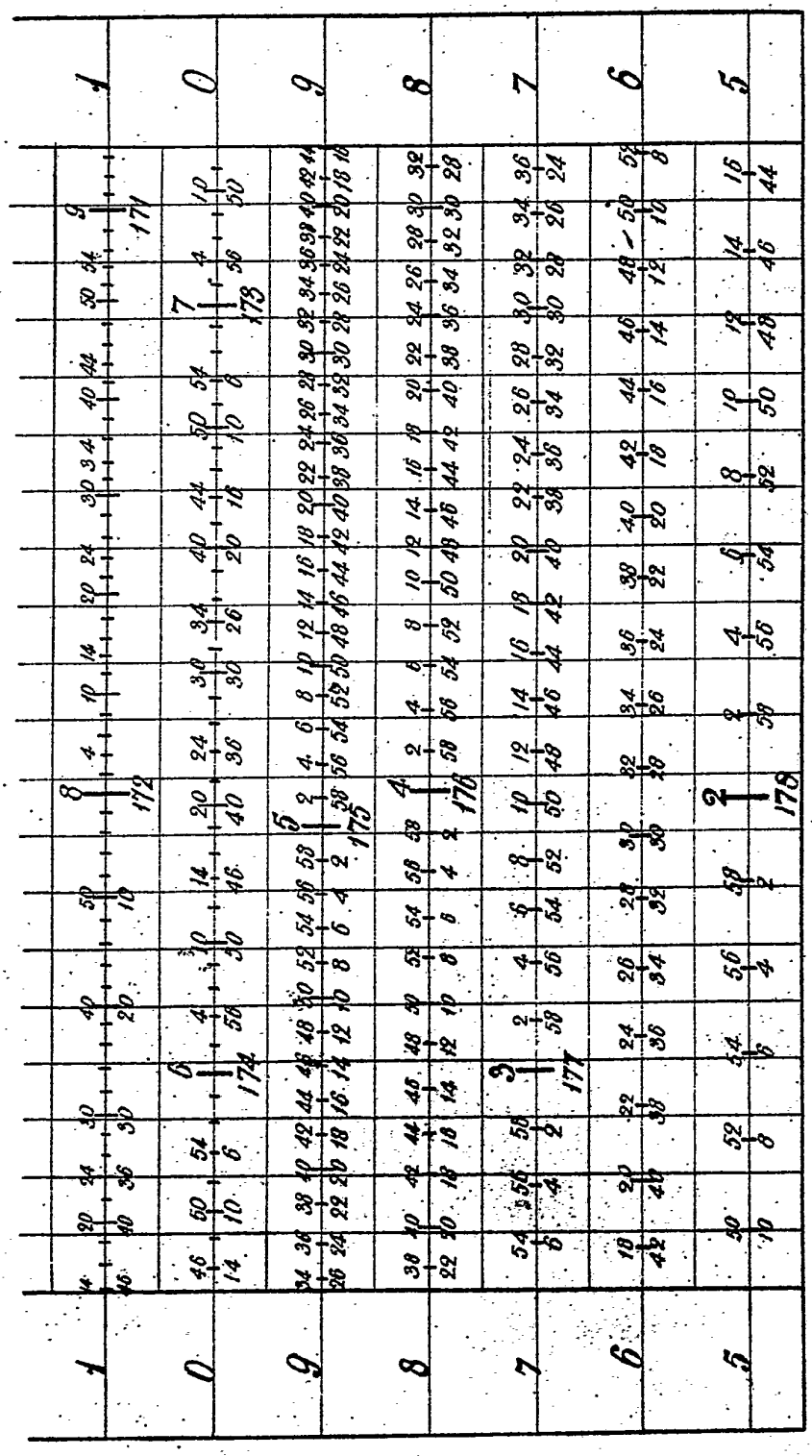
Fig 2.

- SHEET 2

SHEET 2

Fig. 2.d





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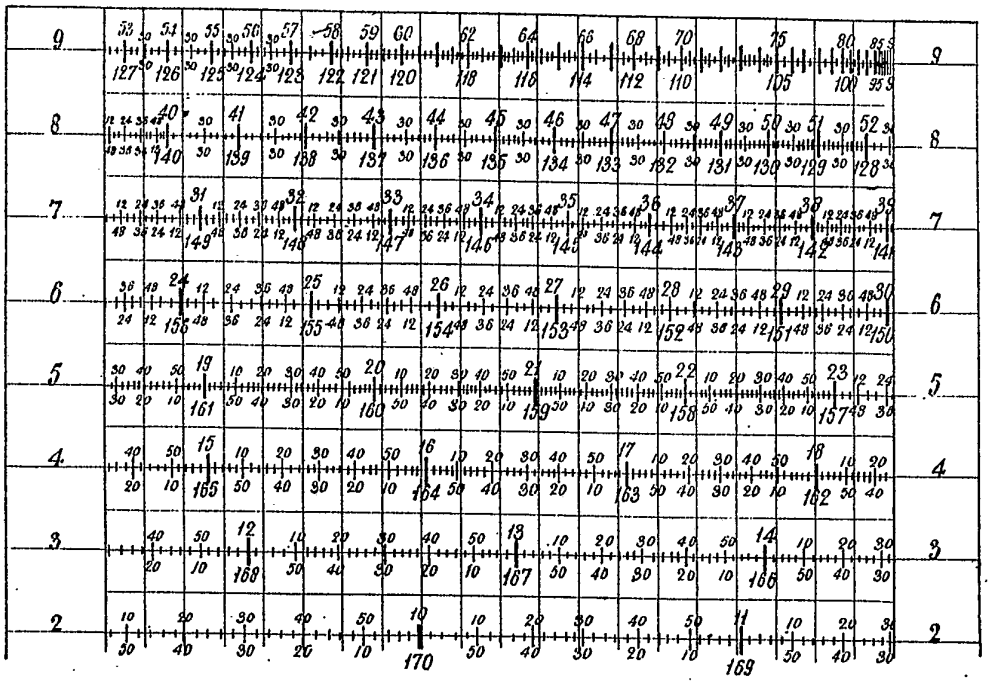

Fig 2.

SHEET 2

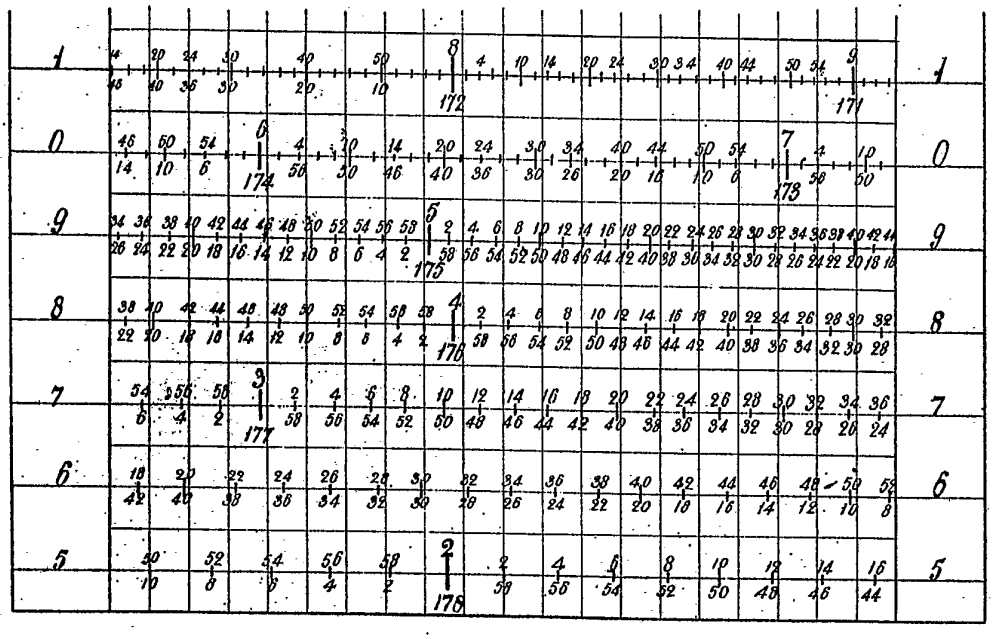

Fig 2.a

6 SHEETS
SHEET 3

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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	80-1	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	90-1	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. 3.

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SHEET 4

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	42·1	42·2	42·2	42·2	42·3	42·3	43·0	43·0	43·0	43·1	43·1	43·2	43·2	43·2	43·3	43·3	44·0	44·0	44·0	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	86·0	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	47·2	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

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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
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9	79-2	79-2	79-3	80-0	80-1	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	90-1	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. 3.

SHEET 4

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	42-1	42-2	42-2	42-2	42-3	42-3	43-0	43-0	43-0	43-1	43-1	43-2	43-2	43-2	43-3	43-3	44-0	44-0	44-0	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	86-0	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	47-2	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. 3a

6 SHEETS
SHEET 5

Charles & Read Ltd. Photo Litho.