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COMPLETE SPECIFICATION.

Improvements in or relating to Slide Rules.

A communication from Luigi Rizzoli, of Bologna, Italy, Engineer.

I, Alfred Julius Boult, of 111, Hatton Garden, in the County of Middlesex, Chartered Patent Agent, 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 applies to a rule modified so as to enable it to be used for tacheometric calculations, giving sines and cosines with a much greater exactitude than hitherto and the coordinates with an approximation hitherto not attained and this by a single position of the slide or movable part of the rule, without any advantages inherent to the rule being lost.

The rule according to this invention as regards the fixed part differs from the ordinary rule only by a scale D of equal divisions being added to the edge of the rule.

The front face of the fixed rule has therefore marked on it in the usual manner along the upper edge a logarithmic scale of numbers, extending through two units or consecutive intervals, of the powers of 10, and along its lower edge another scale or of numbers extending through a single interval or through a single logarithmic unit but of double length.

On the front side of the slide—which is also the same as usual—the same logarithmic tables of numbers are repeated arranged identically with those of the fixed rule.

To read off, a glazed slider C is provided with an indicating line continued on to the metallic part along the edge of the latter and serving to transmit the indications on to the scale of equal parts (Fig. 3) on the side.

The essential modifications of the rule according to this invention are as follows:—

On the other side of the slide B (Fig. 2) instead of the usual scales giving the values of log. sin., log. tan. and of equal divisions, there are engraved or marked the following scales.

1. Along the upper edge, the series of the values of log. sin. A cos. A the value of A varying between 0·64 and 50 if the graduation is the centesimal, or between equivalent angles, if sexagesimal graduations be adopted, the intervals between consecutive lines being as small as is consistent with clearness for reading.

2. Along the central line of the slide, the values of log. $\sin.^2$A are marked between the limits of A = 0.64 and A = 6.38 for centesimal graduation or corresponding limits for sexagesimal graduation.

[*Price 8d.*]

3. Along the lower edge there are marked the values of the same log. sin.^{2}A between the limits of A = 6.30 and A = 100 for centesimal graduation or between corresponding limits for sexagesimal graduation.

At the ends and in the middle of the scales are three transverse lines, so as to subdivide the three scales into six half scales.

At the right hand end of the right hand half scale, and at the left hand end of the left hand half-scale, there are marked numbers which may be just as well the characteristics as the numbers of figures of the natural values of the functions within the semi-scale at the side of which they are arranged. In the example illustrated (Fig. 2) these numbers are the characteristics.

Manner of using the rule. The rule according to this invention is especially adapted for calculations required in surveys made by the method of tacheometry, which calculations are as follows :—

1. Given the generating number N of a point surveyed and the angle A of the depression or elevation of the line of collimation to the horizon to find :

a) The correction to be made in N in order to obtain D, *i.e.*, the horizontal distance of the point surveyed.

b) The difference in the level *h* between the centre of the instrument and the point of collimation on the levelling staff.

Answer. The two determinations are based on two formulae

$$D = N - N.\ \sin.^2 A \text{ and}$$

$$h = N.\ \sin.\ A\ \cos.\ A$$

and are obtained by a single position of the slide.

The left hand (or the right hand) end of the slide is brought under N read on the left hand (or right hand) scale of the upper fixed part. The slider is placed on the angle A read on one of the two lower scales of the slide, and there is obtained at the corresponding point of the upper fixed scale, the correction N. sin.^{2}A which is to be subtracted from N in order to obtain D.

Leaving the slide in the same place, the slider is placed on A, read on the upper scale of the slide, and at a corresponding point of the upper scale of the fixed rule, there will be obtained *h*.

For most values of A it is possible to start from N read either on the right or left hand scale of the fixed rule. For certain values of A, however, it is not immaterial but it is necessary to use one or the other of the scales so as to have A both in the upper and in the lower scale of the slide comprised between the fixed rule (which is always possible).

Then there will be obtained by means of numbers on the side of the half-scales the figures or the characteristics of the results.

Instead of corrections of N, it is possible to find directly the distance D if, instead of placing the slider on A it is placed on 100 − A, as in this case there will be obtained N. cos.^{2}A = D.

2. Given the distance D of a point from the surveying station and azimuthal angle A of its radius vector, to find the rectangular co-ordinates D. sin. A and D. cos. A of the point.

This can be done by means of the new rule in two different ways.

The first is the same as for other rules and consists in using the two lower scales of the rule by referring them to the lower scale of the fixed rule relatively to which they represent not the log. sin.^{2}A but log. sin. A, as the logarithmic unity of the base of this scale is the double of the upper scale of the fixed rule.

If one of the ends of the slide is brought to D on the fixed rule, and the slider on the angle A, there will be obtained on the corresponding end of the lower fixed scale D sin. A. By moving the slider to 100—A in a similar manner D. cos. A will be obtained. Very often the two determinations require two positions of the slide as 100—A may lie outside the fixed rule.

For small angles A or near 100, one of the co-ordinates becomes inexact as the slider comes near the end 100 of the slide where the angles A are crowded in a small space.

The second system of finding the co-ordinates is peculiar to the rule according to the present invention and obviates the above mentioned drawback and at the same time has the great advantage of giving the two co-ordinates with great approximation and with a single position of the slide. This system is based on the formulae D sin. A, D cos. A transformed as follows:

$$D. \sin. A = 2. \quad D \sin. \frac{A}{2} \cos. \frac{A}{2}$$

$$D. \cos. A = D - 2.D \sin.^2 \frac{A}{2}$$

These formulae reduce the determination of coordinates to the use of the scales of the slide, combined with the upper scales of the fixed rule, by following the same method as described for the correction of N and determination of *h*, except that D is doubled and the angle A is halved.

Moreover, by taking care to render A less than 50 which is always possible— the reading of A always remains in the first divisions of the scale, *i.e.* in a position very favourable for obtaining a great approximation to exactness. 3. Although the scale of the tangents has been suppressed it is always possible to find the tangent of any angle by the formula

$$\frac{\sin.^2 A}{\sin. A. \cos. A} = \tan. A$$

which can be determined by a single position of the slider for any angle.

All the described determinations are obtained without appreciable error for angles less than 0·64, if care is taken to operate in an analogous manner, as well as for angles A 10,100 or 1000 times greater, but, of course, the variations in the characteristics must be taken into consideration.

The advantages of the new rule are as follows.

The rule can be used for all calculations for which an ordinary Mannheim rule can be used, and serves for calculations involving trigonometric functions. Sines, cosines, tangents, cotangents, the approximation for sin. and cos. being much greater than in the ordinary rules, as the scales for them are of double length.

The new rule can be moreover used for all calculations required in rapid measuring, the operation being very simple and quick.

Finally, this rule gives, by a single position of the slide, the co-ordinates with an approximation hitherto unattained in apparatus of the same length.

By means of a rule 25 cm. long such as the one shown in the accompanying drawing, and for distances D up to 400 metres, the co-ordinates are obtained with an error which never exceeds 10 cm. and as a rule is within 5 cm.

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

1. A slide rule provided on the reverse side of the slide instead of with the ordinary divisions, with values of log. sin., log. tan. and equal parts, the upper edge being marked, in the manner described with divisions for log. sin. A cos. A along the central line, and along the lower edge the divisions for log. sin.^{2} A, whereby the co-ordinates can be calculated with great exactitude by a single position of the slide, the instrument being suitable for calculations in tacheometric surveys without losing any of the advantages of the ordinary rule, substantially as described.

2. A slide rule substantially as described and illustrated in the accompanying drawings.

Dated this 30th day of June 1896.

BOULT & WADE,
Agents for the Applicants.

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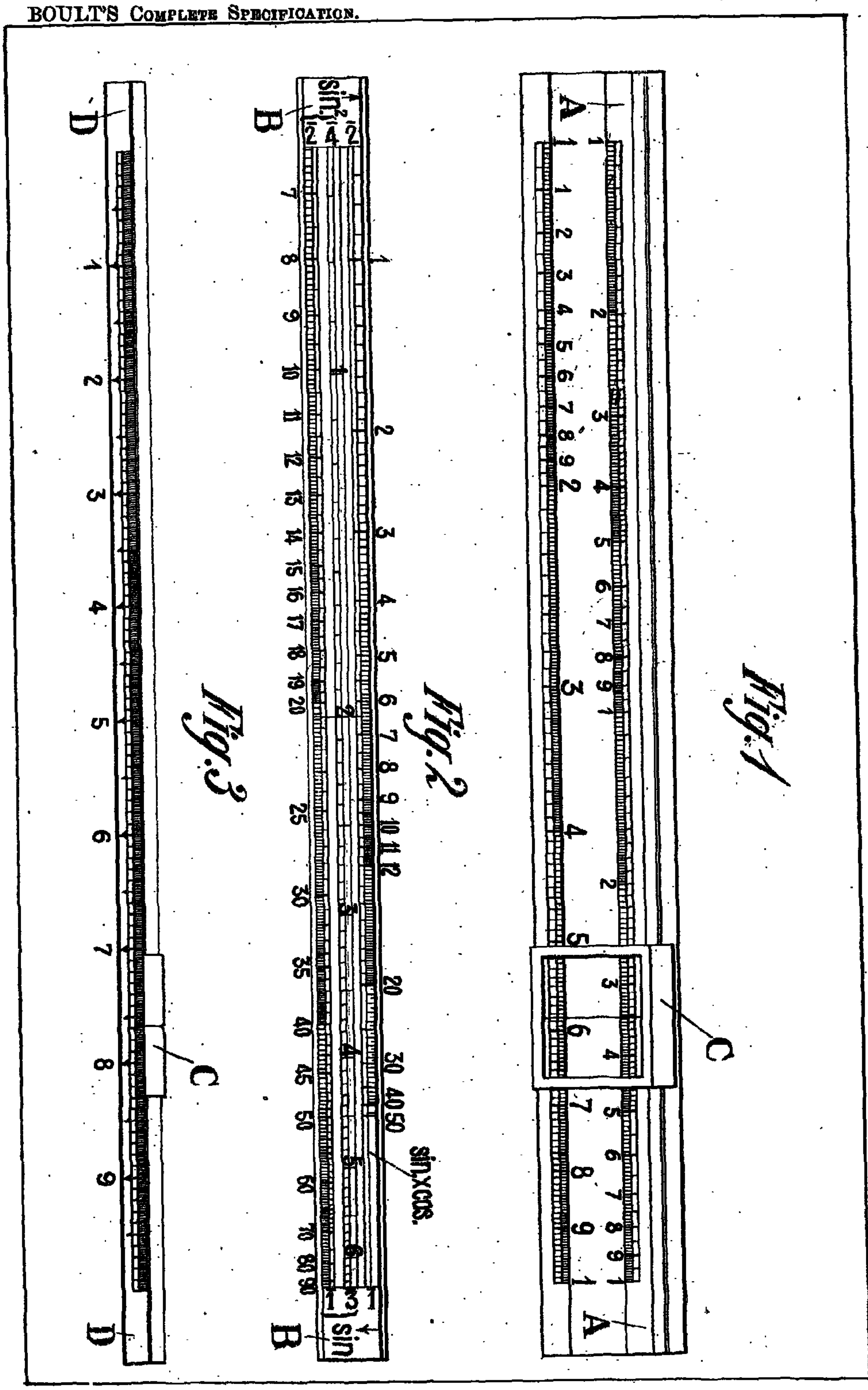
BOULT'S Complete Specification.

(1 SHEET)



[This Drawing is a reproduction of the Original on a reduced scale.]

Malby&Sons, Photo-Litho.