PATENT SPECIFICATION

Application Date: Feb. 25, 1936. No. 5590/36. **468,257**

Complete Specification Left: Jan. 11, 1937.

Complete Specification Accepted: July 1, 1937.

PROVISIONAL SPECIFICATION

Improvements in Slide Rule Calculators, other Scale Devices, and Direction Drawing Instruments

We, HUBERT BOARDMAN, of Carlton House, 144, Radcliffe New Road, Whitefield, in the County of Lancaster, a British Subject, ALBERT EDMUND CLAYTON, of 5, Queens Road, Cheadle Hulme, in the County of Chester, a British Subject, FELIX SAMUEL NAYLOR, of 41, Grosvenor Road, Rugby, in the County of Warwick, a British Subject, and A. G. THORNTON LIMITED, of King Street West, Manchester, 3, in the County of Lancaster, a British Company, do hereby declare the nature of this invention to be as follows:—

The invention concerns the application of groups of two, three, four, five, six or seven related angle and trigonometrical scales designed in accordance with plan described later, to the stock or slide of slide rule calculators, or to direction drawing instruments (such as graduated adjustable set squares), or to a strip or sector of material; for use with a cursor that enables perpendicular to lengthwise or radial projection to be effected; the combination to afford particular advantages when it is desired to inter-relate an angle and its corresponding trigonometrical functions or inter-relate the trigonometrical functions without reference to the angle; and in the case of direction drawing instruments, to permit of these instruments being set direct from trigonometrical function data independent of whether angular dimensions or the means of ascertaining angles from the given data are available.

Where x = a numerical value

$f(x)$ = a function of x, logarithmic or otherwise, and α, β and ϕ denote angle values, the prior art groups of applied scales may be considered as related angle and trigonometrical function scales expressed by the form

$$f(x) = \sin \alpha = \cos \beta = \tan \phi \quad . \quad . \quad . \quad . \quad . \quad (1)$$

and usually comprise such scales as:—

a number scale graduated to values of $f(x)$ and numbered according to x,

a sine scale graduated according to corresponding $f(x)$ values and numbered in angles for the range of α

a cosine scale graduated according to corresponding $f(x)$ values and numbered in angles for the range of β

a tangent scale graduated according to corresponding $f(x)$ values and numbered in angles for the range of ϕ

arranged parallel straight or concentric, the various graduation lines which comprise these scales being positioned to dimensions measured from a common datum or radial respectively.

With such combinations a given cursor position furnishes the various angles whose respective function values are x.

In comparison with these prior art scales where

α = an angle

$f(\alpha)$ = a function of α, logarithmic or otherwise, and x, y and z are numerical values, the newly invented groups of applied scales are related angle and trigonometrical function scales expressed by the form

$$f(\alpha) = \sin^{-1}x = \cos^{-1}y = \tan^{-1}z \quad . \quad . \quad . \quad (2)$$

and comprise such as:—

	an angle scale graduated to $f(\alpha)$ values and numbered according to α
an inverse sine scale labelled	sine graduated to the corresponding $f(\alpha)$ values and numbered according to values of x
an inverse cosine scale labelled	cosine graduated to the corresponding $f(\alpha)$ values and numbered according to values of y
an inverse tangent scale labelled	tangent graduated to the corresponding $f(\alpha)$ values and numbered according to values of z

arranged parallel straight or concentric, the various graduation lines which comprise these scales being positioned to $f(\alpha)$ dimensions measured from a common datum or radial respectively.

With such combinations a positioned

[*Price* 1/-]

cursor furnishes the sine, cosine and tangent of a particular angle.

Only the principal trigonometrical functions, sine, cosine and tangent have so far been referred to, but as occasion arises the invention will incorporate the other familiar functions such as secant, cosecant and cotangent. The so called cosine scales of the invention may in addition be numbered according to versine values, and the angle scales may have double numbering according to the angle and its complement.

Of the so labelled angle, sine, cosine, tangent, cosecant, secant and cotangent scales of the invention the groups of two applied scales which come within the scope of this invention are any two of the forementioned scales other than the angle scale, whilst the groups of three or more may comprise any of the many possible combinations of the scales enumerated.

In regard to the scales applied to direction drawing instruments the principal group to be applied is that where $f(\alpha)$ of eq. $2=\alpha$.

In certain cases where groups of two such labelled scales as tangent and cosine are applied, the need of a cursor may be obviated by arranging the scales in contact with one another.

By the means previously described it will be possible to arrange groups of scales that will furnish, at a single setting of the cursor, all relative proportions of sides also the corresponding angles of any right angled triangle under consideration and so meet a special need in regard to the determination of resolutes of vectors and many other trigonometrical and technical computations.

Dated this 22nd day of February, 1936.

HUBERT BOARDMAN,
ALBERT E. CLAYTON,
FELIX SAMUEL NAYLOR,
A. G. THORNTON, LIMITED,
ALEXANDER JAMES THORNTON,
Director,
SAML. CHAPMAN,
Director,
W. WHINHEAD,
Secretary.

COMPLETE SPECIFICATION

Improvements in Slide Rule Calculators, other Scale Devices, and Direction Drawing Instruments

We, HUBERT BOARDMAN, of Carlton House, 144, Radcliffe New Road, Whitefield, in the County of Lancaster, a British Subject, ALBERT EDMUND CLAYTON, of 5, Queens Road, Cheadle Hulme, in the County of Chester, a British Subject, FELIX SAMUEL NAYLOR, of 41, Grosvenor Road, Rugby, in the County of Warwick, a British Subject, and A. G. THORNTON LIMITED, of King Street West, Manchester, 3, in the County of Lancaster, a British Company, 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 concerns improvements to slide rule calculators, other scale devices and direction drawing instruments, characterised in that a group of inter-related angle and trigonometrical scales as hereafter explained are provided in connection with an instrument including a cursor, such scales being proportioned in accordance with simultaneous equations (2), so that with a single setting of the cursor the various trigonometrical functions of an angle or alternatively the inter-relating of various trigonometrical functions without reference to the corresponding angle are ascertained. Also direction drawing instruments of the adjustable set squares type with a group of scales affording direct means for setting the straight edges of the set square to relative directions which comply with trigonometrical data without the necessity of previously ascertaining the corresponding angle values.

In order to make the underlying principle of the invention clear, the theory underlying the prior art mode and that of the invention will be contrasted.

(I) Prior art mode of applying angle and trigonometrical function scales.

Where x = a numerical value

$f(x)$ = a function of x, logarithmic or otherwise, and α, β and ϕ denote angle values, the prior art groups of applied scales may be considered as related angle and trigonometrical function scales expressed by the form

$$f(x)=\sin\alpha=\cos\beta=\tan\phi \quad \ldots\ldots \quad (1)$$

and usually comprise such scales as:—

a number scale graduated to values of $f(x)$ and numbered according to x,

a sine scale graduated according to corresponding $f(x)$ values and numbered in angles for range of α

a cosine scale graduated according to corresponding $f(x)$ values and numbered

in angles for the range of β

a tangent scale graduated according to corresponding $f(x)$ values and numbered in angles for the range of ϕ

arranged parallel straight or concentric, the various graduation lines which comprise these scales being positioned to dimensions measured from a common datum or radial respectively.

With such combinations a given cursor position furnishes the various angles whose respective function values are x

(II) Related trigonometrical function and angle scales of the invention.

In comparison with these prior art scales where

α = an angle

$f(\alpha)$ = a function of α, logarithmic or otherwise, and x, y and z are numerical values, the newly invented groups of applied scales are related angle and trigonometrical function scales expressed by the form

$$f(\alpha) = \sin^{-1}x = \cos^{-1}y = \tan^{-1}z \quad . \quad . \quad . \quad (2)$$

and comprise such as:—

an angle scale graduated to $f(\alpha)$ values and numbered according to α	
an inverse sine scale labelled	sine graduated to the corresponding $f(\alpha)$ values and numbered according to values of x
an inverse cosine scale labelled	cosine graduated to the corresponding $f(\alpha)$ values and numbered according to values of y
an inverse tangent scale labelled	tangent graduated to the corresponding $f(\alpha)$ values and numbered according to values of z

arranged parallel, straight or concentric, the various graduation lines which comprise these scales being positioned to $f(\alpha)$ dimensions measured from a common datum or radial respectively.

A description of the three instruments represented in Figs. 1, 2, 3, and 4, which incorporate scales in accordance with equation (2) and explanation of their use now follows.

Fig. 1 shows a wooden, metal, or celluloid faced rectangular piece of material grooved on the longitudinal edges for a cursor K, and on the face of which, from the given datum line AB:—

Scale E is an angle scale graduated according to $f(\alpha)$ and numbered according to α. In this particular application the angle scale is uniform i.e. the distances from the datum AB of the various angle values are directly proportional to those angle values.

Scale F labelled Sine, is graduated from AB in accordance with inverse sine values (which are angles) to the same unit as the angle Scale E and numbered according to the corresponding sine values.

Scale G labelled tangent, is graduated from AB in accordance with inverse tangent values (which are angles) to the same unit as the Scale E and numbered according to the corresponding tangent values.

Scale H labelled cosine, is graduated in accordance with inverse cosines and numbered in accordance with cosines.

With the combination shown, when the line M of the cursor K is arranged at the angle say 36.9° on the angle scale E, the sine of 36.9° can be read from the F scale viz:—.6
the tangent of 36.9° can be read from the G scale viz:—.75
the cosine of 36.9° can be read from the H scale viz:—.8.

Similarly if the remaining principal trigonometrical functions, cotangent, cosecant, secant, versine or coversine are required, appropriate scales based on the same principle will be applied.

Thus it will be seen that with the combination it is possible to provide with a single setting of the cursor the answer to such questions as:—

(I) Given the sine, determine the corresponding angle and the tangent and cosine of that angle.

(II) Given the tangent of an angle, determine the sine or cosine of the angle.

Prior art scales do not permit of such group evaluation for a single setting of the cursor.

Fig. 2 shows a form of adjustable set square in which the arm Z is pivoted at W to the main set square piece Y. To the arm Z a quadrant piece X is attached. A fixed cursor K_1, carrying line M_1 is secured to Y and whilst X may move between the cursor K_1 and Y, a screw device at V enables X (and in consequence Z) to be secured in an angular relationship to the main set square Y. The direction of the line M. on the cursor K_1 is through the centre of the pivot W.

Prior art devices normally incorporate only a uniform angle scale J on the circular edge of X; the invention concerns the addition of concentric scales L, O and N, which bear the same relationship in radial projection to the scale J, as do the scales F, G and H, in perpendicular projection to the scale E, of the device represented in Fig. 1.

With this form of adjustable setsquare the edge *ef* may be set in relation to the edge *cd* of the main square to a direction expressed either by means of an angle or the angle's trigonometrical data.

e.g. When the arm is positioned so that .75 in the tangent scale O coincides with the line M_1, the angle between the lines *cd* and *ef* is the angle whose tangent is .75 and the value of this angle, if required, may be read from the angle scale J viz:—36.9°. Also the value of the sine and cosine of this angle may be read from the scales L and N viz:—.6 and .8 without any change of setting.

The instrument shown in Fig. 2, also provides, like the instrument shown in Fig. 1, at a single setting the angle and particular related trigonometrical functions.

In the preceding theoretical statements contrasting the prior art and the invented scales, reference is made to

$f(\alpha)$ = a function of α, logarithmic or otherwise.

The instruments illustrated in Figs. 1 and 2 incorporate scales of the " or otherwise " group where " or otherwise " in the particular cases cited are such that the scales of α are directly proportional to α.

The calculating slide rule shown in Fig. 3 and, with slide readjusted in Fig. 4, incorporates scales corresponding to the scales E, F, G, H, of Fig. 1 but where the $f(\alpha)$ is a logarithmic function of α.

Fig. 3 is a front elevation of a slide rule which comprises a stock *g* in which a slide *h* can move. The stock *g* is also grooved and a transparent cursor K_2, so made as to permit of the cursor's relative movement to the stock or slide. On the transparent face of the cursor, adjacent to the stock and slide, there is an index line marked M_2 that enables perpendicular to lengthwise projections from one scale to another to be effected.

On both stock and slide graduation marks comprise scales for various purposes. Of these scales we refer to:—

(1) The scale on the slide indicated by the letter C and that on the stock marked D are identical logarithmic scales of number to a selected unit from the datum A^1 B^1.

(2) Scale P is a logarithmic tangent scale to same unit as C and D and from the same datum numbered in angles.

(3) Scale Q is a log. tan $\sin^{-1} x$ scale numbered according to values of x.

(4) Scale R is a log. tan $\cos^{-1} x$ scale numbered according to values of x.

With this combination of scales when the cursor is arranged at a position (say) 36.9° on the scale P, the value of the tangent of 36.9° can be read on the scale D, viz:—.75; the value of the sine of 36.9° can be read on scale Q viz:—.6 and the value of the cosine of 36.9° can be read from scale R, viz:—.8.

In comparison to the prior art devices incorporating standard logarithmic trigonometrical scales such a combination of scales offers advantages as regards minimum slide and cursor movements when (important electrical) computation as the undermentioned have to be effected.

Where tan $\alpha = \frac{3}{4}$ determine the value of cos α.

This would be effected by moving the slide so that 4 on scale C is in alignment with 3 on scale D and placing the cursor at C10 or (C1). The value of cos α can then be read from scale R at the cursor line M_2 viz:—.8.

Fig. 4 shows the instrument of Fig. 3, adjusted for this computation.

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

1. Slide rule calculators, scale devices, and direction drawing instruments, characterized in that a group of inter-related angle and trigonometrical scales as herein explained are provided in connection with an instrument including a cursor, such scales being proportioned in accordance with the simultaneous equations (2) so that with a single setting of the cursor the various trigonometrical functions of an angle or alternatively the inter-relating of various trigonometrical functions without reference to the corresponding angle are ascertained.

2. A direction drawing instrument of the adjustable set square type with a group of scales as claimed in Claim 1 affording direct means for setting the straight edges of the set square to relative directions which comply with trigonometrical data without the necessity of previously ascertaining the corresponding angle values.

3. A scale device comprising an instrument including stock scales, and cursor, all so devised and arranged and capable of use to provide inter-related trigonometrical data without reference to trigonometrical tables, as described with particular reference to Fig. 1.

4. A direction drawing instrument of the type of adjustable set square which incorporates hinged contrivances with scales and cursor to provide means for inter-relating angle and trigonometrical functions and permits of relative directions of straight edges of the instrument to be set to trigonometrical data as de-

scribed with particular reference to Fig. 2.

5. A slide rule calculator comprising a stock, slide, cursor device and scale arrangement capable of being used for effecting computations of the type set forth and as described particularly with reference to Figs. 3 and 4.

Dated this 9th day of January, 1937.

For the Applicants,
E. K. DUTTON & CO.,
Chartered Patent Agents,
5, John Dalton Street, Manchester, 2.

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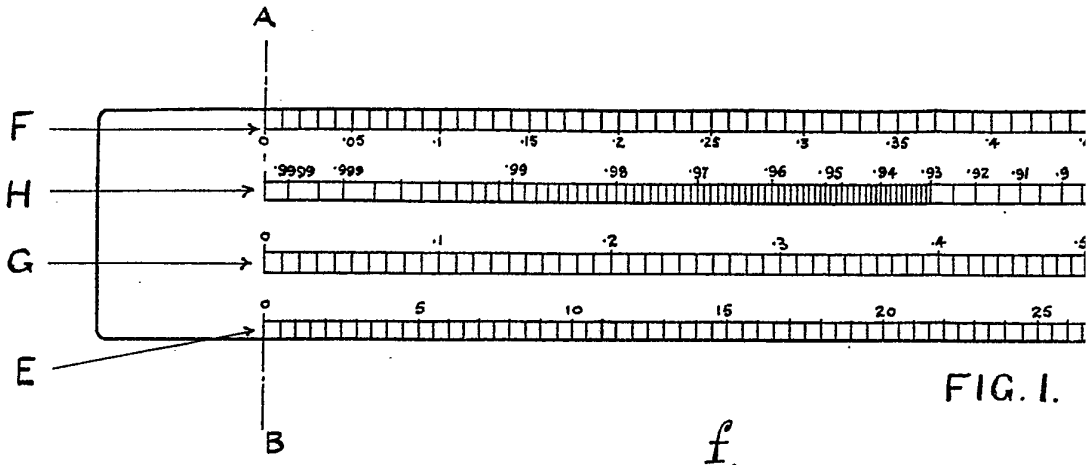

FIG. 1.

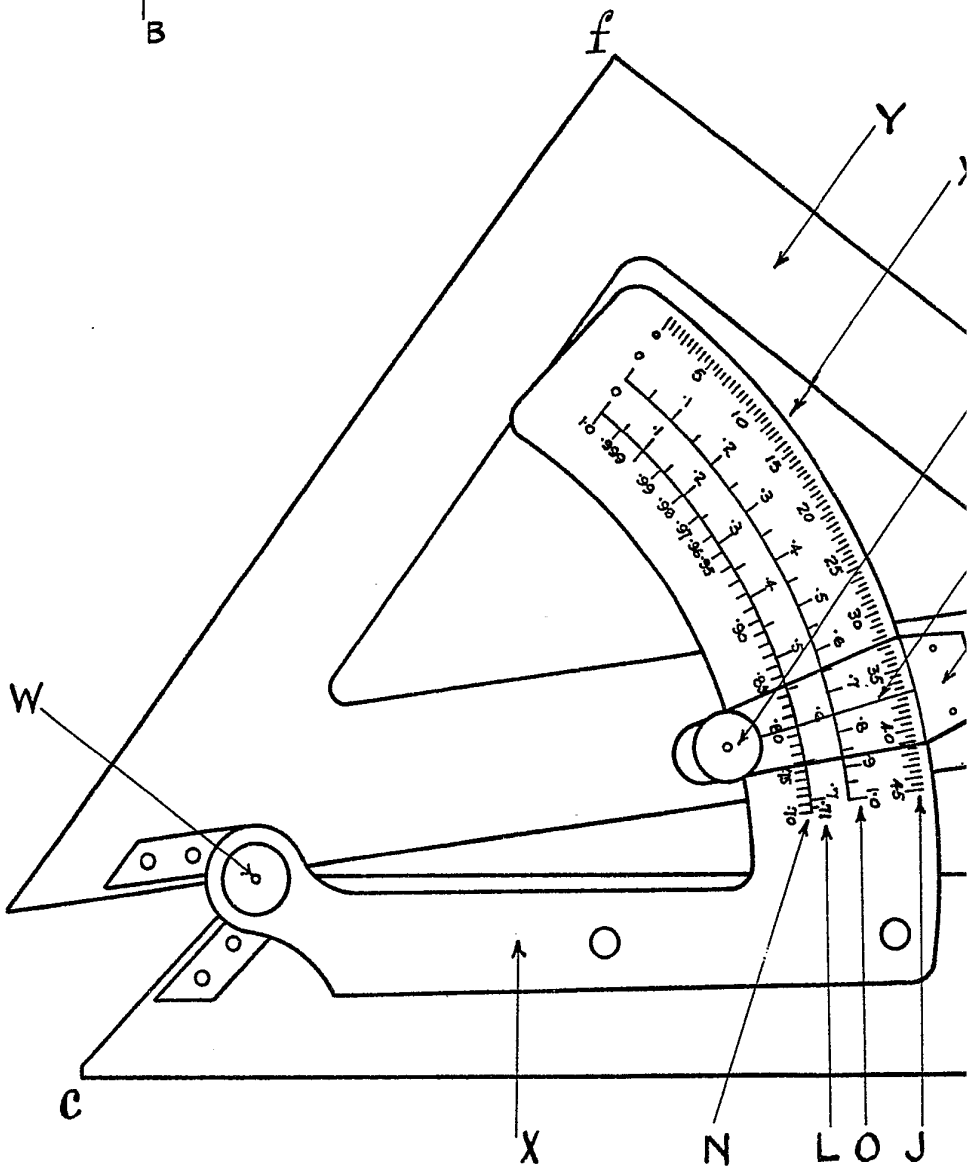

FIG. 2.

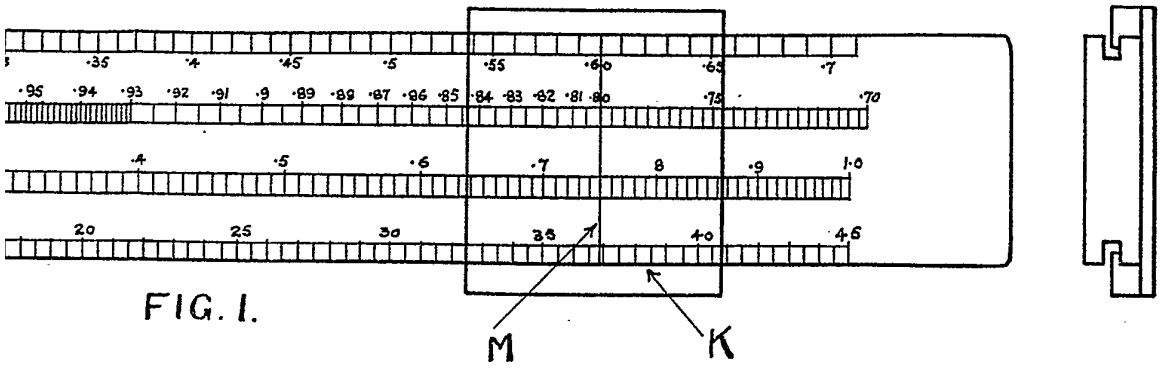

FIG. 1.

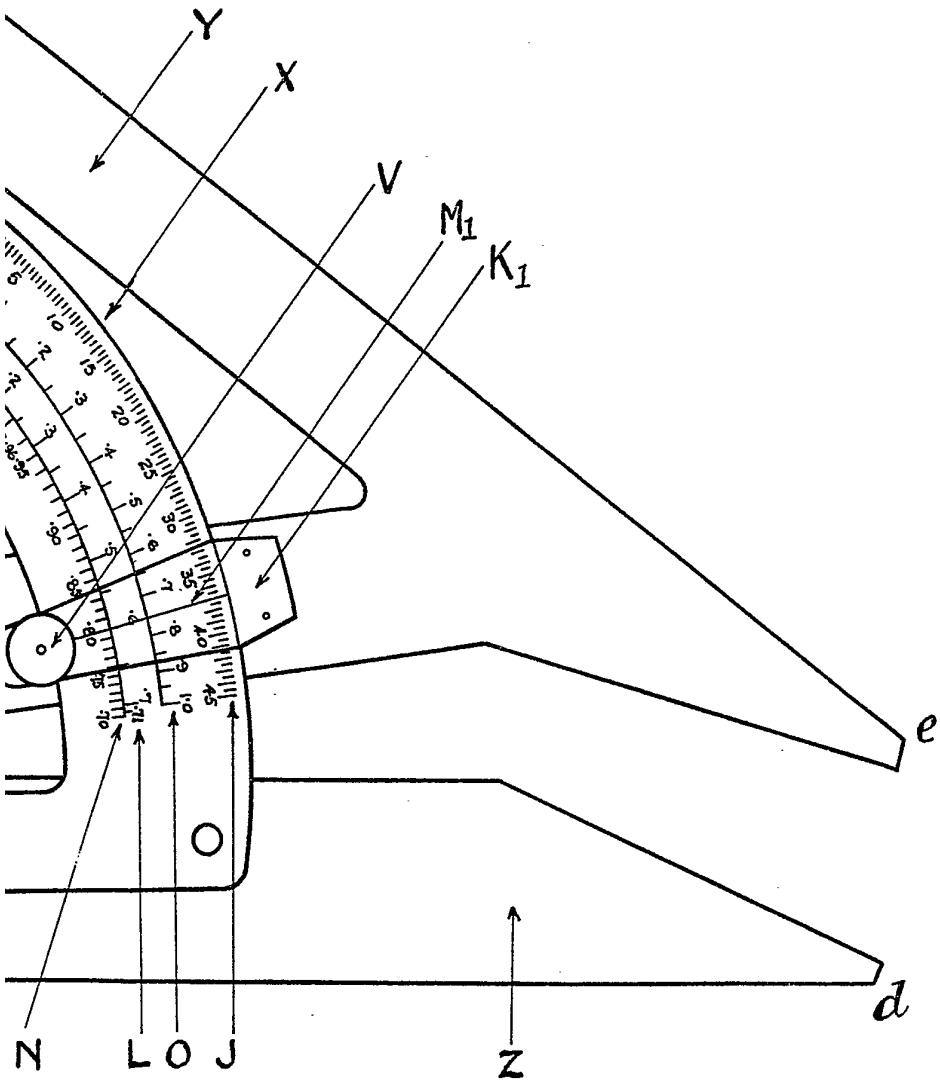

FIG. 2.

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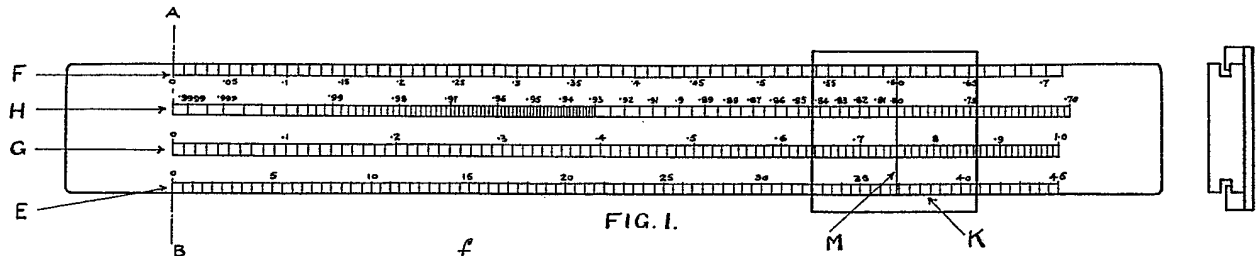

FIG. 1.

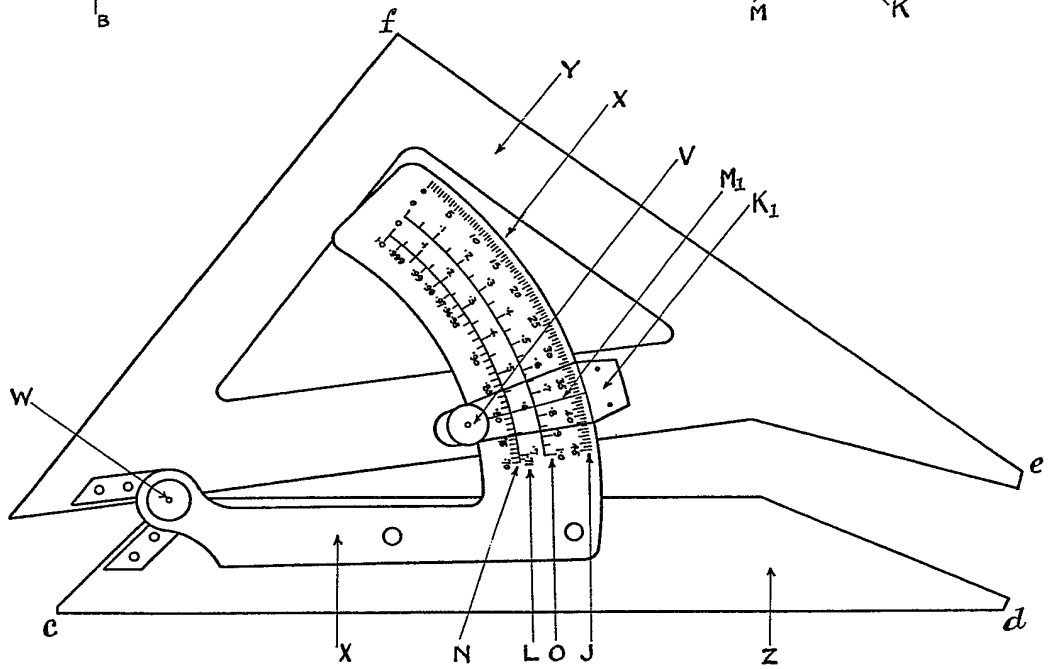

FIG. 2.

Malby & Sons, Photo-Litho

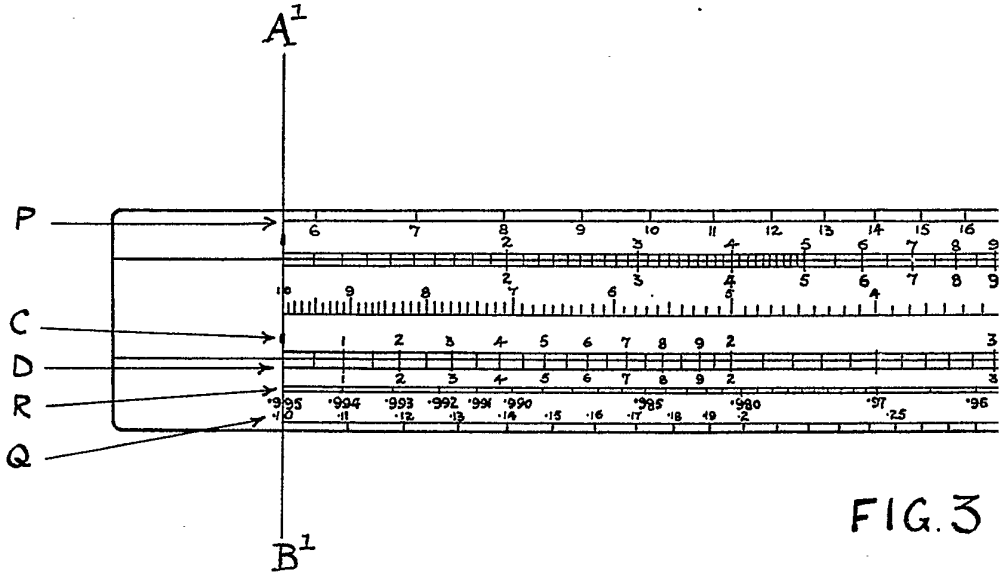

FIG. 3

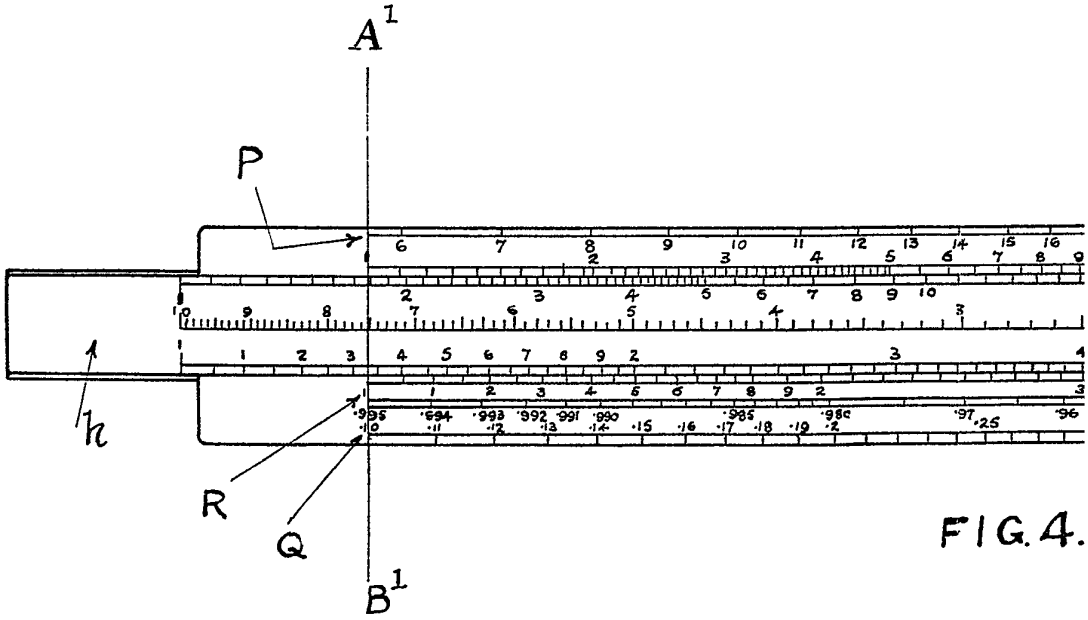

FIG. 4.

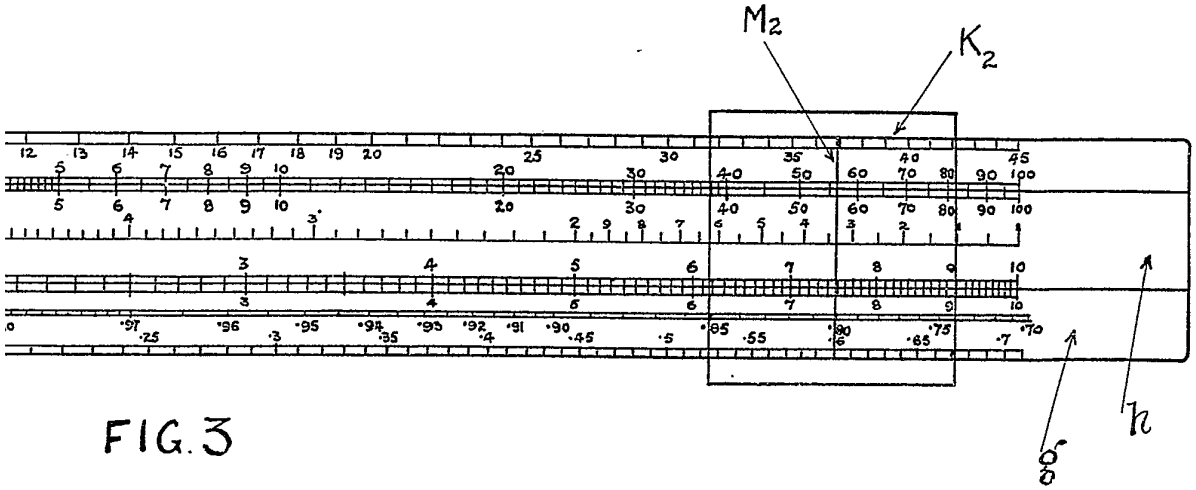

FIG. 3

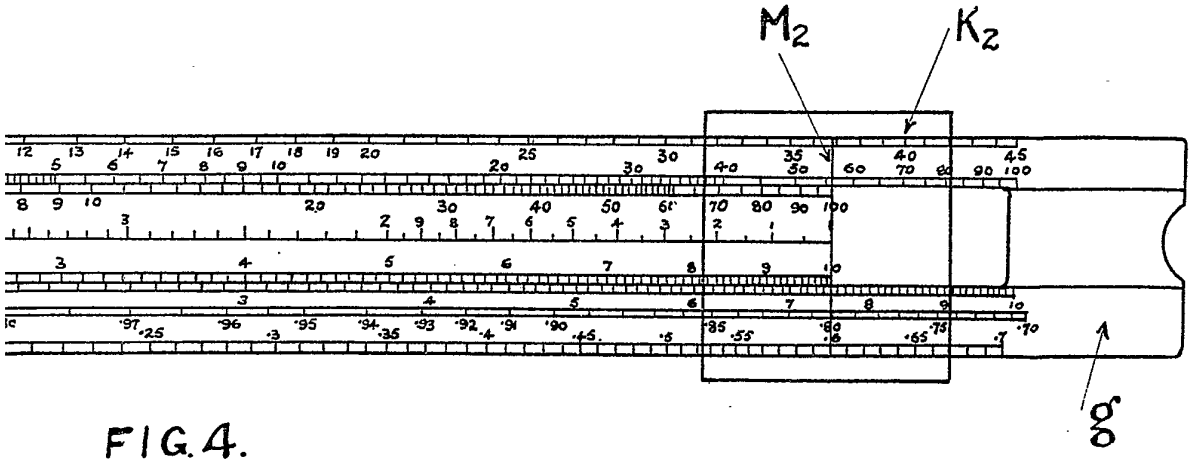

FIG. 4.

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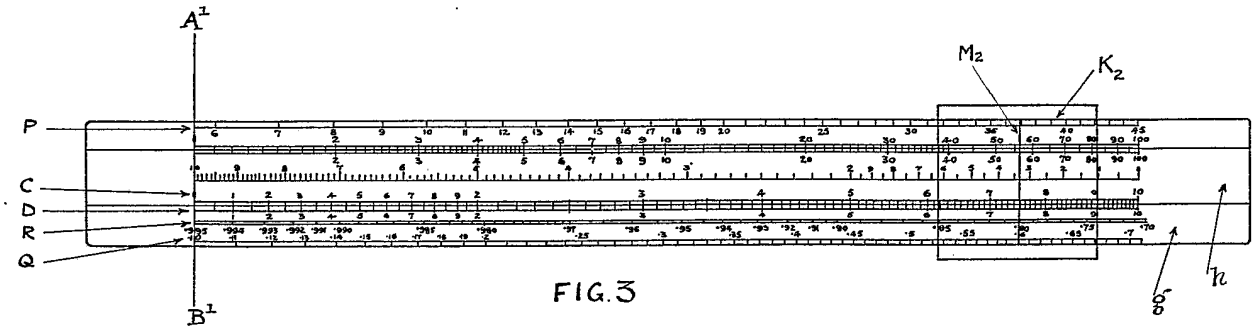

FIG. 3

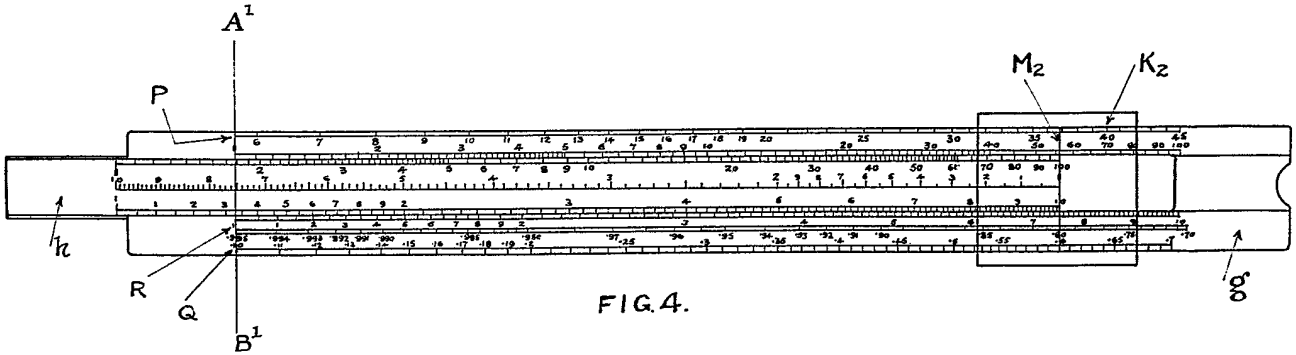

FIG. 4.

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