PATENT SPECIFICATION

195,286

Application Date: April 28, 1922. No. 12,003/22.

Complete Left: Jan. 26, 1923.

Complete Accepted: March 29, 1923.

PROVISIONAL SPECIFICATION.

Improvements in and connected with Slide Rules and the like.

I, Albert John Anido, of 69, Earls Court Road, London, W. 8, of British nationality, do hereby declare the nature of this invention to be as follows:—

This invention relates to improvements in and connected with slide-rules and the like and has for its object to provide an improved arrangement facilitating the evaluation of powers of numbers without the necessity for the use of scales of logarithms of logarithms (log-log-scales).

In accordance with the invention there is provided on the slide rule or the like in addition to the usual scale of equal parts and the logarithmic scale a scale of equal parts representing negative logarithms and graduated in the negative direction.

In the preferred embodiment of the invention applied to the ordinary form of slide rule the three scales, *viz.*, the logarithmic scale and the two scales of equal parts are of the same length with the scales of equal parts on opposite sides of the logarithmic scale, the two scales of equal parts being relatively stationary. The scales of equal parts, as stated, are graduated to read in opposite directions, that which is graduated in the same direction as the logarithmic scale being used where the logarithm of the result is a positive quantity, while the second linear scale is used where the logarithm of the result is negative.

The scales of equal parts may, however, be relatively slidable.

The reversal of the graduations of the second scale of equal parts provides in conjunction with the logarithmic scale, a direct-reading proportional scale of logarithms having a negative characteristic. These scales of equal parts are hereinafter referred to as positive and negative scales.

This combination supplemented by a suitable cursor or movable index may be applied to any slide-rule as a universal method for the evaluation of numbers raised to any power, positive or negative, integral or fractional.

Since the ordinary scales of a slide rule consist of logarithms drawn to some scale, it follows that the distance from the end of the scale to any given division is proportional to the logarithm of the number which that division represents. If a positive scale is placed side by side with, say, scale D, *i.e.* the lower scale, of an ordinary slide rule, there is at once obtained a means of calculating with a considerable degree of accuracy any desired positive power of a number greater than 1.

The positive scale of this rule is graduated from 1 to 100, so that a reading of 100 corresponds to log. 10. Similarly a reading less than 100 on the positive scale corresponds to the logarithm of a number between 1 and 10. In the case of numbers greater than 10, *e.g.* 20, since log. 20 is equal to log. 2 + log. 10, and log. 2 is represented by 30.1 divisions and log. 10 is represented by 100 divisions, log. 20 is therefore represented by 30.1 + 100 or 130.1 divisions. Generally, if the characteristic of the logarithm of a number is "a" then "a" hundreds are added to the reading of the positive scale, so that the hundreds digit of the reading is the value of the characteristic of the logarithm of the number. A number of examples are given below:

Example 1. To Find the Value of

$$(31.4)^{5/3}$$

Move the cursor to 314 on scale D, and under the cursor on the positive scale the reading 49.8 is found. Since the characteristic of log. 31.4 is 1, 100 is added to the reading, which is therefore taken as 149.8. Now 149.8 is multiplied by $^5/_3$, using scale C (*i.e.* the ordinary slide scale) and scale D for this purpose, obtaining 250 which is the number of divisions on the positive scale, which represents the logarithm of the answer. The hundreds digit 2, shows, as explained above, that the characteristic of the logarithm of the answer is 2. Moving the cursor to 50 on the positive scale, 3160 is read on scale D. Since the characteristic is known to be 2, the answer is 316.

A further example is given to show that the method is general for numbers not less than 1 raised to positive powers.

To Find the Value of $6780^{1/36}$.

With the cursor at 678 on scale D the corresponding reading on the positive scale is 83.2. The characteristic of log. 6780 is 3, and 383.2 must therefore be taken as the reading. Divide 383.2 by 36, the result being 10.65, which is proportional to the logarithm of the answer. Since 10.65 is less than 100, the characteristic is zero, and with the cursor at 10.65 on the positive scale, 1.28 is read on scale D. $6780^{1/36}$ is therefore equal to 1.28.

The preceding examples deal with positive powers of numbers greater than 1, and it is clear that some modification of the methods given is necessary if numbers less than 1 and negative powers are to be dealt with effectively, since in such cases the logarithms become negative.

In the present slide rule the system adopted is that of placing a negative scale side by side with scale D. There is now available a means of representing negative logarithms, as will be seen by a consideration of the following case.

If the cursor is moved to 2.0 on scale D, there is read on the positive scale the value 30.1 which is proportional to log. 2. Now log. 0.2 is equal to ($-1+$log. 2) and since 100 divisions on the scale represent one unit of the logarithmic scale, the logarithm whose value is -1, is represented by -100. Log. 0.2 is therefore represented by ($-100+30.1$ divisions) = -69.9 divisions. It will be seen that the division on the negative scale under the cursor reads 69.9. Similarly log. 0.02 is represented by -169.9 divisions, and log. 0.0002 by -369.9 divisions. In the case of the negative scale therefore the hundreds digit assigned to the reading is equal to the number of noughts which follow the decimal point. The divisions of the negative scale are thus proportional to values of negative logarithms, and may be used precisely in the same manner as those of the positive scale, provided only that it is borne in mind that the readings of the negative scale are minus quantities, while those of the positive scale are positive quantities.

Example of the use of the Negative Scale.

To find the value of $0.0475^{0.127}$.

Move the cursor to 475 on scale D. The corresponding reading on the negative scale is -32.3. As there is one nought immediately after the decimal point in 0.0475, the reading is taken to be -132.3. Multiply -132.3 by 0.127, using scales C and D. The product is -16.8. This value being less than 100, the result is a quantity whose first significant figure is in the first decimal place. Move the cursor to 16.8 on the negative scale, and the answer is found to be 0.679.

Examples of the Combined Use of Positive and Negative Scales.

(I). To find the value of 5.25^{-3}.

The reading of the positive scale corresponding to 5.25 is 72. $72x(-3)=-216$ and is negative). Corresponding to 16 on the negative scale, is read 692 on scale D. The answer is therefore 0.00692.

(II). To find the value of 0.525^{-3}.

Corresponding to 525 on scale D, the reading on the negative scale is -28. $-28x-3=+84$, and is positive. The characteristic of the logarithm of the result is, therefore, zero. Moving the cursor to 84 on the positive scale, the answer 6.90 is read on scale D.

(III). It will be clear that values of x in expressions of the form $N^x=M$ can be readily found, no matter what values be assigned to N and M. Example $0.525^x=6.92$.

On +ve scale read (+84) corresponding to 6.92 on scale D.

On −ve scale read (−28) corresponding to 0.525 on scale D.

Then divide (+84) by (−28). The result $=-3=x$.

(IV). Reciprocals can be found by the combined use of the positive and negative scales, since the number on scale D which corresponds to say, N divisions on the positive scale, is the reciprocal of the number on scale D opposite N on the negative scale.

Dated this 28th day of April, 1922.

CRUIKSHANK & FAIRWEATHER,
65/66, Chancery Lane, London, W.C. 2,
and
62, Saint Vincent Street, Glasgow,
Agents for the Applicant.

COMPLETE SPECIFICATION.

Improvements in and connected with Slide Rules and the like.

I, Albert John Anido, of 69, Earls Court Road, London, W. 8, of British nationality, 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 improvements in and connected with slide rules and the like and has for its object to provide an improved arrangement facilitating the evaluation of powers of numbers without the necessity for the use of scales of logarithms of logarithms (log-log-scales).

In accordance with the invention there is provided for this purpose on the slide rule or the like in addition to the usual scale of equal parts and the logarithmic scale, a scale of equal parts representing negative logarithms and graduated in the negative direction.

In the preferred embodiment of the invention applied to the ordinary form of slide rule the three scales, *viz.*, the logarithmic scale and the two scales of equal parts are of the same length with the scales of equal parts on opposite sides of the logarithmic scale, the two scales of equal parts being relatively stationary. The scales of equal parts, as stated, are graduated to read in opposite directions, that which is graduated in the same direction as the logarithmic scale being used where the logarithm of the result is a positive quantity, while the second linear scale is used where the logarithm of the result is negative.

The scales of equal parts may, however, be relatively slidable.

The preferred embodiment of the invention is illustrated in the accompanying drawing, in which the slide rule is shown, for convenience of illustration only, in two halves, the Fig. 1 representing the left hand and Fig. 2 the right hand half of the scale.

As shown, and in accordance with the invention, there is applied to the usual slide rule, in addition to the ordinary scales which include a scale of equal parts such as A, the ordinary slide scale C and the logarithm or lower scale D, a scale of equal parts E graduated in the opposite direction to scale A, the scales A and E being disposed on opposite sides of scale D. G and H are the usual logarithmic scales graduated to half the linear scale of C and D.

The reversal of the graduations of the second scale of equal parts E provides in conjunction with the logarithmic scale D a direct-reading proportional scale of logarithms having a negative characteristic. These scales of equal parts A and E are hereinafter referred to as positive and negative scales respectively.

This combination supplemented by a suitable cursor or movable index F may be applied to any slide rule as a universal method for the evaluation of numbers raised to any power, positive or negative, integral or fractional.

Since the ordinary scales of a slide rule consist of logarithms drawn to some scale, it follows that the distance from the end of the scale to any given division is proportional to the logarithm of the number which that division represents. By placing positive scale A side by side with, say, scale D. *i.e.*, the lower scale of an ordinary slide rule, there is at once obtained a means of calculating with a considerable degree of accuracy any desired positive power of a number greater than 1.

The positive scale A of this rule is graduated from 1 to 100, so that a reading of 100 corresponds to log. 10. Similarly, a reading less than 100 on the positive scale corresponds to the logarithm of a number between 1 and 10. In the case of numbers greater than 10, *e.g.* 20, since log. 20 is equal to log. 2 + log. 10, and log. 2 is represented by 30.1 divisions and log. 10 is represented by 100 divisions, log. 20 is therefore represented by 30.1 + 100 or 130.1 divisions. Generally, if the characteristic of the logarithm of a number is "a" then "a" hundreds are added to the reading of the positive scale, so that the hundreds digit of the reading is the value of the characteristic of the logarithm of the number.

A number of examples are given below.

Example 1. To Find the Value of $(31.4)^{5/3}$.

Move the cursor F to 314 on scale D, and under the cursor on the positive scale A the reading 49.8 is found. Since the characteristic of log. 31.4 is 1, 100 is added to the reading, which is therefore taken as 149.8. Now, 149.8 is multiplied by $^5/_3$ using scale C and scale D for this purpose, obtaining 250 which is the number of divisions on the positive scale A, which represents the logarithm of the answer. The hundreds digit 2 shows, as explained above, that the characteristic of the logarithm of the answer is 2. Moving the cursor to 50 on the positive scale A, 3160 is read on scale D. Since the characteristic is known to be 2, the answer is 316.

A further example is given to show that the method is general for numbers not less than 1 raised to positive powers.

EXAMPLE 2: TO FIND THE VALUE OF $6780^{1/36}$.

With the cursor at 678 on scale D, the corresponding reading on the positive scale is 83.2. The characteristic of log. 6780 is 3. and 383.2 must therefore be taken as the reading. Divide 383.2 by 36, the result being 10.65, which is proportional to the logarithm of the answer. Since 10.65 is less than 100, the characteristic is zero, and with the cursor at 10.65 on the positive scale A, 1.28 is read on scale D. $6780^{1/36}$ is therefore equal to 1.28.

The preceding examples deal with positive powers of numbers greater than 1, and it is clear that some modification of the methods given is necessary if numbers less than 1 and negative powers are to be dealt with effectively, since in such cases the logarithms become negative.

In the present slide rule the system adopted is that of placing a negative scale E side by side with scale D. There is now available a means of representing negative logarithms, as will be seen by a consideration of the following case.

If the cursor is moved to 2.0 on scale D, there is read on the positive scale A the value 30.1, which is proportional to log. 2. Now, log. 0.2 is equal to $(-1+\log. 2)$, and since 100 divisions on the scale represent one unit of the logarithmic scale, the logarithm whose value is -1, is represented by -100. Log. 0.2 is therefore represented by $(-100+30.1$ divisions$)=-69.9$ divisions. It will be seen that the division on the negative scale E under the cursor reads 69.9. Similarly log. 0.02 is represented by -169.9 divisions, and log. 0.0002 by -369.9 divisions. In the case of the negative scale E, therefore, the hundreds digit assigned to the reading is equal to the number of noughts which follow the decimal point. The divisions of the negative scale E are thus proportional to values of negative logarithms, and may be used precisely in the same manner as those of the positive scale, provided only that it is borne in mind that the readings of the negative scale E are minus quantities, while those of the positive scale A are positive quantities.

EXAMPLE OF THE USE OF THE NEGATIVE SCALE.

To find the value of $0.0475^{0.127}$.

Move the cursor to 475 on scale D. The corresponding reading on the negative scale is -32.3. As there is one nought immediately after the decimal point in 0.0475, the reading is taken to be -132.3. Multiply -132.3 by 0.127, using scales C and D. The product is -16.8. This value being less than 100, the result is a quantity whose first significant figure is in the first decimal place. Move the cursor to 16.8 on the negative scale, and the answer is found to be 0.679.

EXAMPLES OF THE COMBINED USE OF POSITIVE AND NEGATIVE SCALES.

(I). To find the value of 5.25^{-3}.

The reading of the positive scale corresponding to 5.25 is 72. $72x(-3)=-216$ and is negative. Corresponding to 16 on the negative scale, is read 692 on scale D. The answer is therefore 0.00692.

(II). To find the value of 0.525^{-3}.

Corresponding to 525 on scale D, the reading on the negative scale is -28. $-28x-3=+84$, and is positive. The characteristic of the logarithm of the result is, therefore, zero. Moving the cursor to 84 on the positive scale, the answer 6.92 is read on scale D.

(III). It will be clear that values of x in expressions of the form $N^x=M$ can be readily found, no matter what values be assigned to N and M.

EXAMPLE.—$0.525^x=6.92$.

On the positive scale read $+84$, corresponding to 6.92 on scale D. On the negative scale read -28, corresponding to 0.525 on scale D. Then divide $+84$ by -28. The result $=-3=x$.

IV. Reciprocals can be found by the combined use of the positive and negative scales A and E, since the number on scale D, which corresponds to, say, N divisions on the positive scale, is the reciprocal of the number on scale D opposite N on the negative scale E.

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. A slide rule in which there is provided in association with a scale of equal parts and a logarithmic scale, a scale of equal parts graduated in the opposite direction to the first, for the purpose of facilitating the evaluation of powers of

numbers without the necessity for the use of scales of logarithms of logarithms (log-log-scales).

2. A slide rule as claimed in Claim 1 in which the two scales of equal parts are disposed on opposite sides of the logarithmic scale.

3. A slide rule constructed and arranged substantially as described with reference to the annexed drawing.

Dated this 26th day of January, 1923.

CRUIKSHANK & FAIRWEATHER,
65/66, Chancery Lane, London, W.C. 2,
and
62, Saint Vincent Street, Glasgow,
Agents for the Applicant.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1923.

Fig. 1.

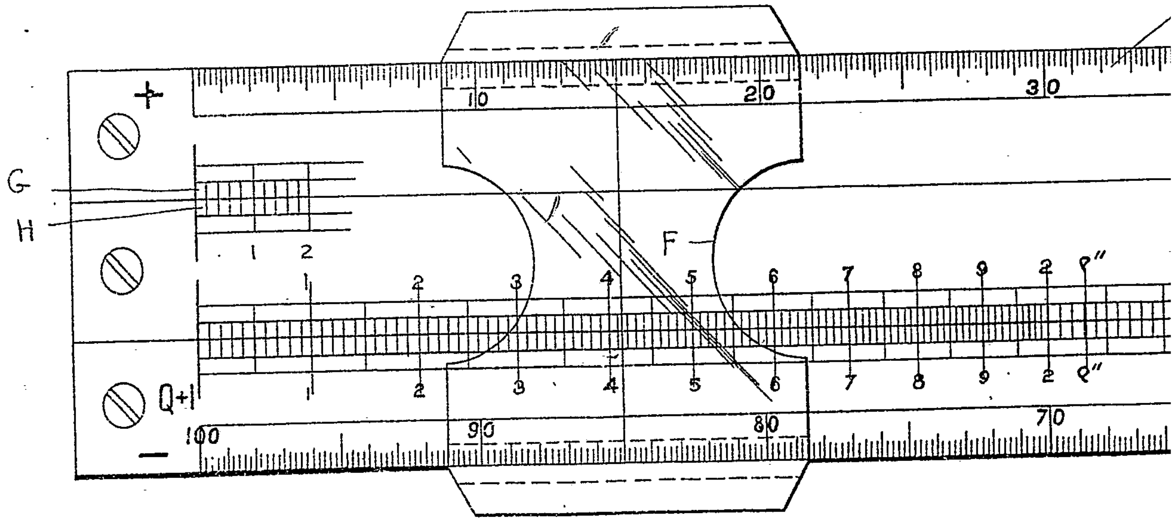
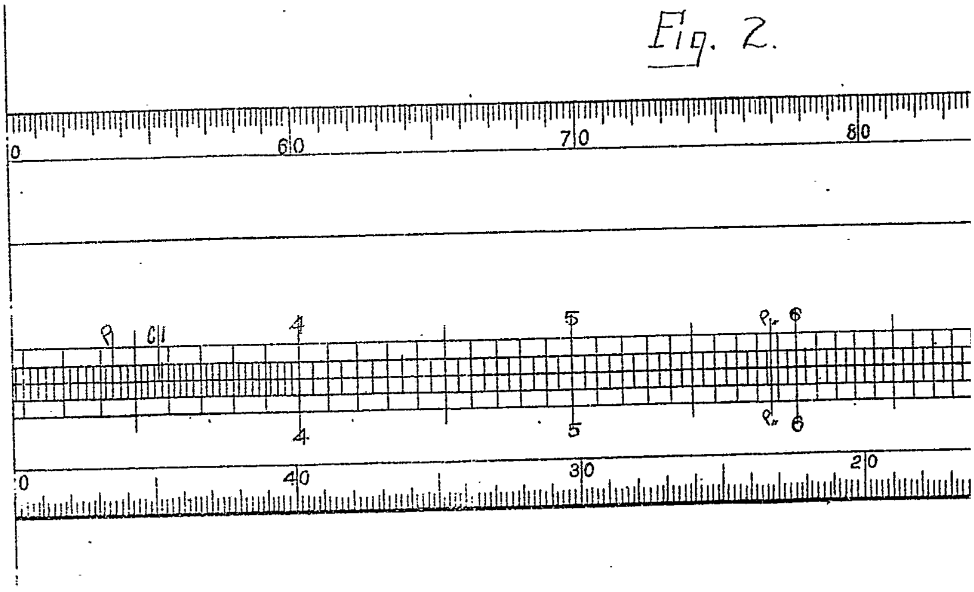


Fig. 2.



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

Fig. 1.

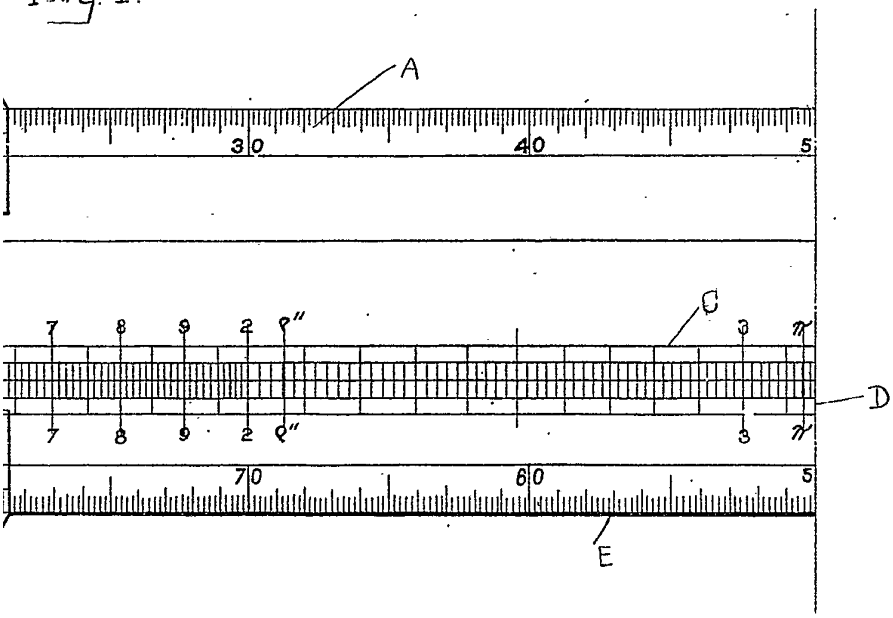
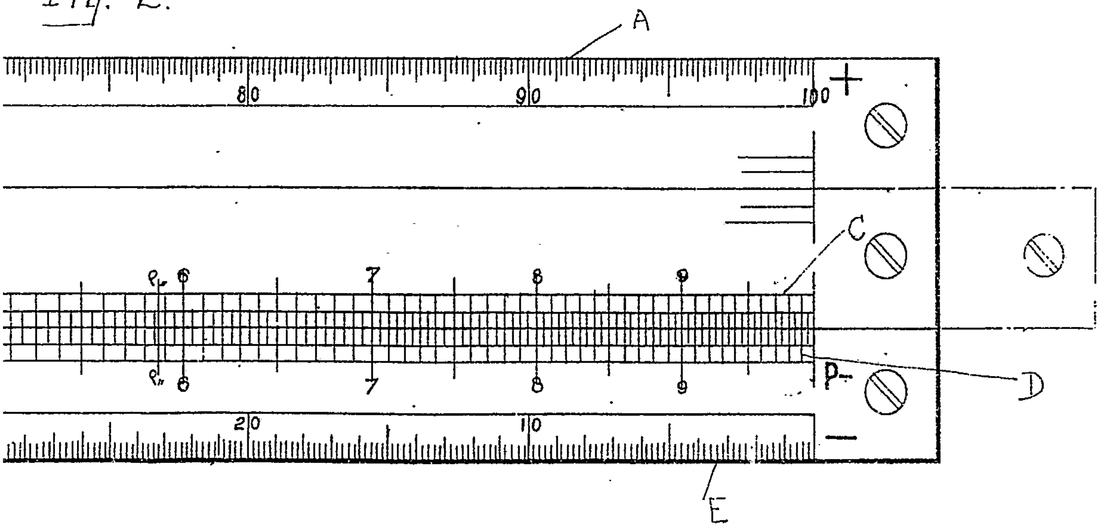


Fig. 2.



Malby&Sons, Photo-Litho.

Fig. 1.

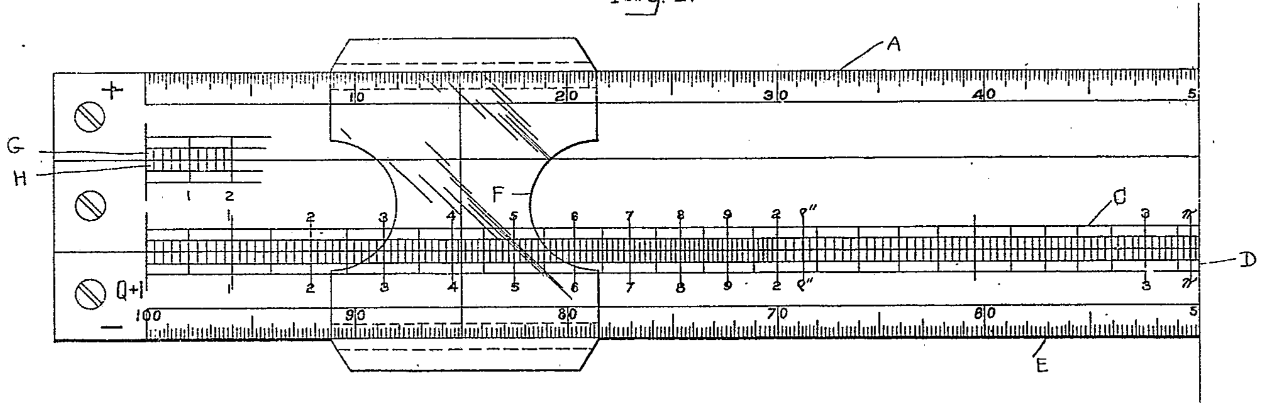
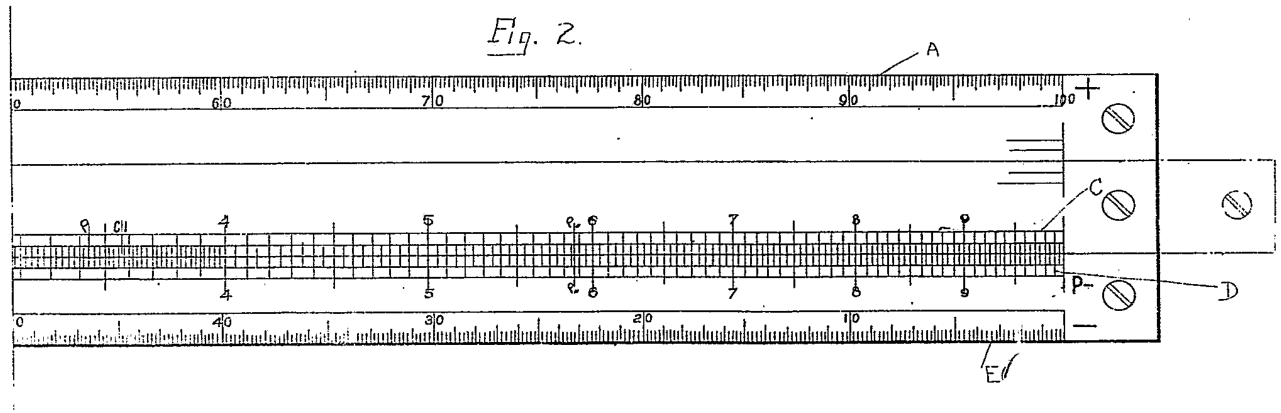


Fig. 2.



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

Malby&Sons, Photo-Litho