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COMPLETE SPECIFICATION.

Improved Computing Scale.

FRANZ ARTHUR SCHULZE, Dr. Phil, unsalaried lecturer at the University of Marburg, cf 3½ Steinweg Marburg, Germany 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:—

The present invention relates to sliding scales for the calculation of powers and roots with any exponent.

The essential features of the new sliding scale consist of a slide-body provided with a logarithmic scale, of a slide, which is moved in the slide body in the well known manner and provided with a scale of the exponents arranged in a right angle to the logarithmic scale. Besides, a finger is arranged on a pivot, vertically below the beginning, respectively the ending of the logarithmic scale.

This finger reaches over every scale on the device and with its help the result is indicated, the slide as well as the finger being rightly adjusted.

In the drawing, in which like letters refer to like parts of the drawing,

Fig. 1 shows a plan view of the new sliding scale,

Fig. 2—5 show diagrammatically the positions of the single parts of the new sliding scale corresponding to the following explanations.

The construction of the new sliding scale is based on the proportions:

$$1)\ \log (a^b) = b \times \log a$$

$$2)\ \log \sqrt[p]{q} = \frac{1}{p} \log q$$

If a logarithmic scale is given in the way that the distance of one point of the scale from the start of the division is equal to the indicated number of the logarithm of Brigg's system, whereby the unit of the chosen scale is equal to the distance of the two indicated numbers 1 and 10, according to the above mentioned first proportion in order to find a^b we must take from the beginning of the scale b times the distance of the point of the logarithmic scale, which corresponds to the number a; the number, which is indicated on this point of the logarithmic scale, which is distant from the beginning of the scale $b \times \log a$, is the searched value for a_b.

To find $\sqrt[p]{q}$ according to the above mentioned second proportion, we must take the p part of the distance between the start of the scale and that point, which corresponds to the number q. The number which is marked at that point of the logarithmic scale, which is distant $\frac{1}{p} \log q$ times from the start of the scale, is the searched value for $\sqrt[p]{q}$.

To find these values mechanically, a logarithmic scale t^1 is arranged on the horizontal border of the slide body L, in which, any scale may serve as an unit, the distances of the marks of division from the start of the scale are equal the logarithms of the numbers of said marks.

The end point E of the logarithmic scale t^1 is arranged on the place in which the scale indicates a number 1, which corresponding to the length of the scale can count for 1, or 10, or 100, and so on.

[*Price 8d.*]

Besides the new sliding scale provides a finger Z, which by means of a small pivot fixed to the end of the said finger, can be inserted into one of the openings 1^1, 1^2 respectively of the slide body and can be turned around this pivot as its centre.

The opening 1^1 is arranged on the slide body L exactly vertically below the start A of the logarithmic scale t^1. The opening 1^2 is also arranged on the slide body L exactly vertical below the end E of the logarithmic scale t^1.

The distances A 1^1 and E 1^2 are equal.

The finger Z is so cut that one of its edges k runs straightly in the direction of the centre of the opening 1^1, 1^2 respectively into which the finger has been inserted. The slide S provides two scales t^2, t^3 respectively which are arranged on the left respectively on the right border of the slide S and in a right angle to the logarithmic scale t^1.

The scale t^2 is so arranged that the numbers provided on said scale show how many times larger the distance A 1^1, which means the distance between the start A of the logarithmic scale t^1 and the opening 1^1, is than the vertical distance of the certain point of the slide scale t^2 from the connecting line 1^1, 1^2 of the two openings. The scale t^2 only indicates numbers which count more than the number 1. The scale t^3 indicates the converse values of the numbers of the scale t^3 which have the correspondingly equal distance of the scale t^1, and is consequently so arranged that the numbers provided on said scale show how many times larger the vertical distance is of the certain point of the scale t^3 from the connecting line of the two openings 1^1 and 1^2, than the distance 1^2 E. The scale t^3 consequently indicates only the numbers between 0 and 1.

In the following lines several examples are quoted so as to explain the use of the new sliding scale.

EXAMPLE 1.

E may be regarded as the start of the logarithmic scale t^1, the finger Z pivoted in the opening 1^1.

The lengths at the right side from the start A may be counted as positive. The scale t^1 will then be composed only of the logarithms of numbers which are larger than the number 1, as the logarithms of the numbers which are smaller than 1 are negative. Only the numbers 1 to 9 are indicated at the logarithmic scale t^1 as it is the general use of common sliding scales. The number 1 which is placed in A counts 1, the next one counts 10, and the next one 100 and so on. In this case, in which A is regarded as the start of the scale, the finger Z is inserted in the opening 1^1 below A. The slide S is now to be slided in such a way, that its left upper corner, the start of the slide scale t^2, is exactly placed below the point P (Fig. 2) of the logarithmic scale t^1. The finger Z may be turned so that its straight lined edge k is placed on the point Q of the scale t^2. R may indicate that point of the logarithmic scale t^1 in which the edge k of the finger Z touches the same. L may indicate the point in which the prolongation of P Q touches the distance 1^1, 1^2.

Now exist the proportion:

$$\frac{A\,R}{A\,P} = \frac{L_1\,P}{L_1\,Q} \text{ consequently } A\,R = \frac{L_1\,P}{L_1\,Q} \times A\,P$$

$\frac{L_1\,P}{L_1\,Q}$ is according to the divisions of the scale t^2 equal to the number indicated in the point Q.

This number may be b. Further the number a is in P so that A P $=\log a$. Consequently is

$$A\,R = \frac{L_1\,P}{L_1\,Q}\,A\,P = b \times \log a = \log a^b$$

Consequently is the number at the point R of the logarithmic scale t^1, equal a^b whereby $a > 1, b > 1$

On the other hand the proportion 1 could be written:

$$A\,P = A\,R \div \frac{L_1\,P}{L_1\,Q}$$

The number r may be indicated at the point R. Consequently: $A\,R = \log r$, consequently $A\,P = \log r \div b = \log \sqrt[b]{r}$

Consequently is the value of the number in the point $P = \sqrt[b]{r}$; whereby $r > 1$, $b > 1$

The slide S is now to be slided so that its upper right corner, the start of the slide-scale t^3 touches the logarithmic scale t^1 at the point C (Fig. 3). The finger Z may be turned so that its edge k touches the point D of the scale t^3. The logarithmic scale t^1 may now be touched by the edge k at the point F. Furthermore the prolongation C D meets the line $1^1, 1^2$ at the point g. The number f is indicated at the point F so that $A\,F = \log. f$. The number d is indicated in the point D so that, according to the division of the scale t^3,

$$\frac{G\,D}{G\,C} = d$$

Now the proportion

$$\frac{A\,C}{A\,F} = \frac{G\,D}{G\,C}$$

or

$$A\,C = A\,F \times \frac{G\,D}{G\,C} = \log f \times d = \log f^d$$

Consequently is the value of the number which is indicated at the point C of the logarithmic scale $t^1 = f^d$, whereby $f > 1$, $d < 1$

The proportion 2 could be written on the other hand

$$A\,F = A\,C \div \frac{G\,D}{G\,C}$$

The number c may be indicated in the point C so that $A\,C = \log c$ Consequently $A\,F = \frac{1}{d} \times \log c = \log \sqrt[d]{c}$ The value of the number at the point F is consequently $\sqrt[d]{c}$; whereby $d < 1$, $c > 1$

EXAMPLE 2

E may be regarded as the start of the logarithmic scale t^1 the finger Z pivoted in the opening 1^2

Now is the point E the start of the scale t^1. The lengths at the left side from E will be counted as negative. The scale t^1 of the slide body L now indicates only numbers between 0 and 1 as the logarithms thereof are negative. The number 1 at the point E counts 1, the next one to the left side 0,1 the next 0,01 and so on.

In this case in which E is regarded as the start of the logarithmic scale t^1, the finger Z is inserted in the opening 1^2 below E. The slide S may now be slided so that its left upper corner the start of the slide scale t^2 is exactly placed under the point H of the logarithmic scale t^1 (Fig. 4). The finger Z may be turned so that his straight line edge k cuts the slide scale t^2 in the point J. K may be the point in which the edge k of the finger Z meets the logarithmic scale t^1. M may be the point in which the prolongation of H J meets the line $1^1\ 1^2$. Now is the proportion:

$$3)\ \frac{E\,K}{E\,H} = \frac{M\,H}{M\,J} \text{ or } E\,K = \frac{M\,H}{M\,J} \times E\,H$$

According to the division of the scale t^2 is the value of $\frac{M\,H}{M\,J}$ equal to the number indicated in the point J. This number may be i. The number h may be indicated at the point H so that $E\,H = \log h$ Consequently is $E\,K = i \times \log h = \log h^i$ Consequently is the value of the number indicated at the point K of the logarithmic scale $t^1 = h^i$; whereby $b < 1,\ i > 1$

On the other hand the proportion 3 could be written

$$E\,H = E\,K : \frac{M\,H}{M\,J}$$

The number k may be indicated at the point K so that $E\,K = \log k$ Consequently

$$E\,H = \frac{1}{i} \log k = \log \sqrt[i]{k}$$

Consequently is the value of the number at the point H equal $\sqrt[i]{k}$, whereby

$$k < 1,\ i > 1.$$

The slide S may now be slided so that his right upper corner, the start of the scale t^3 may touch the logarithmic scale t^1 at the point N (Fig. 5). The finger Z may be turned so that its edge k touches the point O of the scale t^3. The logarithmic scale t^1 may then meet the edge k of the finger at the point T. Further may the prolongation of N O meet the line 1^1, 1^2 in the point U. The number t may be indicated in the point T so that $E\,T = \log t$ The number O may be indicated at the point O. According to the division of the scale t^3 is $O = \frac{O\,U}{U\,N}$

Now is the proportion:

$$\frac{E\,N}{E\,T} = \frac{O\,U}{U\,N}$$

or

$$E\,N = E\,T \times \frac{O\,U}{U\,N}$$

or

$$E\,N = o \log t = \log t^o.$$

The value of the number at the point N is consequently indicated by t^o, whereby

$$t < 1,\ o < 1.$$

On the other hand this proportion can be written:

$$E\,T = E\,N : \frac{O\,U}{O\,N}$$

The number n may be indicated at the point N so that

$$EN = \log n, EJ = \log n \div o = \log \sqrt[o]{n}$$

The number indicated at the point F is consequently $\sqrt[o]{n}$, whereby $o < 1$, $n < 1$.

Corresponding hereto is the calculation of powers and roots found by means of the new sliding scale in the following manner:

CALCULATION OF a^b

I. Case: $a > 1, b > 1$

The finger Z is pivotly inserted into the opening 1^1. The number 1 vertically above 1^1, of the logarithmic scale t^1, of the slide-body L counts in this case: 1. The numbers 1 to the right side of this number count 10, 100, and so on. The slide S is so to be slided that its upper left corner, the start of the slide scale t^2, is exactly placed under such point of the logarithmic scale t^1 of the slide body L which corresponds to the base a of the power a^b The finger Z is then so turned that it is exactly placed on that point of the scale t^2 of the slide S which corresponds with the number b of the exponent. The finger Z then meets the logarithmic scale t^1 in a point which gives the searched value of a^b

II. Case: $a < 1, b > 1$

The finger Z is pivotly inserted into the opening 1^2. The number 1 vertically above 1^2, of the logarithmic scale t^1 counts in this case 1 The numbers 1 to the left side of the same scale count 0,1; 0,01; 0,001; and so on. The slide S is so to be slided that its left upper corner, the start of the scale t^2, is exactly placed under that point of the logarithmic scale t^1 which corresponds to the base a of the power a^b The finger Z is then so turned, that it is exactly placed on such point of the scale t^2 of the slide S which corresponds to the number b of the exponent. The finger Z then meets the logarithmic scale t^1 in a point which gives the searched value for a^b

III. Case: $a > 1, b < 1$

The finger Z is then pivotly inserted in the opening 1^1. The number 1, vertically above 1^1 of the logarithmic scale t^1 counts: 1. The numbers 1 to the right side of the same scale count 10, 100, 1000, and so on. The finger Z is then turned so that it is exactly placed on that point of the logarithmic scale t^1, which corresponds to the base a of the power a^b Further the slide S is moved in such a way, that the finger Z exactly meets that point of the scale t^3 which corresponds to the exponent b of the power a^b The value of the number of the logarithmic scale t^1 which is exactly above the start of the scale t^3 of the slide is the searched value for a^b

IV. Case: $a < 1, b < 1$

The finger Z is then pivotly inserted in the holes 1^2 The number 1 vertically above the opening 1^2 of the logarithmic scale t^1 counts: 1. The numbers 1 to the left side of the same scale count 0,1 0,01, and so on. The finger Z is then turned so that it is exactly placed on such a point of the logarithmic scale t^1 which corresponds to the base a of the power a^b The slide S is then turned so that the finger Z is exactly placed on that point of the scale t^3 of the slide S, which corresponds to the exponent b of the power a^b. That number of the logarithmic scale t^1 which is exactly above the start of the slide scale t^3 is the searched value for a^b

CALCULATION OF $\sqrt[p]{q}$

I. Case: $q > 1, p > 1$

The finger Z is pivotly inserted in the opening 1^1. The number 1, vertically above 1^1 of the logarithmic scale t^1 counts: 1. The numbers 1 to the right side of the same scale count 10, 100, and so on. The finger Z is then turned so that it is placed on that point of the logarithmic scale t^1 which corresponds to the base q of the root $\sqrt[p]{q}$ The slide S is so placed that the point of the scale t^2 of the slide, which corresponds to the exponent p, touches the finger Z. The number of the logarithmic scale t^1 which is now exactly placed above the upper start of the scale t^2 is the searched value for $\sqrt[p]{q}$

II. Case. $q < 1, p > 1$

The finger Z is pivotly inserted in the openings 1^2. The number, vertically above 1^2, of the logarithmic scale t^1 counts: 1 The number, 1 to the left side of the same scale count 0,1, 0,01, and so on. The finger Z is then turned so that it is placed on that point of the logarithmic scale t^1 which corresponds to the base q of the root $\sqrt[p]{q}$. The slide S is so placed that the point of the scale t^2 of the slide which corresponds to the exponent p, touches the finger Z. The number of the logarithmic scale t^1 which is now exactly placed above the upper start of the scale t^2 is the searched value for $\sqrt[p]{q}$

III. Case: $q > 1, p < 1$

The finger Z is pivotly inserted into the hole 1^1. The number 1 vertically above 1^1, of the logarithmic scale t^1 counts in this case: 1. The numbers 1 to the right side of the same scale count 10, 100 and so on. The slide S is so to be slided that his upper right corner the start of the scale t^3 is exactly placed under the point of the logarithmic scale t_1 which corresponds to the base q of the root $\sqrt[p]{q}$ The finger Z is then so turned, that it is exactly placed on such a point of the scale t^3 of the slide S which corresponds to the exponent p of the root $\sqrt[p]{q}$ The finger Z touches the logarithmic scale t^1 of the slide-body L in such a point which gives the searched value for $\sqrt[p]{q}$

IV. Case $q < 1, p < 1$

The finger Z is pivotly inserted into the opening 1^2 The number 1, vertically above 1^2 of the logarithmic scale t^1 counts in this case: 1. The numbers 1 to the left side of the same scale count 0,1, 0,01 and so on. The slide S is so to be slided that his upper right corner, the start of the scale t^3 of the slide S is exactly placed under such a point of the logarithmic scale t_1 which corresponds to the base q of the root $\sqrt[p]{q}$. The finger Z is then so turned that it is exactly placed on such a point of the scale t^3 of the slide which corresponds with the exponent p of the root $\sqrt[p]{q}$ The finger Z then touches the scale t^1 of the slide body L in a point which gives the searched value for $\sqrt[p]{q}$

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:

In a sliding scale to calculate powers and roots with any exponent, a finger turnable around a point vertically situated below the start or the end of the logarithmic scale or the slide body, said finger being adjustable on scales vertically arranged on the slide-scale and indicating the numbers, relating to the exponent of said powers or roots, all substantially as described and for the purpose set forth.

Dated this 19th day of August 1905.

A. MILLER.

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(2 SHEETS)
SHEET 2

Fig. 1.

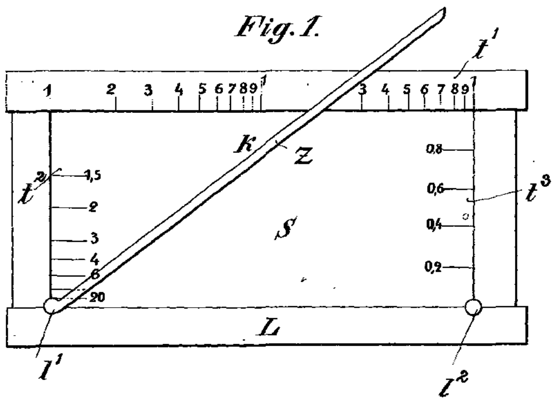


Fig. 2.

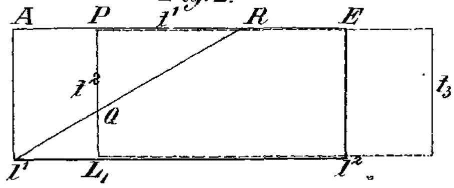


Fig. 3.

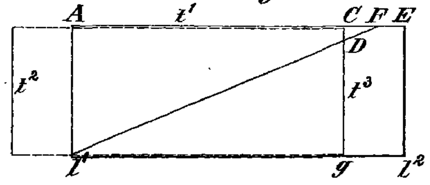


Fig. 4.

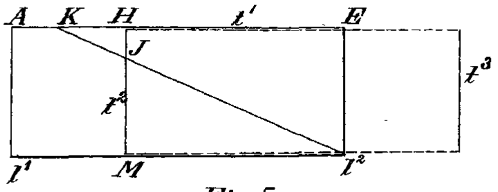
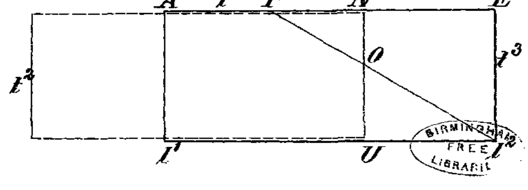


Fig. 5.



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

Fig. 1.

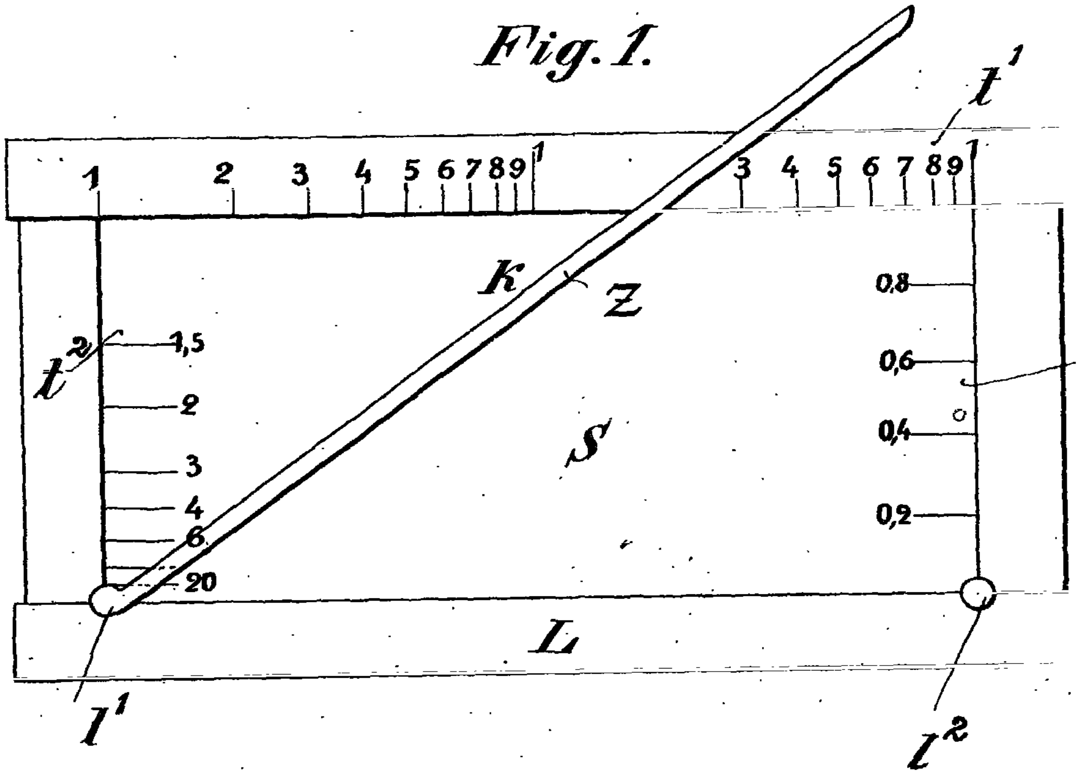


Fig. 2.

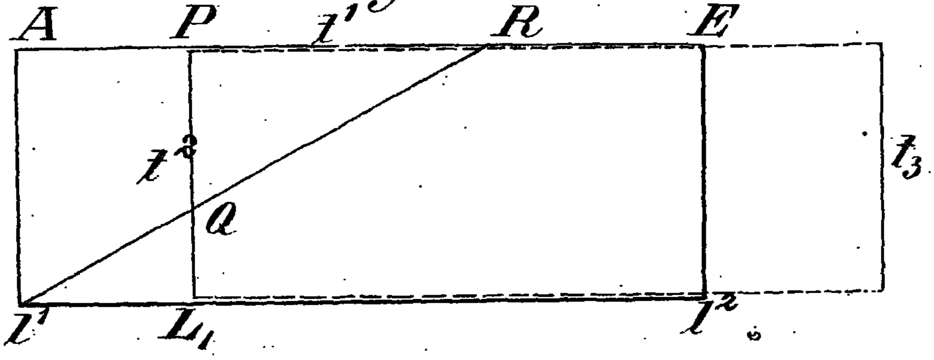


Fig. 3.

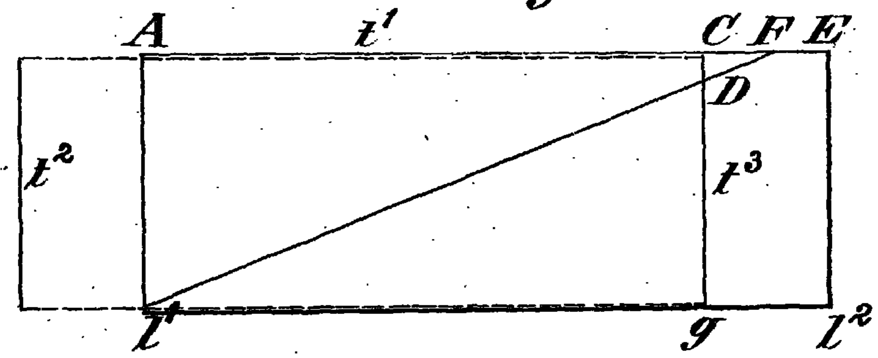


Fig. 4.

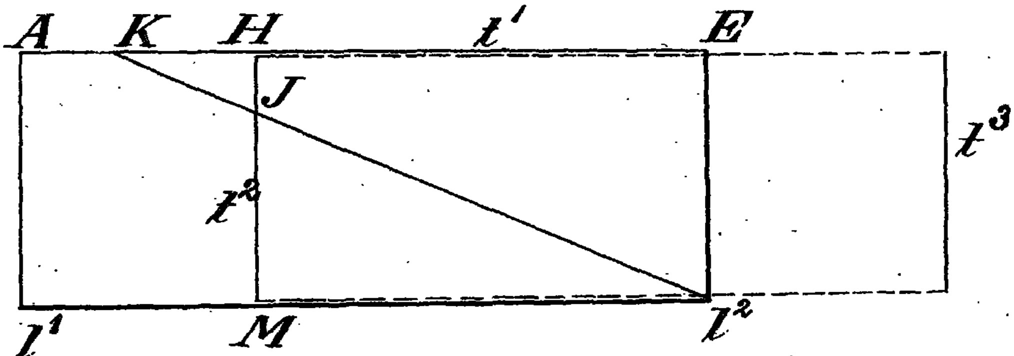


Fig. 5.