June 16, 1925. 1,541,871

F. O. STILLMAN

LOGARITHMIC CALCULATING DEVICE

Filed April 17, 1922

Fig. 1

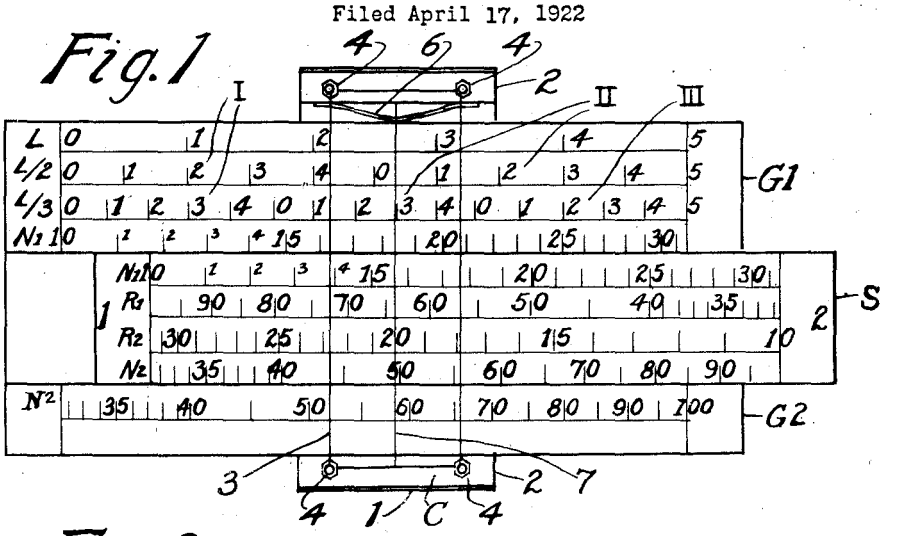


Fig. 2

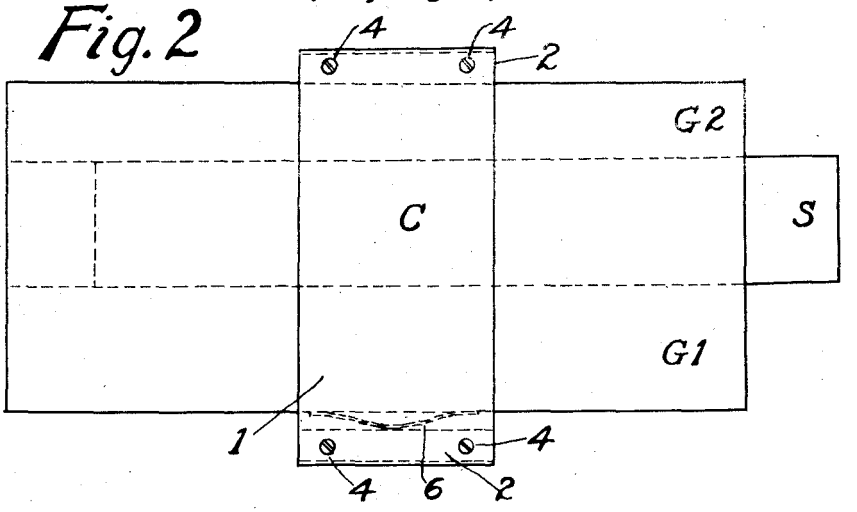
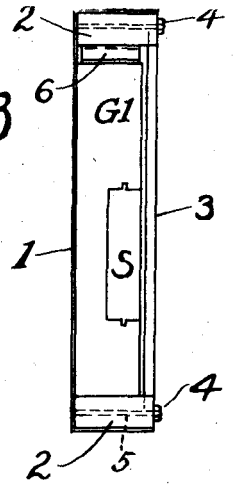


Fig. 3



INVENTOR

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LOGARITHMIC CALCULATING DEVICE.

Application filed April 17, 1922. Serial No. 554,348.

To all whom it may concern:

Be it known that I, FREDERICK O. STILLMAN, a citizen of the United States, and a resident of Melrose, in the county of Middlesex and Commonwealth of Massachusetts, have invented new and useful Improvements in Logarithmic Calculating Devices, of which the following is a specification.

This invention relates to a logarithmic calculating device, preferably of the slide-rule type, having one or more logarithmic scales (numerical values plotted proportional to equally divided logarithmic distances) divided into two equal linear portions which are placed one below the other in registry. These scales together with any auxiliary scales or data are printed on or into an enamel (preferably white) having a celluloid or similar base, which enamel is coated on wood, metal, paper, or any suitable substance. The said enamel and printing is made water-proof and protected for wear by a coat of transparent similar enamel applied over the printing and first named enamel.

The invention in its preferred form is an improvement over the ordinary Mannheim slide-rule in that:

(1) While being just as easily and quickly operated, the former gives, for equal length of rule, four place accuracy instead of three;

(2) The celluloid coating and printing operation while forming a very durable surface are much less expensive than engraving in seasoned celluloid strips.

This invention is further an improvement on divided logarithmic scale slide-rules for the special case of a slide-rule having each logarithmic scale divided into two equal linear portions placed one below the other in registry: no extra mechanical operation and practically no mental operation are necessary to determine the portion of the logarithmic scale in which the answer is to be found. The cursor of the slide-rule described in this invention is constructed so that no opaque material obscures any parts of the scales from view.

Other objects and advantages of this invention will be pointed out in the following description and accompanying drawings. The slide-rule type only is discussed and illustrated, but the same principle is applicable to any of the other types of construction for logarithmic calculating devices.

The preferred embodiment of my invention is illustrated by the following figures:

Figure 1 shows a top view of the rule and cursor giving logarithmic and equally divided scales. (The application of these equally divided scales is described in Patent No. 1,250,379, granted December 18, 1917 to Henry M. Schleicher and myself).

Figure 2 shows a bottom view of the rule and cursor.

Figure 3 shows an end view of the rule and cursor.

The mechanical features relating to the slide-rule construction comprise upper and lower guide members G_1 and G_2, respectively, a slide member S, and a cursor C longitudinally movable on the guide members. With the exception of the cursor the mechanical construction is entirely the same as in the Mannheim, the slide having tongues adapted for reciprocation in grooves in the guide members, the surfaces being always flush and parallel. The cursor C consists of a channel (preferably of metal), 1; two blocks of fibre or other substance, 2, each provided with grooves, 5. The said channel and grooved blocks when assembled restrict movement of the glass, 3, transversely of the slide-rule. The screws or bolts, 4, prevent movement of the glass in the cursor longitudinally of the rule and secure the blocks to the channel. Spring, 6, holds the cursor in any longitudinal position of the guides. The hair-line, 7, serves to register with any longitudinal position on the guide scales.

The remaining discussion is confined to the mathematical features relating to the preferred form of my invention. As shown in Figure 1, the scales on the guide and slide members (with the exception of the equally divided scales, L, L/2, L/3) comprise in each case two consecutive superposed registering portions of a continuous logarithmic scale. These portions may be numbered (or otherwise designated by letters or other indicia). The registering ends of the portions are termed indices. The second portion begins where the first portion leaves off but at the opposite index, Thus the first portion ends and the second portion begins with 3162.

The equally divided scales described in Patent No. 1,250,379 accompany logarithmic scale portions numbered 0, 1, 2, 3, 4, . . . n—1, but it is evident that the same principle holds no matter how the logarithmic portions are designated. For such equally divided scales accompanying continuous logarithmic scales each comprising two consecutive superposed registering portions designated by, say, N_1 and N_2 in consecutive order, the tables in the aforesaid patent become:

	$\sqrt{m}$	$\sqrt{10m}$	$\sqrt{m}$	$\sqrt{10m}$	$\sqrt{100m}$
Log portion N_1	I-N_1	I-N_2	I-N_1	III-N_1	II-N_2
Log portion N_2	II-N_1	II-N_2	II-N_1	I-N_2	III-N_2

Furthermore, the uniform numbering does not need to be 0 to 10; it can be 0 to any integer or fraction thereof. Otherwise the description given in the aforesaid patent applies herein.

The preferred arrangement of scales illustrated in Figure 1 is as follows:

(1) On the upper guide G_1—

(*a*) An equally divided scale marked L (signifying log) numbered from 1 to 5 and subdivided as far as practicable.

(*b*) An equally divided scale marked L/2 (signifying log divided by 2) comprising two sections each one-half as long as scale L and each divided and numbered as said scale L. The two sections from left to right are designated by Roman numerals I and II, respectively.

(*c*) An equally divided scale marked L/3 (signifying log divided by 3) comprising three sections each one-third as long as scale L and each divided and numbered as said scale L. The three sections from left to right are designated by Roman numerals I, II, and III, respectively.

(*d*) The first portion of a logarithmic scale marked N, (signifying first portion of the number scale) beginning at the left index with 10 and ending at the right index with 31.62.

(2) On the slide S—

(*a*) The first portion of a logarithmic scale marked N_1, identically the same as in (1) (*d*).

(*b*) The final portion of a cologarithmic scale marked R_1 (signifying that portion of a reciprocal scale corresponding to N_1), beginning on the right with 31.62 and ending on the left with 100.

(*c*) The first portion of a cologarithmic scale marked R_2 (signifying that portion of a reciprocal scale corresponding to N_2), beginning on the right with 10 and ending on the left with 31.62.

(*d*) The final portion of a logarithmic scale marked N_2 (signifying second portion of the number scale) beginning on the left with 31.62 and ending on the right with 100.

(3) On the lower guide G_2—

(*a*) The final portion of a logarithmic scale marked N_2, identically the same as in (2) (*d*).

(*b*) Trigonometric functions or any factors may be plotted proportional to their logarithms.

The equally divided scale L represents the logarithms and the so called logarithmic scales represent numbers laid off proportional to their logarithms. Therefore, multiplication or division may be performed by adding or subtracting, respectively, the distances corresponding to the numbers. If the use of one slide index brings the desired number setting off scale (outside the indices of the guide scales), the other slide index is to be used, since the same reading is obtained as if the scales were unbroken and repeated to satisfy any logarithmic characteristic.

The arrangement of scales given above makes it possible;

(1) To register the indices of the slide with any position of either portion of the logarithmic scale on the guides without the use of the cursor.

(2) To determine, with the aid of numbers, letters, or other indicia the portion of the logarithmic scale in which the answer of any multiplication or division operation occurs, by the mechanical operations with which the said mathematical operations are performed. Figure 1 shows the digit 1 to the left of the left slide index and the digit 2 to the right of the right slide index. The said digit which is at the index that is on scale, after the slide and cursor setting have been made, indicates the portion of the logarithmic scale in which the answer is to be found. If the factors occur in like scale portions, the sub-numerals of N_1, R_1, N_2, R_2 correspond directly with the said digit. If the factors occur in unlike scale portions, the subnumeral 1 corresponds with digit 2 and subnumeral 2 corresponds with digit 1. Like scale portions are two upper scale portions (designated by subnumeral 1, e. g. N_1 or R_1) or two lower scale portions (designated by subnumeral 2, e. g. N_2 or R_2). The application of this principle will be made clear in the following directions for mathematical operations.

Multiplication.—One of two methods may be used according to which is more convenient.

Method 1. Set the cross-hair of the cursor in registry with the first factor on the guide scale portion N_1 or N_2 (whichever contains the factor). Bring the second factor under the cross-hair using scale portion R_1 or R_2. The answer is at the slide index which is

on scale in guide scale portion N_1 or N_2. If the factors are in N_1 and R_1, or N_2 and R_2, the digit 1 or 2, respectively, indicates that the answer is in the guide scale portion N_1 or N_2 according to whether the left or the right index of the slide is on scale. If the factors are in N_1 and R_2, or N_2 and R_1, the digit 1 indicates that the answer is in guide scale portion N_2, and the digit 2 indicates that it is in guide scale portion N_1.

For example, multiply 2 times 6. Set the cross-hair of cursor to 2 in the upper guide scale portion N_1. Bring 6 in R_1 under the cross-hair. The left slide index is on scale and the factors occur in like scale portion. Therefore, the answer 12 is at the index in the upper guide scale portion N_1.

Method 2. Set one index of the slide to the first factor in the guide scale. Bring the cross-hair of the cursor to the second factor in slide scale portion N_1 or N_2. (If the second factor is off scale bring the other slide index to the first factor.) The answer is under the cross-hair in the upper guide scale portion N_1, if the factors occur in like scale portions with the left slide index on scale or if the factors occur in unlike scale portions with the right slide index on scale; otherwise the answer is in lower guide scale portion N_2.

For example, multiply 2 times 6. Set the right slide index to 2 in the upper guide scale portion N_1. Bring the cross-hair of the cursor to 6 in slide scale portion N_2. The right slide index is on scale and the factors occur in unlike scale portions. Therefore, the answer 12 is under the cross-hair in the upper guide scale portion N_1.

Division.—Set the cross-hair of the cursor to the dividend in guide scale portion N_1 or N_2. Bring the divisor to the cross-hair using slide scale portion N_1 or N_2. The quotient is in the guide scale portion N_1 or N_2 at the index of the slide which is on scale. If the factors occur in like scales the quotient is in guide scale portion N_1 or N_2 according as the left slide index or the right slide index is on scale. If the factors occur in unlike scales the quotient is in guide scale portion N_2 or N_1 according as the left or the right slide index is on scale.

For example, divide 12 by 6. Set the cross-hair of the cursor to 12 in the upper guide scale portion N_1. Bring 6 in the slide scale portion N_2 under the cross-hair. The right slide index is on scale and the factors occur in unlike scale portions. Therefore, the quotient 2 is at the index in upper guide scale portion N_1.

Involution.—The general rules for involution are described in Patent No. 1,250,379; rules for square root and cube root only will be given here.

Square root. Set in the guide scale portion N_1 or N_2 the cross-hair of the cursor to the number of which the square root is sought. Take the reading in the scale L. Note whether the number is in scale portion N_1 or N_2 and whether it has the form of m or 10m (which standard mathematical form is explained in Patent No. 1,250,379). Under these two types of headings for square roots in the above table will be found a Roman numeral accompanying N_1 or N_2. The Roman numeral I or II designates the section of scale L/2 in which the L scale reading is to be set. Having made this setting the said N_1 or N_2 indicate the guide scale portion in which the square root of the number is to be found. Rules applying only to the special case embodied in this invention are as follows. If the number is in scale portion N_1 the L scale reading will always be set in section I of the L/2 scale. If the number is in the scale portion N_2 the L scale reading will always be set in section II of the L/2 scale. If the number is of the form m the root will be found under the cross-hair (reset in the L/2 scale) in the upper guide scale portion N_1. If the number is of the form 10m the root will be found in guide scale portion N_2.

For example, find the square root of 25. The number is in the scale portion N_1 and is of the form 10m. Therefore, the L scale reading corresponding to the scale portion N_1 setting of 25, namely, 3979 is set in section I of the L/2 scale, and the square root 5 is found in the lower guide scale portion N_2 under the cross-hair.

Cube root. Set in the guide scale portion N_1 or N_2 the cross-hair of the cursor to the number of which the cube root is desired. Take the L scale reading. Note whether the number is in the scale portion N_1 or N_2 and whether it has the form of m or 10m or 100m. Under these two types of headings for cube roots in the above table will be found a Roman numeral accompanying N_1 or N_2. The Roman numeral I, II, or III designates the section of the L/3 scale in which the L scale reading is to be set. Having made this setting the said N_1 or N_2 indicate the guide scale portion in which the cube root of the number is to be found. Rules applying only to the special case embodied in this invention are as follows: If the number is of the form m the L scale reading will be set in section I or II of the L/3 scale according as the number occurs in the guide scale portion N_1 or N_2. If the number is of the form 10m the L scale reading will be set in section III or I of the L/3 scale according as the number occurs in guide scale portion N_1 or N_2. If the number is of the form 100m the L scale reading will be set in section II or III of the L/3 scale according as the number occurs in guide scale portion N_1 or N_2. If the L scale setting is made in section I or III of the

L/3 scale the cube root is found in the same scale portion N_1 or N_2 as the number. If the L scale setting is made in section II of the L/3 scale the root is found in guide scale portion N_1 or N_2 according as the number is in guide scale portion N_2 or N_1, respectively.

For example, find the cube root of 27. The number is in scale portion N_1 and is of the form 10m. Therefore, the L scale setting corresponding to the scale portion N_1 setting of 27, namely, 4314 is to be made in section III of the L/3 scale and the cube root 3 is found in the upper guide scale portion N_1 under the cross-hair.

Evolution.— Square of a number. Set the cross-hair of the cursor to the number in guide scale portion N_1 or N_2. Take the L/2 scale reading and note whether the section is I or II in which the reading is taken. Set the L/2 scale reading in the L scale. This Roman numeral accompanied with N_1 or N_2, in whichever scale portion the number occurs, gives in the above table the scale portion N_1 or N_2 in which the square is found. Another rule applying only to the special case embodied in this invention is as follows. The square of a number is found in guide scale portion N_1 or N_2 according as the L/2 scale reading is made in section I or II, respectively.

For example, find the square of 2. The L/2 scale reading 6021 corresponding to the upper guide scale setting of 2 is in section II. Therefore, the 6021 setting made in the L scale gives the square 4 in the lower guide scale portion N_2 under the cross-hair.

Cube of a number. Set the cross-hair of the cursor to the number in guide scale portion N_1 or N_2. Take the reading in the L/3 scale and note whether the section is I, II, or III in which the reading is taken. Set the L/3 scale reading in the L scale. The above Roman numeral accompanied with N_1 or N_2, in whichever scale portion the number occurs, gives in the above table the scale portion N_1 or N_2 in which the cube is found. Rules applying only to the special case embodied in this invention are as follows. The cube of a number is found in the same guide scale portion N_1 or N_2 as the number if the L/3 scale reading is taken in section I or III. The cube is found in the other scale portion if the L/3 reading is taken in section II.

For example, find the cube of 2. The L/3 scale reading 9031 corresponding to the upper guide scale setting of 2 is in section II. Therefore, the setting 9031 made in the L scale gives the cube 8 in the lower guide scale portion N_2 under the cross-hair.

It is evident that the special rules regarding square roots, cube roots, squares, and cubes may be indicated on the L, L/2, and L/3 scales so that the cumbersome table may be omitted. Furthermore, the use of a logarithmic scale divided into three equal linear portions placed one below another in registry accompanying scales L and L/3 render simple rules for cubes and cube roots similar to the rules for squares and square roots applying to the use of a logarithmic scale divided into two equal linear portions accompanying scales L and L/2.

Logarithm of a number.—Set in the guide scale portion N_1 or N_2 the cross-hair of the cursor to the number of which the logarithm is wanted. If the number is in the upper guide scale portion N_1 the L scale reading gives the mantissa of the logarithm directly, the decimal point being placed to the left of the left hand digit. If the number is in the lower guide scale portion N_2, 0.5 must be added to the L scale reading properly pointed off. The usual rules for characteristic must be observed.

For example, find the logarithm of 4. The L scale reading is .1021. The number is in the lower guide scale portion N_2. The characteristic of the number is 0. Therefore, the logarithm is 0.6021.

I claim:

In a logarithmic calculating device having two members capable of parallel reciprocation with respect to one another, each of said members carrying a scale comprising two consecutive superposed portions of a continuous logarithmic scale, either of said two members having indicia to indicate which of the said two logarithmic portions contains the answer of a mathematical operation.

Signed at Chrome, New Jersey, this 15th day of April, 1922.

FREDERICK O. STILLMAN.