Oct. 31, 1950 S. G. ISSERSTEDT 2,527,734

LOGARITHMIC CALCULATOR

Filed Aug. 22, 1946 4 Sheets-Sheet 1

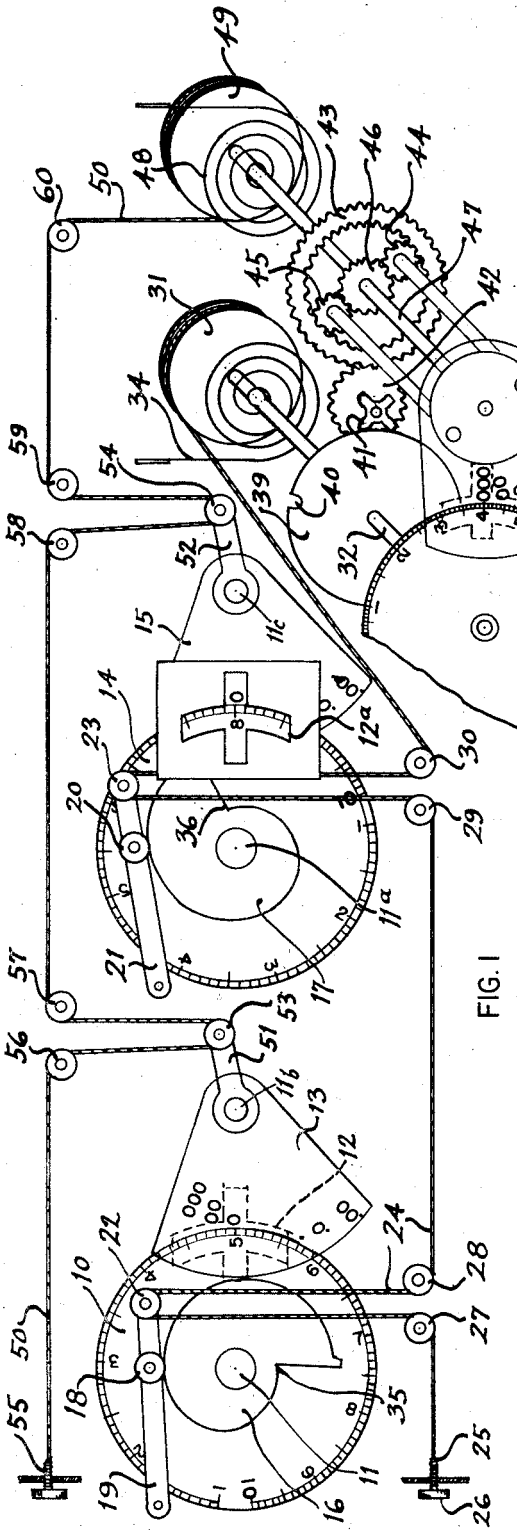

FIG. 1

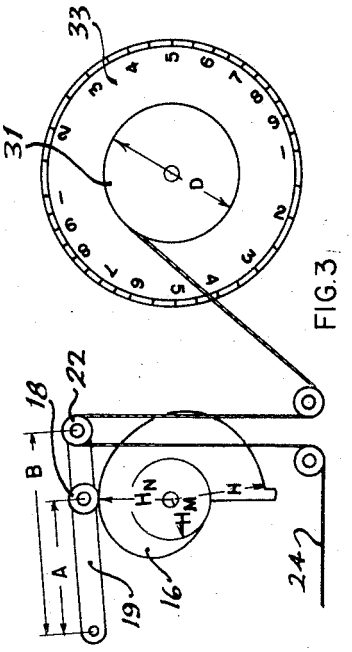

FIG. 3

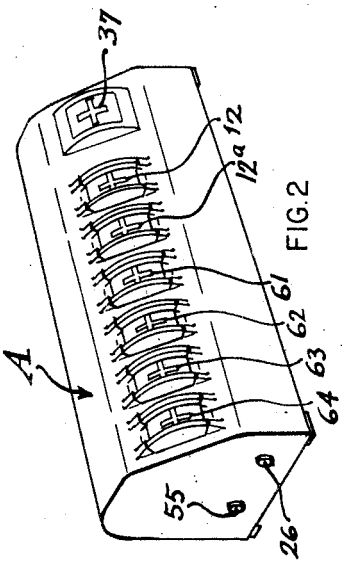

FIG. 2

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LOGARITHMIC CALCULATOR

Filed Aug. 22, 1946 4 Sheets-Sheet 2

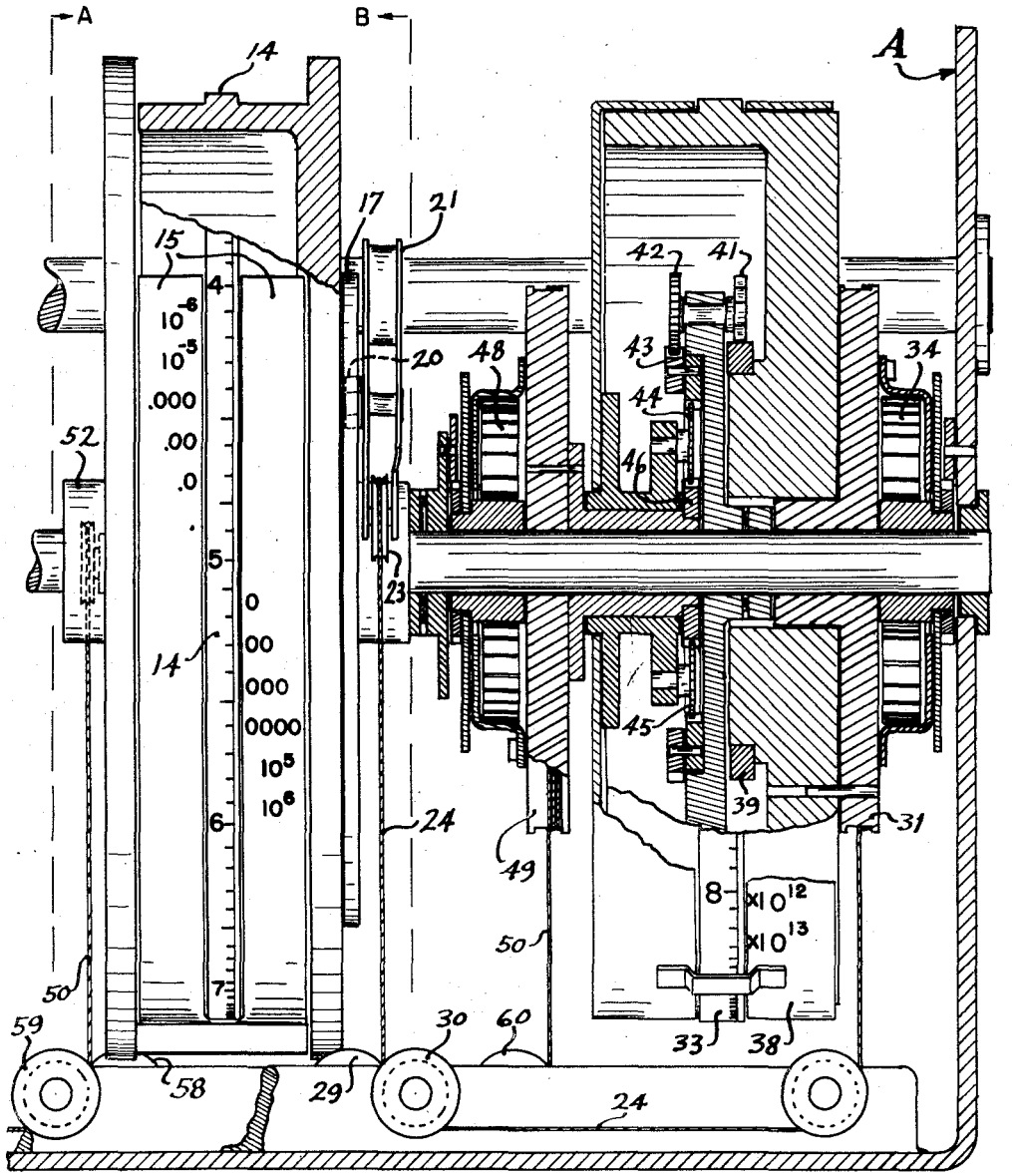

FIG. 4

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LOGARITHMIC CALCULATOR

Filed Aug. 22, 1946 4 Sheets-Sheet 3

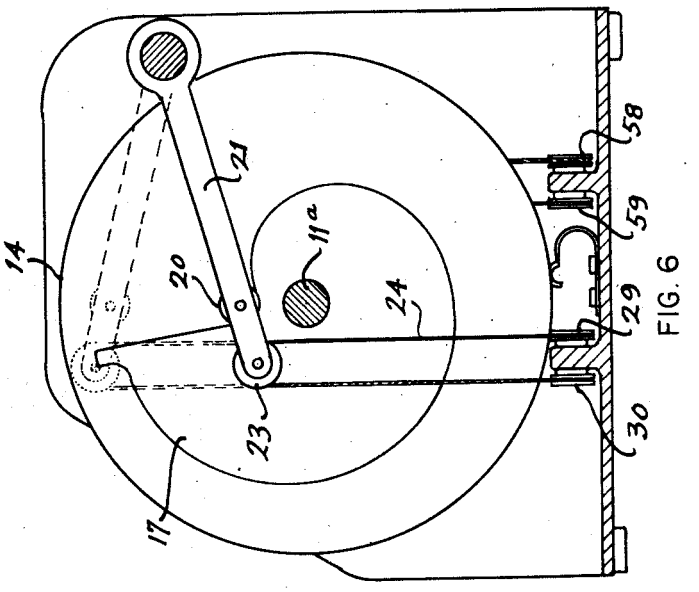

FIG. 6

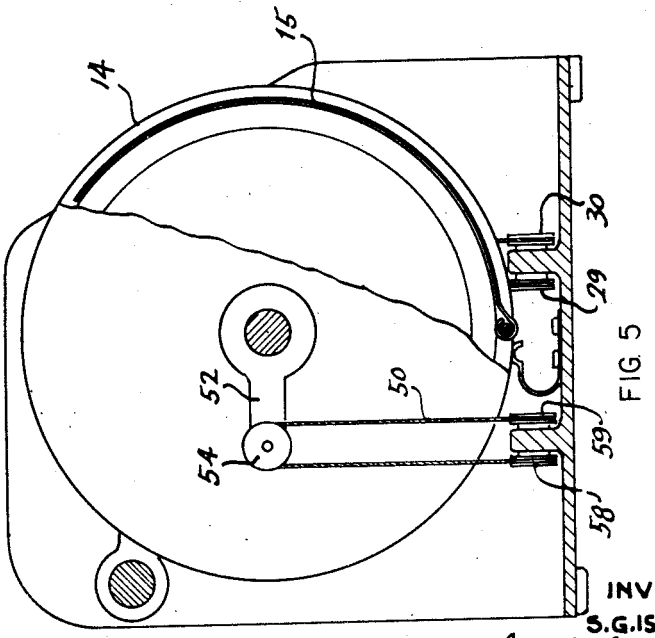

FIG. 5

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LOGARITHMIC CALCULATOR

Filed Aug. 22, 1946 4 Sheets-Sheet 4

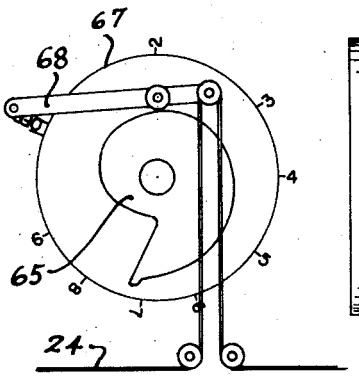

FIG. 7

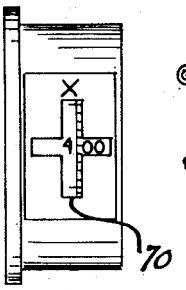

FIG. 8

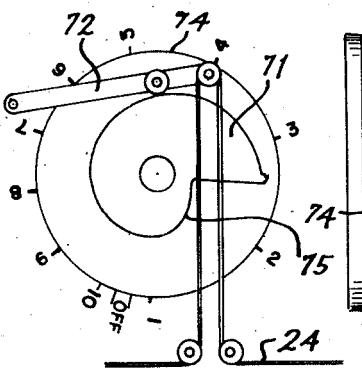

FIG. 9

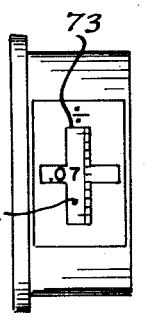

FIG. 10

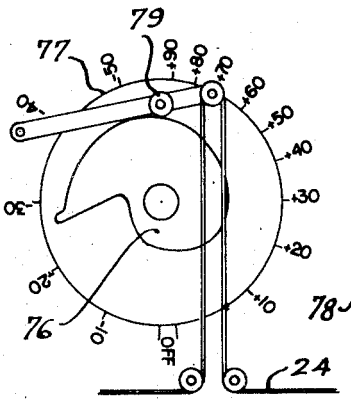

FIG. 11

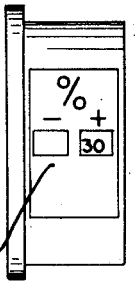

FIG. 12

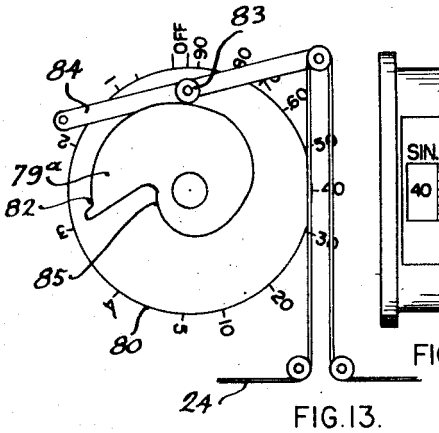

FIG. 13.

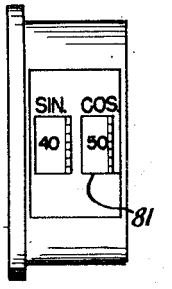

FIG. 14

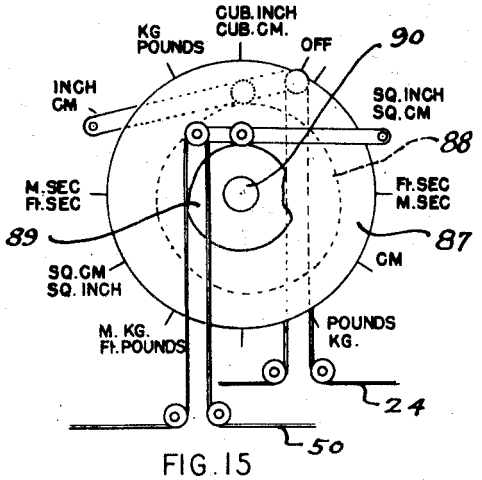

FIG. 15

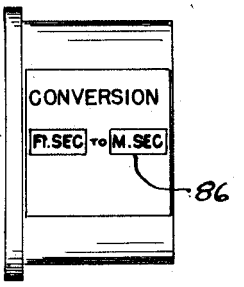

FIG. 16

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UNITED STATES PATENT OFFICE

2,527,734

LOGARITHMIC CALCULATOR

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Application August 22, 1946, Serial No. 692,324

2 Claims. (Cl. 235—61)

1

This invention relates to calculators, using logarithmic operative means.

For the purpose of calculation the slide rule which is predominantly employed particularly in the engineering field and the accounting field provides a means for obtaining complicated calculation. However, difficulties arise in the use of the slide rule since it does not disclose the decimal point which must be assumed, and, therefore, often gives rise to inadvertent error. Moreover a serious disadvantage arises in the case where a calculation is being made involving a number of factors when two or more calculations are thus involved. In this case it is only possible to check the result in terms of the last two factors so that for a complete check on the result, the calculation has to be done from the beginning again. Thus, while the slide rule provides a much quicker means of calculation than by conventional calculation, it is often subject to these disadvantages that require rechecking. Furthermore the logarithmic scales of the slide rule naturally vary to present unequal graduations for equal numerical increases which require considerable care in adjusting it which give rise to frequent error in the hands of a not fully skilled operator.

It is an object of the present invention to provide a calculator which may be operated much more easily than the slide rule and which will be less subject to error but through which the calculation can be rechecked because of the fact that the component figures of the calculation, as well as the result, are always visible.

A further object of the invention is to provide a calculator employing indicators on which two or more numbers can be set and which will instantaneously show the result of the multiplication or division of the numbers shown on the indicators.

A further object of the invention is to provide a calculator on which the numerical value of two or more factors or divisors is easily set in such a manner that no unnecessary zeros appear and on which the factors, divisors and result appear on the indicators simultaneously and in such a manner that they may be easily read.

A further object of the invention is to provide a calculator of this character which will multiply and divide numbers to which its indicators are set and on which the numerical value of one or more factors or divisors can be varied simultaneously and the effect of this variation observed instantaneously on the result indicator.

A further object of the invention is to provide a calculator which may be designed to make all

2

calculations which can be made with standard and special slide rules but which does not have the disadvantages of the slide rule calculation.

Further objects of the present invention will be evident from a consideration of the following specification taken in conjunction with the accompanying drawings, wherein,

Figure 1 is a schematic view of the arrangement of the basic parts of the present invention used for the multiplication of two factors.

Figure 2 is an isometric view of a computer of the proposed type using six scales and cams.

Figure 3 shows the relationship of cam 16 to drum 31 and scale 33.

Figure 4 is an axial view of a drum assembly of the proposed type showing the last of a series of indicator dials attached.

Figure 5 is a view A of Fig. 4.

Figure 6 is a view B of Fig. 4.

Figure 7 shows a cam and scale similar to those of Figure 1 with the terminus of the cam extended to facilitate multiplication.

Figure 8 is a schematic view of the casing of the indicator dial of Fig. 4.

Figure 9 shows a cam and scale similar to Fig. 7 which is used for dividing one factor by another.

Figure 10 is a schematic view of a casing for the mechanism of Fig. 9.

Figure 11 shows a cam and scale of the proposed type which may be used for the addition or subtraction of percentages.

Figure 12 is a schematic view of a casing which is used to house the mechanism of Fig. 11.

Figure 13 shows a cam and scale adapted to the handling of trigonometric functions.

Figure 14 is a schematic view of a casing suitable to the device of Fig. 13.

Figure 15 shows a cam and scale designed to handle conversion factors.

Figure 16 is a schematic view of a suitable casing for use with the device of Fig. 15.

The calculator in its basic form makes use of the fact that the product of a number of factors may be obtained by adding the logs of the factors and determining the number belonging to the sum of the logs, and that every positive number is the product of an integral power of ten and of a number less than ten but not less than one, and that every logarithm is the sum of an integer and a number less than one but not less than zero. The integral term is called the "characteristic" of the logarithm while the non-negative term, less than one, is called the "mantissa."

The calculator mechanism divides numbers, to which its dials are set, into characteristics and

mantissa of their logarithms, adds or substracts these characteristics and mantissa separately, and instantaneously indicates on a result dial the number belonging to the sum of the logarithms of the numbers to which the dials of the calculator are set.

Referring to the drawings, and particularly to Fig. 1, 10 represents diagrammatically an indicator dial rotatably mounted on shaft 11, the dial being visible through the visual opening 12. The dial 10 is numbered from one to ten with decimal divisions between. Co-operating with this dial is a movable scale such as dial segment 13 which may be of transparent material and which is designed to vary the value of the numeral set on dial 10. Dial 10 and dial segment 13 may be adjusted so that the number to be multiplied appears in the visual opening 12 indicated by dotted lines. Dials 14 and dial segment 15 are similar to dials 10 and dial segment 13 and they may be rotated so that the second factor to be multiplied appears in the visual opening 12A. The product of two factors appearing in the visual openings 12 and 12A will then appear on the visual opening 37 and can be read directly from dials 33 and dial segment 38 which are operated by the mechanism that will now be described.

In conjunction with the dial 10, a cam 16 is mounted on shaft 11 while in conjunction with dial 14 a cam 17 is mounted on shaft 11A.

The peripheral surface of cam 16 is designed to engage with the roller 18 of a pivoted lever 19 while the cam 17 is designed to engage the roller 20 of a pivoted lever 21. These levers carry suitable pulleys 22 and 23 respectively at their free ends opposite to the fulcrum point each of which is designed to receive thereover the cable 24. The cable is designed rotationally to operate the necessary indicating means while the cams are so designed to operate in conjunction with the levers 19 and 21 to cause operation of the necessary indicating means in proportion to the sum of the logs of the numbers to which the dials, attached to the cams 16 and 17 are set.

The cable 24 is anchored at one end as at 25 and the anchoring point preferably takes the form of an adjustment device such as the screw 26 so that the zero on the result indicator 33 may be set accurately with all indicators in the zero position in order to correct errors which may be caused by stretching of the cable, by play between the rollers and their shafts, or by unequal temperature expansion of the mechanism. The cable 24 extends first over a suitable pulley 27 anchored to any stationary mounting such as a portion of the cabinet A, then extends over the pulley 22, is fitted around a pulley 28, mounted similarly to 27 and then extends to the pulley 29 and over pulley 23, in like manner to pulley 22, and thence around the anchored pulley 30, finally to be wound on the drum 31 which is rigidly carried on the shaft 32 of the answer-indicating dial 33. The shaft 32 is connected to a suitable spring 34 which maintains the cable 24 under tension and maintains the rollers of the lever arms in constant bearing engagement with the cam surfaces.

It should be understood that the cams 16 and 17 are cut to provide a cam rise which through pivoted levers 19 and 20 cause pulleys 22 and 23 to move proportionately to the log of the number set on the dial in question and thereby causes rotation of the drum 31 and the answer-indicating dial 33 connected thereto in proportion to the sum of the logarithm of the numbers to which dials 10 and 14 are set. The answer-indicating dial 33 has a logarithm scale. If the cam rise of cams 16 and 17 were uniform a logarithm scale would have to be used on the dials 10 and 14. Preferably, however, the cams 16 and 17 are designed to produce in effect a linear scale for the dials connected thereto wherein graduations are substantially equally spaced throughout the extent of the dials. This obviously greatly facilitates the use of the calculator.

It will be obvious from a consideration of Figure 1, that if the dial 10 is set at one, the roller 18 will be disposed at one terminal 35 of the peripheral cam surface of cam 16. Likewise in the case of dial 14, the roller 20 will be set at one terminus 36 of the peripheral cam surface of cam 17.

The length of the cable is designed so that with both dial 10 and dial 14 set at one, the indicating dial 33 would also indicate one. It should be noted that the total height of the cams 16 and 17, the length of the lever arms 19 and 21 and the diameter of the drum 31 of the answer-indicating means are correlated and designed so that in moving the cam in engagement with the rollers of these lever arms from the terminus 35 or the terminus 36 of the cam surface to their opposite extremities produces a movement of 180 degrees of the drum 31. Therefore as the cams are designed to change the length of the cable in proportion to the logarithm of the number to which each dial is set, and as the scale of the dial of the answer-indicating means is logarithmic, it is apparent that if only one dial is operated, for instance either dial 10 or dial 14, to position a given number of the scale before the indicating opening 12 or 12A, the corresponding number will also appear at the indicating opening of the answer-indicating dial. Thus, assuming that dial 10 is first operated to position the numeral 5 before the indicating opening 12 then the dial 33 of the result indicator will position the numeral 5 in the indicating opening 37. The cable will thereby be shortened in proportion to logarithm 5 and this will rotate drum 31 and the logarithmic scale 33 attached thereto to also indicate 5 in the visual opening 61. If, then the dial 14 is rotated so that numeral 8 will appear before its indicating opening 12A, such movement will cause an additional shortening of the cable 24 in proportion to logarithm 8 and an additional rotation of drum 31 until it has rotated proportionately to the sum of logarithm 5 plus logarithm 8 and thus the numeral 4 will appear on logarithmic scale 33 in visual opening 37.

When the dial 33 moves past 180 degrees, which will occur whenever the sum of the logarithms of the numbers to which dials 10 and 14 are set are greater than one, means is provided to actuate the scale 38 to dispose a zero in conjunction with the numeral 4 in the opening 37 and, of course, to dispose more than one zero in this position if the manipulation of the dials required added zeros in accordance with the calculation being performed.

In order to add the required zeros when the dial 33 is moved past 180 degrees a disc 39 may be provided on shaft 32 formed with a notch 40 designed to engage one of the arms 41 of an actuator designed to rotate the gear 42 when the actuator is rotated. Gear 42 is designed to mesh with the ring gear 43 formed with external and internal teeth, the latter being designed to rotate the planetary gears 44 and 45 which in turn mesh with the sun gear 46. Gear 46 is

mounted on a shaft 47 which is connected to indicating scale 38 and consequently rotation of the gear 42 when caused by the disc 39 will proportionately move the scale 38 to dispose the necessary number of zeros in the indicating opening 37.

The shaft 47 is spring held by suitable spring 48 and carries the drum 49 which latter is designed to receive cable 50, the spring 48 maintains cable 50 under tension.

The dials 13 and 15 are designed to vary the numbers set on the dials 10 and 14 by an integral power of ten and the mechanism is designed to indicate the multiplication of these integral powers of ten on the segment 38 and thereby vary the number appearing on the result-indicating dial 33 accordingly.

The dials 13 and 15 are freely rotatable on the shafts 11b and 11c respectively and provided with the operating arms 51 and 52 respectively each having at their free ends a pulley 53 and 54 respectively.

The cable 50 is anchored at one end 55 preferably by means of a suitable adjusting device to which compensation may be provided for any variation in the cable due to stretch and temperature changes, etc. The cable is designed to pass over a suitable pulley 56, then over the pulley 53 of arm 51, over further guide pulleys 57 and 58, then over the pulley 54 and extends over the guide pulleys 59 and 60 after which it extends around the drum 49. It will be apparent from this therefore that if the scale 13 or the scale 15 is operated, the corresponding lengthening or shortening of the unwound portion of the cable caused by the swinging movement of the arms 51 and/or 52 of the scales 13 and 15, the shaft 47 will be rotated in a clockwise or anticlockwise direction as the case may be thus to vary the value of the result indicated by the result indicator 33.

Thus the setting of dial segments 13 and 15 will shorten or lengthen the cable 50 by an amount proportional to the characteristic of the logarithm of the numbers which appear in the visual openings 12 and 12A, and rotate drum 49 according to the sum of these characteristics, thus modifying the number appearing in visual opening 37 by ten or a multiple of ten, depending upon the multiplication of the powers of ten by which the numbers appearing in the openings 12 and 12A were modified by operating dial segments 13 and 15.

The rise of the cam 16 and its relationship to the drum 31 is determined as follows: Referring to Figure 3, the height H_n of the cam 16 to the contact point with the roller 18 when the scale attached to the cam is set to the number N, is—

$$H_n = H_m + \lg. NC_m$$

H_m is the minimum height of the cam 16

lg. N is the log of the number to which the scale 10 is set.

C is a constant dependent upon the dimensions of the cam 16, the lever 19, the drum 31, etc. Its numerical value is determined by the following formula (see Fig. 3).

$$C = \frac{AD\pi(H - H_m)}{B4}$$

A is the length of the lever 19 from the fulcrum point to the axis of the roller 18.

B is the length of the lever 19 from the fulcrum point to the axis of the roller 22.

$D\pi$ is the circumference of the drum 31.

H is the maximum height of the cam 16.

H_m is the minimum height of the cam 16.

The length of the arms 51 and 52 attached to segments 13 and 15, the diameter of the drum 49 and the ratio between gears 44, 45, and internal gear 47 are chosen so that angular movement of the dial segments 13 or 15 produce equal angular movements of dial segment 33.

For example: the multiplication of 50×80 is performed by the mechanism in the following manner. Dial 10 is rotated until the numeral 5 appears in the visual opening 12. Through the lever 19 and the cable 24 associated therewith the drum 31 is rotated in proportion to the logarithm of 5 and the numeral 5 will then appear in the visual opening 37 on scale 33. The dial segment 13 is then adjusted so that the number 50 appears in the visual opening 12 by placing zero behind the 5 which already is set on dial 10. Through the arm 51 and the cable 50 associated with the dial segment 13, the drum 39 and the dial segment 38 are moved proportionately so that the numeral 50 would appear in the visual opening 37 by placing an additional zero behind the numeral 5 which already appears in this opening on dial 33. At this stage, therefore, the numeral 50 will appear in the visual opening 12 and the numeral 50 will also appear in the visual opening 37 of the result indicator. In order to multiply this by 80, the dial 14 and the dial segment 15 would then be moved so that 80 appears in the visual opening 12A. The dial 14 is first moved until the numeral 8 appears in visual opening 12A. When the numeral 2 appears in opening 12A, the drum 31 will be rotated an additional amount in proportion to logarithm 2, therefore the total rotation of the drum 31 will be in proportion to logarithm 5 plus logarithm 2, so that 10 would appear in the visual opening 37. However, the dial will have been turned 180 degrees and, as described above, through the operation of the disc 40 and the gearing 41, 42, 43, 45, the dial segment 38 will be advanced one position so that an additional zero will be added and the number 100 will appear in visual opening 37.

At this stage, the numeral 50 will appear in visual opening 12, the numeral 2 will be in visual opening 12A, and the result 100 will appear in visual opening 37. After the dial has been rotated sufficiently so that the numeral 8 appears in visual opening 12A, the drum 31 and the scale 33 will have been rotated in proportion to logarithm 5 plus logarithm 8, and therefore the numeral 4 will appear in visual opening 37 ahead of the two zeros appearing on dial segment 38, and the result read in visual opening 37 will be 400. At this stage a 50 will appear in visual opening 12, 8 will appear in visual opening 12A, and the result 400 will appear in visual opening 37. Dial segment 15 is then moved so that 80 will appear in visual opening 12A and thereby dial segment 38 will be rotated so that three zeros appear in visual opening 37 ahead of the Figure 4, and the result appearing in visual opening 37 will be 4,000. Thus, 50 will appear in visual opening 12; 80 will appear in visual opening 12A, and the result of the multiplication of these two figures, 4000, will appear in visual opening 37.

From the above description it is apparent that the result of the multiplication of any two numbers which appear in visual openings 12 and 12A will appear instantaneously in visual opening 37.

While the schematic arrangement in Figure 1 shows only two scales and associated cams, levers and pulleys, it is apparent that additional scales and cams may be added, thus making possible the multiplication of three or more factors.

Figure 2 shows an isometric view of the computer containing six scales and cams which will, in visual opening 37, instantaneously indicate the product of the figures which are set to appear in visual openings 12, 12A, 61, 62, 63 and 64. The details of construction of a computer of this type are shown in Figures 4, 5 and 6.

The shape of cams 16 and 17 and their relationship to the scales 10 and 14 is designed to produce rotations of the drum 31 in proportion to the logarithms of the numbers to which scales 10 and 14 are set, thus indicating the product of these numbers in visual opening 37, but the cam shapes and the scales may be designed to perform many other calculations such as division, addition and subtraction of percentages, multiplication with trigonometric functions, etc.

This will become evident from consideration of Figures 7 to 16 which illustrate a number of combinations of scales and cams which may be introduced into the calculator to perform calculations other than multiplication. The cam 65 and the scale 67 shown schematically in Figure 7, are similar to the cam 16 and the scale 10 shown in Figure 1. However, in cam 65, the terminus 35 of cam 16 has been extended so that after the cam roller has reached this terminus and the numeral one appears in the visual opening, the cam may be rotated farther until an indication such as "Off" appears in the visual opening without raising or lowering the lever 68. Figure 8 shows schematically the casing shown in Figure 4 and a visual opening 70 similar to visual openings 61 and 62 in Figure 3. As the scale and the cam associated therewith are designed for multiplication, a multiplication sign or any other marking should appear above the visual opening as indicated in Figure 8, to make it clear to the operator that the calculator will multiply with any number appearing in the visual opening 70.

Figures 9 and 10 show a cam and scale combination similar to Figures 7 and 8. However, the rise of cam 71 and the graduations on scale 74 have been designed so that if it is operated in conjunction with a mechanism as shown in Figure 1, the figure appearing in the result indicator of the calculator will be divided by the figure appearing in the visual opening 73. As the cam and the scale have been designed for division, a division mark or any other indication should appear above the visual opening 73 so that it is apparent to the operator of the calculator that the result has been divided by any figure appearing in visual opening 73.

While the multiplication cam and scale shown in Figures 7 and 8 were designed to shorten the effective length of cable 24 in proportion to the logarithm of the number to which the scale 67 is set, the division cam 71 and the division scale 74 are designed to lengthen the cable in proportion to the logarithm of the number to which the scale 74 is set. Therefore, while the multiplication cam and scale produce counter-clockwise rotation of the drum 31, the division cam 71 and division scale 74 produce clockwise rotation of the drum in proportion to the logarithm of the number set on the scale.

For instance, to divide six by two, the multiplication cam 65 would be rotated until the numeral 6 appeared in visual opening 70, thereby causing counter-clockwise rotation of the drum 31 and the scale 33 and therefore causing the numeral 6 to appear in the visual opening 37. Adjusting the division cam 71 so that the numeral 2 would appear in visual opening 73 would cause clockwise

rotation of the drum 31 and logarithm scale 33 attached thereto, and thus the total rotation of drum 31 and scale 33 would be in proportion to logarithm 6 minus logarithm 2 (equal to logarithm 3) and therefore the numeral 3 would appear on scale 33. The division cam also preferably has a terminus 75 which will not produce any rise of the lever 72 so that the scale connected with the cam may be rotated past the numeral 1 until a mark such as "Off" appears in the visual opening without lengthening or shortening the effective length of cable 24.

Addition or subtraction of a certain percentage are achieved by designing the cam so that if a certain percentage appears in the visual opening 78 the effective length of the cable is shortened in proportion to the logarithm of

$$\frac{100+\text{percentage}}{100}$$

and if a minus percentage appears in visual opening 78 so that the effective length of the cable is lengthened in proportion to the logarithm of

$$\frac{100+\text{percentage}}{100}$$

The cam has a neutral section 76 and when the roller 79 is on this neutral section an indication such as "Off" will appear in the visual opening 78. If it is desired to, for instance, add 30%, the scale 77 is rotated until plus 30 appears in the visual opening 78 and the cam rise is designed so that the effective length of cable 24 is shortened in proportion to logarithm 1.3 and that therefore the cable drum is rotated in an anti-clockwise direction in proportion to logarithm 1.3. If it is desired to, for instance, subtract 30%, the scale 77 is rotated until minus 30 appears in visual opening 78 and the effective length of the cable is thereby lengthened in proportion to logirithm of 0.7. Thus the drum 31 and the logarithmic scale 33 are rotated in proportion to the logarithm of 0.7, thus indicating on logarithmic scale 33 in visual opening 37 an equivalent of the multiplication with 0.7 which is the same as subtracting 30%.

Figures 13 and 14 show a cam 79a and a scale 80 suitable for multiplication with the sine of an angle, the multiplication being achieved by shortening the effective length of cable 24 in proportion to the logarithm of the since of the angle appearing in visual opening 81.

The cam 79a has a terminus 82 and when the roller 83 rests on this terminus a designation such as "Off" will appear in the visual opening 81. Counter-clockwise rotation of the scale 80 will reduce the angles appearing in visual opening 81 and the rise of the cam 79a is designed to be in proportion to the logarithm of the sine of the angle appearing in the visual opening 81. Thus the rotation of drum 31 and the logarithmic scale 33 attached thereto will be in proportion to the logarithm of the sine of the angle, and thus the sine of the angle may be read directly in visual opening 37 and may be multiplied and divided by operation of the other scales in the calculator, such as scale 67 and scale 74. The length of the lever 84 is chosen so that rotation of the cam 79a from terminus 82 to terminus 85 will cause the effective length of cable 24 to be lengthened twice as much as cable 24 is lengthened by operating cams 65 and 71 through their full range. Thus, by rotating cam 79a from terminus 82 and 85 the drum 31 and the scale 33 are rotated 360 degrees instead of 180 degrees. There-

fore, when the scale 89 is moved past 5°45′ a zero is subtracted from the result indicated in visual opening 37 by operation of the ratchet 41 and the gearing 42, 43 and 44 in a manner described above. This subtraction of the zero when the scale is moved past 5°45′ is required due to the fact that the characteristic of the logarithm of the sine of an angle is smaller by one for angles between 35′ to 5°45′ than for angles between 5°45′ to 90°. As the cosine of an angle is equal to the sine of 90° minus the same angle, a second scale may be attached to cam 79*a* indicating the cosine of an angle corresponding to the sine of an angle and the second scale may also be visible through visual opening 81, thus facilitating the multiplication with the cosine of an angle.

Figures 15 and 16 show another cam and scale combination designed to perform conversion from one unit to another. This is accomplished by multiplication with a conversion factor. For instance, to convert from square inch to square centimeter, the result is multiplied by 6.452, or to convert from square centimeter to square inch the result is multiplied by 0.155. The cams are designed so that when the desired conversion appears in visual opening 86 the effective lengths of cables 24 and 50 are lengthened or shortened in proportion to the logarithm of the conversion factor. Two cams, 88 and 89, are mounted together with scale 87 to rotate on shaft 90. The cam 88 shown in dotted lines is designed to shorten or lengthen the effective length of cable 24 in proportion to the mantissa of the logarithm of the conversion factor of the conversion appearing in visual opening 86 and thereby rotate drum 31 and scale 33 attached thereto in proportion to the mantissa of the logarithm of the conversion factor.

Cam 89 is designed to shorten or lengthen the cable 50 in proportion to the characteristic of the logarithm of the conversion factor. Thus, by rotating only the scale 87, multiplication with the conversion factor is achieved.

It is evident that scales and cams may be designed to perform many other calculations such as those performed by standard and special slide rules. The design of new cams and scales must be carried out with regard to the mathematical properties of the present device. In this respect it is relevant to describe the device in terms of operation and operative elements concerning the handling of mathematical functions. It will therefore be noted that each cam having a dial in fixed relation thereto is representative of a mathematical function which preferably is in the form of a logarithmic relation as between the scale marked on the dial and the contour of the cam. Whether or not this relation must be logarithmic depends on the nature of the problem to be solved. Since each point on the dial may represent the magnitude of a function in itself, whether expressed in the form of numerals or otherwise it is obvious that by rotating the dial to any point of adjustment in order to enter one element of a problem, the operator effects a change of magnitude of mathematical function on the dial. This change of magnitude is transmitted by means of a cord operatively related with the cam to a result indicating dial by causing rotation of a drum operatively related thereto.

The cord is thus a medium of transmitting such change of magnitude of function accruing from each such dial.

The calculator thus provides means whereupon a mathematical problem may be entered by adjusting a series of independent dials whereby the total change of function accruing from said dials thereby is transmitted by an appropriate medium to cause a change of magnitude of function represented on the result indicating dial which is in direct relation with the total change of magnitude of function of the dials and hence a solution of the problem entered.

What I claim as my invention is:

1. A calculator comprising mantissa computing instrumentalities in the form of a plurality of independently mounted cams having contours representing logarithmic functions, a lever associated with each of said cams and movable in accordance with the contour thereof, a revolvable drum and an indicator dial associated therewith, a cord reeled upon said drum and extending to an anchorage, means for rotating said drum to cause tensioning of said cord, means on said levers in engagement with said cord between said drum and said cord anchorage whereby the radial position of said drum and said indicator dial is determined by the radial positions of said cams in respect to their associated levers, and means for computing the characteristic comprising plural characteristic entering instrumentalities and a result characteristic indicator in the form of a radially movable dial and means operatively connecting said characteristic indicator to said drum comprising a gear mechanism providing incremental radial movement of said indicator after predetermined radial movement of said drum.

2. A calculator as claimed in claim 1 and a drum mounted coaxially with said characteristic indicator and operatively related thereto, a characteristic cord reeled on said drum and extending therefrom to an anchorage, means for tensioning said characteristic cord, and wherein the characteristic entering instrumentalities are associated with each of said cams and engage said characteristic cord to cause radial positioning of the drum operatively related to said characteristic indicator.

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