March 19, 1940. K. S. LION 2,193,929

AUTOMATIC CALCULATION APPARATUS

Filed Feb. 23, 1937

FIG. 1.

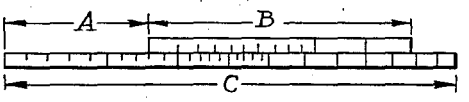


FIG. 2.

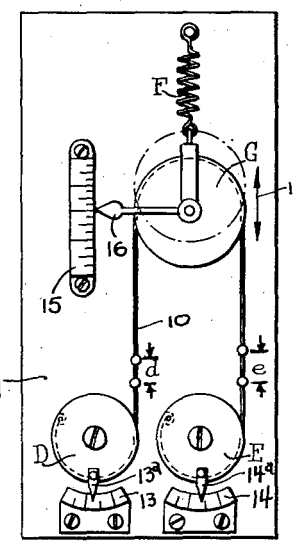


FIG. 4.

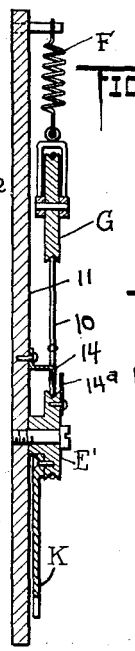


FIG. 5.

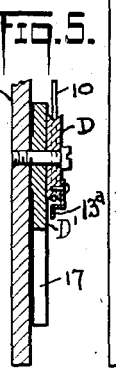


FIG. 3.

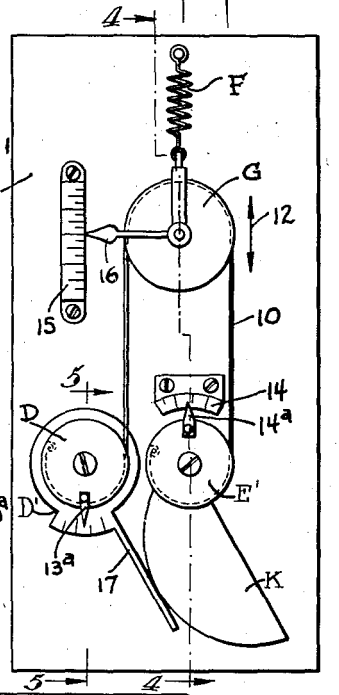
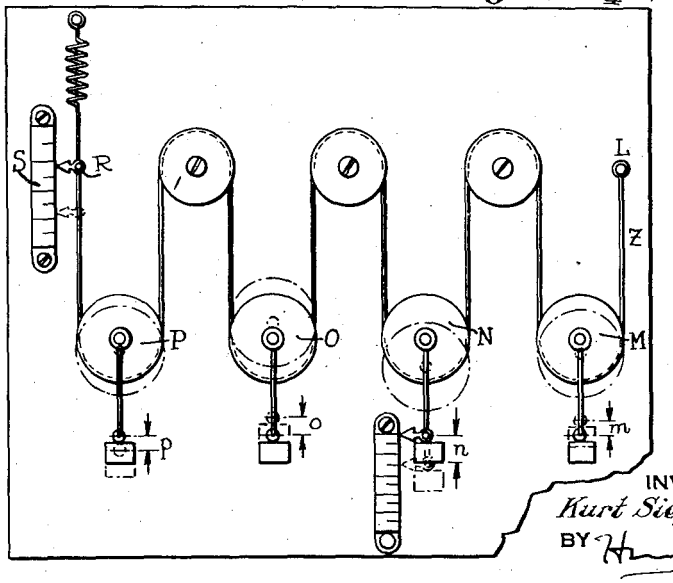


FIG. 6.



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AUTOMATIC CALCULATION APPARATUS

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Application February 23, 1937, Serial No. 127,000½. In Germany June 29, 1936

2 Claims. (Cl. 235—61)

The object of this invention is to provide a mechanical device for determining the result of a definite given equation of several variable factors which may be dependent upon or independent of each other. Such calculations which often reoccur in the same way are found, for example, in medical X-ray work when it is necessary to determine certain quantities or values such as the duration of irradiation, dose, current, voltage, distance, thicknesses of filters, loads of tubes, and the like.

Until now, the determination of these values has had to be effected by means of tables, curves, nomograms, and slide rules, a procedure which necessitated also mathematical operations. These methods, however, make possible the occurrence of various errors, calculating mistakes and mistakes in decimals, which mistakes may be costly and must be avoided, especially in medical X-ray work where such errors may give rise to great danger.

Other objects and features of the invention will be more fully understood from the following description to be read in connection with the accompanying drawing in which:

Fig. 1 diagrammatically illustrates a conventional slide rule;

Fig. 2 is a view in elevation of an apparatus embodying the invention;

Fig. 3 is a view in elevation of an apparatus embodying the invention in modified form;

Fig. 4 is a sectional view taken on the line 4—4 of Fig. 3;

Fig. 5 is a fragmentary sectional view taken on the line 5—5 of Fig. 3; and

Fig. 6 is a view in elevation of an apparatus embodying the invention in another modified form.

The system is based on the ordinary slide rule in which, according to Fig. 1, length B is added to length A. The length C equals the sum of the lengths A and B, and thus, when the scales are logarithmic the product A×B may then be read off.

The length B, however, is not independent of the length A, inasmuch as its starting point is determined by the terminal point of line A, and that means that the length B is determined by the value of another factor. Thus, the length B can be adjusted only after A has been determined. In order to avoid this condition, which occurs in similar manner with nomograms and which makes their use difficult to less experienced operators, the following changes are made:

According to Fig. 2 a ribbon 10 is fixedly connected to and wound around the turnable roller D, runs over the roller G and has its end fixed to the roller E. The rollers D and E are rotatably mounted on baseboard 11 but cannot be shifted, whereas the roller G may be shifted in the direction of the double arrow 12 either upwardly or downwardly, its position depending upon the spring F and upon how much ribbon is wound off from the rollers D and E.

If from the roller D, bearing an indicator 13*a*, the length *d* is wound off and from the roller E, bearing an indicator 14*a*, the length *e* is wound off, the shifting of the roller G in the direction of the spring equals $(d+e)/2$; that is, in proportion to the sum $(d+e)$. If now, on the scales 13 and 14 at D and E, respectively, logarithms are put in place of the values *d* and *e*, and if the scale 15 at G shows half measure and is logarithmic also, then the indicator 16 associated with the scale at G will indicate the product $d \times e$. The advantage of this arrangement lies in the fact that the scales at D and E are fixed and can be simply and independently adjusted and also that the result may be read off on a separate scale, which gives the correct position to the decimal point.

The separation of the two scales lends the possibility of further improving the construction of the invention for cases in which the two factors which are to be adjusted are dependent upon one another as, for instance, in Fig. 2 where the value *e* is a function of the value *d*. A calculation of this type might be the determination of the electrical input to an X-ray tube, which is the product of current and voltage, there being a dependent relationship between current and voltage because the voltage drops with increasing current. A further important example of such a calculation might be the determination of an X-ray dose as a function of the tube voltage and the filter thickness, since the absorbing capacity of the filter is largely dependent upon the voltage.

Thus, if the scale of the dependent factor is adjusted simultaneously with the adjustment of the other factor, problems such as those mentioned can be solved. An apparatus capable of such operation is shown diagrammatically in Fig. 3, which illustrates an arrangement basically similar to that illustrated in Fig. 2, in that it embraces a first fixed rotatable roller, a second fixed rotatable roller, a flexible ribbon connected to and wound about said rollers, and a third roller over which the ribbon passes, the third roller being urged by a spring or the like so as to hold taut the length of the ribbon which is not wound

upon the first mentioned rollers, the third roller being provided with a suitable scale and pointer. By turning the roller E', the curved disk K, fixedly associated therewith, is turned and effects a shifting of the movable scale D', by acting on the extension arm 17. If the electrical input of an X-ray machine is to be determined from the current and voltage, the result indicated is the product of both values. The dropping of the voltage with increasing current is taken into account by the fact that when the current indicator is regulated on the current scale the adjustment of this indicator automatically changes the voltage scale. If then, the voltage indicator is adjusted to the desired position on the voltage scale which was previously shifted, the result indicator will indicate on its scale the true value of the electrical input, the voltage drop having been considered.

If more than two factors are to be jointly considered to give a single result, as where X-ray dosage is to be determined from exposure time, voltage, current, distance and filter, then the following form of the invention may be used; according to Fig. 4 a flexible ribbon Z that is fastened at point L lies around shiftable rollers M, N, O, and P. These rollers are held in position by ribbons or rods fixed thereto, their point of rotation being movable by these either upwardly or downwardly. Thereby, the point R is shifted as indicated on scale S by a pointer. The shifting of the pointer R on the scale S is proportional to the sum of the shiftings m, n, o, and p, and if all the scales are correspondingly divided logarithmically, indicates the product of $m \cdot n \cdot o \cdot p$.

Since many changes may be made in the invention without departing from the scope thereof, it is intended that all matter set forth in the above description, or shown in the accompanying drawing, be regarded as illustrative only and not in a limiting sense.

I claim:

1. A calculating apparatus of the character described, including a first adjustably mounted member, first indicator means operatively associated with said first adjustable member, a first scale bearing element adapted to cooperate with said first indicator means and being fixedly mounted, a second adjustably mounted member, second indicator means operatively associated with said second adjustable member, a second scale bearing element adapted to cooperate with said second indicator means and being adjustably mounted, an operating arm adjustable with said first adjustable member and adapted to change the position of said second scale bearing element in accordance with changes in the adjustment of said first adjustable member, a third scale bearing element, third indicator means arranged in operative relationship with said third scale bearing element, and means including a flexible ribbon connected to said first adjustable element and to said second adjustable element for changing the position of one of said last mentioned elements with respect to the other in accordance with changes in the adjustment of at least one of said two first mentioned adjustable members.

2. A calculating apparatus of the character described, including a first adjustably mounted member, first indicator means operatively associated with said first adjustable member, a first scale bearing element adapted to cooperate with said first indicator means and being fixedly mounted, a second adjustably mounted member, second indicator means operatively associated with said second adjustable member, a second scale bearing element adapted to cooperate with said second indicator means and being adjustably mounted, an operating arm adjustable with said first adjustable member and adapted to change the position of said second scale bearing element in accordance with changes in the adjustment of said first adjustable member, said second adjustable scale bearing member having an extending portion against which said operating arm bears, a third scale bearing element, third indicator means operatively associated with said third scale bearing element, and means for changing the position of one of said two last mentioned elements in accordance with changes in the adjustment of said first and second adjustable members.

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