No. 845,463. PATENTED FEB. 26, 1907.

H. T. HINCKS.

SLIDE RULE.

APPLICATION FILED MAY 31, 1905.

3 SHEETS—SHEET 1.

FIG. 1.

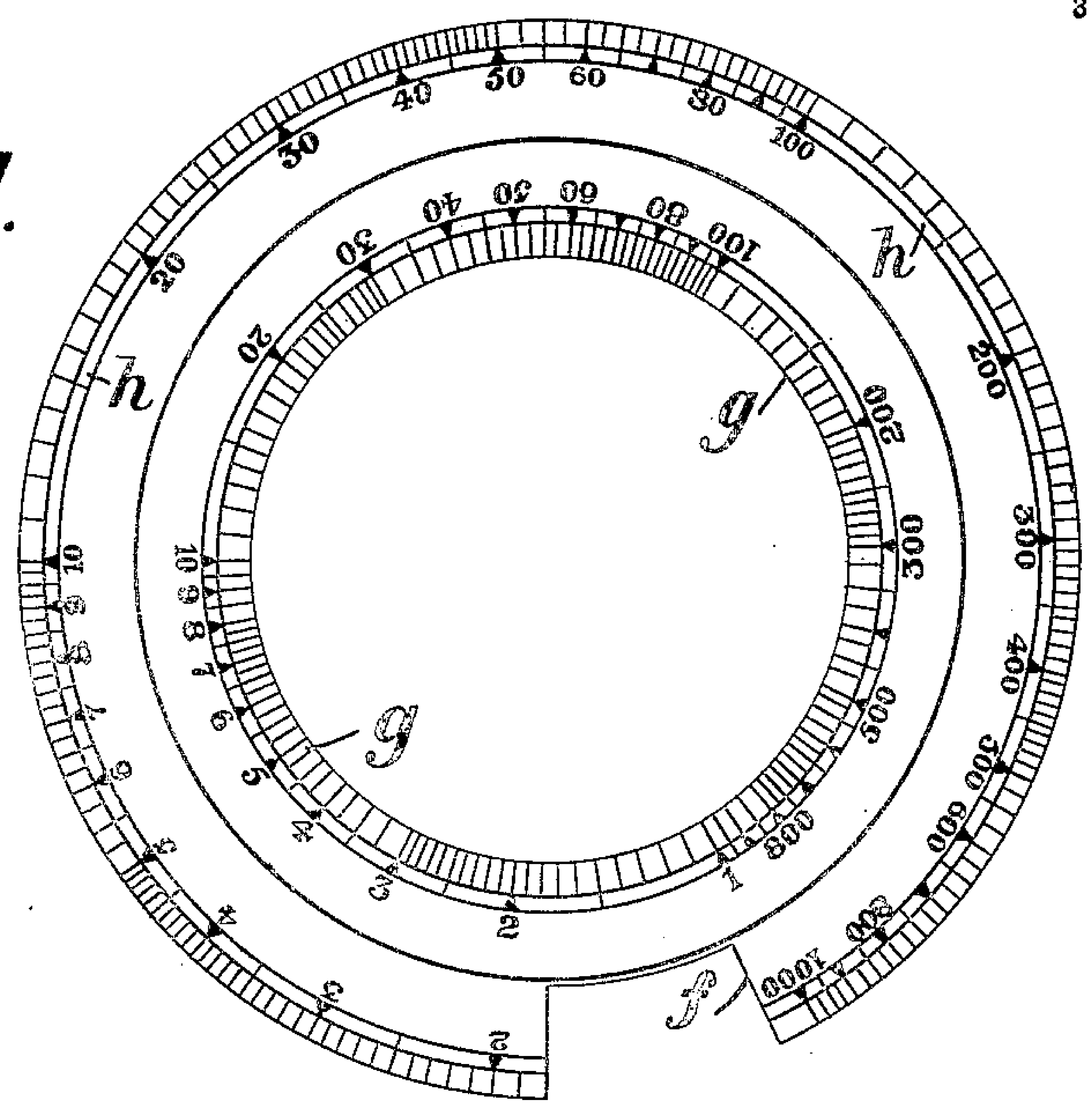
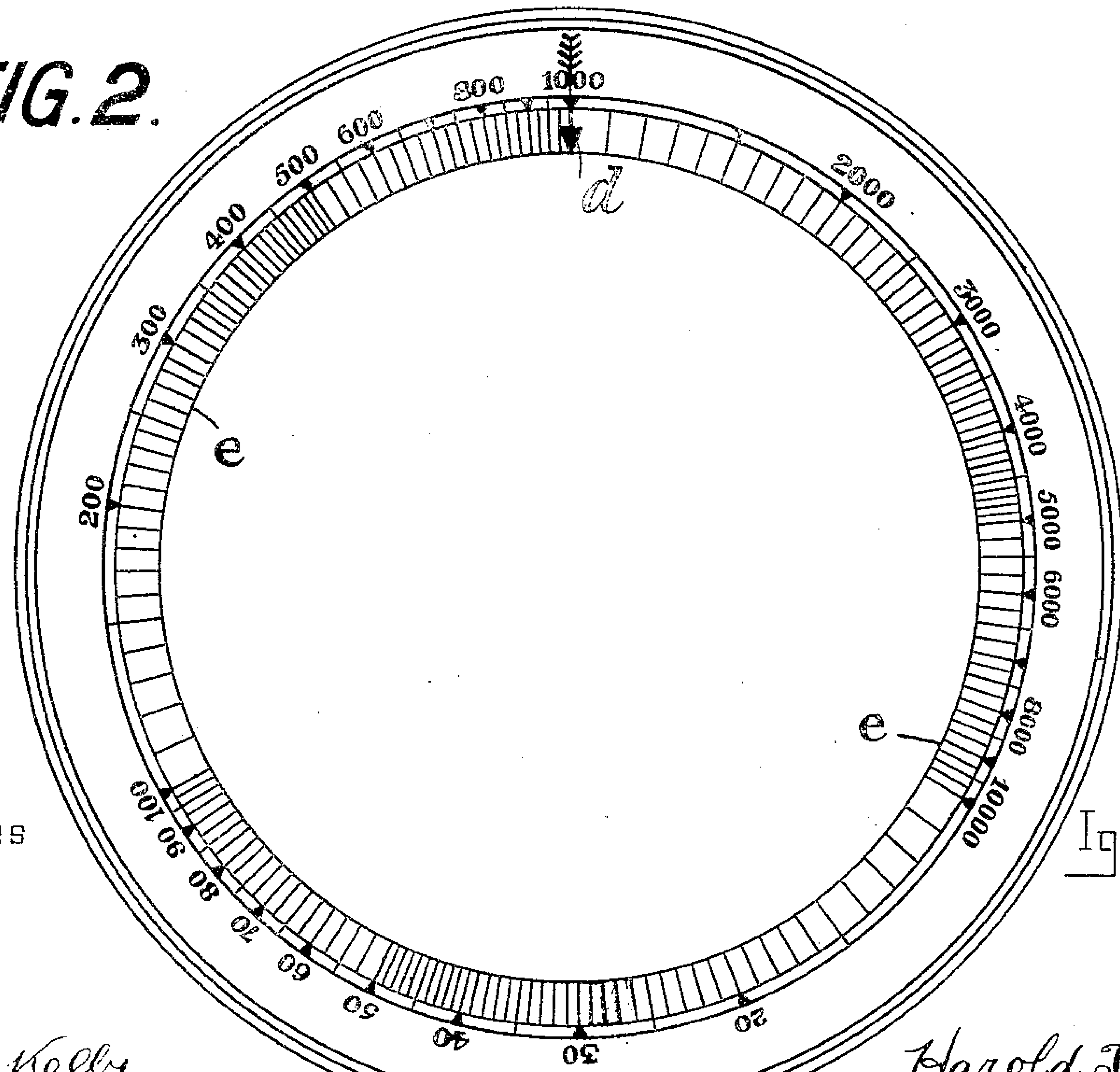


FIG. 2.



Witnesses

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Inventor

Harold T. Hincks
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Edward P. Thompson

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3 SHEETS—SHEET 2.

FIG. 3.

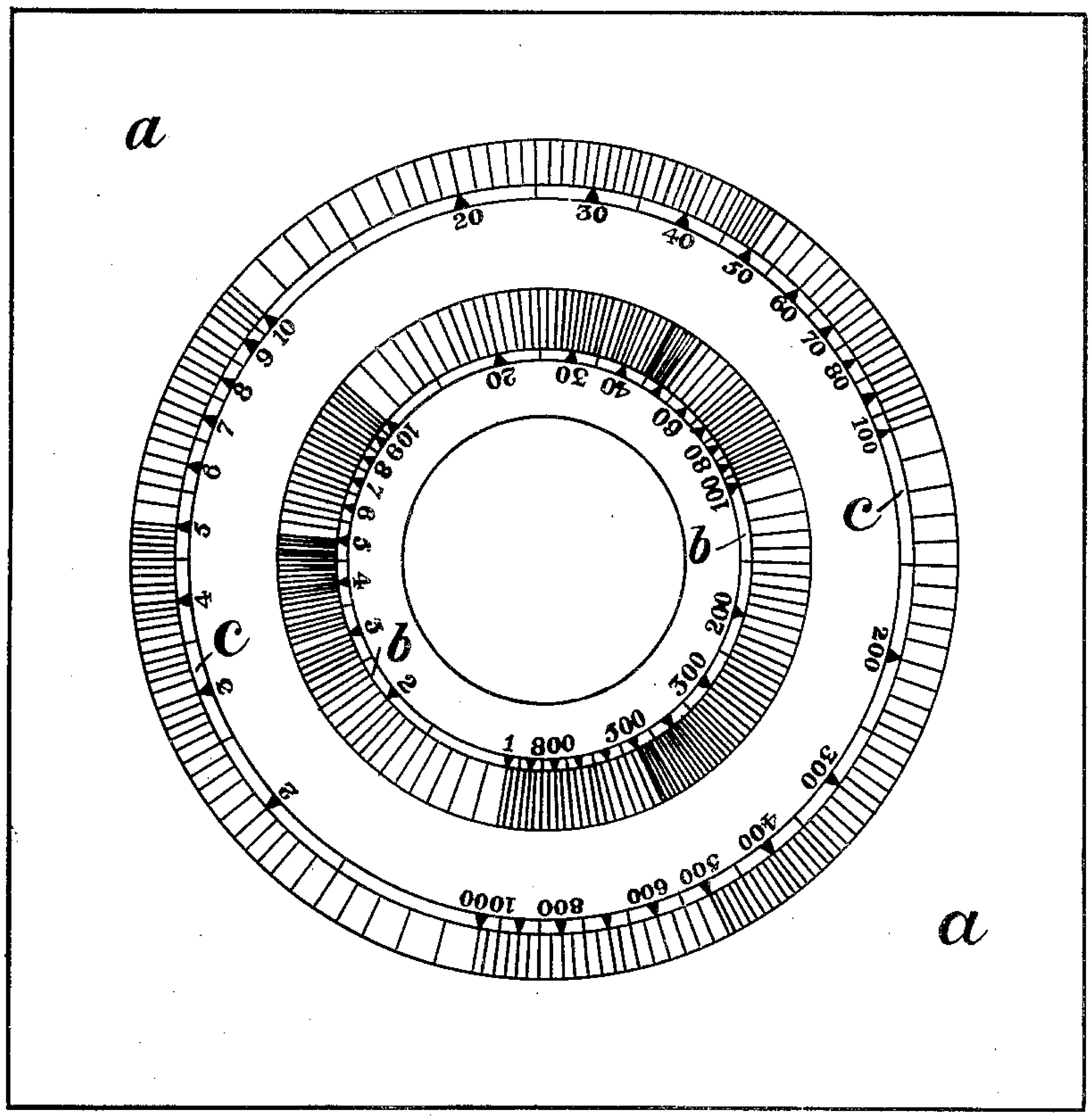


FIG. 5.

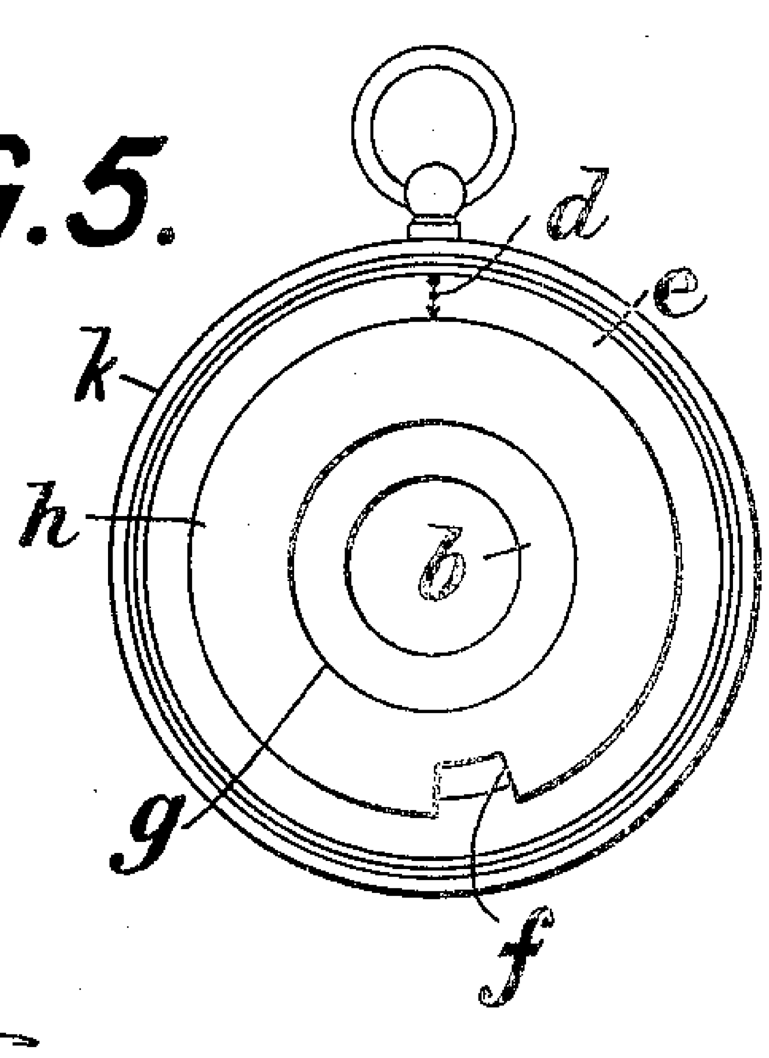
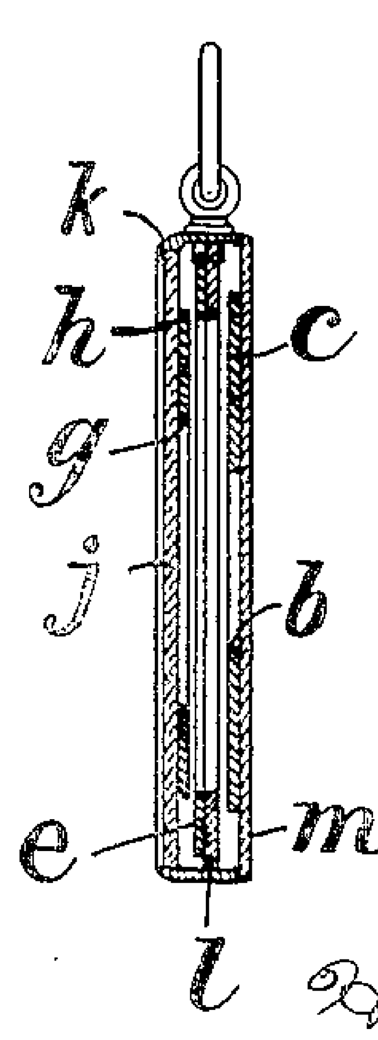


FIG. 6.



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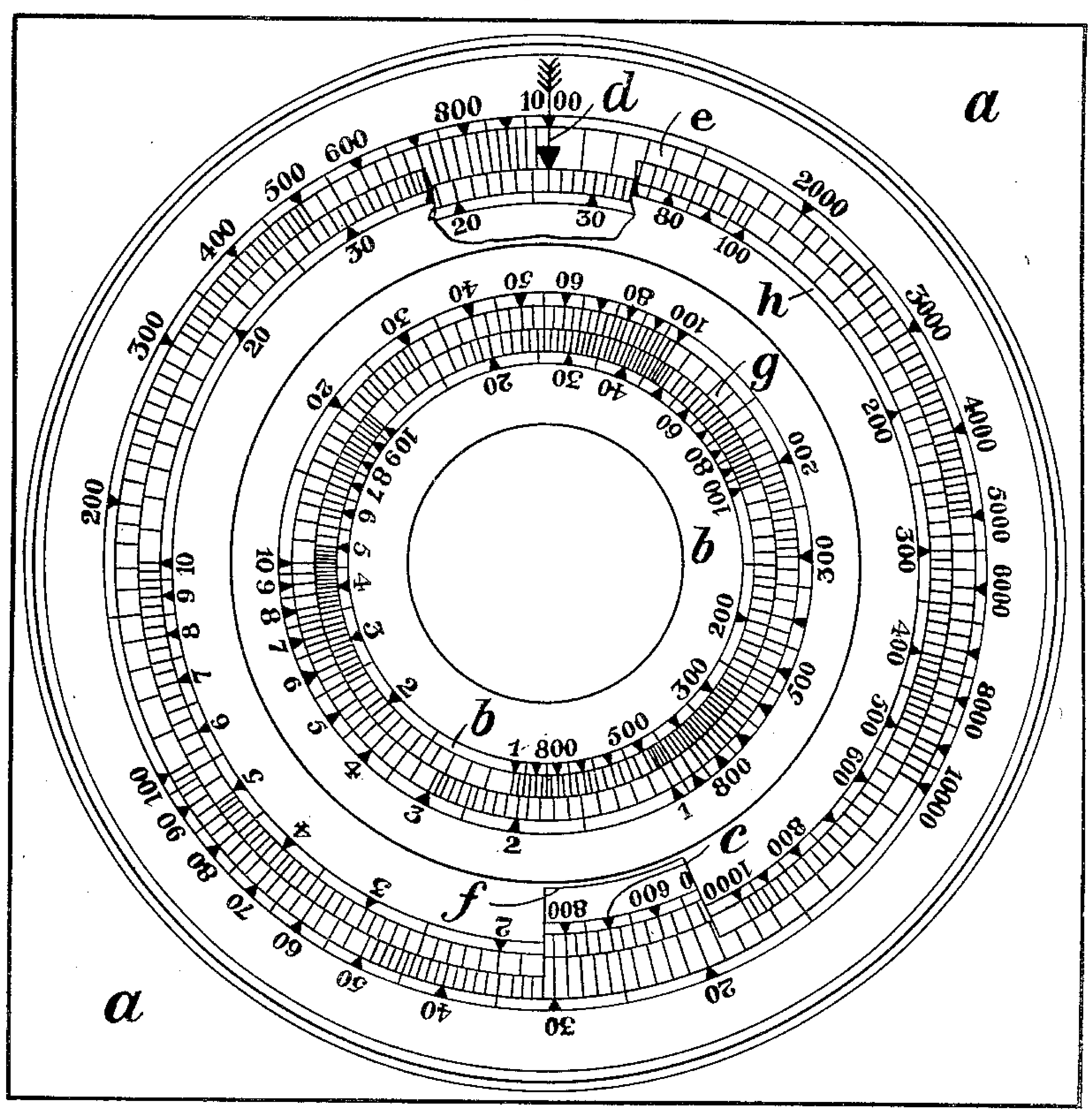
3 SHEETS—SHEET 3.

FIG. 4.



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UNITED STATES PATENT OFFICE.

HAROLD T. HINCKS, OF CHESTER, ENGLAND.

SLIDE-RULE.

No. 845,463. Specification of Letters Patent. Patented Feb. 26, 1907.

Application filed May 31, 1905. Serial No. 263,175.

To all whom it may concern:

Be it known that I, HAROLD THORNTHWAITE HINCKS, a subject of the King of Great Britain, residing at Chester, in the county of Chester, in the Kingdom of England, electrical engineer, have invented certain new and useful Improvements in Slide-Scales, for which application has been made in Great Britain, No. 19,061, dated September 3, 1904.

This invention has been specially designed by for me for calculating electric conductors, in which given three of the following—the amperage, the volts lost in circuit, the length of wire, and the area of wire—the remaining element can be calculated.

The slide-rule is necessarily based on Ohm's law, $C=E/R$, where C is equal to the current in conductor in amperes, E to the actual fall of pressure or voltage, commonly called "drop," and R to the ohmic resistance of the conductor. If C equals E/R, it necessarily follows that E equals CR, or, in other words, the drop of voltage is equal to the current multiplied by resistance. If both sides of the above equation are multiplied by C, we have the equation EC equals C^2R; but EC are volt amperes or watts. Therefore the total loss of power in a circuit, in watts, is equal to the C^2R losses, and as these can be made fixed quantities it follows that the losses in a cable are entirely independent of the voltage. Following this reasoning, for the same power in a conductor if the voltage be doubled only half the amperes will be required, which brings down the C^2R losses to one-quarter the original amount, which means that the conductor for the same original percentage loss can either be reduced to one-quarter the original size or will carry four times the power. The next point to consider is the resistance of a conductor. There are three points to watch in calculating the resistance: first, the conductivity of metal; second, area of cross-section of conductor; third, length of conductor. The continuous-current constants should be equal to the area in one-one-thousandths of a conductor that will carry an electric currrent one thousand yards with a resistance of one ohm, extra allowance being made for variation of resistance, bad joints, sag, &c., to about 5.7 per cent.

The alternating-current constants for various power factors can be readily found by the following simple equations:

For single phase:

$$\text{Alternating-current constant} = \frac{\text{Continuous-current constant}}{\text{power factor}}$$

For two phase, (four-wire:)

$$\text{Alternating-current constant} = \frac{\text{Continuous-current constant}}{\text{power factor} \times 2}$$

For three phase:

$$\text{Alternating-current constant} = \frac{\text{Continuous-current constant}}{\text{power factor} \times 1.732}$$

This invention entails the use of five scales, one for each of these four elements, and a fifth—a fixed datum-scale for constants—dependent on the kind of electric current and the quality of the conductor.

Referring now to the accompanying drawings, Figure 1 is an enlarged view of the "area" and ampere scale; Fig. 2, an enlarged view of the length-of-circuit scale; Fig. 3, an enlarged view of the "constant" and "drop-of-voltage" scales; Fig. 4, an enlarged view of the device when fixed in position; Fig. 5, a view of the device in watch form; Fig. 6, a sectional side view of Fig. 5.

Figs. 1–3 show the present invention with the scales separate, and Fig. 4 shows them all together in their working position for clearness. No frame or mounting is shown beyond a base-plate *a* in these figures, and attached concentric to the circular base-plate *a* is a logarithmic scale *b* of the "volts lost in circuit." Surrounding this and some distance from it is the datum-scale *c*, also fixed to the back, which works in conjunction with the "adjusting-point" *d*, marked on the outer sliding scale *e* "Total length of circuit in yards." The datum-scale *c* might instead be on the outside, so as to turn with the yard-scale in conjunction with an adjusting-point fixed to the volt-scale *b*. Surrounding the datum-scale *c* is the logarithmic scale *e* of the total length of circuit in yards (or feet or meters.) This is movable in any convenient manner, and over the blank between the volt-scale and the yard-scale and covering the datum-scale (except at one point where a slot or cut-away part *f* is cut to see the datum-scale) are two logarithmic scales *g* and *h*—namely, "Total amperes in circuit" and "Area of conductor in one one-thousandths of square inch (or circular mils,)" the ampere-scale *g* working in conjunction with the volt-scale *b* and the area-scale *h* working in conjunction with the yard-scale *e*.

The mode of working is as follows: The constant-scale *c* is first fixed once for all in its proper position in conjunction with the adjusting-point *d* relatively to the special quality of conductor and circuit, whether continuous or alternating or single phase or polyphase. The two center scales *g* and *h* are now turned round until the three known elements coincide on the four principal scales. The required element—the fourth—is now found at once on its respective scale. The circular slide-rule has been so arranged that once the constant is fixed to meet the calculation to be made, whether for simple continuous current or the more complicated alternating current with its phase and power factor, the calculation is the same as far as the operator of the slide-rule is concerned. For instance, suppose twenty K. W. has to be delivered at a factory for driving it five hundred yards away from the generating-station, loss of power not to exceed five per cent., voltage at generating-station 440. Then if this is a simple parallel continuous-current system the drop in voltage would be 22. The current to be delivered would be $\frac{20 \times 1000}{418}$ equals 48.0 amperes nearly. Now three factors are known—namely, volts lost in circuit 22, total amperes in circuit 48, total length of circuit in yards 500×2 equals 1,000. The constant for continuous current in copper wire is 25.9, which number we turn to the adjusting-point *d*, and having fixed "48" on the ampere-scale *g* opposite "22" on the voltage drop-scale *b* by revolving it it is easy to see that the area of conductor opposite 1,000 yards is fifty-seven one-thousandths of a square inch nearly, or, writing it as a decimal, it equals .057 of a square inch. Suppose in the above calculation it was an alternating current instead of continuous, the voltage being the same, the calculation is made out in exactly the same form, but with a different constant, as above explained. The load being a motor one only, the power factor of the line, it would be fair to assume for the sake of calculation, would be about .80. The constant for copper wire with single-phase alternating current having an .80 power factor is 32.4. Having fixed this, it is found that the area of conductor required is .070 of a square inch. Looking it up on the table of the sizes of conductors it will be found that one No. 1 S. W. G. solid wire or 19/15 S. W. G. cable meets the case. Again, suppose in the above calculation it was a three-phase alternating current and the voltage the same. Assuming the same power factor, the constant would be 18.6. Area of conductor required would be .039 of a square inch.

Figs. 5 and 6 show the present invention in watch form. In these drawings, *j* is the glass to which the area-scale *h* and "ampere-scale" *g* are secured, which glass is rotatable in the casing *k*. *l* is a fixed ring carrying the length of circuit-scale *e*, while *m* is the back of the device, rotatable on the casing *k* and carrying the datum-scale *c* and voltage-scale *b*.

In thus describing my invention I do not bind myself to this exact arrangement, as it is perfectly obvious that the scales can be turned round by gearing or any other suitable device and, further, that in place of them being in a circle they can be arranged longitudinally side by side, in which case the two scales previously described as attached to the glass can pull out together, while the scale for the total length of circuit can slide independently in another groove or alongside the other slide.

I have described the invention only for calculating electric conductors; but it is obvious that it can be applied to any problem on the basis of the type "*a*" equals "*b/c*" or "*a/b*" equals "*c/d*" or even such formula as "*a*" equals "b/c^2." In each of the above instances the scales are made out logarithmically, but in more complicated formula not necessarily so.

In applying my invention to hydraulics the scales would be, first, datum; second, head; third, area or diameter of pipe; fourth, length of pipe, and, fifth, volume of water. The factors of other formulæ will be easily recognized in general terms. The scales would be first, datum; second, pressure, whether of water, electricity, or other matter or condition of matter; third, area of transmission means whether pipes, wire, or other media; fourth, length of the transmission means, and, fifth, the quantity, whether of water, electricity, or other matter.

I declare that what I claim is—

1. In a slide-rule of the character described two fixed concentric logarithmic scales; a concentric sliding piece rotatative about said scales and comprising a logarithmic scale working with the outer of said fixed scale, a second concentric sliding piece with a cut-away part and comprising two further scales rotatative over said fixed scales and working with the inner of said fixed scales whereby a portion of the outer of said two fixed scales can be viewed substantially as described.

2. A sliding scale of the character described comprising a frame a glass rotatative in said frame, two concentric logarithmic scales on said glass there being a cut-away portion on the outer of said scales, a fixed plate or ring a logarithmic scale on said plate or ring said scale working the outer of said concentric scales, and a back piece rotatative in said frame two concentric logarithmic scales on said back piece, the inner scale working with the inner of the first concentric scales and the outer showing under the cut-away portion of

the outer of said first concentric scales and working with the scale on the fixed plate or ring substantially as and for the purpose described.

3. A slide-rule of the character described comprising a base-plate *a*, a logarithmic scale *b*, attached to said base-plate and concentric therewith for indicating the volts lost in an electric circuit, a datum-scale *c*, surrounding the first-named scale at some distance therefrom, fixed to said base, for working in conjunction with a point *d*, an outer sliding logarithmic scale *e*, provided with the point *d*, for indicating the total length of said circuit, said scale *e* surrounding said datum-scale *c*, two logarithmic scales *g*, and *h*, for indicating the total amperes in said circuit and the area for said circuit respectively and movable over the blank space between said scale *b*, and said scale *e*, and covering the datum-scale, except at one portion where a slot *f* is formed for seeing the datum-scale, said scale *g*, working in conjunction with said scale *b*, and said scale *h* working in conjunction with said scale *e*.

In witness whereof I have hereunto signed my name, this 18th day of April, 1905, in the presence of two subscribing witnesses.

HAROLD T. HINCKS.

Witnesses:

ALGERNON J. YORKE,
ARTHUR G. N. KNIGHT.