March 16, 1948. O. E. BATORI 2,437,722

SLIDE RULE

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Fig. 2

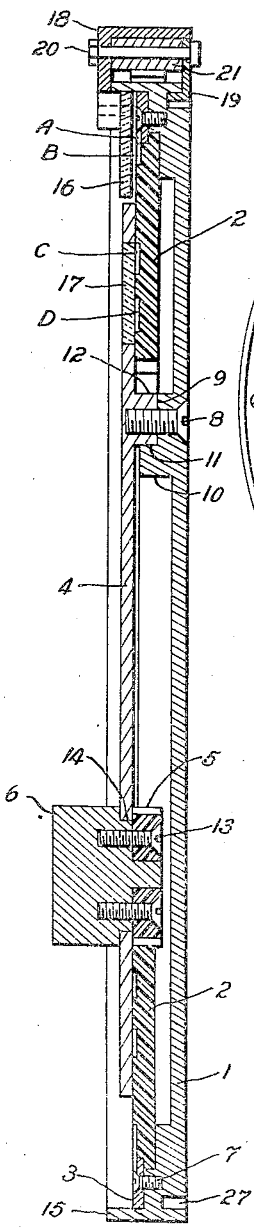

Fig. 1

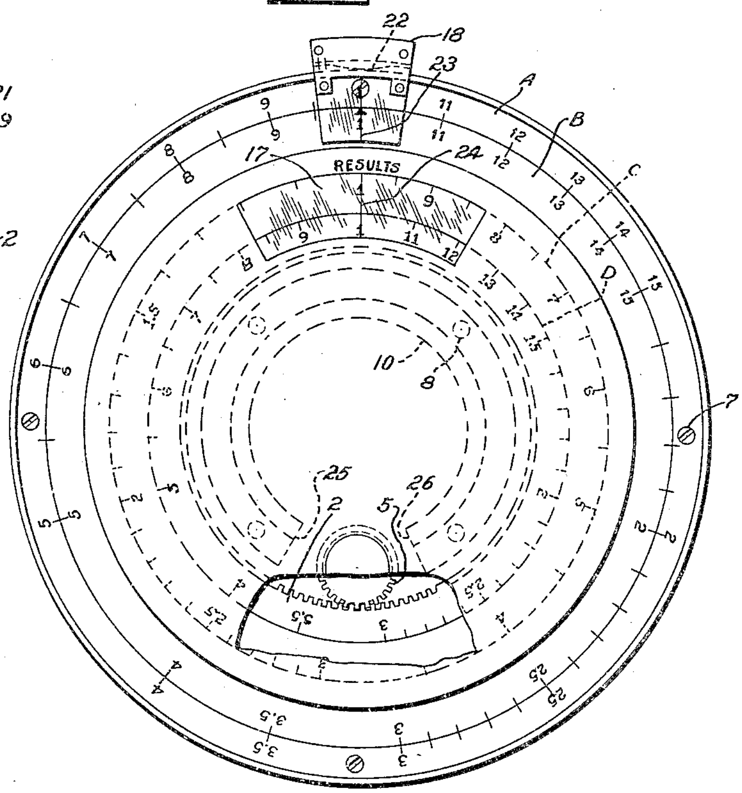

Fig. 4

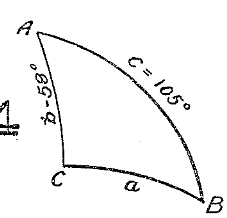

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Fig. 3

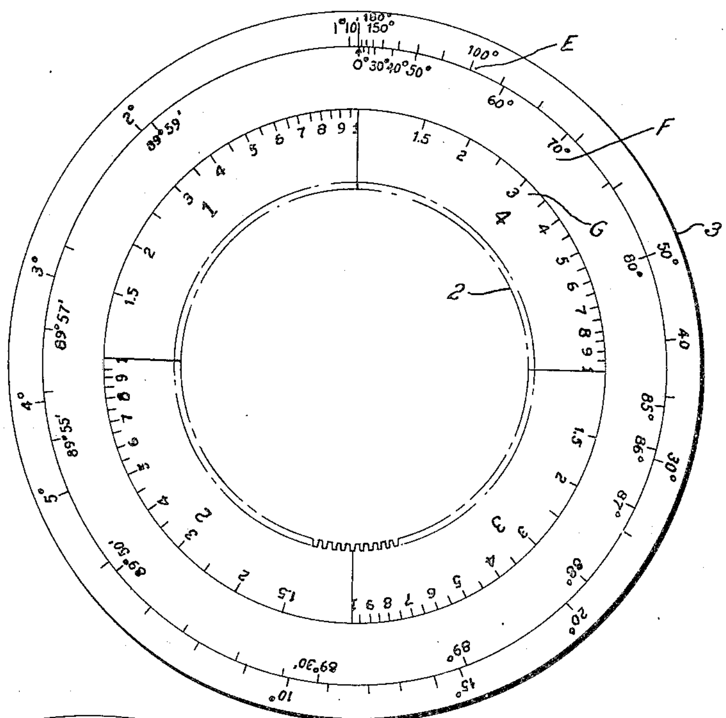
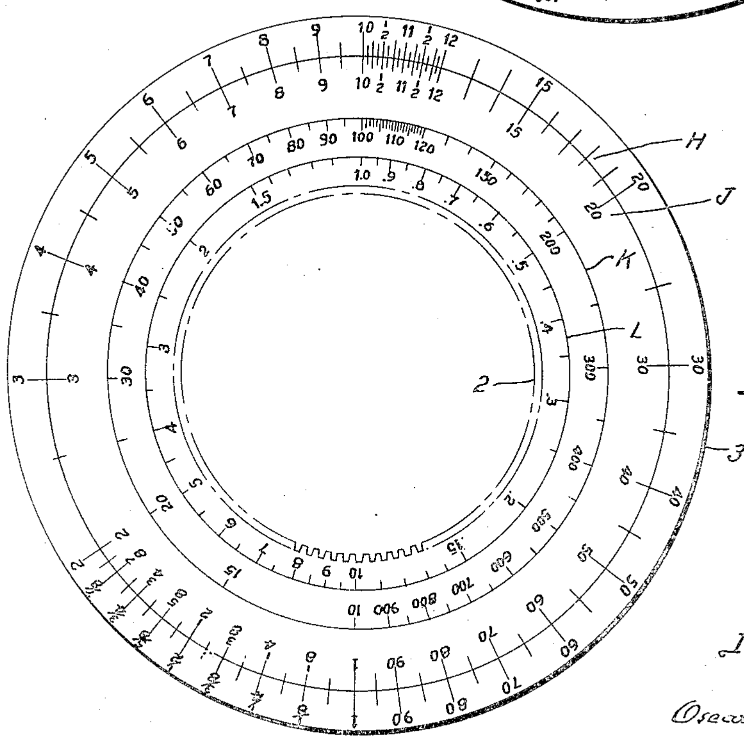


Fig. 5



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UNITED STATES PATENT OFFICE

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SLIDE RULE

Oscar E. Batori, New York, N. Y.

Application March 16, 1946, Serial No. 654,951

5 Claims. (Cl. 235—84)

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This invention relates to computing devices of the slide rule type.

Through the present invention a computer is provided by which new and better solutions are created for numerical and trigonometric problems. Specifically, solutions for spherical triangles and computations involving different terms are simplified and expedited.

For the sake of better explanation, brief comparison is made between prior computers of the slide rule type and this invention.

Prior computers of the slide rule type, to perform a simple computation, apply, in general, two coacting scales on two relatively movable members: one, called the base scale, on the base member; the other, the slide scale, on the slide member. These two scales are used for the six ingredients of simple multiplications and divisions: for the multiplicand, multiplier, and product in case of multiplication, and for dividend, divisor, and quotient in case of division. To get the result of a computation certain rules have to be known and be followed in the procedure; it has to be known on which of the scales are the factors to be set and the result to be found. For users without mathematical background the procedure is complicated and difficult. Furthermore, the results are indicated at various locations along the length of the scales. In case of computers of the circular type, this means that the numbers appear in different positions, slant or upside down, inconvenient for reading.

One important object of this invention is to simplify the procedure of computations by the application of a special result scale and a designated, exclusive result indicator. This result indicator is for the results only, indicates all results of any kind of computation, at a permanent location of the device and with the numbers in vertical positions. It simplifies the procedure and eliminates the inconvenient readings of the circular computers with respect to the results. The advantage of the result indicator is particularly evident in computations with different terms involved, as it will be described later.

Regarding mechanical arrangement, prior computers have, in general, two members: one base and one slide member. This invention has three members: one base, one slide, and one fixed indicator member. Prior computers have one hand-operated moving indicator. This invention has two indicators: one hand-operated and one fixed indicator, automatic in operation.

Another important object of this invention is to provide new computer solutions for frequently

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occurring spherical triangle problems, so as to simplify and expedite the solution and to eliminate the mental estimation of the absolute values of numbers, implied in all slide rule operations.

One further object of this invention is to provide new solutions for computations involving different terms. Specifically, to provide new solutions for computations in which fractional and decimal values are combined and the proportion of fractional values is to be expressed in decimal or other values.

The invention also resides in the new mechanical arrangement and in the selection and disposition of scales on the relatively movable parts.

These and other objects of the invention and the means for their attainment will be hereinafter more fully described and one embodiment of it, by which the invention may be realized, illustrated in drawings, and particularly pointed out in the appended claims.

In the drawings:

Figure 1 is a plane view showing the face of the computer;

Figure 2 is a sectional view of it;

Figure 3 shows the selected and disposed scales for the solution of spherical triangles;

Figure 4 indicates a spherical triangle, illustrative for the solutions of the spherical triangles by this invention;

Figure 5 shows the selected and disposed scales for the solution of computations with fractional, percentage, and decimal values.

In all figures the scales are indicated with main divisions. The subdivisions, with few exceptions, are not indicated.

In the one embodiment of this invention shown in said figures, it consists of a base member 1 which has at its outer edge a forwardly direct flange 15. Circular ring 3 is accommodated by base member 1 and within flange 15. It is fixed to the base member by screws 7. Ring 3, it will be understood, is an integral part of the base member 1 and will be referred to as base member, similarly as to base member 1 itself, which holds ring 3 in place. Ring member 2 is in front of base member 1 and within ring 3, concentric with them. Ring member 2 is held in place by the base members 1 and 3, which also provide for the bearing surface for rotation. Ring member 2 has on its front and outer edge a circular recess, which fits in in the inner circular edge of ring 3. Ring 2 is rotatable around the center of the device. Its inner edge is built up as an internal gear, which matches and coacts with pinion 5. Pinion 5 is firmly secured by screws 13 to driving knob

6. Internal gear ring 2, pinion 5, and knob 6 comprise a driving mechanism for the rotation of ring 2. By rotating knob 6, pinion 5 and ring gear 2 are also rotated. Knob 6 and pinion 5 are carried by result indicator member 4, yet to be described. Result indicator member 4 has a circular hole in it at 14, in which the recessed part of knob 6 fits in. The circular ring surface 14 of this hole serves as bearing surface for rotation of knob 6. Result indicator member 4 is in front of ring member 2 and concentric with it. It is accommodated by base member 1 and secured to it permanently by screws 8. It has a circular offset ring part 12 on its rear face which fits in in the circular offset ring part 10 of base member 1, at 9 and 11. These offset ring parts of base member 1 and result indicator member 4 are discontinued at 25 and 26 to accommodate pinion 5. Result indicator member 4 has an opening and a transparent window 17 in it, which exposes parts of the scales on ring member 2. Window 17 has in its middle a fine scratched line 24; all results of any kind of computation are indicated at this line 24, which is vertical and permanent in position. It will be understood, that reading the results in the result indicator means to read them at this indicator line 24. The invention has a second indicator 18, called peripheral indicator, which travels on the periphery or outer part of base member 1 on flange 15 and groove 27, which provide the circular paths for the peripheral indicator. The paths are free from any interference of other parts of the device and are in the full circumference of the device. The peripheral indicator consists of parts 18 and 19, which are clamped together with screws 20 and held in place and in spaced relationship by part 21. Spring 22 acts radially and outwardly and holds the indicator against its path on flange 15 and groove 27. It has a transparent plate 16 fixed to it, which has a fine scratched line 23 in its middle. The peripheral indicator is used in the operation to set and read the scales on ring 3 and the exposed outer scale of ring member 2, to be described hereinafter.

Figures 1 and 2 show the selected and disposed scales for simple computations. Scale A is a standard logarithmic scale on base member 3, fixed in position. Scales B, C and D are standard logarithmic scales, placed on ring member 2 and rotate with it. These latter three scales are identical with scale A, except scale C, which is inverted with respect to scale A and also to scales B and D. All four scales, A, B, C and D, are of the same modulus. Scale B is exposed in its full length, scales C and D are concealed by result indicator member 4, except at the indicator window 17, where they are exposed. By moving ring member 2 and with it the three scales B, C and D thereon, their relative position changes with respect to scale A on one hand, and to the result indicator 24 on the other hand. The base scale A, the three slide scales B, C and D, and the fixed indicator 4, 24, constitute a cooperative system in such a way that the results of any computation are indicated at the permanent result indicator 24. This result indicator shows the results of any computation and their reciprocal values: Scale C is for the results, scale D for the reciprocals of the same results, both being indicated automatically, simultaneously, in the same permanent result indicator 24.

The procedures for simple divisions, multiplications, and for the respective reciprocals are demonstrated in illustrative examples hereinafter, with comparative notes to the procedures with prior slide rules.

In Figure 3 are shown scales E, F and G, selected for solutions for spherical triangle problems. Scale E is on base member 3 and is fixed. It is a logarithmic haversine scale for angles from 1° 10′ to 180°. Haversine, it will be understood, is the notation of the expression

$$\frac{1-\text{cosine } A}{2}$$

for angle A. This scale will give natural haversines in connection with scale G, yet to be described, from 0.0001 to 1.0. Scales F and G are on ring member 2 and are rotatable with the ring member together. Scale F is a logarithmic cosine scale for angles from 89° 59′ to 0° and gives natural cosines in connection with scale G from 0.0001 to 1.0. Scale G is a logarithmic scale for numerical values, for numbers from 0.0001 to 1.0, comprising, in the present embodiment of this invention, a scale of four logarithmic unit lengths. Scales E, F and G are of the same modulus; scale G is inverted with respect to scales E and F.

Scale G is divided by dividing lines in four quadrants, corresponding to its four logarithmic unit lengths. Each unit length is labeled by a numeral, corresponding to the numerical values in the unit: the first quadrant contains numbers from 1.0 to 0.1, is labeled with the numeral 1; the second quadrant represents numbers from 0.1 to 0.01, is labeled by the numeral 2; the third has numbers from 0.01 to 0.001, labeled by 3; and the fourth has numbers from 0.001 to 0.0001, labeled by 4. In all cases the labeling numbers determine and indicate the position of the first figure in the numbers with respect to the decimal point. Thus, in quadrant 1, the first figure has the first place from the decimal point, as in 0.1, the numeral 1; in quadrant 2, the second place from the decimal point, as in 0.01, the numeral 1 and so on. The labeling of the four logarithmic unit lengths determines thus the absolute values of the respective natural haversines, required in the addition and subtraction involved in the haversine method for the spherical triangles, described hereinafter.

For spherical triangles, this invention applies, as mentioned before, the haversine method, which is simple, fast, direct, and without auxiliary elements. The formula states, with reference to Figure 4, that:

$$\text{Hav } a = \text{Hav } A \times \cos(90°-c) \times \cos(90°-b) + \text{hav } (c-b);$$

and

$$\text{Hav } A = \frac{\text{Hav } a - \text{hav } (c-b)}{\text{Cos } (90°-c) \times \cos(90°-b)}$$

In the first formula there is involved an addition of two natural haversines, in the second a subtraction. This invention shows the natural haversines in absolute values by the labeled scales, ready for addition or subtraction. In case of logarithmic or prior slide rule computations the absolute values, that is, the position of the decimal point is determined by mental estimation. This invention eliminates the mental estimation from the procedure. A further advantage of the solution is that the natural haversines are shown in a permanent indicator (24) and in vertical positions.

The scales E, F and G and result indicator 24 comprise a cooperative system and create a new solution for spherical triangles. The procedure is demonstrated in an illustrative example hereinafter.

Figure 5 shows the scales H, J, K and L, for computations involving fractional and decimal values of numbers. Scale H is for numbers from 1 to 100 and with fractional subdivisions. It is on base member 3 and fixed in position. Scales J, K and L are on rotatable ring member 2 and rotate with it. Scale J is identical with scale H, that is, it is a scale with fractional subdivisions. The fractional subdivisions are partly shown between the numbers 1 and 2, and 10 and 12. Scale K is for percentage values between 10 and 1000, has subdivisions in the decimals of the numbers, as it is shown partly between the numbers 100 and 200. Scale L is a numerical scale for numbers between 0.1 and 10, with decimal subdivisions. All beforementioned scales are logarithmic scales, of the same modulus and concentric.

Scales H, J, K and L, with the result indicator **4**, **24**, comprise a cooperative system for computations in which proportions of fractional numbers and their reciprocals are expressed in percentage and in decimal values, with the results indicated at a permanent result indicator.

Illustrative examples are presented hereinafter to demonstrate the new solutions and procedures of this invention. In the examples, the notation "index," it will be understood, is the initial point of scales B and F, marked with an arrow in Figures 1 and 3. Set in alignment two graduations on two adjacent scales, means, to bring the respective graduations opposite to each other.

Illustrative Example 1

Relates to a simple division.

Division: $\frac{4}{2}=2$ Reciprocal: $\frac{2}{4}=0.5$

Solution:

Set 4 on scale A in alignment with 2 on scale B,

Read result in result indicator at 24=2 on scale C, and the reciprocal of the quotient 0.5 on scale D.

Illustrative Example 2

Multiplication.

$$2\times4=8$$

Solution:

Set index of B to 2 on scale A,
Move indicator line 23 to 4 on scale B,
Move index of B to indicator line **23**,
Read in result indicator at 24 result=8

In Examples 1 and 2 the results are indicated in the fixed result indicator, at a permanent location of the indicator and in vertical position.

No prior slide rule has this advantage of permanent indication.

Illustrative Example 3

Relates to the solution of a spherical triangle, in which two sides and the included angle are given and the three unknown parts are required. The triangle is shown in Figure 4.

Given:

$A=48°$; $b=58°$ (32°); $c=105°$ (75°), (15°), $c-b=47°$.

Required: $a=65° 40'$, B and C.

The solution is based on the haversine formula, given hereinbefore. The right side of this formula consists of two parts:

The first part is:

$$\text{Hav } A \times \cos(90°-c) \times \cos(90°-b) = \text{Hav } 48° \times \cos 15° \times \cos 32°.$$

The second part is: Hav $(c-b)$ = hav 47°.

Solution of the first part:

Set index of scale F to 48° on scale E,
Indicator 23 to 15° on scale F,
Index to indicator 23,
Indicator 23 to 32° on scale F,
Index to indicator.
Read resultant=0.1351, in the first quadrant, in result indicator at 24.

Solution for the second part:

Set index to 47° on scale E,
Read resultant=0.159, in result indicator at 24 in first quadrant.

Third step:

Add the two natural haversines:

$$\begin{array}{r} 0.1351 \\ 0.159 \\ \hline 0.2941 \end{array}$$

Set 0.2941 in result indicator at 24, in first quadrant.
Read final result=65° 40′ on scale E opposite index.

The procedure for the determination of angles B and C is similar, except one subtraction of natural haversines is required.

In the solutions selected and accordingly disposed scales perform the computation in which all the natural haversines are indicated mechanically in absolute values without mental estimation and in a permanent result indicator, in vertical positions. It is an entirely new solution.

Illustrative Example 4

Relates to computations with fractional and decimal values. Proportions of fractional numbers are expressed in percentage and their reciprocals in decimal values.

Given:

Proportion in fractions:

$1\frac{1}{8}/1\frac{1}{4}$

Reciprocal in fractions:

$1\frac{1}{4}/1\frac{1}{8}$

Required:

Percentage of proportion:

90

Proportion in decimals:

1.112

Solution: Set in alignment—

$1\frac{1}{4}$ on scale H
$1\frac{1}{8}$ on scale J

Read percentage of proportion=90 in result indicator 24 on scale K and reciprocal proportion=1.112 in result indicator at 24 on scale L.

In this solution the percentage and reciprocal are indicated at the same permanent indicator line **24** and in vertical position.

There is no other computer on record which indicates the results at a permanent result indicator.

I claim:

1. A computer comprising a fixed circular base member having thereon an exposed logarithmic scale; a rotatable ring member in front of and within the base member, having an outer exposed logarithmic scale and two inner partly concealed logarithmic scales thereon, one of last said two scales inverted with respect to the other scales; a result indicator member in front of the ring member, fixed to the base member and of a diameter to conceal an inner marginal part of the ring member and the scales thereof and having an annular segmental opening in alignment with said inner concealed scales of the ring member to expose to view parts thereof; a movable peripheral indicator, supported by the outer edges and outer cylindrical surface of the base member, said indicator being cooperative with said exposed scales of the base and ring members, respectively.

2. A computer comprising a fixed circular base member having thereon an exposed logarithmic haversine scale; a rotatable ring member in front of and within the base member, having an outer exposed logarithmic cosine scale and an inner partly concealed logarithmic numerical scale thereon, last said scale inverted with respect to the first said two scales; a result indicator member in front of the ring member, fixed to the base member and of a diameter to conceal an inner marginal part of the ring member and the logarithmic numerical scale thereof and having an annular segmental opening in alignment with said numerical scale to expose to view parts thereof; a movable peripheral indicator, supported by the outer edges and outer cylindrical surface of the base member, said indicator being cooperative with said exposed scales of the base and ring members, respectively.

3. A computer comprising a fixed circular base member having thereon an exposed logarithmic haversine scale of four logarithmic units for angles from 1° 10′ to 180°; a rotatable ring member in front of and within the base member having an outer exposed logarithmic cosine scale of four logarithmic units for angles from 89° 59′ to 0° 0′ and an inner partly concealed logarithmic numerical scale of four logarithmic units for numbers from 0.0001 to 1.0, each logarithmic unit marked by limiting lines at its start and end and designated by a numeral indicative of the position of the figure in the number in relation to the decimal point in it, last said scale inverted with respect to the first said two scales; a result indicator member in front of the ring member, fixed to the base member and of a diameter to conceal an inner marginal part of the ring member and the numerical scale thereof and having an annular segmental opening in alignment with said numerical scale to expose to view parts thereof; a movable peripheral indicator, supported by the outer edges and outer cylindrical surface of the base member, said indicator being cooperative with said exposed scales of the base and ring members, respectively, whereby the absolute values of natural haversines and cosines are indicated automatically by the scales themselves without mental estimate.

4. A computer comprising a fixed circular base member, having thereon an exposed logarithmic scale of fractional subdivisions; a rotatable ring member in front of and within the base member having an outer exposed logarithmic scale with fractional subdivisions, identical with first said scale and two inner partly concealed logarithmic scales with decimal subdivisions, of which one is of percentage values, the other of numerical values, last said scale inverted with respect to the first said three scales; a result indicator member in front of the ring member and fixed to the base member and of a diameter to conceal an inner marginal part of the ring member and the two inner scales thereof and having an annular segmental opening in alignment with the two inner scales of the ring member to expose to view parts thereof; a movable peripheral indicator, supported by the outer edges and outer cylindrical surface of the base member, said indicator being cooperative with said exposed scales of the base and ring members, respectively, whereby the proportions and the reciprocals of the proportions of fractional values are indicated in percentage and decimal values at a permanent indicator and in vertical position.

5. A computer comprising a fixed circular base member having thereon an exposed logarithmic scale; a peripherally supported rotatable ring member in front of and within the base member, having an outer exposed logarithmic scale and two inner partly concealed logarithmic scales thereon, one of last said two scales inverted with respect to the other scales and said ring member built as an internal spur gear; a result indicator member in front of the ring member, fixed to the base member and of a diameter to conceal an inner marginal part of the ring member and the scales thereof and having an annular segmental opening in alignment with said inner concealed scales of the ring member to expose to view parts thereof, said result indicator member accommodating on its front face a driving knob which in turn holds a driving pinion placed at the rear face of the result member, said pinion in contact with the internal gear of the ring member, to rotate it mechanically; a movable peripheral indicator supported by the outer edges and outer cylindrical surface of the base member, said indicator being cooperative with said exposed scales of the base and ring members, respectively.

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