Feb. 9, 1926.

1,572,547

R. W. MALLDER

CALCULATOR

Filed Dec. 12, 1922

Fig. 1.

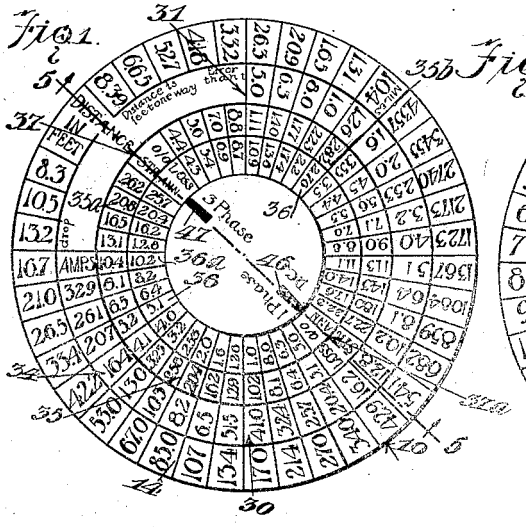



Fig. 2.

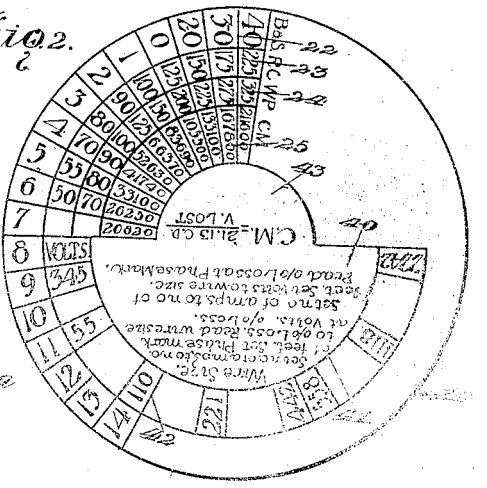



Fig. 3.

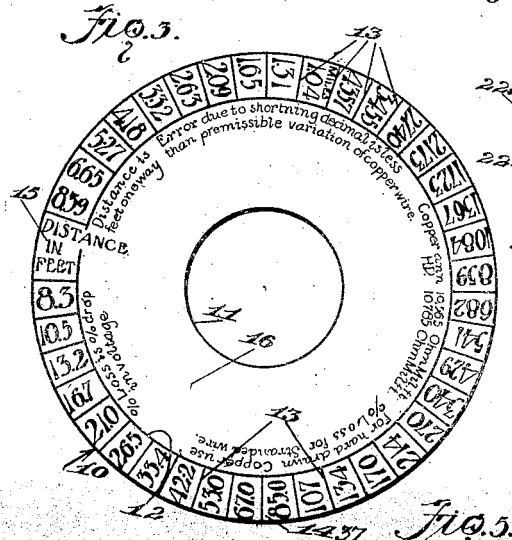



Fig. 4.

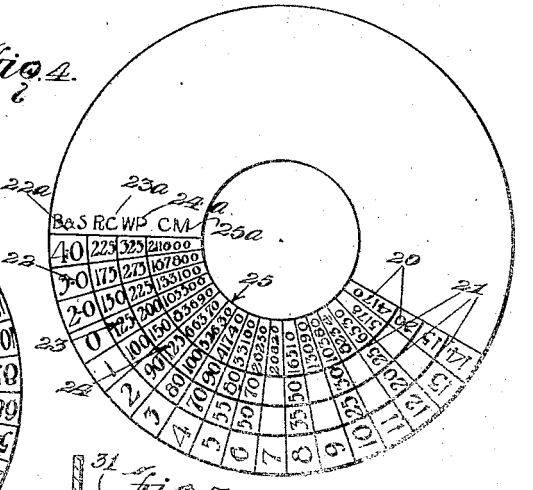



Fig. 5.

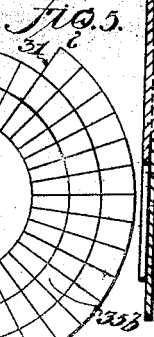
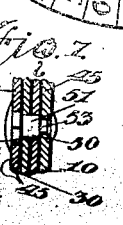


Fig. 6.



Fig. 7.



WITNESSES

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Patented Feb. 9, 1926. 1,572,547

# UNITED STATES PATENT OFFICE.

ROBERT WILLIAM MALLDER, OF DUBUQUE, IOWA.

## CALCULATOR.

Application filed December 12, 1922. Serial No. 606,452.

*To all whom it may concern:*

Be it known that I, ROBERT WILLIAM MALLDER, a citizen of the United States, and a resident of Dubuque, in the county of Dubuque and State of Iowa, have invented certain new and useful Improvements in Calculators, of which the following is a specification.

This invention relates in general to calculators of the tabular type, and more particularly to a wire size calculator especially adapted for the use of linemen, wiremen, architects or engineers for determining wire sizes for light and power.

The object of the invention is to provide a device of this character by which the proper size wire may be determined for a given voltage, current, distance and percent loss or by which the percent loss may be ascertained for a given voltage, current, distance and wire size, the calculator being so organized and constructed that the necessity for carrying out mathematical calculations is obviated while at the same time the calculator may be quickly set and shows at a glance the advantages or disadvantages of using a higher or lower voltage.

Other objects and advantages of the invention reside in certain novel features of the construction, combination and arrangement of parts which will be hereinafter more fully described and particularly pointed out in the appended claims, reference being had to the accompanying drawings forming part of this specification, and in which:

Figure 1 is a view in elevation of one side of the calculator embodying the present invention;

Figure 2 is a similar view of the opposite side of the calculator shown in Figure 1;

Figure 3 is a view of one side of the main disk embodied in the calculator;

Figure 4 is a similar view of the opposite side of the disk shown in Figure 3;

Figure 5 is a view in transverse section, taken approximately on line 5—5 of Figure 1;

Figure 6 is a view in elevation of the small disk, the tables being omitted; and

Figure 7 is a fragmentary view in section showing the construction employing a rivet for associating the disks of the calculator with each other.

Before proceeding with the detail description of the construction of the calculator and the manner of using the same, it is thought best, in order to acquaint those skilled in the art with the manner of making or producing the calculator, to advert to the principles underlying the calculator and to the properties of the materials with which it deals as well as to include the tables from which the quantities or numbers employed in the calculator are derived, each table being accompanied by a short description pointing out its salient and more important features. It is to be understood however that these principles and tables are not for use in conjunction with the calculator but are necessary for an understanding of the manner in which it is produced.

The principle of the device is the geometrical or logarithmic progression in the sizes of the Browne & Sharpe or American Wire Gauge.

This progression is obtained as follows:

| | Logarithms. |
|---|---|
| The diameter of size 0000 is 460. mils | 2.662758 |
| The diameter of size 36 is 5. mils | .698970 |
| Logarithmic difference | 1.963788 |

There are 39 sizes between No. 0000 and No. 36. Therefore the logarithmic difference for each size will be 1/39 of log. 1.963788 or log. .0503535. There will be this difference of .0503535 in the logarithm of a wire diameter and the next larger size. As the circular mils. is the square of the diameter in mils., there will be a difference of 2X.0503535 or log. .100707 in the circular mils.

This device is so made and constructed that all the quantities in the various cooperating tables have this progression of .100707 in the logarithms of the numbers representing them.

*Copper wire.*

Circular 73 of the Bureau of Standards

(June 25, 1918) on copper gives the following specifications of the American Society for Testing Materials on copper wires.

Annealed wire:

Resistivity at 68 F. not to exceed 891.58 lbs. per mile-ohm.

Permissible variation of diameter for wires .010 or larger 1% over or under.

Hard drawn wire:

Resistivity at 68 F. not to exceed 910.15 lbs. per mile-ohm.

Permissible variation of diameter for wires .100 or larger 1%, and smaller than .100, 1 mil over or under.

*Formulæ.*

The formulæ used in calculating the device are as follows:

C. M.=circular mils. C=current in amperes. D=distance in feet one way. E= volts lost. K=resistance of 1 mil-foot of copper. The value of K for 891.58 lbs. per mile-ohm is 10.565, and the value for 910.15 lbs. per mile-ohm is 10.785.

$$C.M.=\frac{2KCD}{E}$$ for direct current or single phase.

$$C.M.=\frac{\sqrt{3}KCD}{E}$$ for 3 phase current.

The different factors or numbers used on the scales or tables are obtained as follows:

*Wire sizes.*

The wire sizes used are sizes No. 0000 to No. 14 of the B. & S. sizes. The diameters and area in C. M. used in figuring this device were taken from Table No. 6 of Circular No. 31 of the Bureau of Standards (2nd ed. Jan. 1st, 1914).

The carrying capacity in amperes for rubber covered and weatherproof wires is taken from the latest edition of the "National Electric Code."

*Amperes.*

The starting point of the ampere table is 1 ampere and log. .000000. In table No. 1, the column headed, "Theoretical log. amps.", is obtained by starting with log. .000000 and subtracting .100707 for each amperage less than 1, and adding .100707 for each succeeding amperage greater than 1. The columns headed, "Theo. amps.", gives the number in 5 significant figures corresponding to the log. in the first column. The column headed, "Amps. used," is obtained by shortening the decimal from the column headed, "Theo. amps."

TABLE No. 1.

*Amperes.*

| Theoretical log. amps. | Theo. amps. | Amps. used. | Theoretical log. amps. | Theo. amps. | Amps. used. |
|---|---|---|---|---|---|
| 2.517675 | 329.36 | 329 | 1.007070 | 10.164 | 10.2 |
| 2.416968 | 261.20 | 261 | .906363 | 8.0805 | 8.10 |
| 2.316261 | 207.14 | 207 | .805656 | 6.3923 | 6.40 |
| 2.215554 | 164.27 | 164 | .704949 | 5.0593 | 5.10 |
| 2.114847 | 130.28 | 130 | .604242 | 4.0201 | 4.00 |
| 2.014140 | 103.31 | 103 | .503535 | 3.1881 | 3.20 |
| 1.913433 | 81.928 | 82.0 | .402828 | 2.5283 | 2.50 |
| 1.812726 | 64.975 | 65.0 | .302121 | 2.0050 | 2.00 |
| 1.712019 | 51.525 | 51.5 | .201414 | 1.5930 | 1.60 |
| 1.611312 | 40.861 | 41.0 | .100707 | 1.2610 | 1.26 |
| 1.510605 | 32.405 | 32.4 | .000000 | 1.0000 | 1.00 |
| 1.409898 | 25.693 | 25.7 | 9.899293-10 | .79264 | .800 |
| 1.309191 | 20.373 | 20.4 | 9.798586-10 | .62831 | .630 |
| 1.208484 | 16.161 | 16.2 | 9.697879-10 | .49875 | .500 |
| 1.107777 | 12.817 | 12.8 | | | |

*% Loss.*

The percent loss is obtained the same way as the amperes in Table No. 1. Starting with log. 1.409898 the percent loss is the same as the amperes and the same numbers are used for both. The column headed, "Theoretical log. loss," in Table No. 2, gives these logs., and the column headed, "% Loss, annealed," gives the numbers corresponding (with shortened decimal).

Stranded wire is assumed to have 1.02 times the resistance of a solid wire of the same cross section. The increase in resistance is due to the increased length of wire required in stranding. 2% is assumed as standard by the standards committee of the American Institute of Electrical Engineers.

The % loss for stranded wire is obtained by adding .008600 to each log. of the column headed, "Theoretical log. loss," (that is: multiplying by 1.02), and shortening the decimal.

The % loss for hard drawn wire will be 10.785/10.565 or 1.0208 times the loss for annealed wire. Therefore, the same % loss can be used for both stranded and hard drawn wire.

The % loss 3 phase will be 3/2 or .866 times the loss for single phase. The % loss for annealed wire is obtained by adding log. 9.937530–10 to each log. in the column headed, "Theoretical log. loss," (that is: multiplying by .866), and shortening the decimal.

The % loss for 3 phase stranded is obtained by adding log. 9.937530–10 plus log. .008600 to the logs. in the column headed, "Theoretical log. loss", (that is: multiplying by .866 and 1.02), and shortening the decimals.

TABLE No. 2.

*%Loss.*

| Theoretical log. loss. | % Loss, 1 phase and D. C. | | % Loss, 3 phase. | |
|---|---|---|---|---|
| | Annld. | Strd. | Annld. | Strd. |
| 1.409898 | 25.7 | 26.2 | 22.3 | 22.7 |
| 1.309191 | 20.4 | 20.8 | 17.6 | 18.0 |
| 1.208484 | 16.2 | 16.5 | 14.0 | 14.3 |
| 1.107777 | 12.8 | 13.1 | 11.1 | 11.3 |
| 1.007070 | 10.2 | 10.4 | 8.80 | 9.00 |
| .906363 | 8.10 | 8.20 | 7.00 | 7.10 |
| .805656 | 6.40 | 6.50 | 5.50 | 5.60 |
| .704949 | 5.10 | 5.20 | 4.40 | 4.50 |
| .604242 | 4.00 | 4.10 | 3.50 | 3.55 |
| .503535 | 3.20 | 3.25 | 2.70 | 2.82 |
| .402828 | 2.53 | 2.58 | 2.20 | 2.23 |
| .302121 | 2.00 | 2.05 | 1.74 | 1.77 |
| .201414 | 1.60 | 1.62 | 1.38 | 1.40 |
| .100707 | 1.26 | 1.29 | 1.09 | 1.11 |
| .000000 | 1.00 | 1.02 | .870 | .880 |
| 9.899293-10 | .800 | .810 | .690 | .700 |
| 9.798586-10 | .630 | .640 | .540 | .560 |
| 9.697879-10 | .500 | .510 | .430 | .440 |

*Voltage.*

The voltage used in calculating this device is 110 and corresponding log. 2.041393. From this voltage as a basis, the voltages in Table No. 3 are obtained as follows:

The column headed, "Theoretical log. volts," starts with log. 2.041393 and .100707 is subtracted for each succeeding voltage under 110, and .100707 is added for each succeeding voltage over 110.

The column headed, "Volts", gives the number to 5 significant figures corresponding to the logs. in the first column.

The column headed, "Volts used", is obtained from the column headed, "Volts", by shortening the decimal.

TABLE No. 3.

*Voltage.*

| Theoretical log. volts. | Theor. volts. | Volts used. | Theoretical log. volts. | Theor. volts. | Volts used. |
|---|---|---|---|---|---|
| 1.537858 | 34.503 | 34.50 | 2.544928 | 350.70 | |
| 1.638565 | 43.567 | | 2.645635 | 442.22 | 442.0 |
| 1.739272 | 54.862 | 55.00 | 2.746342 | 557.62 | 558.0 |
| 1.839979 | 69.180 | | 2.847049 | 703.15 | |
| 1.940686 | 87.234 | | 2.947756 | 886.65 | |
| 2.041393 | 110.00 | 110.0 | 3.048463 | 1118.0 | 1118. |
| 2.142100 | 138.71 | | 3.149170 | 1409.8 | |
| 2.242807 | 174.90 | | 3.249877 | 1777.8 | |
| 2.343514 | 220.53 | 221.0 | 3.350584 | 2241.7 | 2242. |
| 2.444221 | 278.11 | | | | |

*Distance.*

The distance is obtained from the formula,

$$D=\frac{C.M.E}{2KC}.$$

Changing to a logarithmic formula, we have: Log. D=log. C. M.—log. volts lost—log. 2K—log. C.

Table No. 4 gives the distances used on this device and is obtained as follows:

Using No. 0000 wire and 1 amp. at 1% loss and 110 volts, and K for annealed copper at 10.565, we have the log. dist.=log. 4.042009 or the distance is 11016 feet.

The column headed, "Theoretical log. feet", in Table No. 4, is obtained by adding .100707 for each succeeding distance greater than 4.042009, and subtracting .100707 for each succeeding distance less.

The column headed, "Feet", gives the numbers to 5 significant figures corresponding to the logs. in the column headed, "Theoretical log. feet".

The column headed, "Feet used", is obtained from the column headed, "Feet", by shortening the decimal.

TABLE No. 4.

*Distance.*

| Theoretical log. feet. | Feet. | Feet used. | Theoretical log. feet. | Feet. | Feet used. |
|---|---|---|---|---|---|
| 0.020092 | 8.3194 | 8.300 | 3.337060 | 2173.0 | 2173. |
| 1.020799 | 10.490 | 10.50 | 3.437767 | 2740.1 | 2740. |
| 1.121506 | 13.228 | 13.20 | 3.538474 | 3455.2 | 3455. |
| 1.222213 | 16.680 | 16.70 | 3.639181 | 4357.0 | 4357. |
| 1.322920 | 21.034 | 21.00 | 3.739888 | 5494.0 | 5492. |
| 1.423627 | 26.523 | 26.50 | ---------- | 1.0405 M | 1.04 M |
| 1.524334 | 33.445 | 33.40 | 3.840595 | 6927.8 | 6017. |
| 1.625041 | 42.173 | 42.20 | ---------- | 1.3121 M | 1.32 M |
| 1.725748 | 53.180 | 53.00 | 3.941302 | 8735.8 | 8712. |
| 1.826455 | 67.058 | 67.00 | ---------- | 1.6545 M | 1.65 M |
| 1.927162 | 84.560 | 85.00 | 4.042009 | 11016. | 11035. |
| 2.027869 | 106.62 | 107.0 | ---------- | 2.0863 M | 2.09 M |
| 2.128576 | 134.45 | 134.0 | 4.142716 | 13890. | 13886. |
| 2.229283 | 169.52 | 170.0 | ---------- | 2.6307 M | 2.63 M |
| 2.329990 | 213.79 | 214.0 | 4.243423 | 17515. | 17550. |
| 2.430697 | 269.58 | 270.0 | ---------- | 3.3173 M | 3.32 M |
| 2.531404 | 339.94 | 340.0 | 4.344130 | 22087. | 22070. |
| 2.632111 | 428.65 | 429.0 | ---------- | 4.1830 M | 4.18 M |
| 2.732818 | 540.53 | 541.0 | 4.444837 | 27850. | 27825. |
| 2.833525 | 681.59 | 682.0 | ---------- | 5.2747 M | 5.27 M |
| 2.934232 | 859.17 | 859.0 | 4.545544 | 35119. | 35112. |
| 3.034939 | 1083.7 | 1084. | ---------- | 6.6523 M | 6.65 M |
| 3.135646 | 1366.6 | 1367. | 4.646251 | 44284. | 4430. |
| 3.236353 | 1723.2 | 1723. | ---------- | 8.3872 M | 8.39 M |

All distances greater than 1 mile are expressed as miles, and the feet used corresponds to decimal parts of a mile used.

Referring now to the accompanying drawings wherein for the sake of illustration is shown the preferred embodiment of the invention, the numeral 10 designates generally a main or large disk which is of circular form and provided with a central circular aperture or opening 11. A circular line 12 is applied to one face of the disk 10 adjacent the circumferential edge of and concentric with the disk and defines an outer annular or circular panel which is divided up into a circular series of spaces by a plurality of radial lines 13. The radial lines are so arranged as to divide the outer annular panel into thirty-eight spaces 14 having an angular extent of 9° each and a single heading receiving space 15 having an angular extent of 18°. In the spaces 14 a circular series of numbers expressing distance or length in feet and miles are placed, these numbers being taken from the Table 4 as will appear from a comparison of these drawings and the table. In the space 15 the words "Distance" and "Feet" are placed. It is to be noted that as shown in Figure 3

the circular line 12 is broken adjacent the space 15 and through the gap in this line the word "Distance" extends so that this word is disposed not only in the space 15 but also partly in the panel 16. Also it is to be noted that as shown in the drawings the numbers are placed on the calculator by starting to the left of the center of the disks and proceeding in a counter-clockwise direction. From Figure 3 it will be plain that the line 12 not only defines the outer panel which is divided up into the spaces 14 and 15 but also a large inner panel 16 which is blank except that around the outer marginal portion thereof miscellaneous instructions and items of information concerning the use of the calculator are applied, as may be noted from the inspection of Figure 3 of the drawings.

One face of the disk 10 is constructed in the manner thus described and is shown in Figures 1 and 3 and the other face of this disk 10 is constructed as shown in Figures 2 and 4 and will now be described. As shown to best advantage in Figure 4, this other face of the disk has applied thereto for a section of its angular extent a plurality of radial lines 20, preferably nineteen such lines being applied to the face of the disk and these lines being spaced apart at equal angular distances of 9° each. Arcuate lines 21 are applied to the section of the face of the disk which bears the radial lines 20 and these arcuate lines intersect the radial lines 20 and are struck from the center of the disk so as to be concentrically arranged on the disk. In this manner there is provided four arcuate series of number or quantity receiving spaces such series being designated at 22, 23, 24 and 25, respectively. In the outer series of number receiving spaces 21 the B. & S. wire gauge sizes are applied and are properly headed, as indicated at 22ª. In the series 23 an arcuate series of numbers or quantities expressing the ampere capacity of rubber covered wire is placed and is headed "RC" as at 23ª; in the series 24 an arcuate series of quantities expressing the ampere capacity of weatherproof wire is placed and is headed "WP", as at 24ª; and in the innermost series is placed an arcuate series of numbers representing the circular mils corresponding to the wire size and headed "CM" as at 25ª. The corresponding quantities or numbers of these four series are radially alined. Arcuate series 23, 24, and 25 do not enter into the operation of the calculator, as far as solving problems is concerned, but are placed on the device for reference purposes.

There is thus provided a main or large disk having one face bearing a circular series of numbers expressing distance in feet and miles and having its other face bearing four concentric arcuate tables having corresponding quantities radially alined and expressing respectively B. & S. wire gauge sizes, ampere capacity of rubber covered wire, ampere capacity of weatherproof wire and wire size in circular mils. The distance table has no other relation to the wire size table than that of a fixed position so that either table can not be moved without a corresponding angular movement of the other.

A small disk 30 is provided and is fitted in face to face relation against the panel 16 of the disk 10, this disk 30 having the same diameter as the panel 16 and having an arcuate recess 31 cut in its marginal edge so that all of the reading matter around the marginal edge of the panel 16 may be viewed by rotating the disk 30. The recess 31 also greatly facilitates manipulation of the disk 30. The exposed face of the disk 30 has applied thereto three circular lines 32 in spaced concentric relation which together with the radial lines 33 define on the disk concentric series of number receiving spaces designated at 34, 35 and 36. The series of number receiving spaces 34 make up a complete circle or annulus except for the recess 31, while the number receiving spaces 35 and 36 make up a practically complete annuli except for the spaces provided for heading to be presently described. It is to be understood that the series of number receiving spaces 35 and 36 do not need to be radially alined with those of 34, although shown in such relation for the sake of simplifying the illustration. The spaces 35 and 36 can be offset say 4½° to spaces 34 with good advantage as it will readily distinguish between the two tables. Spaces 35 and 36 have no relation to spaces 34 other than a fixed position, so that either table can not be moved without a corresponding angular movement of the other. The number receiving spaces 34, 35 and 36 each have an angular extent of 9° but in the series 35 and 36 diametrically opposite spaces of 18° are left to provide for the proper headings as will presently appear, these spaces being designated at 37 and 37ª, respectively. In the series of number receiving spaces 34 are placed an arcuate series of quantities expressing the amperes, the series of quantities being headed "Amps." and the quantities making up the series being taken from the Table #1.

The 18° spaces 37 and 37ª divide the series of number receiving spaces 35 and 36 into two semi-annular sets designated at 35ª and 36ª and 35ᵇ and 36ᵇ, respectively, the sets 35ª and 36ª being provided to receive concentric semiannular series of quantities expressing the percent loss for stranded and annealed wire, respectively, a single phase or direct current and the sets 35ᵇ and 36ᵇ being provided to receive concentric semi-

annular series of quantities expressing the present loss for stranded and annealed wire respectively with a three phase current. The number of quantities applied in the set $35^a$ of the series of spaces 35 are subheaded "Str" while the numbers of quantities applied in the set $36^a$ of the series of spaces 36 are subheaded "Ann". Both the subheading "Str" and "Ann" occur under a main heading "% Loss" and these headings are all disposed in the space 37. The numbers or quantities applied in the set $35^b$ of the series of spaces 35 are subheaded "Str" wire; the numbers or quantities applied in the set $36^b$ in the series of spaces 36 are subheaded "Ann". As before both the subheadings "Str" and "Ann" occur under a main heading "% Loss" and the three headings are all disposed in the space $37^a$. The numbers or quantities applied to sets $35^a$ and $36^a$, and $35^b$ and $36^b$ are all taken from the Table No. 2. The numbers in the sets $35^a$ and $36^a$ are preferably applied in different colored inks or in different styles of inks from the numbers applied in the sets $35^b$ and $36^b$ so that these sets may be readily distinguished from each other.

It is to be noted that all tables are placed on the calculator by starting to the left of the center of the disk and proceeding counter-clockwise around the disk. The ampere table must start with the largest ampere quantity; the distance table with the smallest distance quantity; and all % loss tables with the largest quantities.

A segment 40 is fitted in face to face relation against the side of the large disk 10 which bears the tables 22, 23 and 24, and this segment 40 is of such size that it does not in any position cover the table 22. The disk 40 is ruled with an arcuate line 41 and radial lines 42. Starting to the left of the center and proceeding in a counterclockwise direction the radial lines are spaced respectively the following distances from each other: 9°, 9°, 9°, 9°, 18°, 9°, 18°, 9°, 18°, 9°, 9°, 18°, 9°, 18°, 9°. In the first 9° space is placed the word "Volts"; in the second "34.5"; in the fourth "55"; in the fifth "110"; in the sixth "221"; in the seventh "442"; in the eighth "558"; in the ninth "1118" and in the last "2242". There is thus provided an ampere table of voltage which coacts with a table of wire sizes on the disk 10. The segment 40 is provided with a semi-circular extension 43 which is fastened by means of glue, cement, rivets or the like to a spacing washer 44 which operates in central openings of the disks 10 and 30, the washer 44 being also secured to a circular plate 45 which is larger than the opening in the disks 10 and 30 and which bears against the disk 30 to hold the same in proper relation with respect to the disk 10. This circular plate 35 has applied thereto diametrically opposite reading indicators 46 and 47, the indicator 46 being cooperable with the sets $35^a$ and $35^b$ and consequently being an indicator for % losses with one phase currents and the indicator 47 being cooperable with the sets $35^b$ and $36^b$ and constituting an indicator for multiphase or three phase currents. As the plate 45 is ridgidly connected with the segment 40 it is constrained to partake of the motion of the segment and consequently the motion of the voltage table which is applied to this segment 40. When it is desired to ascertain the wire size, the user of the table manipulates the disk 30 to set the nearest number of amperes of the ampere table to the nearest number of feet in the distance table. The next step is to set the phase mark or reading indicator 46 or 47 as the case may be to the nearest % loss. Then the operator may read the wire size at the volts used by consulting of course the wire size radially alined with the volts used. If it is desired to ascertain the % loss, the first step is to set the nearest number of amperes in the ampere table to the nearest number of feet. Next, set the number of the volts table corresponding to the volts used to the wire size in the cooperating wire size table. After these adjustments are made the % loss may be read at 46 or 47 as the case may be.

Instructions indicating the steps necessary to operation may be applied to the face of the segment 40, as shown in Figure 2 and also the formula

$$\text{C.M.} = \frac{2 \times 10.565 \times c \times d}{\text{volts lost}}$$

may be placed below these instructions and thus enable the user to figure or solve his own problems. In lieu of placing the instructions of the formula on the segment 40 they may be placed on the unoccupied part of the face of the disk 10 which bears the Tables 22 to 25, inclusive. In lieu of providing a washer 44 and securing it to the plate 45 and disk 30 a rivet may be employed, as shown in Figure 7, the rivet being designated at 50 and having a rounded portion 51 freely rotatable with respect to the disks 10 and 30 and having squared portions 52 and 53 engaged with the segment 40 and plate 45, respectively, so as to constrain the segment and plate to corresponding motion while permitting free relative adjustment of the disks 10 and 30.

In assembling the calculator shown in Figures 1 to 5, the washer 44 is fastened to the under side of the segment 40 and the semi-circular extension 43 thereof. The assembled segment and washer are then placed over the face of the disk 10 which bears the tables 22 to 25, inclusive and the segment is turned until the quantity 110 of

the volt table coincides or is radially alined with the quantity 0000 of the table 22, and maintaining the disk and segment in this relative position they are turned over and the disk 30 is applied to the face of the large disk 10 which bears the table 14. The quantity one ampere of the ampere table is then set to the quantity of 2.09 miles of the distance table. The plate 45 is next positioned on the washer 44 with the single phase or direct current reading indicator 46 coinciding with the one per cent loss for annealed wire, and the parts in this relative position are suitably secured or fastened to each other.

If desired the blank spaces on the disk 10 may be utilized for advertising matter if the instructions are not placed thereon; and if the instructions are placed on the disk 10 the blank space of the disk 40 may be utilized for advertising.

I claim:

1. In a calculator of the character described, a large disk having one face bearing a table expressing distances, and having its other face bearing table expressing wire sizes, a rotatable small disk fitted against the face of the large disk which bears the distance tables, said small disk bearing a table of amperes and a related table of percent loss, the ampere table being cooperable with the distance table, a segment fitted against the face of the large disk which bears the table of wire sizes, and bearing a table of voltages cooperable with the table of wire sizes, and a reading indicator cooperable with the percent loss table and constrained to partake of the motion of the segment bearing the voltage table.

2. In a calculator of the character described, a disk having a table expressing distances and a table expressing wire sizes, a rotatable disk coacting with the first disk and having a table of amperes and related tables of percent loss for stranded and annealed wires with single and multi-phase currents, the ampere table being cooperable with the distance table, a segment also coacting with the first disk and bearing a table of voltages cooperable with the table of wire sizes, and a plate connected with the segment and coacting with the rotatable disk, said plate having two reading indicators, one cooperable with the percent loss table for single phase currents and the other cooperable with the percent loss table of multi-phase currents.

3. In a calculator of the character described, a large disk having one face bearing around its marginal edge a circular table expressing distances and having its other face bearing around its marginal edge an arcuate table expressing wire sizes, a rotatable small disk fitted against the face of the large disk which bears the distance table, said small disk bearing an arcuate table of amperes, and an arcuate table of percent loss, the quantities of the ampere table bearing a fixed relation to the quantities of the percent loss table and the quantities of the ampere table being adapted to be selectively brought into radial alinement with any one of the quantities of the distance table of the large disk, a segment fitted against the face of the large disk which bears the table wire sizes, said segment bearing an ampere table of voltages, the quantities of the voltage table being adapted to be selectively brought into radial alinement with the quantities of the wire sizes table, a plate connected with the segment and bearing against the small disk and having a reading indicator cooperable with the percent loss table of the small disk.

4. In a calculator of the character described, a large disk having one face bearing around its marginal edge a circular table expressing distances and having its other face bearing around its marginal edge an arcuate table expressing wire sizes, a rotatable small disk fitted against the face of the large disk which bears the distance table, said small disk bearing an arcuate table of amperes and a plurality of related tables of percent loss for single phase and multi-phase currents, bearing a fixed relation to the quantities of the percent loss table being alined with the corresponding quantities of the ampere table and the quantities of the ampere table being adapted to be selectively brought into radial alinement with any one of the quantities of the distance table of the large disk, a segment fitted against the face of the large disk which bears the table of wire sizes, said segment bearing an ampere table of voltages, the quantities of the voltage table being adapted to be selectively brought into radial alinement with the quantities of the wire sizes table, a plate connected with the segment and bearing against the small disk, said plate having diametrically opposite reading indicators, one of the reading indicators being cooperable with the percent loss tables for single phase currents and the other reading indicator being cooperable with the percent loss tables for multi-phase currents.

ROBERT WILLIAM MALLDER.