Feb. 28, 1961

J. W. THOMPSON

2,973,143

CALCULATOR

Filed Feb. 19, 1958

Fig. 1.

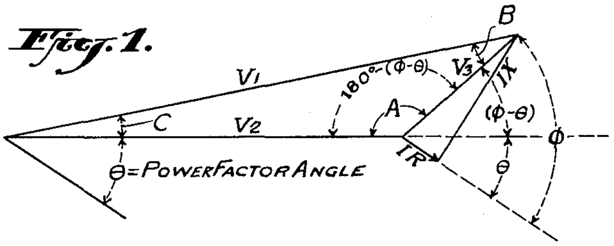


Fig. 2.

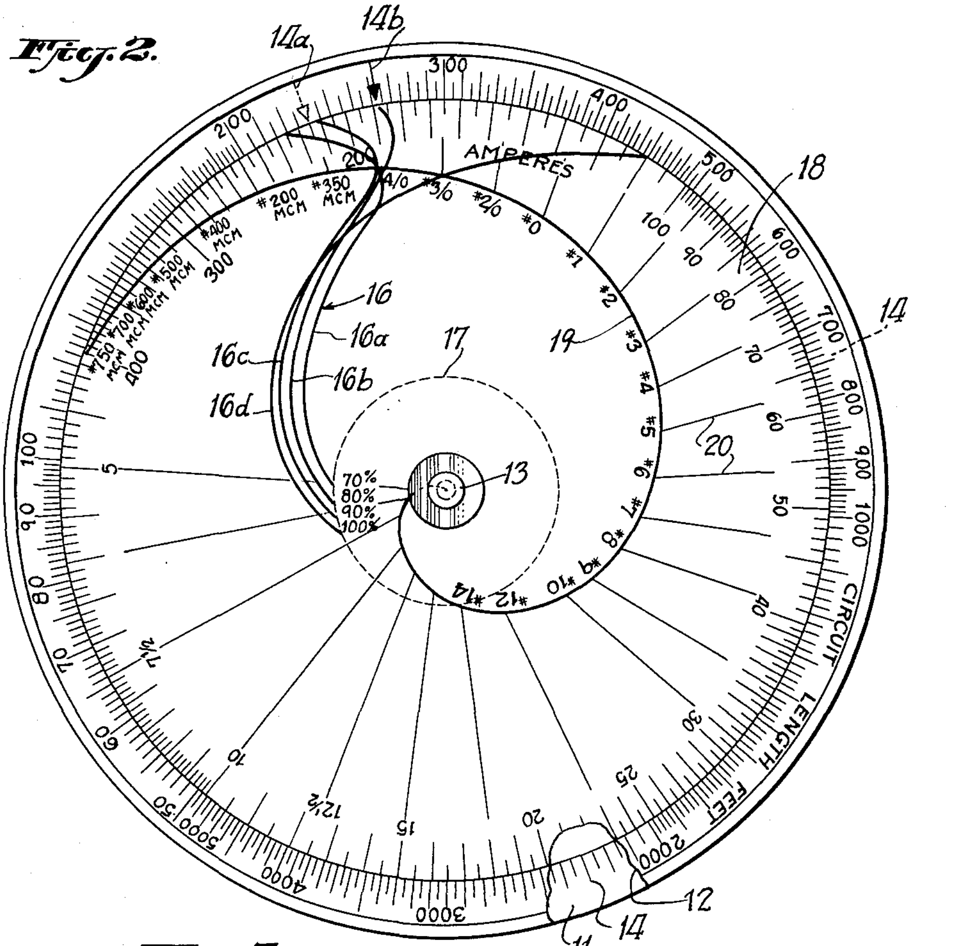
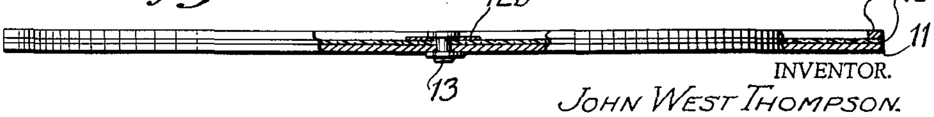


Fig. 3.



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CALCULATOR

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This invention relates to a calculator for determining the proper size of electrical cable for given conditions of load, power factor and circuit length.

The invention may be embodied in a calculator adapted for any desired range of conditions and for purposes of illustrating the invention the present embodiment is intended for balanced 3-phase, 3-wire, 220 volt, 60 cycle circuits; loads from 5 to 400 amperes; circuit lengths up to 5,000 feet; power factors 70% to 100% at 10% intervals; regulation 3% or less; three single conductor cables in one conduit made of magnetic material; resistance of conductors corrected for 60° C. temperature and A.C.-D.C. resistance ratio in larger sizes; reactance increased 50% for magnetic effect of conduit and random lay of cables.

In determining the size of cable for any given installation, the two factors that have to be considered, namely, the voltage drop and the heating of the cable, are independent of each other so that hitherto, it has been necessary for an electrician charged with the duty of connecting motors or other loads, to first calculate or otherwise obtain the correct size for the specified voltage drop and after that to check the result with a separate table to see if the cable would carry the current without overheating.

For the practical man, busy with the details of his job and impatient for results, the foregoing procedure is indirect and unsatisfactory. A distinguishing feature of the calculator made in accordance with this invention is that it takes into account both factors that have to do with the size of cable and in a single reading gives the correct size with respect to both the voltage drop and the safe amperes for the cable. As far as known, the present calculator is the only one that accomplishes both these requisites in a single reading.

Of the two factors above mentioned, voltage drop is the more important for economic reasons. One reason is that excessive voltage drop results in low voltage at the motor causing it and the machinery it drives to slow down with consequent loss in production. To give an idea of what this may amount to, take the case of a factory with a yearly production of say $50,000,000 and assuming volume to depend more or less directly on speed, a 1% reduction in speed would mean a loss in production approaching $500,000. Another reason is that subnormal voltage makes a motor sluggish, that is, it does not respond readily to changes in load, so the speed fluctuates continually and is never steady. This affects not only the quantity but also the quality of the product.

Further and other objects, features and advantages of the invention will more clearly appear from the detailed description given below, taken in conjunction with the accompanying drawings, illustrating, by way of example, the presently preferred embodiment of the invention, and in which:

Fig. 1 is a diagrammatic illustration of the theoretical considerations underlying the invention;

Fig. 2 is a plan view, on a somewhat enlarged scale, of a calculator device embodying the invention; and

Fig. 3 is a side elevational view of the device shown in Fig. 2, with certain parts broken away to better illustrate the structure.

Before describing the calculator device, the mathematical theory on which it is based first will be discussed.

The two most important factors in the problem to determine the size of cable for a given installation have been pointed out above and also the reason why a simple solution of the problem was needed for the benefit of practical electricians as well as the owners of the industries where they are employed. What follows is a mathematical analysis of the problem omitting non-essential details. The design of the calculator was based on the results of this analysis

In an electric circuit supplying a load located at a distance from the point of supply, one has to deal with the following voltages:

V_1=voltage at source of supply.
V_2=voltage at point of application.
V_3=voltage to overcome the resistance and reactance of the cable.

All three of these quantities are "vector" quantities, that is, they have direction as well as magnitude and cannot be treated by ordinary algebraic methods. Various schemes have been devised to deal with them, but the graphic is the best for present purposes. So, taking the voltage at the load as the reference voltage, the triangle of voltages can be drawn as shown in Fig. 1.

Experience has shown that voltage drop should not exceed 3% of load voltage. So, if V_2 is taken as 100 volts, V_1 will be 103 volts, and to find V_3 it will be sufficient if the angle at A can be evaluated. This can be done as follows:

Voltage V_3 can be resolved into two components,

IR, the voltage to overcome the resistance of the cable.
IX, the voltage to overcome the reactance of the cable.

These two components are at right angles to each other, and the IR component is parallel to the current vector, as shown in the diagram (Fig. 1), in which the angle $A=180-(\phi-\theta)$ and where $\phi=\tan^{-1}X/R$ and θ=power factor angle=$\cos^{-1}$ (P.F.). Knowing the value of angle A, the remaining angles and the side V_3 can be found by trigonometrical formulas giving $V_3=V_2 \sin C/\sin B$.

In the diagram it is seen that:

$$(IR)^2+(IX)^2=V^2_3$$

where

I=load in amperes
$R=Lr/1000$, r being resistance per 1000 feet of cable; L the length of circuit in feet
$X=Lx/1000$, x being the reactance per 1000 feet of cable; L as before, the length of circuit in feet.

Substituting these values of R and X in the equation and rearranging gives:

$$IL=\frac{V_3\times 1000}{\sqrt{r^2+x^2}}$$

Taking logarithms of both sides gives:

$$\log IL=\log V_3+\log 1000+\operatorname{colog}\sqrt{r^2+x^2}$$

In this equation the values of r and x have been determined by measurement for each size cable and widely published in the form of tables.

All of the foregoing values have been based on the assumption that V_2, the reference voltage, was 100 volts. The present embodiment of this invention is intended for a 220 volt circuit in which the corresponding voltage would be 127.02 so the value of V_3 in the equation must be increased by 127.02/100 or 1.2702.

With this change, the final equation becomes:

$$\log IL = \log V_3 + \log 1.2702 + \log 1000 + \operatorname{colog}\sqrt{r^2+x^2}$$

If the sum of all the terms on the right hand side of this equation is represented by the letter K, it can be written as follows:

$$\log IL = K$$

The design of the calculator rests on this equation. Its apparent simplicity is deceptive because the calculation of V_3 involves a series of trigonometrical formulas and $\operatorname{colog}\sqrt{r^2+x^2}$ is not much simpler. Furthermore, since the quantity represented by K has a definite and distinct value for each size cable and power factor, separate calculations have to be carried out for each of the 23 sizes of cable and 4 different power factors for each size, making altogether 92 separate and distinct calculations of the value of K (hereinafter sometimes referred to for convenience as "circuit constant").

Referring more particularly to Figs. 2 and 3 showing a presently preferred embodiment of the invention, the calculator device is designated in its entirety as **10** and comprises a lower disc **11** and an upper disc **12** pivotally secured together at their centers for relative angular movement about a pivot member **13**. The upper disc **12** is transparent and the lower disc **11** is preferably an opaque disc of relatively stiff material. Preferably the upper disc is provided with a rim **12***a*, serving as a reinforcement and to facilitate rotation of the upper disc, and with a pivot reinforcement center **12***b*.

LOWER DISC

The lower disc **11** is provided adjacent its peripheral border, closely adjacent the internal diameter of the rim **12***a*, with a circular logarithmic scale **14**, reading in a clockwise direction, representing the length of the electrical circuit and in the present embodiment graduated in feet covering circuit lengths from 50–5000 feet. The lower disc **11** is also provided with a group **16** of power factor curves **16***a*, **16***b*, **16***c* and **16***d*, in the present embodiment representing power factors of 70%, 80%, 90% and 100%, respectively. The manner of plotting these curves and their function will be more fully described hereinafter, but in general, referring to the present embodiment, these curves may be defined as commencing at a central zone, in the present embodiment defined by a circle designated **17** within the sector defined by radial lines intersecting scale **14** at about 71 feet and 98 feet, respectively, extending generally outwardly and terminating on the arc defining the inner circle of the length scale **14** within the sector defined by radial lines intersecting the scale **14** at about 215 feet and 450 feet, respectively. The group of curves **16** is disposed within a sector of about 145°. The scale **14** is provided with conversion indicators, such as the arrows **14***a* and **14***b*, at the 230 ft. and 262 ft. points, respectively, for the purpose to be hereinafter described.

UPPER DISC

The upper transparent disc **12** is provided with a circular logarithmic scale **18** disposed closely adjacent the inner circle of scale **14** and representing load, in the present embodiment graduated in amperes and marked from 5–400 amperes. The scale **18** is inverted with respect to the scale **14**, i.e., it reads in a counter-clockwise direction. The dics **12** is also provided with a spiral curve **19**, hereinafter referred to as an indicator curve, the particular form and function of which will be more particularly referred to hereinafter. The indicator curve **19** is provided at spaced intervals along its length with a plurality of lines such as **20** radiating outwardly from the pivotal center, starting adjacent to and preferably intersecting the curve **19**, and extending to closely adjacent said scale **18**. At the points of intersection of the radial lines **20** and the curve **19** there are number designations marked along the curve **19** representing electrical cable sizes, and in referring hereinafter to the individual radial lines **20**, they will be designated by the separate cable size numbers, which in the present embodiment start with #14 AWG as the smallest and run up to #750M CM (750,000 circular mils) as the largest.

If the above equation $\log IL = K$ is plotted for any particular size cable with the scale for log I on a radius, the log L on the circumference of a circle, the resulting curve takes the form of a spiral. The shape of the spiral is the same for all sizes of cable but they are displaced relative to each other by amounts that depend on the value of K. Since 23 different sizes of cable and 4 power factors are included in the calculator, there would have to be 92 separate spirals drawn on the face of the disc, to cover all cases. Obviously, this would be impractical considering the limited space available on the face of the disc.

The fact that all the spirals are identical in shape makes it possible to utilize the single spiral **19** on the transparent disc **12** that will serve for each and all sizes of cables and power factors by simply rotating the disc about its axis **13** until the spiral **19** on it coincides with the position of the original. This arrangement did away with the crowding of spirals on the disc but the question of finding the exact position the single spiral should occupy in order to have it coincide with the original, remained to be solved. How the answer was found in the so-called power factor curves will be explained below.

If the safe amperes I a given cable can carry is substituted in the particular equation representing that size of cable and power factor, the derived value of L with the given value of I fixes the point of intersection of the original spiral with the circle passing through the given value of I on a radially extending ampere scale. The transparent disc **12** carrying the single spiral **19** is now rotated until the indicator spiral passes through the said point of intersection, its position will coincide exactly with that of the original spiral and the problem of fixing the position of the indicator spiral is thereby solved.

If this procedure is applied to all 23 cables, keeping the power factor the same, the 23 points of intersection will give the form of the curve for that particular power factor. Curves for the remaining power factors can be found in the same way, thus completing the group called the power factor curves designated **16***a*–**16***d*, inclusive.

In the preceding description of the construction of the calculator the ampere scale was assumed to be located on a radius of the disc. To mark the safe ampere capacity of each of the 23 different sizes of cables on this radial scale, whose total length, in the present embodiment, is about 2½ inches, presented a problem because the distinguishing marks coming so close together gave the appearance of crowding besides making the reading of them difficult. The numbers marking the different sizes of cables were therefore transferred to the indicator spiral **19** at the points of intersection of said spiral by circles, such as **17**, passing through said radial ampere scale readings respectively as above described. The indicator spiral **19** being considerably longer than the radius, allowed a convenient distance between cable size numbers.

The manner of using the calculator and the wide range of its usefulness will be understood more fully from the examples set forth below.

EXAMPLES OF USES

Example I.—Suppose a 30 H.P. motor taking 75 amperes at 90% power factor, distant 108 feet from the source is to be connected; the point on the ampere scale **18** corresponding to 75 amperes is found in the sector between radial lines **20** marked #3 and #4, respectively, on the indicator spiral **19**, and when the 75 ampere point is made to coincide with the 108 ft. point on the circuit length scale **14**, the above sector will be found in the area to the left of the 90% power factor curve **16c**. Hence, in this case, the correct size, #3 cable, is fixed entirely by the heating effect; whereas, if it were possible to disregard the heating effect and only consider the voltage drop, the calculator shows that a #6 cable half the size of #3 would be sufficient, since the 90% power factor curve intersects the indicator curve between cable sizes #6 and #7 and nearer cable size #6.

Example II.—On the other hand, if the 30 H.P. motor taking 75 amperes at 90% power factor had been located 380 feet away, the corresponding sector of the calculator between the radial lines **20** marked #3 and #4 would fall to the right of the curve **16c**, and the size of cable, #1/0, would be fixed entirely by the voltage drop which if disregarded and only heating effect taken into consideration, a #3 cable would be sufficient, although it is only half the size of #1/0. Similarly, for all sectors of the calculator falling left of the power factor curves, the heating effect determines the size of cable; while for sectors that fall to the right of those curves, the size is fixed by the voltage drop.

From the above examples, it is seen how in the first case the heating effect acts in a manner to require the use of a cable twice the size that would be sufficient for voltage drop alone, and vice versa, in the second case it is the voltage drop that acts in a way to require a cable twice the size necessary to take care of heating effect alone.

Only in the rare cases where the point on the ampere scale **18** falls on one of the radial lines **20**; and the corresponding cable number on the indicator spiral **19** falls on one of the power factor curves **16**, do the two factors balance each other and give a cable that is large enough to keep the voltage drop within the specified 3% and at the same time no larger than necessary to take care of the heating effect.

It will be noted that the largest cable considered in the calculator is 750M CM. If the conditions call for a larger size the problem can usually be solved by installing two circuits in parallel instead of one as illustrated in Example III below.

Example III.—A synchronous motor-generator set taking 365 amperes at 90% power factor is to be connected by a circuit 400 feet in length. What size of cable should be used?

Placing the 365 point on the ampere scale **18** opposite the 400 point on the circuit length scale **14** note that the 90% power factor curve **16c** does not intersect the indicator spiral **19** within the limits of the calculator. This shows that for a single circuit the conditions call for a cable larger than 750M CM, the largest treated in the calculator. However, by installing two circuits in parallel, each circuit would carry ½ of 365 or 182.5 amperes, and placing this point of the ampere scale **18** opposite 400 on the circuit length scale **14**, note that the 90% power factor curve **16c** now crosses the indicator spiral **19** between sizes #300 and #400M CM and taking as always the larger a 400,000 circular mil cable is the correct size to use for each of the two circuits.

Installing two circuits in parallel instead of one is in keeping with accepted practice because cables of more than 750M CM are unwieldly and difficult to install, besides requiring special care at switch and terminal points. For these reasons it is often more convenient to avoid the use of the heavier cables by installing two circuits of medium size connected in parallel instead of the one large cable.

Example IV.—In case the given load is stated in kw. instead of amperes, the equivalent amperes can be found as follows: if the load of the synchronous motor-generator set mentioned above had been stated as 125 kilowatts at 90% power factor the equivalent amperes could be obtained at once by placing the 125 point on the ampere scale **18** opposite the point **262**, marked by a solid arrow-head **14b**, and reading opposite 90 on the circuit length scale **14**, the value 365 amperes on the ampere scale **18**, which is the equivalent of the 125 kw. at 90% power factor.

Example V.—If the load is stated in H.P. as is generally done in the case of motors, an approximate value of the equivalent amperes can be found in a similar way by using the point 230 on ampere scale marked by an outlined arrow-head **14a**, instead of the 262, and reading opposite one of the points on the circuit length scale **14** between 85 and 90, depending on the size of the motor, the equivalent amperes on the ampere scale.

The calculator gives the size of cable for a voltage drop of 3%. If any other voltage drop is desired, the calculator can be used without change, provided the circuit length is taken as the actual, multiplied by the ratio of 3 to the new voltage drop. For example, if 2% voltage drop is desired, the circuit length should be taken as 3/2 times the actual. Similarly, for a 6% voltage drop, the length to use in the calculator would be 3/6, or one-half the true length.

The calculator can also be used for voltages other than 220, if the length of circuit is multiplied by the ratio of 220 to the new voltage. Taking as an example a 440 volt, 3-phase motor of 60 H.P. taking 76 amperes at 80% power factor, 600 feet from the source that is to be connected, the values to be used in the calculator would be 76 amperes and 300 feet with power factor 80%, giving #1 cable for the correct size.

For given lengths of circuit and amperes load, the indicator spiral usually indicates a size of cable somewhere between two standard sizes which means that an intermediate size of cable would be required to give exactly 3% voltage drop. Since such sizes are not commercially available, a choice has to be made between the two nearest standard sizes, and if the larger is taken, the voltage loss would necessarily be somewhat less than 3%. The possibility of using the smaller of the two at a slightly increased loss can be investigated with the help of the calculator. What the percentage loss would be if the smaller of the two sizes is taken, can be found as in Example VI below.

Example VI.—Suppose a 3-phase, 220 volt, 30 H.P. motor taking 80 amperes at 80% power factor is to be connected by a circuit 300 feet in length. The calculator shows that the exact size would be a cable between #1 and #2. If the smaller #2 is chosen, the loss can be found by rotating the transparent disc **12** until the #2 point on the indicator spiral **19** lies directly over the 80% power factor curve **16b**, and reading 265, the new circuit length, opposite point 80 on the ampere scale **18**. The new voltage drop will then be 3%×300/265 or 3.4% approximately against 2.8% for the #1 cable.

The calculator amongst other advantages also provides a convenient means of checking existing circuits which with the natural growth of the business or regrouping of machinery may have become overloaded. To do this, note the amperes in the circuit at the time of maximum load and with this and the known circuit length use the calculator to find the correct size of cable for this particular length of circuit and amperes. Comparing this with the existing cable will indicate whether or not the circuit is overloaded.

The calculator is simple and easy to apply, as will be evident by using it to solve the following example:

Example VII.—Suppose it is required to find the size of cable to use for a circuit supplying a mixed load of lighting and induction motors amounting to 130 amperes at a distance of 350 ft. assuming a power factor of 90%. Opposite point 350 on the circuit length scale **14** place the point 130 of the ampere scale **18**, and note that the point on the indicator spiral **19** where the 90% power factor curve **16c** crosses it is between cables numbered #3/0 and #4/0. Taking the larger of the two #4/0 is the correct size.

The ease and rapidity with which the result was obtained in the foregoing examples, should appeal to practical electricians employed in industrial plants, and also to those engaged in contracting work. In engineering offices also, where many estimates have to be made, its use will save valuable time, since it gives immediate answers to wiring problems.

The importance of the calculator consists not only in the fact that it is a helpful device for the practical electrician, but more particularly, it affords a means of insuring the owners of industrial plants against a loss in production due to the slowing down of motors as a result of excessive voltage loss in feeder circuits.

The calculator described gives the correct size of the cable for a circuit of any length and ampere load coming within its range; no knowledge of electric circuit theory is required by the user; nor any preliminary calculations on subsequent checks; it takes into account both the voltage drop and ampere carrying capacity of the cable and in a single reading gives the correct size with respect to both factors.

While I have described my invention in detail in its present preferred embodiment, it will be obvious to those skilled in the art, after understanding my invention, that various changes and modifications may be made therein without departing from the spirit or scope thereof. I aim in the appended claims to cover all such modifications.

I claim as my invention:

1. A calculator for determining the size of electrical cables for desired conditions comprising a lower disc and a transparent upper disc pivotally secured together for relative angular movement one with respect to the other, one of said discs having adjacent its peripheral margin a circular logarithmic scale of circuit length and a series of power factor curves extending generally outwardly from a central zone toward said circuit length scale, the other of said discs having a circular logarithmic scale of amperes disposed closely contiguous said circuit length scale, concentric therewith but inverted with respect thereto, and an indicator curve extending along a generally spiral path from a central area of said disc toward said ampere scale, said power factor curves and indicator curve being so disposed that upon relative angular movement of said discs said indicator curve will be intersected by said power factor curves at progressively varying positions lengthwise of said indicator curve, said last mentioned disc having a series of radial lines extending outwardly from said indicator curve at definite intervals along said curve corresponding to cable sizes respectively.

2. A calculator for determining the size of electrical cables for desired conditions comprising a lower disc and a transparent upper disc pivotally secured together for relative angular movement one with respect to the other, one of said discs having adjacent its peripheral margin a circular logarithmic scale of circuit length and a series of power factor curves extending generally outwardly from a central zone toward said circuit length scale, the other of said discs having a circular logarithmic scale of amperes disclosed closely contiguous said circuit length scale, concentric therewith but inverted with respect thereto, and an indicator curve extending along a generally spiral path from a central area of said disc toward said ampere scale along which at definite intervals are numbers denoting standard conductor sizes from #14 AWG to 750,000 CM; said indicator curve and the power factor curves being so disposed that upon relative angular movement of said discs, the indicator curve will be intersected by the curve having the same power factor as the load power factor; the position of the said point of intersection on the indicator curve giving the correct size of conductor for the given conditions of load, length of circuit and power factor.

3. A calculator for determining the size of electrical cable for desired conditions, comprising a lower disc and a transparent upper disc pivotally secured together for relative angular movement one with respect to the other, one of said discs having adjacent its peripheral margin a circular logarithmic scale of circuit length and a series of load power factor curves extending generally outwardly from a central zone and terminating adjacent said circuit length scale, said series of curves covering a segment substantially less than 180°, the other of said discs having a circular logarithmic scale of amperes disposed closely contiguous said circuit length scale concentric therewith and a generally spiral indicator curve extending from a central area of said disc to closely adjacent said ampere scale and covering a segment substantially more than 180°, said last mentioned disc having a series of radial lines extending outwardly from closely adjacent said indicator curve, denoting a series of different cable sizes respectively, and terminating adjacent said ampere scale at points corresponding to the ampere carrying capacity of respective cables.

4. A calculator for determining the size of electrical cable for a given load, power factor and circuit length comprising a lower disc and a transparent upper disc pivotally secured together for relative angular movement one with respect to the other, one of said discs having adjacent its peripheral margin a circular logarithmic scale of circuit length and a series of load power factor curves extending generally outwardly from a central zone and terminating adjacent said circuit length scale, said series of curves covering a segment substantially less than 180°, the other of said discs having a circular logarithmic scale of amperes disposed closely contiguous said circuit length scale concentric therewith and a generally spiral indicator curve extending from a central area of said disc to closely adjacent said ampere scale and covering a segment substantially more than 180°, said last mentioned disc having a series of radial lines passing through points on the indicator curve denoting the sizes of cables and terminating on the ampere scale at points corresponding to the ampere carrying capacity of the respective cables.

5. A calculator for determining the size of electrical cable for desired conditions comprising a lower disc and a transparent upper disc pivotally secured together for relative angular movement about an axis of rotation one with respect to the other, one of said discs having adjacent its peripheral margin a circular logarithmic scale of circuit length and a series of power factor curves extending generally outwardly from a central zone and terminating adjacent said circuit length scale, the other of said discs having a circular logarithmic scale of amperes disposed closely contiguous said circuit length scale, concentric therewith but inverted with respect thereto, and an indicator curve following a spiral path generated about the axis of rotation in accordance with the equation $\log IL=K$, with the value of log I measured on the radius and the value of log L measured on the circumference of a circle both originating on said axis of rotation and where I is the current in amperes, L is the circuit length and K is the circuit constant, said curve extending from a central area of said disc to closely adjacent said ampere scale, said last mentioned disc having a series of radial lines extending outwardly from said indicator curve and denoting cable sizes respectively.

6. A calculator for determining the size of electrical cable for desired conditions comprising a lower disc and a transparent upper disc pivotally secured together for relative angular movement about an axis of rotation one with respect to the other, one of said discs having adjacent its peripheral margin a circular logarithmic scale of circuit length and a series of power factor curves extending generally outwardly from a central zone and ter-

minating adjacent said circuit length scale, the other of said discs having a circular logarithmic scale of amperes disposed closely contiguous said circuit length scale concentric therewith but inverted with respect thereto, and an indicator curve following a spiral path generated about the axis of rotation in accordance with the equation log $IL=K$, with the value of log I measured on the radius and the value of log L measured on the circumference of a circle both originating on said axis of rotation and where I is the current in amperes, L is the circuit length and K is the circuit constant, said curve extending from a central area of said disc to closely adjacent said ampere scale and provided lengthwise thereof at definite intervals with cable size designations, said last mentioned disc having a series of radial lines extending outwardly from said cable size designations on the indicator curve and terminating at spaced intervals along the ampere scale at points corresponding to the ampere carrying capacity of the respective cable sizes so designated.

7. A calculator for determining the size of electrical cables for desired conditions comprising a lower disc and a transparent upper disc pivotally secured together for relative angular movement one with respect to the other, one of said discs having adjacent its peripheral margin a circular logarithmic scale of circuit length and

a series of power factor curves extending generally outwardly from a central zone toward said circuit length scale, the other of said discs having a circular logarithmic scale of amperes disposed closely contiguous said circuit length scale concentric therewith and an indicator curve extending along a generally spiral path from a central area of said disc toward said ampere scale, said ampere scale being provided with two indicator marks one of which designates a factor for converting kw. to amperes and the other of which designates a factor for converting H.P. to amperes, said power factor curves and indicator curve being so disposed that upon relative angular movement of said discs said indicator curve will be intersected by said power factor curves at progressively varying positions lengthwise of said indicator curve, said last mentioned disc having a series of radial lines extending outwardly from said indicator curve and denoting cable sizes respectively.

References Cited in the file of this patent

UNITED STATES PATENTS

2,379,931	Schaevitz	July 10, 1945
2,413,314	Cruzan	Dec. 31, 1946
2,544,224	Hachmuth	Mar. 6, 1951