June 22, 1948.

W. T. ALLEN

2,443,882

CALCULATOR

Filed April 1, 1943

2 Sheets-Sheet 1

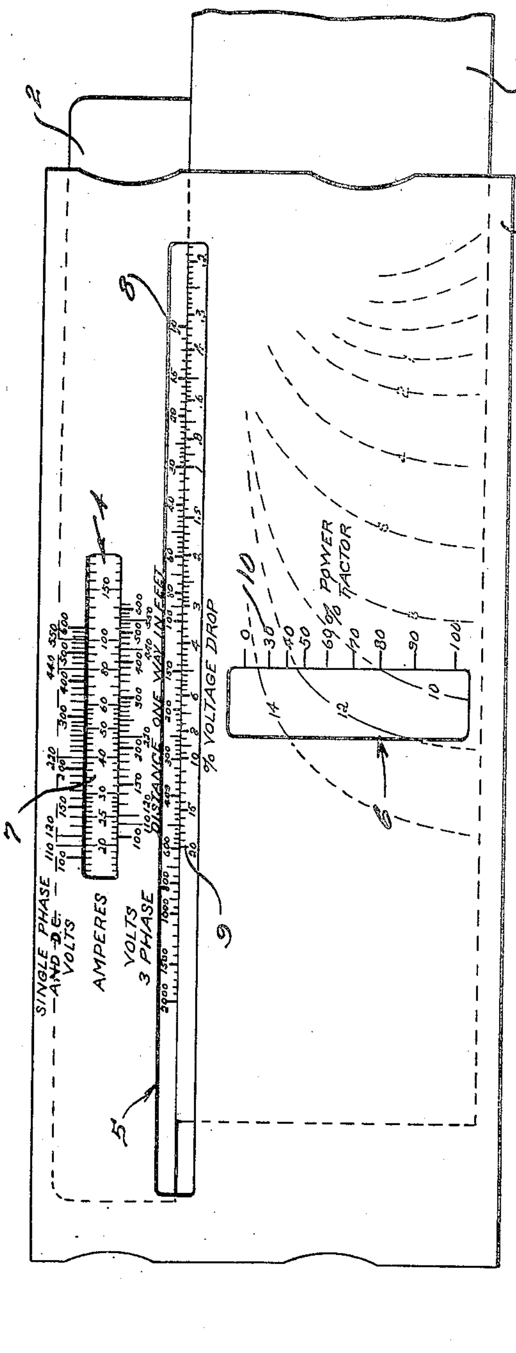

Fig. 1.

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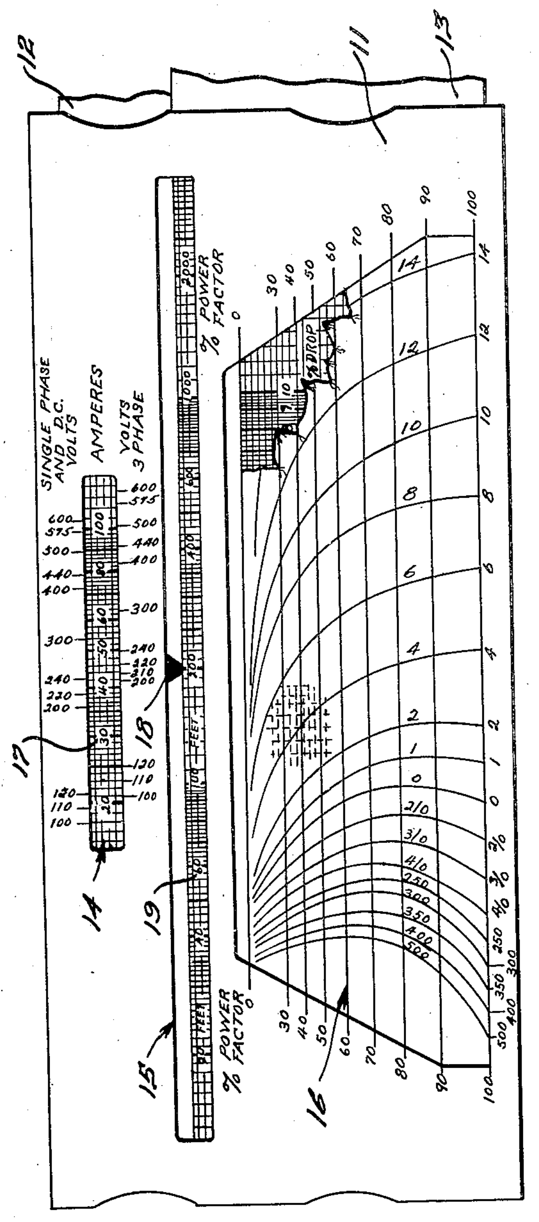

Fig. 2

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CALCULATOR

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Application April 1, 1943, Serial No. 481,396

2 Claims. (Cl. 235—70)

This invention relates to calculators, and more particularly to a voltage drop, wire size calculator for determining percentage voltage drop and/or wire size for an electric wiring system.

In the past, various slide and rotary calculators have been used to aid in the determining of percentage voltage drop or wire size for wiring systems, but these calculators have been open to the objection that they were computed for a single value of power factor for the system and required the use of charted conversion factors to correct the results to the actual power factor of the system.

An object of the present invention is to provide a voltage drop, wire size calculator in which provision is made for a direct reading which shall take into account the actual power factor of the circuit.

Another object of the invention is to provide a voltage drop, wire size calculator in which the six variables, system voltage, current, length of wire, power factor, voltage drop, and wire size may all be set or read directly from the calculator.

Other objects and features of the invention will be readily apparent to those skilled in the art from the specification and appended drawings illustrating certain preferred embodiments in which:

Figure 1 is a view of a slide type calculator according to the present invention.

Figure 2 is a view of a slightly modified form of calculator also of the slide type.

The calculator shown in Figure 1 involves a body portion 1 containing two slides 2 and 3. The body portion 1 comprises a flat stiff envelope within which the two flat stiff slides 2 and 3 are disposed so as to be longitudinally movable. In the face of the body portion 1 are three windows, 4, 5 and 6, within which portions of the slides and indicia thereon are visible. At the top and bottom edges of window 4 upon the body portion 1 are placed the indicia indicating the system voltage. These are disposed on regular logarithmic scales with the upper set of indicia indicating single phase alternating current and direct current voltages and with the lower set of indicia indicating voltages for three phase systems. The upper portion of the slide 2 is provided with indicia, indicated at 7, representing the circuit amperes or the value of current which the circuit is designed to carry. These indicia are upon a logarithmic scale and are visible through the window 4 for purposes of setting the position of the slide 2. Upon the lower portion of the face of slide 2 are disposed indicia, indicated at 8, on a logarithmic scale, representing the distance one way in feet of the length of the circuit wiring. These are visible through the window 5. The slide 3, upon its face adjacent the upper edge, is provided with indicia indicated at 9 representing the percentage voltage drop of the circuit; these indicia again are on a logarithmic scale, are immediately opposite the indicia of distance in feet, and are visible through the window 5.

Adjacent to the edge of the window 6 are placed indicia indicated at 10 representing the power factor of the circuit, again on a logarithmic scale and placed on the face of the body portion 1. Upon the main body portion of the slide 3, and placed so as to be visible through the window 6 when disposed therebeneath, are curved lines representing the sizes of wires which may be used in the wiring system. These curves may be computed and drawn for any desired wiring size—for example, from No. 14 wire through a wire size of 500 MCM. These curves may be determined by computing the actual percentage voltage drop for the various wire sizes, at expected wire spacing and temperature, at the various power factors. The plotting of the values obtained, of percentage voltage drop against percentage power factor, will result in the plurality of curves for the different wire sizes.

The computations of the percentage voltage drop for various wire sizes at normal conduit wire spacing and temperature and at the various power factors may be carried out by various formula computation and the following is an example of one manner of computation.

The inductive reactance of the wires for various sizes and at their normal conduit spacings is computed from the formula

$$X \text{ equals } 2 \text{ pi } f\left(80+714.1 \log \frac{D}{r}\right) 10^{-6}$$

Where small f equals frequency, D equals distance between conductor centers, r equals radius of conductors in the same units as D; the logarithm being to the base 10. The resistance of the various size wires is taken from standard tables. These values of reactance and resistance are converted into voltage drop per amp. and then into percent voltage drop per amp. at any arbitrary selected voltage. Entering the standard Mershon chart in the standard handbook using various values of power factors and the above values of percentage reactance and percentage resistance drops, values are obtained directly of the percent impedance voltage drop per ft. per amp. at the various power factors. From these values, the curves upon the main body portion of the slide 3 which correspond to the various wire sizes of conductors may be plotted. The selection of constant wire size curves is purely arbitrary as other variables could be used in plotting the curves. For example, the wire size indicia could have been placed at the side of the window 6 and the curves plotted as lines of constant power factor.

In setting the indicia upon the slide, the voltage scales at the top and bottom of the window 4, the current scale 7, the distance scale 8, and the percent voltage drop scale 9 are all plotted upon the same logarithmic scale which is arbitrarily selected. The use of logarithmic scales is purely arbitrary for convenience and the calculator can be arranged with indicia of other scales, such as arithmetic scales. The location of the voltage scale at the top of the window 4 is arbitrarily placed. Then the location of the voltage scale at the bottom of the window 4 is determined by the relation between single phase and three-phase voltages. The current scale 7 is arbitrarily placed upon the slide 2 in a generally central location upon the slide so that the indicia will appear within the window 4 in the normal movement of the slide. The indicia of the distance in ft. of scale 8 are arbitrarily placed upon the scale 2 in a generally central location for the range of values desired and have no particular relation to either the current scale 7 nor the voltage scales at the top and bottom of the window 4. The percentage drop indicia of scale 9 are similarly placed upon the slide 3 in a generally central location, again having no particular relation to the previously described scales but arranged upon the same selected logarithmic scale. The power factor scale 10 is arbitrarily placed at the side of the window 6 and may have any convenient modulus. In the particular scale herein shown, it was found convenient to make the power factor scale a reverse logarithmic scale so as to secure wider spacings and more accurate readings in the upper values of power factor. Any other form of scale for the power factor would simply have changed the shape of the wire size curve on the main body portion of the slide 3.

With the scales previously described set upon the slides, the location of the curves of constant wire size are plotted directly upon the main body portion of the slide from the values computed as previously described.

In the use of the calculator, the value of the circuit amperes is set opposite the proper system voltage. In the position of the slides shown, it is assumed that the circuit current is 25 amperes and the circuit voltage 120 volts on a three phase system. The indicia for 25 amperes is set opposite 120 volts, three phase as shown, thus determining the position of the slide 2. Let us then assume that the power factor of the circuit is 80% and the system uses No. 10 wire. The slide 3 is then moved to intersect the curve for No. 10 wire with the indicia at 80% power factor in the position shown. Assuming that the wiring distance one way in feet is 200 ft., the percent voltage drop may be read opposite the indicia for 200 ft. on the percent voltage drop scale. This indicates, for the example taken, a voltage drop of 6.7%. The calculator can, of course, be utilized in other ways, depending on the known and unknown factors. For example, in the example given, if a percent drop of 6.7 is taken as permissible, then the setting of current and voltage is made as before and the slide 3 is moved to place 6.7% voltage drop opposite the indicia for 200 feet, then opposite the power factor indicia of 80, it is seen that a No. 10 wire may be used. Similarly, the chart may be used where other limits are unknown; for example, if allowable wire size and percentage drop are known, the allowable maximum distance in feet may be computed.

It is also to be understood that while the curves have been ploted for various wire sizes, they might be plotted just as well for other of the six variable factors; for example, the wire size might have been placed in the form of indicia upon the body portion 1 and the curves might be drawn for varying percentages of power factor. Similarly, the relative positions of the variables upon the calculator may be varied and the calculator may assume any mechanical form desired rather than the slide form shown; for example, it may be in the form of rotating discs.

In Figure 2 is shown a slightly modified form of the calculator which utilizes a main body portion 11 within which are disposed the slides 12 and 13. The body portion 11 is provided with windows 14 and 15 and with a large transparent window 16. The indicia as to system voltage and current are similar to those previously described in connection with the preferred form of the invention, the system voltages again being disposed above and below the edges of window 14 and the circuit current indicia 17 being disposed on the slide 12 to be visible through the window 14. In this embodiment, on the lower portion of the slide 12 is disposed the arrow of indicator 18 to give a datum point. Upon the upper portion of the slide 13 are disposed the indicia of the wire distances at 19. The main portion of the slide 13 is provided with logarithmic indicia indicating the percentage voltage drop. The wire size curves are here drawn directly upon the transparent window 16 so that they are now stationary. The power factor percentages are placed on the face of the body portion 11 and have indicia lines crossing the transparent window 16. In using the calculator of Figure 2 the same example will be taken. The slide 12 will be fixed in position by placing the current indicia 25 opposite the three phase system voltage of 120 volts. This locates the position of the datum arrow or indicator 18. The slide 13 is then moved to place the proper value of the wire length opposite the indicator 18, in this example the indicia for 200 feet being placed opposite the indicator. Then the horizontal line for 80% power factor is followed to its intersection with the curve for No. 10 wire. Reading through the transparent window 16, it will be seen that this point of intersection occurs at a value of percentage voltage drop of 6.7%.

It is seen that according to the calculator of this invention all six of the major variables in the computation of the system characteristics may be directly set and/or read by manipulation of the calculator so that it is unnecessary to correct, from tables, for variation in the power factor of a circuit but that by the calculator the percent voltage drop, the wire size or other variables may be directly read from the calculator with the actual circuit power factor taken into effect. This obviously facilitates and accelerates the determining of the unknown quantity in a system.

While certain preferred embodiments of the invention have been specifically disclosed, it is understood that the invention is not limited thereto, as many variations will be readily apparent to those skilled in the art and the invention is to be given its broadest possible interpretation within the terms of the following claims.

What is claimed is:

1. In a voltage drop, wire size calculator, stationary and movable elements, system voltage and circuit current indicia disposed on the stationary and a movable element and determining the location of the movable element when the proper current indicia is disposed opposite the proper voltage indicia, a second movable element, wire length and percentage voltage drop indicia on said first and second movable elements disposed in opposed relation, percentage power factor and wire size indicia on said second movable element and said stationary element, the one of said last mentioned pair of indicia located on the movable element being in the form of a set of curves, one for each of a plurality of different values of the variable, the calculator by the setting of its movable elements permitting the reading of percentage voltage drop or wire size for the proper value of percentage power factor of the circuit.

2. In a voltage drop, wire size calculator, stationary and movable elements, system voltage and circuit current indicia disposed on the stationary and a movable element and determining the location of the movable element when the proper current indicia is disposed opposite the proper voltage indicia, a second movable element, wire length and percentage voltage drop indicia on said first and second movable elements disposed in opposed relation, wire size indicia disposed on said second movable element, said wire

size indicia being in the form of a set of curves one for each value of wire size, percentage power factor indicia disposed on said stationary element so that said wire size indicia may be located with respect thereto, the calculator being set by positioning the movable elements and providing for the reading of percentage voltage drop or wire size for any actual value of percentage power factor of the circuit.

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Certificate of Correction

Patent No. 2,443,882. June 22, 1948.

WALLACE T. ALLEN

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Column 2, line 42, in the formula, for "714.1" read *741.1*; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 14th day of September, A. D. 1948.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.

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