200 ohms ; or in other words the joint resistance of the lamps in the three-wire system will be four times the joint resistance of the same number of lamps in multiple arc.

The total electromotive force in the three-wire system of course will be twice that of the electromotive force in the multiple arc system.

Again, the total current will equal $\frac{\text{total electromotive force}}{\text{total resistance}}$

or, $C = \frac{200}{200} = 1$ ampere, or in other words, the total current required for the lamps in the three-wire system, will be ½ of the

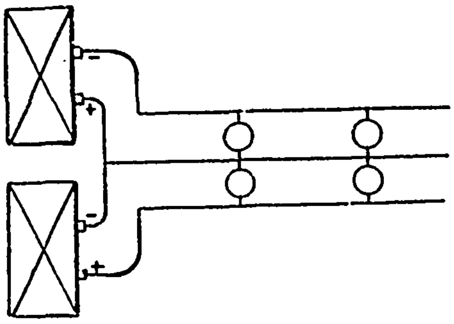

FIG. 12.—THREE-WIRE SYSTEM.

total current required for the same number of lamps in the multiple arc system.

With this demonstration in mind we are ready to form

Rule XI. For the same kind and same number of lamps the joint resistance of the lamps in the three-wire system is four times that of the multiple system ; the total electromotive force of the lamps in the three-wire system is twice that of the multiple arc system, and the total current strength of the lamps in the three-wire system is one-half the corresponding unit in the multiple arc system.

It can easily be seen that as the joint resistance of the lamps is four times greater in the three-wire system than in the multiple arc system, the resistance of the positive and negative conductors will be four times greater for the same percentage of loss. In other words, the cross-section of the wires in the three-wire system is ¼ that of the wires in the multiple arc system for the same percentage of loss. This gives us :

Rule XII. In order to find the proper size of wire for the three-wire system, first find the size of wire for the same number and kind of lamps on the multiple system in accordance with Rules VI and VII, then divide the number of circular mils by four.

The sum of the lengths of the positive and negative wires is the entire length of the circuit in the three-wire system, and the amount of copper required for the circuit is equal to one-fourth the amount of copper required in a multiple arc circuit ; the length of the central or neutral wire, if of the same size as the positive and negative leads will be only one-half the length of the total circuit ; hence the total amount of copper in the three-wire system will be ¼ + ⅛ = ⅜ of the amount necessary in the case of the multiple system.

As a matter of fact the neutral wire may be made smaller than the positive and negative wires, as it seldom will be called upon to carry more than a fraction of the maximum current. For practical reasons, however, it is advisable to make all three wires of the same size.

It will be seen that as the number of circular mils per wire in the three-wire system is ¼ the cross-section per wire in the multiple system, the carrying capacity in amperes of course is also reduced to ¼.

When Table 1 for the three-wire system is used it should be borne in mind that *only twice* the number of lamps may be carried by the wires, as the current is reduced to ½ for the same number of lamps.

The three-wire system in a building is generally followed throughout the whole network of feeders, mains, branches and sub-branches, down to circuits of from three to six lights ; smaller numbers would then be connected in simple multiple arc.

EXPLANATION OF TABLES.

Wiring Tables 3, 4 and 5 may be used by any one who does not care to study the principles underlying the calculations of the sizes of wires ; but even to those who thoroughly understand the demonstrations, the tables will be found of great convenience.

The first thing to do is to select the table for the lamps which are to be used. Let us consult the table for data relating to the 100 volt lamps.

We find in the horizontal columns at the top and bottom, numbers which correspond to "lamp-feet." (Lamp-feet is a brief expression used to denote the product obtained by multiplying the number of lamps by the distance in feet.) At the left of the table we find three vertical columns filled with figures representing circular mils ; and also underlined figures giving the numbers of the Brown & Sharp gauge. Each horizontal column corresponds to a vertical column.

The radial lines starting near the left hand corner represent percentages of loss. Each small space in the inside columns represents 2000, in the middle columns 500, and in the outside columns 125 ; that is to say in the horizontal columns the numbers represent lamp feet ; in the vertical columns the numbers represent circular mils, except where underscored, when they represent the number of the wire according to Browne & Sharp gauge.

Although the difference would be very slight in any case, it is necessary to note, for those who may desire absolute accuracy in determining the circular mils, that the short heavy lines beneath the Browne & Sharpe gauge figures in the vertical column, are the correct gauge lines and may be understood as extending the full width of the table.

The figures given in the columns represent thousands. For instance, 100 denotes 100,000 ; 4.25 = 4250 ; 2.5 = 2500, etc.

Example : Find the size of wire for 100 110 volt lamps at 1000 feet distance, at 10 per cent. loss.

Demonstration : 100 x 1000 = 100,000 lamp-feet. We find 100 in the *inside* horizontal column ; we follow the vertical 100 line until it intersects the 10 per cent. line. We take a ruler and lay it horizontally through this point and find it strikes about 88 in the *inside* vertical column. The proper size of wire has a sectional area of 88,000 circular mils. If we wish to wire on 5 per cent. loss we follow the vertical 100 line until it intersects with the 5 per cent. line and obtain by laying a horizontal line through this point about 186,000 circular mils.

From this demonstration we deduct the following general rule for computing from wire tables :

Rule XIII. Find the number of lamp-feet (lamp x feet), in one of the horizontal columns, follow the vertical line until it intersects the desired percentage line. A horizontal line laid through this point will show in the corresponding vertical column the cross-section of the wire in circular mils.

In consulting the table, always use corresponding columns. If the lamp-feet are found in the middle column, the circular mils must be read from the middle column ; if the lamp-feet are found in the outside column, the circular mils must be read from the outside column, etc.

Example : Find the size of wire for 20 110 volt lamps, at 900 feet distance at 5 per cent. loss.

Demonstration : 20 x 900 = 18,000. We find 18 in the *middle* horizontal column ; we follow the vertical 18 line until it intersects with the 5 per cent. line, and following the horizontal line we find in the middle column 33,500 circular mils.

Example : Find the size of wire for 50 110 volt lamps at 100 feet distance at 5 per cent. loss.

Demonstration : 50 x 100 = 5,000 lamp-feet. We find 5 in the middle lower column, and a glance shows us that the wire is over 9,300 circular mils or a little larger than No. 11 B. & S. gauge. We can find the same result by taking 5,000 in the outside horizontal column.

Rule XIV. The number of lamp-feet within moderate numbers can always be found in one of the three horizontal columns. Select the one which will intersect with the desired percentage line farthest from the left lower corner. If the number of lamp-feet is too great, and cannot be found in the table, divide it by 10 and find the circular mils for one-tenth the number of lamp-feet first, and then multiply the result by 10.

Example : Find the size of wire for 1,000 110 volt lamps, 1,000 feet distance at 10 per cent. loss.

Demonstration : 1,000 x 1,000 = 1,000,000 lamp-feet. Divide by 10 = 100,000 lamp-feet. Size of wire for 100,000 lamp-feet = 88,000 circular mils, for 10 x 100,000 = 1,000,000 lamp-feet = 10 x 88,000 = 880,000 circular mils.

The 55 and 75 volt tables, of course, are to be used in the same manner as explained in the case of the 110 volt table.

It will be noticed that the small spaces in the three *vertical*