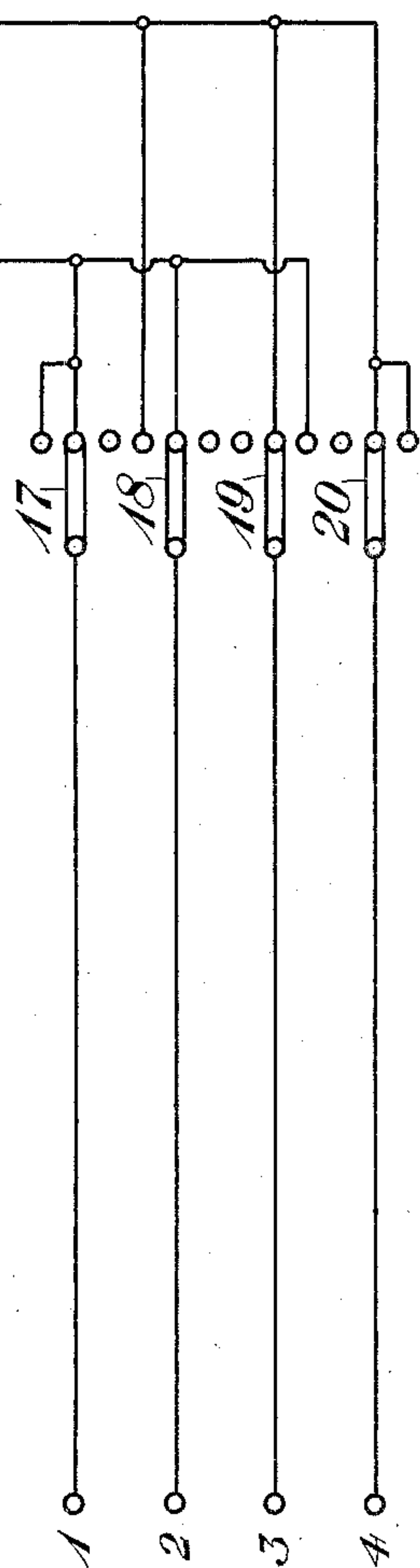
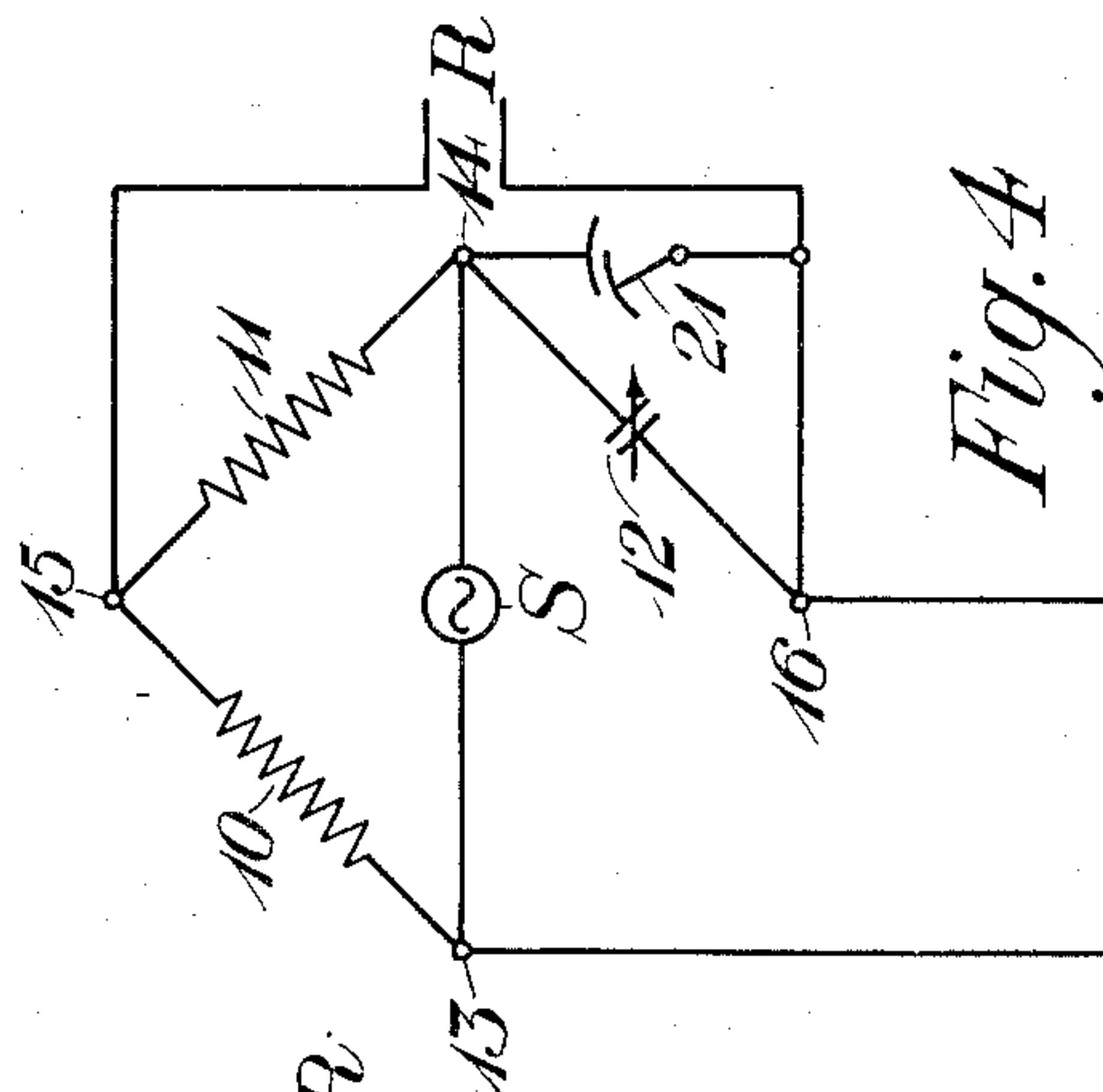
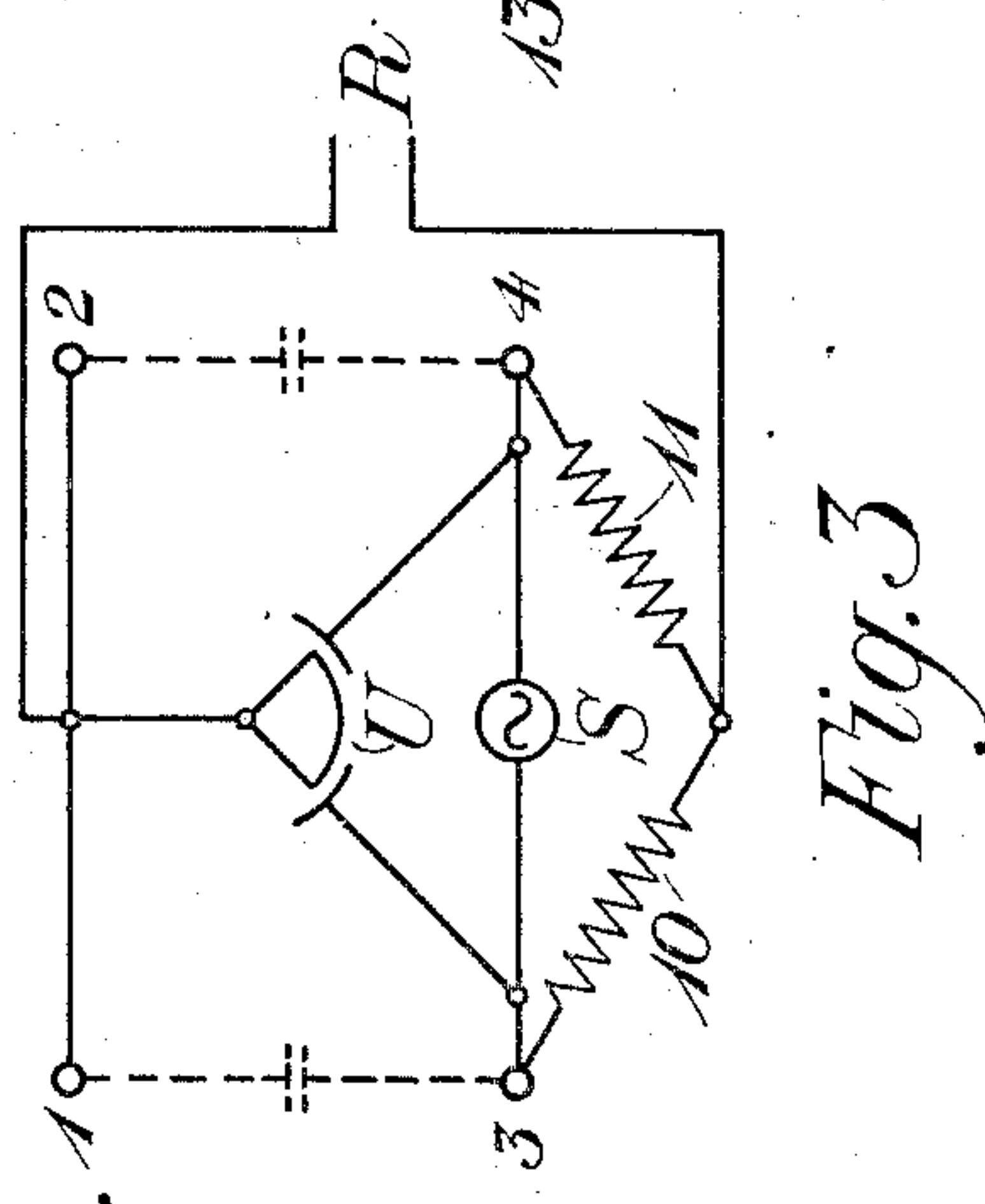
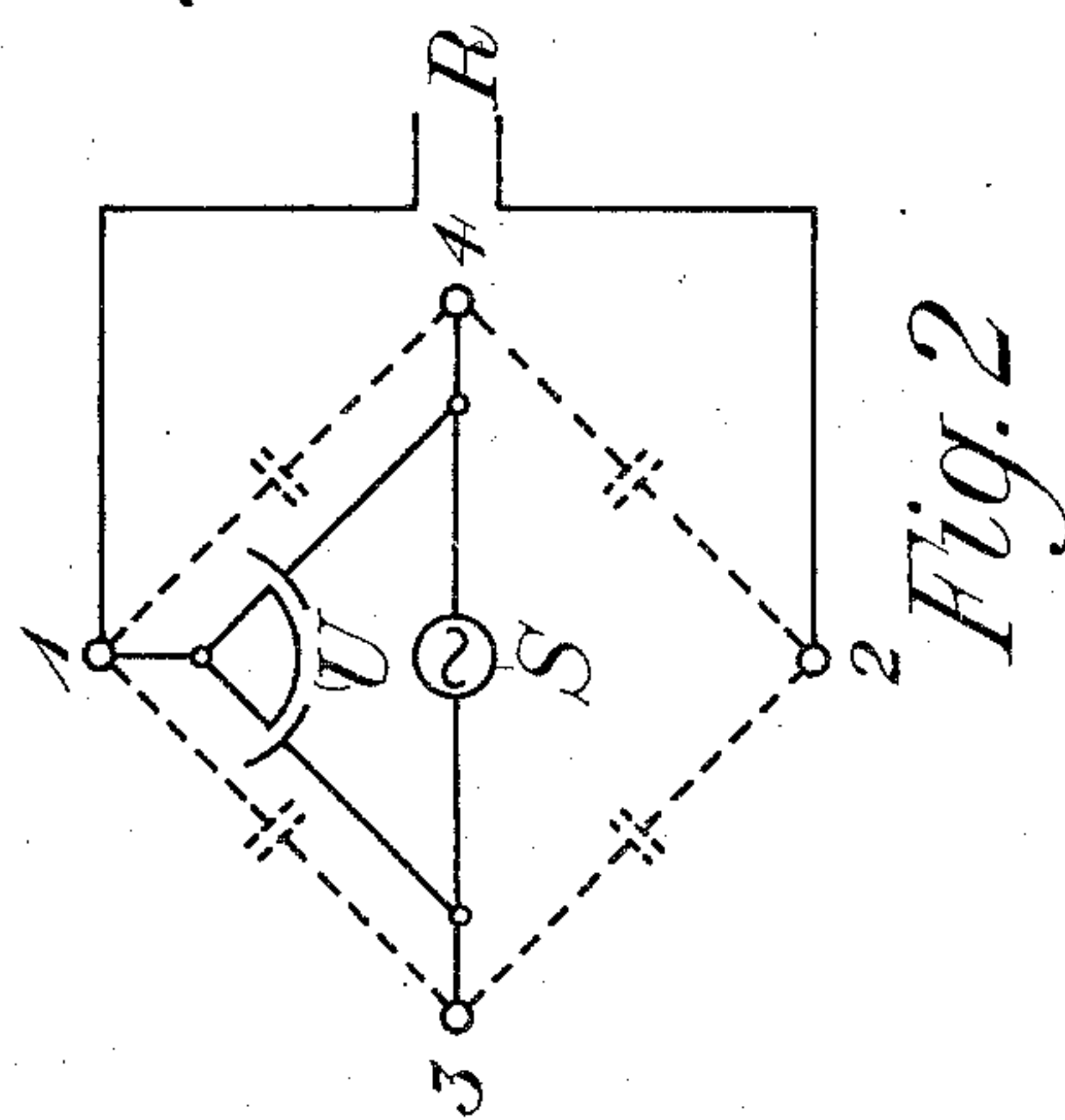
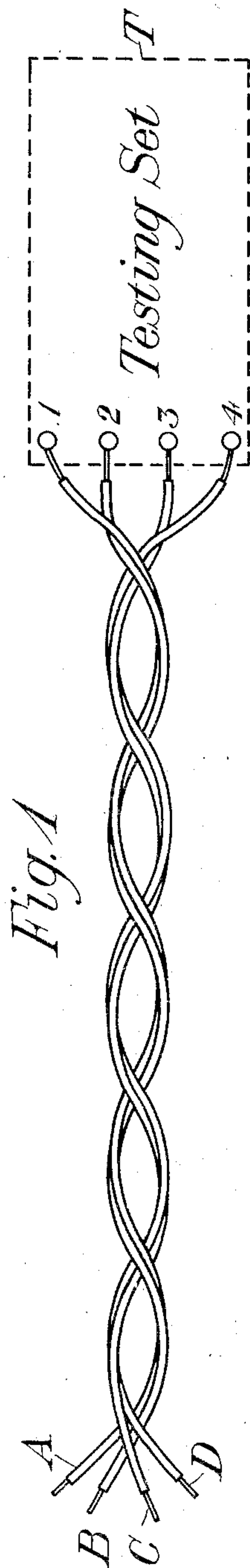


H. S. OSBORNE.
METHOD OF CONSTRUCTING TELEPHONE CIRCUITS.
APPLICATION FILED JAN. 22, 1918.

1,320,489.

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METHOD OF CONSTRUCTING TELEPHONE-CIRCUITS.

1,320,489.

Specification of Letters Patent.

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To all whom it may concern:

Be it known that I, HAROLD S. OSBORNE, residing at New York, in the county of New York and State of New York, have invented certain Improvements in Methods of Constructing Telephone-Circuits, of which the following is a specification.

This invention relates to the construction of telephone cables and more particularly to a method of splicing the different lengths of a cable, the conductors of which are used as the conductors of loaded telephone lines. Cables used for this purpose as ordinarily constructed consist of a plurality of sets of conductors, each set being known as a "quad." Each quad consists of two pairs of conductors, the conductors of each pair being twisted about each other, and the pairs of each quad being also twisted about each other. The two conductors of each pair when connected in series form the conductors of a so-called "side" or "physical" circuit, and in addition may be connected in parallel so that each pair forms one line conductor of a so-called "phantom" circuit. In loading the circuits each loading section is made up of a plurality of lengths of cable and the conductors of the several lengths of cable are spliced together, the conductors of a quad of one length of cable being joined to the conductors of a quad in the next length, etc.

In circuits as thus constructed a disturbance commonly known as "cross-talk" is liable to occur, this condition being largely due to inequalities in the capacities of the conductors of one pair with relation to those of another pair. Such disturbance may occur between the phantom circuit and each of its sides, and also between the side circuits. It has heretofore been customary in making the splices, to determine the capacity unbalance between the phantom and its side circuits as well as between the side circuits of each quad of the several cable lengths, and then choose the conductors that are to be spliced so that the unbalances may neutralize each other as far as possible. This method resulted in a reduction of the cross-talk but failed to take into consideration the requirement that the mutual capacities of the circuits of each loading section should be substantially equal. It is proposed by the present invention to overcome this difficulty by determining the deviation of the mutual

capacities of the circuits of each cable length from a predetermined standard, and then splice the section so that not only will the capacity unbalances of adjacent sections neutralize each other, but the capacity deviations of the circuits of adjacent lengths of cable will neutralize each other. While it may not be practicable in all instances to so choose the conductors to be spliced as to accomplish both of these results, by giving due consideration to both requirements it will be possible to greatly reduce the cross-talk and at the same time maintaining the loading sections substantially uniform.

The invention will be more fully understood by reference to the following description taken in connection with the accompanying drawing in which:

Figure 1 is a view showing in a somewhat conventional manner one quad of a cable length with its conductors applied to the terminals of a testing apparatus the details of which are not shown;

Fig. 2 is a schematic diagram of the connections for determining side to side unbalances;

Fig. 3 is a similar diagram of the connections for determining phantom to side unbalance; and

Fig. 4 is a simplified diagram of the connections for determining the capacity deviation.

Referring to Fig. 1 a quad is shown composed of four conductors A, B, C and D, the conductors A—B and C—D of each pair being twisted about each other, and the pairs being also twisted in a similar manner in order to render the mutual inductance more uniform. Conductors A and B may form the conductors of one side circuit while conductors C and D form the other side circuit. Conductors A and B in parallel and C and D in parallel form the sides of a phantom circuit.

The capacity unbalances and capacity deviations of these several circuits may be determined in any desired manner, but as here shown, the four conductors are connected to the terminals 1, 2, 3 and 4 of a combination testing set indicated conventionally at T. The details of this set are not shown and form the subject matter of another application, it being sufficient for present purposes to state that the set is so constructed that by a few simple manipulations the cir-

cuits may be adjusted to make the various capacity unbalance and deviation measurements without varying the connection of conductors A, B, C and D to the terminals of the instrument.

For instance, in order to determine the side to side unbalance producing cross-talk, the circuits may be adjusted as shown in Fig. 2. A source of current variations S may be connected to the terminals of one pair of conductors, say 3 and 4, while a receiver R is bridged across the other pair of terminals 1 and 2. The capacities of the four conductors may be represented as shown in dotted lines and form the four legs of a Wheatstone bridge. It will be seen at once that any unbalance of these capacities will cause an actuation of the receiver corresponding to the cross-talk effect. By adjusting an air condenser U, the two halves of which are in parallel with two arms of the bridge, the capacities may be balanced, and the condenser U will then indicate the capacity unbalance between the side circuits.

To determine the unbalance between the phantom and one side circuit, the source S as shown in Fig. 3 may be connected to the terminals of one side circuit, say 3 and 4, and the receiver R may be bridged across mid-points of connections between the terminal pairs 1—2 and 3—4, the connection between the terminal pair 3—4 including resistance arms 10 and 11. Any unbalance in the capacities between the phantom circuit and side circuit 3—4 will produce cross-talk in the receiver. Accordingly the capacities (indicated in dotted lines) may be shunted by the two halves of an air condenser U and by adjusting the latter until a balance is obtained, the setting of the condenser U will indicate the unbalance between the phantom circuit and side 3—4. Similarly the balance between the phantom circuit and side 1—2 may be determined by interchanging terminals 1 and 3 and terminals 2 and 4 so that the source S is applied to the side circuit conductor terminals 1 and 2.

In order to determine the capacity deviation the circuits may be arranged as shown in simplified form in Fig. 4. A Wheatstone bridge of which resistance arms 10 and 11 form two arms and a standard capacity 12 forms the third arm has a source S applied to its terminals 13—14 and a receiver R bridged across the other pair of terminals 15—16. The standard capacity 12 may be set to the predetermined standard with which the capacity of a given circuit is to be compared. The side or phantom circuit to be tested may then form the fourth arm of the bridge. This may be accomplished by means of a switch having arms 17, 18, 19 and 20. With the switch in normal or middle position, terminals 1 and 2 will be connected in parallel to terminal 13 of

the bridge, while terminals 3 and 4 will be connected in parallel to terminal 16 of the bridge so that the capacity of the phantom circuit may be determined. With the switch in its upper position, terminals 3 and 4 will be disconnected and terminals 1 and 2 connected to terminals 13 and 16 respectively so that the capacity of the side circuit connected to terminals 1 and 2 may be determined. Similarly with the switch in lower position the capacity of the side circuit connected to terminals 3 and 4 may be determined. It will now be apparent that if the capacity 12 is adjusted to the standard capacity with which a given circuit is to be compared, and the air condenser 21 in parallel therewith be adjusted until no tone is heard in the receiver, the setting of the condenser 21 will indicate the deviation of that circuit from the standard capacity.

After similar determinations have been made as to the circuits of all of the quads of adjacent cable lengths, the conductors of a quad of one cable length may be connected to the conductors of a quad of another cable length in such manner that the capacity unbalances and capacity deviations of the circuits of the two quads will neutralize each other so far as possible. While it may be impractical to do this in all cases, consideration should be given to both capacity unbalance and capacity deviation in selecting the quads to be spliced together. As the maximum unbalances which are met with are usually more serious than the maximum deviations, the best results are secured if unbalances are given first consideration, care being taken that no high deviations are produced in so doing. Quads of adjacent lengths should therefore be picked out in which the highest unbalances occur, and quads having opposite unbalances spliced together, the individual pairs of conductors being spliced so that as far as possible both side to side and phantom to side unbalances tend to neutralize each other. When the quads having the highest unbalances are thus disposed of, quads having high deviations should be picked out and the same procedure followed, provided no high resultant unbalances occur. In case the deviations are of such magnitude and size as to add up to a high resultant, capacity unbalance may have to be sacrificed somewhat to deviation. In case a high unbalance at one splice is unavoidable, care should be taken at other splices in the same loading section to build up another unbalance of opposite sign. With regard to the algebraic sum of the deviations of the several lengths making up a loading section it should be noted that while a total capacity in excess of the standard for a section cannot be remedied, a low total capacity may be remedied by the use of a

building out condenser, and therefore it is desirable where large deviations cannot be avoided that the resultant capacity should be low rather than high.

5 By splicing the cable lengths making up a loading section in accordance with the method above outlined it will be seen that cross-talk due to capacity unbalance may be substantially eliminated and the total
0 capacity of each loading section maintained practically constant, and while the method above outlined is quite efficient, other methods differing in some respects from that described might be utilized to accomplish
5 the desired ends without departing from the spirit of the invention as defined in the appended claims.

What is claimed is:

1. The method of balancing different
0 groups of adjacent conductors which consists in determining the differences in capacities of one group with respect to those of another, and the variation of the capacities of each group from a predetermined standard, and then so combining the
5 capacities of the groups that they tend to balance both as to capacity difference and variation from the standard.

2. The method of balancing successive
0 groups of conductors, between the conductors of each of which groups are inequalities in the capacities, which consists in determining such inequalities both as respects their variation from each other
5 and from a predetermined standard and then so joining the conductors in successive groups that said inequalities tend to be neutralized both as respects variation from each other and from the standard.

3. The method of balancing a phantom
0 circuit, between the elements of successive sections of which there are inequalities in

capacity, which consists in determining the inequality of the capacities between the side
45 circuits of the phantom and between the side circuits and the phantom, and the variation of the capacities of said circuits from predetermined standards, and then so joining such elements in the successive sections
50 as to produce a minimum total unbalance and a minimum total variation from the standard.

4. The method of balancing adjacent conductors arranged in successive groups
55 which consists in determining the differences in capacities of the conductors of one group with respect to those of another group in the series and the variations of the capacities of each group from a predetermined standard, and then so combining the con-
60 ductors of successive groups that the capacities tend to balance both as to capacity difference and variation from the standard.

5. The method of balancing successive
65 groups of adjacent conductors which consists in determining the variations of the capacities of the conductors of each group from a fixed standard, and then so combining the conductors of successive groups that said variations of the capacities tend
70 to balance.

6. The method of balancing successive
75 groups of conductors which consists in determining the unbalances of the capacities between the conductors of each group and the deviation of said capacities from fixed standards, and then so joining the con-
80 ductors of successive groups that the total unbalance and deviation shall be a minimum.

In testimony whereof I have signed my name to this specification this 15th day of January, 1918.

HAROLD S. OSBORNE.