No. 724,594. PATENTED APR. 7, 1903.

J. H. MASON.

TELEPHONE SYSTEM.

APPLICATION FILED APR. 12, 1902.

NO MODEL. 2 SHEETS—SHEET 1.

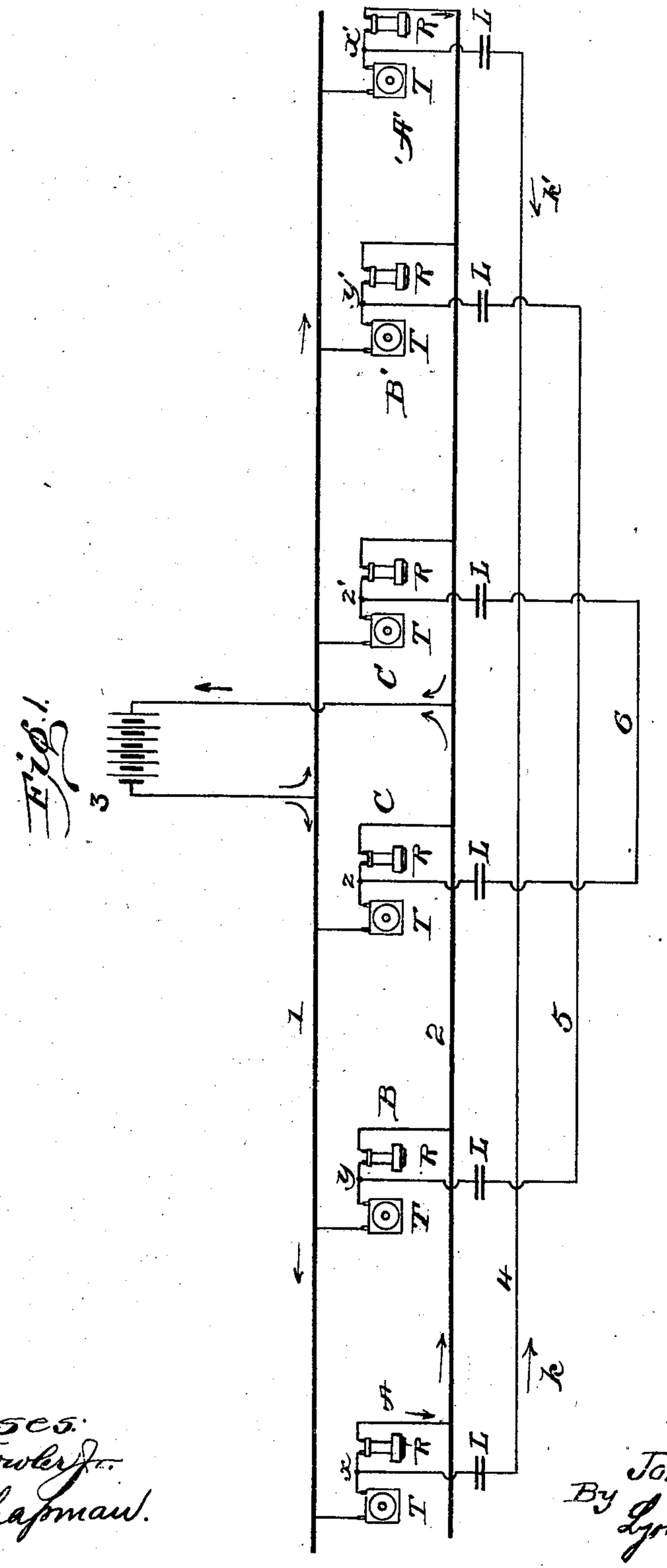

Fig. 1.

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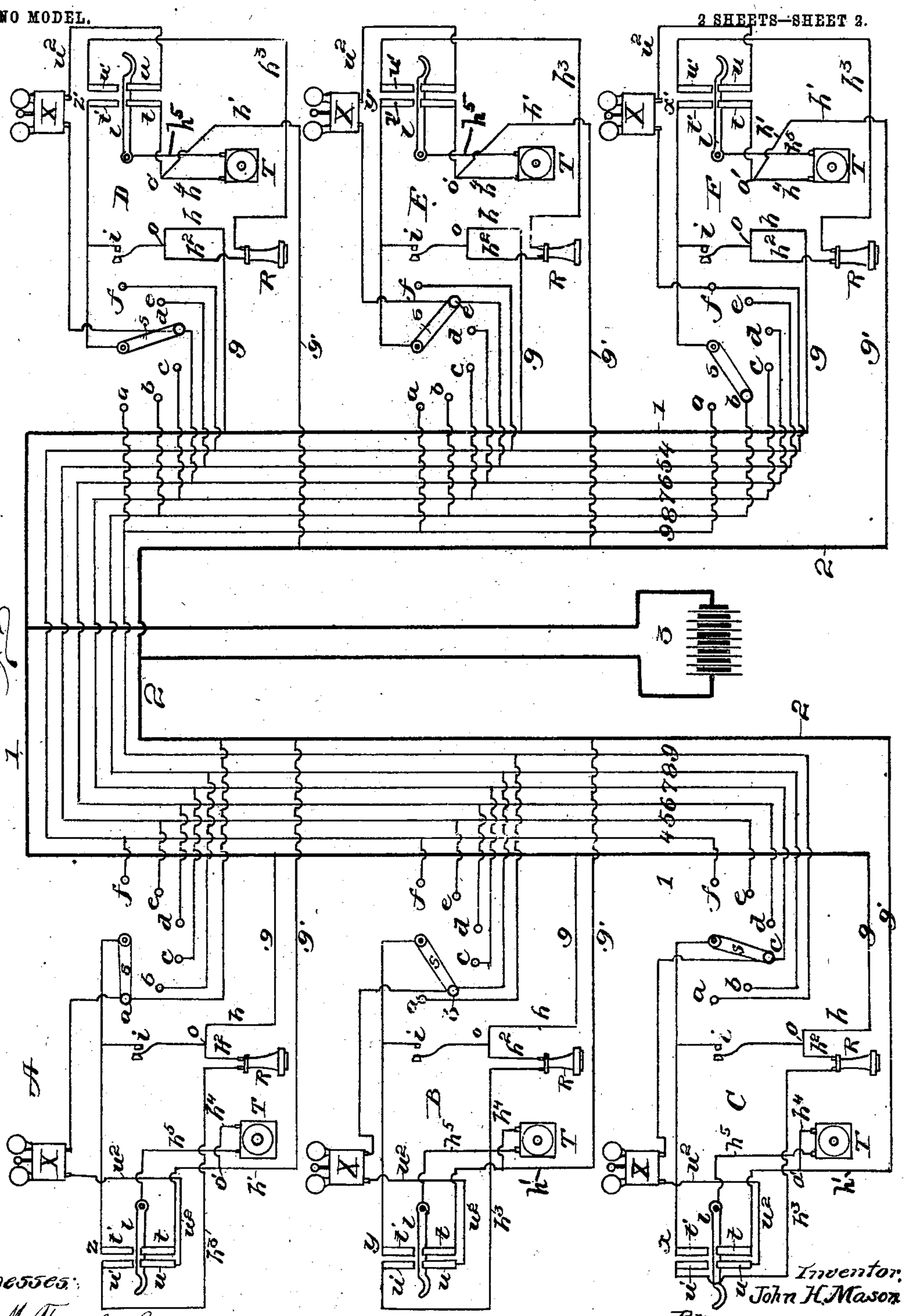

Fig. 2.

UNITED STATES PATENT OFFICE.

JOHN H. MASON, OF PHILADELPHIA, PENNSYLVANIA, ASSIGNOR TO WHEATSTONE BRIDGE TELEPHONE COMPANY, OF SOUDERTON, PENNSYLVANIA, A CORPORATION OF SOUTH DAKOTA.

TELEPHONE SYSTEM.

SPECIFICATION forming part of Letters Patent No. 724,594, dated April 7, 1903.

Application filed April 12, 1902. Serial No. 102,622. (No model.)

To all whom it may concern:

Be it known that I, JOHN H. MASON, a citizen of the United States, residing at Philadelphia, in the county of Philadelphia and State of Pennsylvania, have invented certain new and useful Improvements in Telephone Systems, of which the following is a specification.

My invention has reference to improvements in telephone systems, and has for its object an improved system of telephonic intercommunication between any number of pairs of stations disposed along a trunk-line and still avoiding all cross-talk, notwithstanding the great saving of conductors which I secure. In my system a complete metallic circuit is used between each pair of conjugated stations, and still the number of line-wires used is reduced in such manner that when there are n stations the number of line-wires used is only $n + 2$.

The principle of my invention and the means for carrying the same into effect will appear from the following detail description, with reference to the accompanying drawings, in which—

Figure 1 illustrates in diagram six telephone-stations connected in accordance with my invention in such manner that three pairs of intercommunicating stations may be worked simultaneously. Fig. 2 is also a diagrammatic view showing my system with six stations, each capable of communicating with every other one without cross-talk.

The fundamental idea which underlies my invention is most readily understood by reference to Fig. 1. Two main lines 1 2 are charged by a battery 3 or other source of current, and, by preference, the source of current is one of low internal resistance. A storage battery would most readily recommend itself for use in my system; but any other suitable source of current may be used. In multiple-arc branches across the two main lines are arranged the telephone-stations A B C A′ B′ C′, the equipment of which is shown in the drawings as reduced to a transmitter T and a receiver R in series with each other. By preference, although not necessarily so, I use transmitters which in a state of rest have a rather high resistance. The receivers are also preferably, but not necessarily, made of comparatively high resistance. If the resistance of the receivers is comparatively low, an extra resistance should be added to the wire which connects it with the line 2.

In the arrangement so far described it will be seen that the transmitter and receiver at each station form together a multiple-arc branch of a system of transmission of electrical energy fed by a source of constant potential and low internal resistance, the same as is exemplified by a modern system of incandescent electric lighting. In such systems the cutting in or out of one branch does not appreciably affect the other branches. Consequently where the multiple-arc branches contain telephonic apparatus the variation of the resistance of one branch will not appreciably affect the other branches, and from this it follows that speech uttered against any one of the transmitters will not appreciably affect the receivers in the other branches. Under these circumstances then telephonic intercommunication cannot be practically carried on.

Now in accordance with my invention there are used, in addition to the two main lines 1 2, auxiliary lines, one extending between each pair of stations which are desired to be put into communication. These auxiliary lines are marked in the drawings 4, 5, and 6, each terminating at the respective stations between the transmitter and receiver, and in each may be placed one or more condensers L, as indicated. Thus the auxiliary line 4, which connects the stations A and A′, terminates at these stations at the points x and x', respectively. The auxiliary line 5, which connects the stations B and B′, terminates there at the points y and y', respectively, and the auxiliary line 6, which connects the two stations C and C′, terminates at the points z and z', respectively. By reference to the drawings it is seen that if we consider any one of two conjugated stations—say A and A′—the current from the battery divides upon the line 1, one branch running to the left and the other to the right, and each branch completed through a transmitter and receiver and one-half of the main line 2, as

indicated by the unlettered arrows marked on the drawings. In this arrangement of circuit the left-hand half of the main line 1, together with the transmitter at station A, forms one side of a Wheatstone balance, the right-hand half of the main line 1, together with the transmitter at station A′, forming the other side of the Wheatstone balance which branches from the first. Similarly the left-hand half of the main line 2, together with the receiver at station A, forms the third side of the Wheatstone balance, while the right-hand half of the main line 2, together with the receiver at station A′, forms the fourth side of the Wheatstone balance. The points x and x' are equipotential points, under the assumption that a balance of resistances exists as in the Wheatstone balance. Consequently in the normal condition of transmitters at stations A and A′ no current will flow through the auxiliary line 4, which here constitutes the bridge-wire of the Wheatstone balance, even if the condensers L were not placed in that line.

What has here been said about the auxiliary line 4 with reference to stations A and A′ is also true of the auxiliary line 5 with reference to stations B and B′ and is also true of the auxiliary line 6 with reference to stations C and C′—that is to say, each of the auxiliary lines constitutes a bridge-wire of a Wheatstone balance, of which the portions of the main lines which extend from the battery to the pairs of conjugated stations with their transmitters and receivers form the sides. These sides must be balanced as respects resistance in a manner well understood by those skilled in the art in order that the best effects be produced—that is to say, in order that no current at all may flow in the bridge-wires or auxiliary lines even if the condensers L were not used. I have found, however, that such critical balance is not necessary.

Under the assumption that the Wheatstone balances are in a state of practical equilibrium and that speech is uttered against any one of the transmitters—say against the transmitter of station A—the resistance on that side of the balance which extends from the battery along the left-hand half of the main line 1 and through the transmitter up to the point x is varied, is alternately increased and decreased. When this happens, the points x and x' will be at different potentials and current will flow through the auxiliary line or bridge wire 4 first in one direction and then in the other.

When the resistance of the transmitter is reduced, the current takes its course as follows: from the positive pole of the battery to the juncture of the same with the middle of line 1. At this point the current divides, one part passing through the left-hand half of line 1, through the transmitter and receiver at station A, and through the left-hand half of line 2 back to the negative pole of the battery. The other half passes from the junction of the positive pole with the line 1 over the right-hand half of line 1, through the transmitter and receiver at station A′, and by the right-hand half of main line 2 back to the negative pole of the battery, all in the directions indicated by the unlettered arrows. The resistance of the transmitter at A having been reduced, the current through the left-hand side of the Wheatstone balance will be stronger than that through the right-hand side. Consequently the potential of the point x will be higher than that of the point x', and a momentary electrical impulse will pass through the bridge-wire 4 in the direction of the arrow k, which will be added to the current already passing through the receiver at station A′. The passage of this momentary impulse will not be impeded by the presence of the condensers in the bridge-wire.

When the resistance at the transmitter at station A is increased, the current through the main lines will pass as before; but in this case the current passing through the right-hand side of the balance will be greater than that on the left-hand side. In consequence thereof the potential at point x' will be higher than that at x and a momentary impulse will pass through the bridge-wire 4 in the direction of the arrow k and which will be added to the current already passing through the receiver at station A. In this manner the current strength through the receivers is varied and speech is reproduced. Thus it will be seen that when speech is uttered against the transmitter at A both the home receiver and the distant receiver at A′ are actuated by unidirectional varying currents, while alternating currents flow through the auxiliary line or bridge-wire 4. During such operation neither of the intermediate stations is affected.

What has been explained with reference to the two conjugated stations A and A′ is also true of the conjugated stations B and B′ and of the conjugated stations C and C′. Either of these pairs of stations may converse with each other without affecting the other, since each pair has its own auxiliary line or bridge-wire.

In the arrangement so far described, where the system is a rigid one—that is to say, unalterable—owing to the absence of switches each bridge-wire or auxiliary line can only serve for two particular stations; but when the system is equipped as shown in Fig. 2 each bridge-wire may do service for more than two stations. In fact, it may serve for connecting one station with any of the other stations of the system. While, therefore, in the arrangement shown in Fig. 1 it is possible only to converse between three pairs of stations, there being altogether six stations, it is, with the arrangement shown in Fig. 2, possible to establish intercommunication of each station with every other station on the system, and there being six stations altogether fifteen different combinations are possible, although

only three can work simultaneously. In Fig. 2 the main line 1 2 is charged by a source of current 3 in the same manner as in the case of the arrangement shown in Fig. 1; but in this case the auxiliary lines 4, 5, 6, 7, 8, and 9 extend throughout the whole length of the main line, and branch connections from the same terminate at each station at the contacts of a switchboard, which contacts are marked *a b c d e f*. The stations themselves are in this figure of the drawings marked A, B, and C at one end of the line and D E F at the other end of the line. The equipment of the stations is identical, so that the description of the arrangement at one station will serve for all other stations. Taking, then, for instance, the station F, it will be seen that the main line 1 is extended into this station by conductors *g h* to a push-button *i*, the other side of which push-button is connected with the switch-lever *s*, which can be turned over any of the contacts at which the auxiliary lines terminate at this station. The other main line 2 is connected by conductors *g' h'* with one of the two springs *t u*, with which the telephone-hook *l* makes contact when the receiver is in place. From a point *o* on the conductor *h* a branch h^2 is extended to the telephone-receiver R, the other end of which is connected by conductors h^3 to one of the two springs *t' u'*, with which the telephone-hook makes contact when the receiver is removed from the hook, the other one of these springs *t'* being connected with the same wire which connects the rear side of the push-button with the switch-lever, as before described. From a point *o'* of the conductor *h'* a shunt-wire h^4 connects with one terminal of the transmitter T, the other terminal of which is connected by a conductor h^5 with the telephone-hook. The contact-spring *u* is connected by conductors u^2 with the call-bell X, which in turn is connected with one of the contacts of the switchboard, in this case with the contact *f*, which may be called the "home" contact of station F. Each station has such a home contact—station A, the home contact *a;* station B, the home contact *b*, &c.

Suppose now any one of the stations desires to establish communication with any of the other stations. The rule of the system is that each party shall keep his switch-lever normally upon his home contact. This is necessary in order that each party may be in condition to speak or be spoken to after it has received a call. If now station F desires to establish communication with, say, station B, the operator at F will turn the switch-lever upon contact *b*, as shown, and will operate the push-button *i*. This sends a battery-current through the call-bell of station B, as follows: from the main line 1 by conductors *g h*, through push-button *i*, to switch-lever *s*, contact *b*, auxiliary wire 8, to station B, which it enters at contact *b* at that station and then passes to and through the call-bell and by conductors u^2 to spring-contact *u*, then by the telephone-hook across to the spring-contact *t*, and from thence by conductors *h'* and conductor *g'* to the main line 2, and thus back to the battery. Having made the signal, the operator at F lifts his telephone from the hook, whereby the latter is allowed to rise and bridge the spring-contacts *t' u'*, as is usual in telephone systems, while the operator at B, having received the signal, will likewise lift the telephone from the hook, which will also rise to bridge the spring-contacts *t' u'*. In this condition the two stations B and F are in speaking connection and in the same kind of speaking connection as is found between any of the two conjugated stations shown in Fig. 1—that is to say, the transmitter and receiver at each station are connected in series across the main line and a point between the transmitter and receiver at one station is connected with a point between transmitter and receiver at the other station by the auxiliary line or bridge-wire 8. This can be traced as follows: The main lines terminate at the station F at the two points *o o'*, and between these two points the transmitter and receiver are shunted in series with each other, as follows: from conductor h^2 to and through the receiver and by conductors h^3 to spring-contact *u'*, to the telephone-hook *l*, then by conductor h^5 to and through the transmitter, and by conductor h^4 to the point *o'*. This closes the shunt across the main conductors, with the transmitter and receiver in series. Now one point of this branch circuit would be on the telephone-hook, and since this latter makes contact with spring *t'* the upper point of that spring—the point *x'*—is also a point in the branch between the transmitter and receiver, and this point, as we have seen, is connected with the switch-lever, which in turn rests upon the contact *b*, which is connected with the auxiliary line or bridge-wire 8. Precisely the same connections are found at station B, where the point *y* corresponds to point *x'* at station F, so that it is true that these two stations are now in speaking connection in the same manner as any two conjugated stations shown in Fig. 1.

It will now be understood that each station may call every other station by turning its switch-lever upon the contact which is marked with the letter corresponding to that under which the station to be called is or may be known and then operating its push-button.

The presence of the condensers L in the auxiliary lines while not impeding the passage of telephonic currents does prevent the passage of direct currents from accidentally crossing neighboring electric conductors or from other sources.

It is evident that in the arrangement shown in Fig. 1 the locations of transmitters and receivers may be exchanged without affecting the operation of the system. While this operation is simple and efficient and the circuit connections here shown are well adapted to accomplish the result aimed at, it will be clear

to those skilled in the art that numerous other circuit arrangements may be employed to accomplish the same result in accordance with the principles of my invention. I therefore wish it to be understood that I do not propose to be limited to the employment of the specific arrangement herein shown and described nor am I limited to the arrangement of transmitters located directly in the charged main-line circuit, since it is evident that I can use transmitters in local-battery circuits connected with the line by means of induction-coils in the usual manner. In that case the secondaries of the induction-coils would take the place of the transmitters shown in the arrangements represented in the drawings, and the currents in the branches of the Wheatstone balance would be modified by variation of electromotive force instead of by variation of resistance; but the result would be the same. The receive may of course be also inductively connected with the line.

Having thus fully described my invention, what I claim, and desire to secure by Letters Patent, is—

1. A telephone system comprising a number of stations capable of being variously connected in pairs, with the transmitters and receivers of each pair normally in substantially balanced sides of a Wheatstone balance, and auxiliary lines each adapted to terminate between transmitter and receiver at two connected stations and constituting the bridge-wire of the Wheatstone balance, substantially as described.

2. A telephone system comprising a charged main line, a telephone transmitter and receiver for each station, connected in series, and both in a branch across the main line, and an auxiliary line adapted to connect a point between transmitter and receiver of one station with a like point of another station, substantially as described.

3. A telephone system having the transmitter and receiver at each station connected in series and both in a multiple-arc branch of a charged constant-potential main line, whereby the instruments of each pair of stations are each in a side of a Wheatstone balance, and auxiliary lines for connecting stations in pairs and constituting the bridge-wires of the Wheatstone balances constituted by such pairs, substantially as described.

4. The combination of a main line, a generator of low internal resistance for charging the line, a telephone transmitter and receiver for each station, both of high resistance, connected in series with each other, and in a branch across the line, and an auxiliary line or lines for connecting stations between transmitter and receiver, substantially as described.

5. A telephone system comprising a charged main line, a telephone transmitter and receiver for each station, connected in series in a branch across the main line, an auxiliary line adapted to connect a point between transmitter and receiver of one station with a like point of another station, and a condenser or condensers in each auxiliary line, substantially as described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

JOHN H. MASON.

Witnesses:
J. JEROME LIGHTFOOT,
F. T. CHAPMAN.