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METHOD OF TESTING TRANSMISSION LINES

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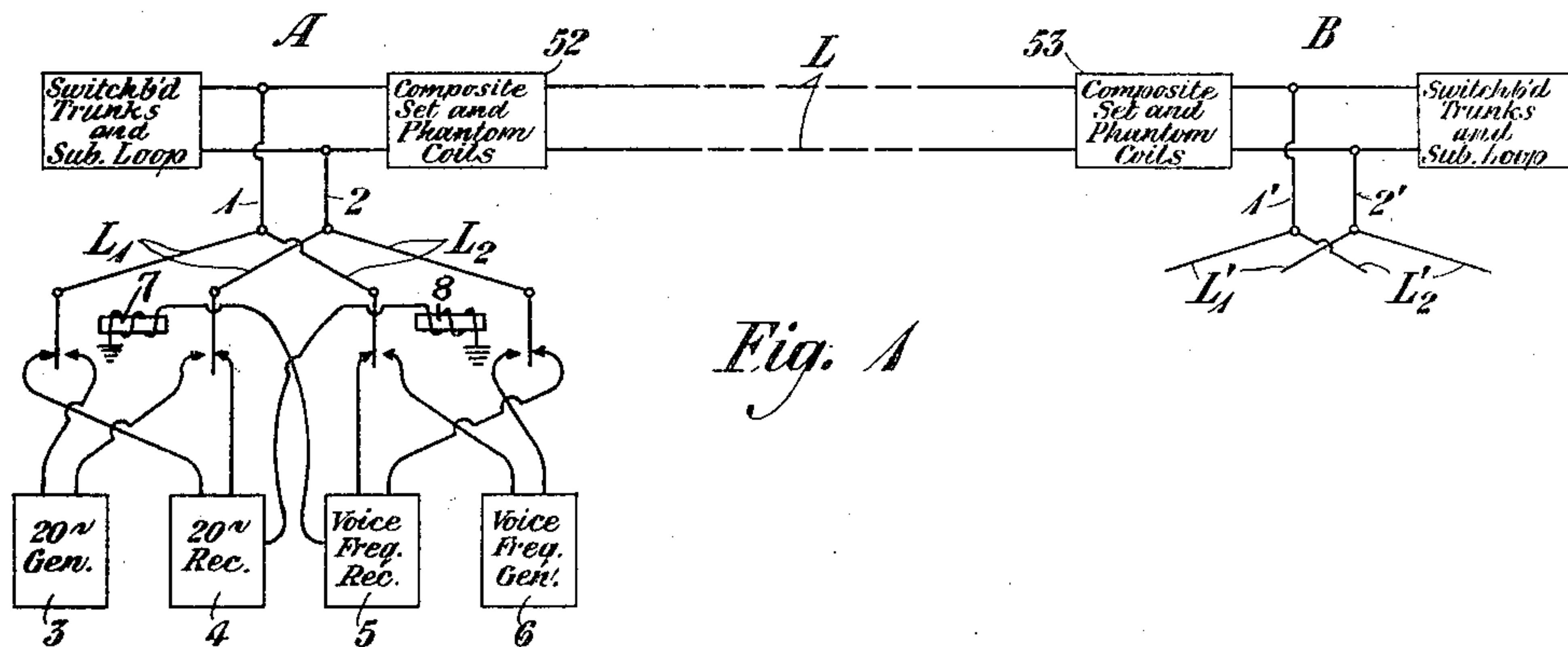


Fig. 1

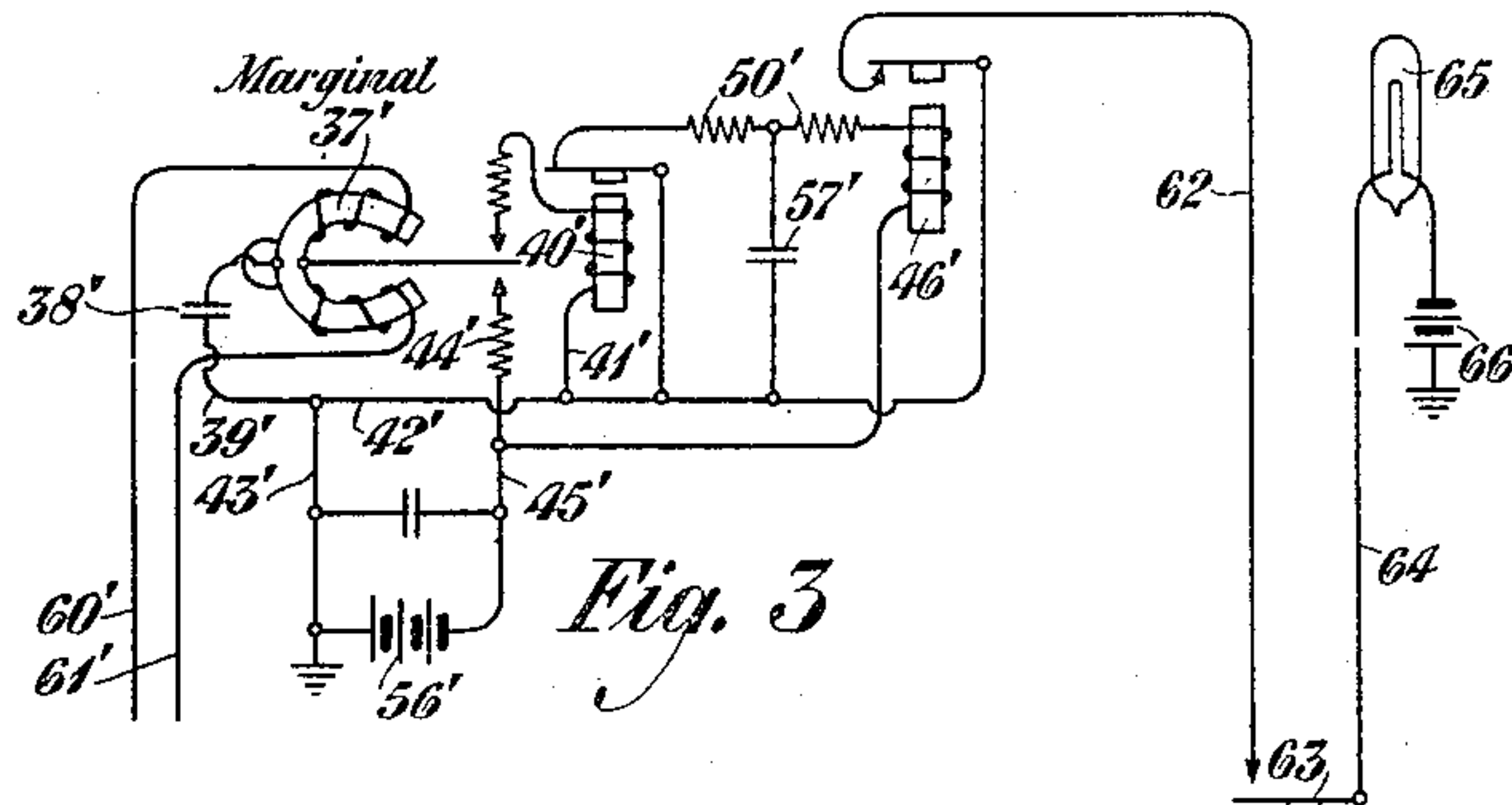


Fig. 3

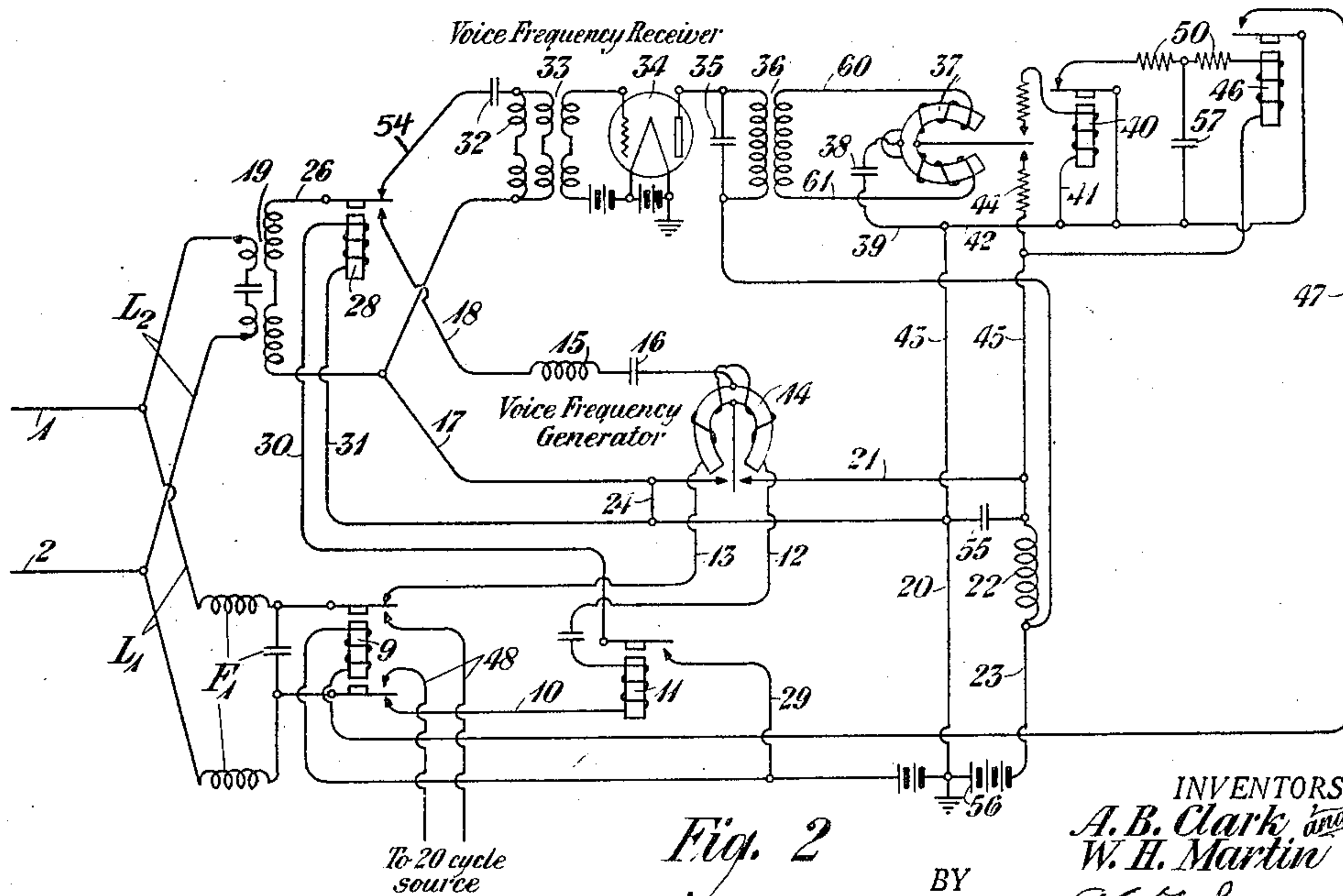


Fig. 2

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UNITED STATES PATENT OFFICE.

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METHOD OF TESTING TRANSMISSION LINES.

Application filed May 13, 1922. Serial No. 560,634.

To all whom it may concern:

Be it known that we, ALVA B. CLARK and WILLIAM H. MARTIN, residing at Brooklyn and New York, in the counties of Kings and Bronx and State of New York, respectively, have invented certain Improvements in Methods of Testing Transmission Lines, of which the following is a specification.

This invention relates to a method of and means for testing the transmission efficiency of lines and is particularly applicable to telephone systems in which the currents utilized for signaling purposes lie within the voice frequency range.

It has been the practice in former types of telephone and telegraph transmission systems to utilize different frequency levels for talking and for signaling; for example the signaling currents might have a frequency in the neighborhood of 135 cycles, while the components of the voice current would have frequencies varying from about 300 to 2000 cycles. Interference between the different frequency levels was prevented by the use of selective apparatus. Such arrangements presented several disadvantages in that they necessitated the provision at repeater and similar installations of separate repeating or relaying apparatus for the ringing and voice currents, for the reason that the coils and amplifiers efficient at voice frequencies were inefficient at the ringing frequency and vice versa. In order to obviate such disadvantages and the ensuing duplication of equipment, arrangements have been proposed in the past for raising the level of the ringing or signaling channel to the same frequency level as that of the voice channel. Arrangements in which voice frequency current is utilized for signaling purposes are illustrated in the co-pending application, Serial No. 369,938, in the name of L. Espenschied, and in the co-pending application, Serial No. 515,881, in the names of A. B. Clark, D. K. Gannett, and H. Nyquist, and reference may be had thereto for a complete illustration of such systems.

In accordance with this invention it is proposed to utilize the voice frequency signaling currents in systems of the above type as a means for testing the transmission efficiency of the circuits. Since the frequencies utilized for this type of signaling are in the important part of the voice range, and as

signaling currents are sent over the lines just prior to their employment for conversation, the efficiency of transmission of the signaling current is a measure of the transmission efficiency of the circuit for the voice currents, which has obvious advantages. This feature would make possible the detecting of line or repeater troubles which lower the circuit transmission and thus avoid annoyance to customers who might otherwise be given a circuit when it was in uncommercial condition. An additional advantage would be that no circuit time is required for testing purposes. In general the method of testing the circuit would consist in adjusting the ringing apparatus so that it would be operated near its margin, in which case an increase in equivalent of the circuit would cause failure of operation of the ringer and thus be detected. This might be accomplished by arbitrarily limiting the range of the ringer by adjustment of the sensitivity of the receiving circuit thereof to the maximum equivalent which shall be considered commercial for the given line. Circuit trouble which lowers the transmission efficiency of the circuit beyond this commercial limit would then result in ringing failure and would cause the circuit to be reported in trouble. This method of testing the circuit might be slightly modified by allowing the ringing apparatus to function at all times regardless of the line, but by adjusting a portion of the receiving apparatus of the ringer, such as a marginal relay, so that it would fail to function when the circuit equivalent increased beyond commercial limits. The failure in functioning of this portion of the ringer might serve to report the unsatisfactory condition of the line. In this arrangement it would be desirable that the amount of voice frequency signaling current sent out at the distant end be of a fixed or known value.

The invention may be more fully understood from the following description together with the accompanying drawing in the Figures 1, 2 and 3 in which are shown arrangements embodying the features and principles of the invention. Fig. 1 illustrates schematically an arrangement of a transmission system in which voice frequency currents are utilized for signaling purposes. Fig. 2 shows the voice frequency

signaling receiving and generating circuits suitable for this invention and adapted to be associated with the system shown in Fig. 1. The invention in a slightly modified form may be illustrated by the addition of the arrangements of Fig. 3 to those of Fig. 2 in a manner to be pointed out hereinafter.

In Fig. 1 are shown two stations, A and B, interconnected by the line L. The transmission line L may include such apparatus as composite sets, phantom coils or repeaters illustrated schematically as the arrangements 52 and 53. Bridged across the transmission line at the station A by conductors such as 1 and 2, or other suitable switching arrangements, are the circuits L_1 and L_2 . The circuit L_1 is associated with a 20 cycle generating apparatus 3 and a 20 cycle receiving apparatus 4. The circuit L_2 is associated with a voice frequency receiving apparatus 5 and a voice frequency generating apparatus 6. When the operator at circuit A transmits low frequency signaling current into the line, such as 20 cycle current, a part of this current will be transmitted over circuit L_1 to the 20 cycle receiving apparatus 4 which, upon responding thereto, will operate the relay 8. The relay 8 will connect circuit L_2 to the voice frequency generating apparatus 6, which in turn will transmit these signals over the line L by means of current within the voice frequency range. The voice frequency signals coming in from a station such as B will be transmitted over circuit L_2 to the voice frequency receiving apparatus 5, which, upon responding thereto, will operate the relay 7. The relay 7 will connect the circuit L_1 to the 20 cycle generating apparatus 3 whereby the low frequency signaling currents suitable for operating the apparatus at the switchboard of station A will be transmitted thereto. Similar arrangements to those already described with respect to station A will be provided at station B associated with conductors 1' and 2' and the circuits L_1' and L_2' .

In Fig. 2 is shown in detail one arrangement of the low frequency and the voice frequency receivers and generators associated with the transmission line at each station. Associated with line L_1 is the filtering device F_1 which readily allows the transmission of the low frequency signaling currents, such as 20 cycle currents, transmitted from the switchboard. This filtering device is so designed that it has a very high impedance to voice frequencies and therefore prevents the 20 cycle relays and circuits about to be described from causing an appreciable loss of energy to the speech currents or to the voice frequency signaling currents. The filter also serves to prevent voice frequency harmonics in the 20 cycle current from being transmitted to L_1 and thus to L_2 and the voice frequency re-

ceiving circuit, and locking the latter in operated position. The line L_1 is associated with the windings of a polar relay 14, which is operated by the 20 cycle current transmitted from the switchboard. The 20 cycle current from the switchboard will be transmitted over the contacts of relay 9 and thence over conductors 13, 12 and 10 through the windings of the polar relay 14 and also through the winding of relay 11. This will operate the relay 11 as well as the relay 14. The operation of relay 11 closes the following circuit: from battery, conductor 29, contact and armature of relay 11, conductor 30, winding of relay 28, conductors 31 and 20 to ground. The closing of this circuit will operate relay 28 which will disconnect conductor 26 from conductor 54 and connect it to conductor 18 thereby disconnecting the voice frequency receiving apparatus which will be described later, from the line, and connecting the voice frequency generating apparatus to the line.

The form of voice frequency generator illustrated in the drawing consists of an oscillating circuit controlled by the polar relay 14. The polar relay 14 in response to the 20 cycle signaling current alternately charges and discharges the condenser 16 in the oscillating circuit 20 times a second. When the armature of relay 14 rests on the right-hand contact, the oscillating circuit includes the condenser 55, which is charged to the potential of battery 56, conductor 21, the right-hand contact and armature of relay 14, condenser 16, inductance 15, conductor 18, make contact and armature of relay 28, conductor 26, winding of transformer 19, conductors 17, 24 and 20 to ground. When the armature of relay 14 rests on the left-hand contact, the circuit is the same as above except that condenser 55 and conductors 21, 20 and 24 are no longer in circuit, the circuit being established directly from condenser 16 to conductor 17 through the left-hand contact of relay 14. The inductance 15, together with capacity 16, is highly resonant at 800 cycles making the circuit oscillatory for that frequency. The alternate charging and discharging of the condenser 20 times a second in the oscillating circuit creates a damped train of 800 cycle oscillations for each charge and for each discharge. These oscillations are transmitted from the oscillating circuit through the transformer 19 to circuit L_2 and thence out over the line. The relation of the design of transformer 19 to the line impedance connected to line L_2 and to the impedance of the oscillating circuit just described, is such as to cause the line resistance to provide the proper damping coefficient to the oscillations to obtain the optimum results. The voice frequency generator may be of any form, such as for example a vacuum tube

oscillator or a motor generator instead of the form just described.

The voice frequency receiving arrangements are connected to line L_2 through transformer 19 and include a series resonant circuit 32 tuned to approximately the signaling frequency, which may be, for example 800 cycles. The series resonant circuit 32 is of relatively low impedance as it is impracticable to construct such a circuit to have a very high impedance. To prevent this low impedance circuit from causing too great a loss in the telephone circuit the transformer 19, through which it is connected to the line is constructed to operate as an inequality ratio coil and to step up the impedance in the proper proportion. In practice the series resonant circuit may not be tuned to the exact carrier frequency of the incoming signal, such as 800 cycles, but is tuned slightly lower. This results in a beat phenomenon which causes the effect that the demodulated wave produced by the detecting tube 34 has greater amplitude than in the case when the circuit is tuned exactly to the incoming frequency. This feature results in greater efficiency of response to the signal. Associated with the series resonant circuit is a detector 34 of the well known vacuum bulb type. Associated with the output transformer 36 of the tube is a bridged condenser 35 which tunes it to be resonant at 40 cycles, which is the frequency of occurrence of the trains of 800 cycle oscillations transmitted over the line L from the generating circuit at the distant station. This arrangement results in maximum sensitivity to the ringing signal and low sensitivity to interference. The 40 cycle current thus produced by the detecting action of the vacuum bulb 34 is transmitted by the tuned output transformer 36 to a polar relay 37 and serves to operate this relay at the same frequency of 40 cycles. This vibrating operation of the polar relay 37 causes sustained operation of the succeeding neutral relay 40 in the following manner: Each time the armature of the polar relay 37 strikes the lower contact, condenser 38 is charged to the potential of battery 56 through the circuit from condenser 55 (which is maintained at the potential of battery 56, as has been pointed out) over conductor 45 and 44 the lower relay contact and the relay armature. The other terminal of condenser 38 is grounded through conductors 39, 43 and 20. When the armature of the polar relay 37 strikes the upper contact condenser 38 discharges through relay 40 and conductors 41, 42, 43 and 20 to ground. The sensitivity of relay 40 is such that when the polar relay operates with a speed of approximately 40 cycles the discharges of condenser 38 produce enough current to operate said relay. Operation of the

polar relay at an appreciably lower speed than 40 cycles, however, does not result in sufficient current in relay 40 to cause its operation. This prevents false operation of relay 40 from interference of such a nature as to cause a low frequency operation of the polar relay.

When relay 40 operates, its contacts open up the circuit which otherwise exists through the winding of relay 46. This circuit is as follows: from ground and battery 56, conductor 23, coil 22, conductor 45, winding of relay 46, resistances 50, contact of relay 40 and conductors 42, 43 and 20 to ground. Upon opening of the contact of relay 40, however, the current does not immediately cease flowing in the winding of relay 46 but continues to flow into condenser 57 until the latter is charged to the potential of the battery 56. This causes relay 46 to release with a certain time lag with respect to the operation of relay 40, which lag is determined by the sensitivity of relay 46 and by the time constant of the condenser 57 and the resistance 50 which is in series with relay 46. This time lag serves as an additional check to prevent any false operation of the signaling means which might occur should the actual voice currents which are not intended for signaling purposes serve to actuate the relay 37 and the relay 40. As any such actuation of these relays would only be of a temporary nature, the relay 40 would be restored to normal before the relay 46 could release under these conditions, discharging condenser 57 and reestablishing the current through the latter relay. When the relay 46 is released, the following circuit is closed: from ground, conductors 20, 43 and 42, armature and contact of relay 46, conductor 47, winding of relay 9 to battery and ground, thereby operating relay 9. This will connect to the line L_1 the conductors 48 which lead to a source of suitable low frequency ringing current such as 20 cycle current to operate the switchboard apparatus. At the close of the ringing signal, polar relay 37 stops vibrating and relay 40 is released, returning to its normal unoperated position. Relay 46, however, operates with a time lag which is shorter than the lag at the beginning of the ring, and which is determined by the time constant of the condenser 56 and its discharge path through the two resistances 50 in parallel. This latter feature has been found valuable in preventing interference with the ringing signal by disturbing currents.

As has been pointed out heretofore, the method of testing the transmission efficiency of the line circuit consists in general in adjusting the ringing circuit and apparatus so that it will be operated near its margin in which case an increase in the transmission equivalent of the circuit beyond that de-

5 sirable for commercial purposes would cause failure of operation of the ringer and would thus be detected. This might be accomplished by adjustment of the relay 37. The relay 37 in accordance with this invention will be adjusted so that when the line L is at or above the maximum transmission equivalent desirable for commercial purposes, the voice frequency signaling current will not operate it. The relay 37 however will be operated by the voice frequency signaling currents when the line L is below said maximum equivalent. Accordingly any circuit trouble which might lower the transmission efficiency of the circuit, or in other words raise the equivalent beyond the commercial limit would result in ringing failure and cause the circuit to be reported in trouble.

20 The invention might be slightly modified so that the actual ringing signal would not fail to function upon an increase in line equivalent, but that another portion of the ringing receiving apparatus would fail to function under such conditions and thus give an indication of the circuit condition. Such an arrangement would be illustrated by combining Fig. 3 with Fig. 2 by bridging conductors 60' and 61' across conductors 60 and 61. Associated with conductors 60' and 61' is the winding of a relay 37', similar to relay 37 of Fig. 2 except for a slight difference in adjustment which will be pointed out later. Associated with and controlled by the armature of relay 37' is a relay 40'. The relay 40' in turn controls the relay 46', a time lag being introduced between the operation of these relays which is somewhat less than that introduced between relays 40 and 46 as described above. The circuit arrangement of relays 40' and 46' is substantially the same as that with respect to relays 40 and 46 of Fig. 2, like reference characters being used to denote like parts in both figures and no detailed description thereof will be given. In this modification of the invention the relay 37 will be adjusted so that the signaling current will operate it under practically all line conditions and accordingly there will be at no time a failure in the ringing signal itself. The relay 37' however will be so adjusted that it will be operated by the signaling current whenever the line is below the maximum equivalent suitable for commercial purposes but it will not be operated by the signaling current when the line is at or above this maximum equivalent. With this arrangement, if the line equivalent is satisfactory from a commercial standpoint, the voice frequency signaling current transmitted over the line will operate both relay 37 and relay 37'. In a manner previously pointed out relay 37 will cause relay 46 to release, which will complete a circuit for the ringing signal

over conductor 47. The operation of relay 37' will in like manner cause the release of relay 46' which will hold open at its contact the following alarm circuit which would otherwise be completed over the second armature and contact of relay 46; from ground, conductor 43', armature and contact of relay 46', conductor 62, contact and armature 63 of relay 46, conductor 64, filament of lamp 65, to battery 66, and ground. Accordingly if the line equivalent is satisfactory both relays 37 and 37' will be operated, the actual ringing signal will function, and the alarm lamp 65 will not operate. However if due to circuit trouble the transmission equivalent of the line now increases above the maximum limit suitable for commercial purposes, the voice frequency signaling current will operate the relay 37 but will not operate the relay 37'. Under these conditions the circuit for alarm lamp 65 will be closed at the contact of relay 46 and will not be opened at the contact of relay 46' and the alarm signal 65 will operate to give an indication of the unsatisfactory condition of the line.

While the arrangements of the invention have been illustrated as embodied in certain specific arrangements which are deemed desirable and with a certain type of voice frequency signaling circuit, it is understood that they are capable of embodiment in other forms, arrangements, and circuits without departing from the spirit of the invention as defined in the appended claims.

What is claimed is:

1. In a telephone transmission system in which the currents utilized for signaling purposes lie within the central portion of the voice frequency range, the method of testing the transmission efficiency of the line for talking purposes which consists in adjusting the signal receiving apparatus so that it will operate only when the transmission equivalent of the line is within certain limits.
2. In a telephone transmission system in which the currents utilized for signaling purposes lie within the central portion of the voice frequency range, the method of testing the transmission efficiency of the line which consists in applying said voice frequency signaling currents to one end of the line to effect a responsive device at the other end of said line, and adjusting said responsive device so that it will operate only when the current received thereat is equal to that received when the line circuit is at its lowest desirable efficiency for talking purposes.
3. In a telephone transmission system in which the currents utilized for signaling purposes lie within the central portion of the voice frequency range, the method of testing the transmission efficiency of the line for talking purposes which consists in ad-

justing a portion of the signal receiving apparatus so that it will fail to operate when the transmission equivalent of the line is not within certain limits.

5 4. A telephone transmission system comprising a line, means for talking over said line, means for applying currents within the central portion of the voice frequency
10 of signaling, and a signal receiving apparatus at the other end of said line responsive to said voice frequency signaling currents, said receiving apparatus being adjusted to respond to said voice frequency signaling
15 currents only when the transmission equivalent to the line is within certain limits.

5. A telephone transmission system comprising a line, means for talking over said line, means for applying currents within
20 the central portion of the voice frequency

range to one end of said line for purposes of signaling, a signal receiving apparatus at the other end of said line responsive only to said voice frequency signaling currents, a relay in said receiving apparatus, a signal
25 circuit controlled by said relay, a second relay in said receiving apparatus, and an alarm circuit controlled by both of said relays, said second relay being adjusted so that it will operate only when the line
30 equivalent is within certain limits and said first relay being adjusted so that it normally will be operated when the line equivalent is beyond said limits.

In testimony whereof, we have signed our
names to this specification this 11th day of
May 1922.

ALVA B. CLARK.
WILLIAM H. MARTIN.