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VOICE FREQUENCY SIGNALING

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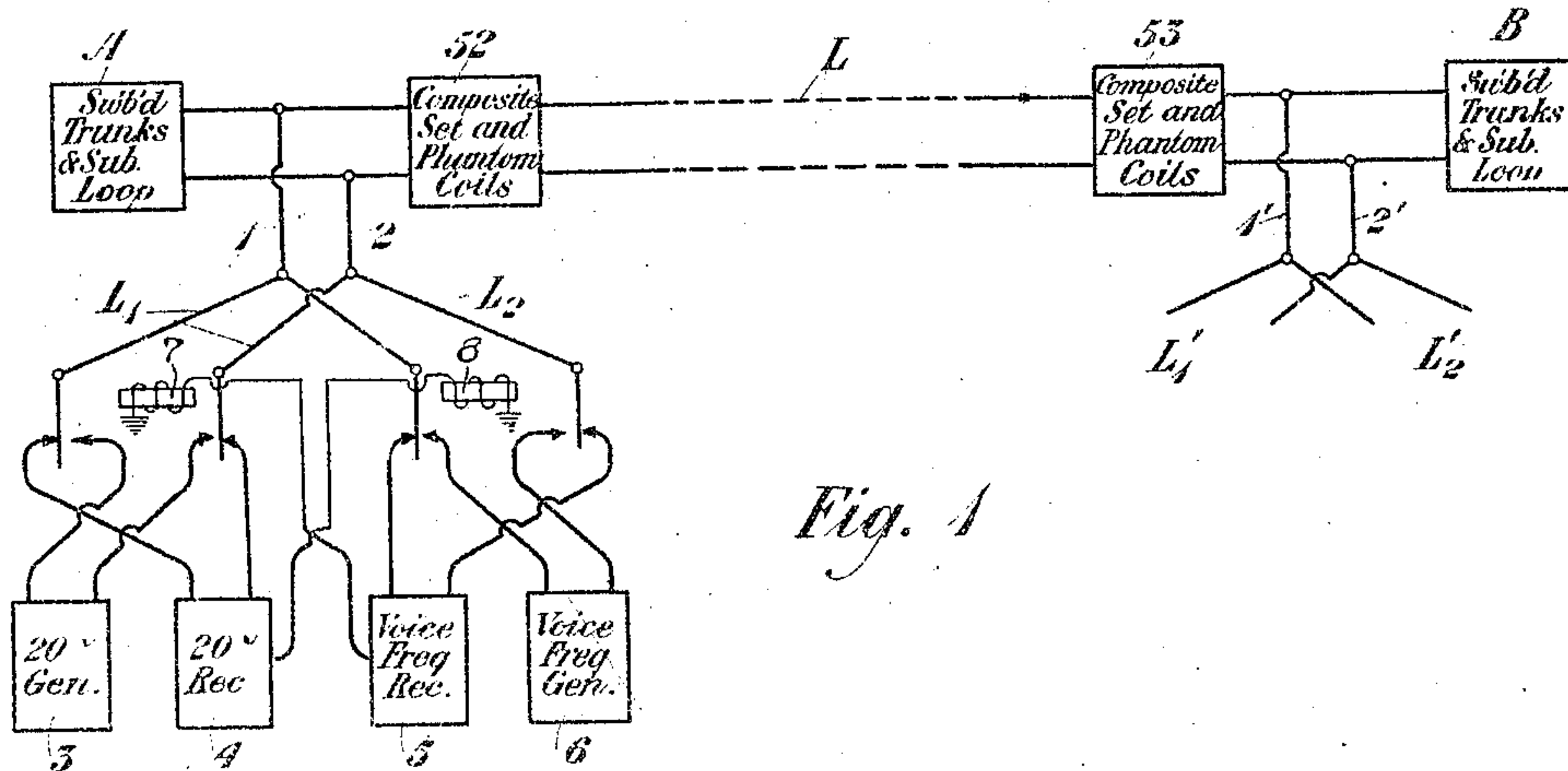


Fig. 1

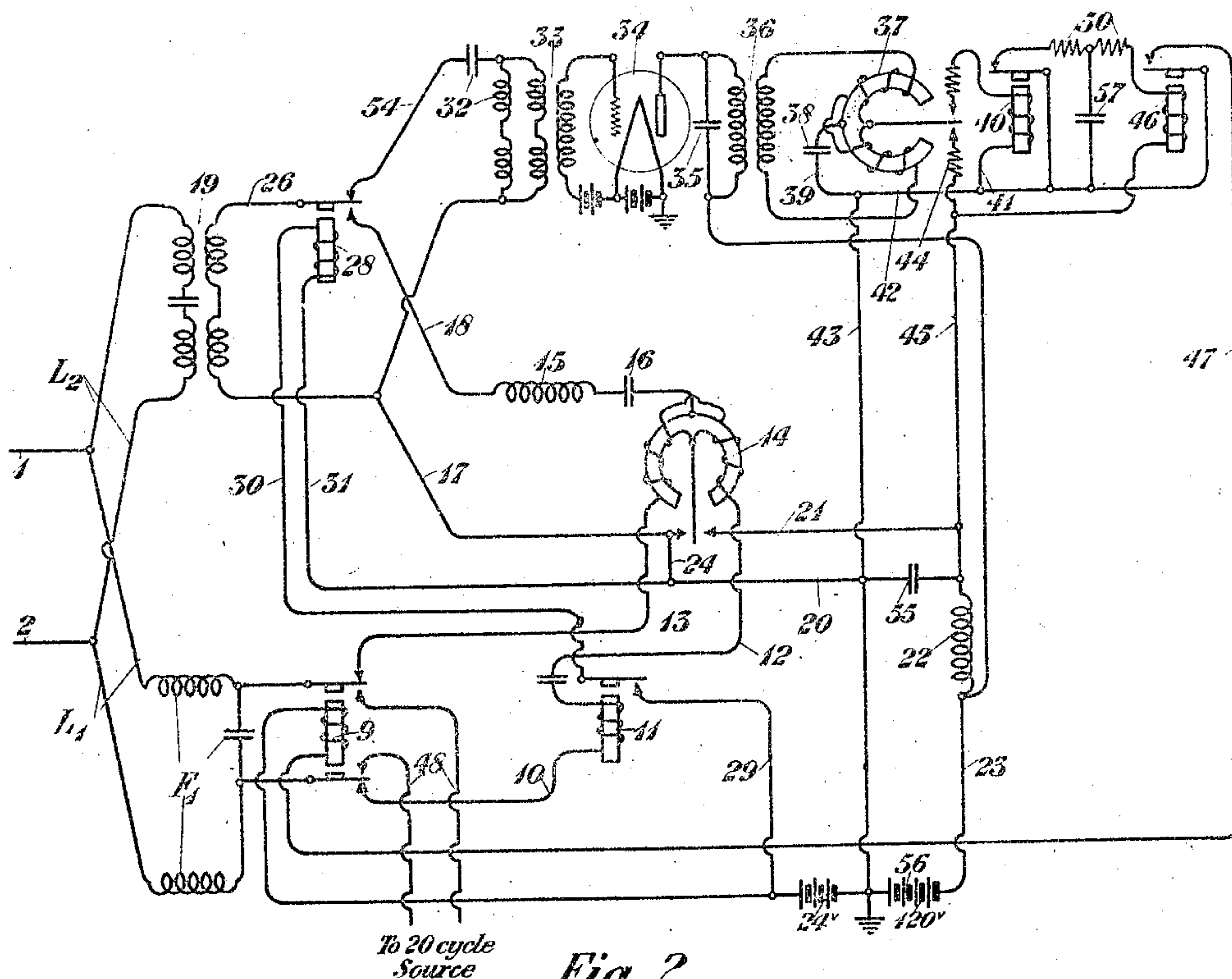


Fig. 2

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UNITED STATES PATENT OFFICE.

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VOICE-FREQUENCY SIGNALING.

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To all whom it may concern:

Be it known that we, ALVA B. CLARK, DANFORTH K. GANNETT, and HARRY NYQUIST, residing at Brooklyn, Elmhurst, and Elmhurst, in the counties of Kings, Queens, and Queens, and State of New York, respectively, have invented certain Improvements in Voice-Frequency Signaling, of which the following is a specification.

This invention relates to signaling and more particularly to methods of and means for transmitting and receiving ringing signals in telephone transmission systems.

In present day telephone and telegraph practice it is customary to provide a transmission system with a plurality of channels, each of which serves to transmit current independently of the others. Interference between the various channels is prevented by employing for each channel different frequencies or bands of frequencies and apparatus selectively responsive thereto. The frequency range is thus divided into a number of levels, and a separate transmission channel is provided for each frequency level. Two of the channels used in telephone practice are the voice channel and the ringing channel, the frequency level of the latter being generally below that of the former. For example, the ringing currents might have a frequency in the neighborhood of 135 cycles, whereas the components of the voice currents would have frequencies varying from about 300 to 2000 cycles.

This arrangement necessitates at repeater and similar installations the provision of separate repeating or relaying apparatus for ringing and voice currents; for the reason that coils and amplifiers efficient at voice frequencies are inefficient at the ringing frequency and vice versa. The present invention proposes to do away with this duplication of apparatus by raising the ringing channel to the same frequency level as that of the voice channel, so that the same apparatus may be efficiently employed for the transmission of currents of both.

It is a further feature of the invention to

provide arrangements whereby a false operation of the signaling apparatus by the actual voice currents may be prevented. To accomplish this purpose the currents of voice frequency, when utilized for signaling purposes, are generated and transmitted out over the system in an intermittent or periodic manner as a set of impulses at a predetermined rate, this rate being determined, if desired, by the frequency of the signaling current at the switchboard. The receiving apparatus is then so designed as to respond to interruptions of the voice frequency current at this predetermined rate only and to be unresponsive to other currents within the voice frequency range which do not have this predetermined intermittent characteristic. Other features and purposes of the invention will appear more fully from the detailed description hereinafter given.

The invention is illustrated in the accompanying drawing, in the Figure 1 of which is shown a schematic arrangement thereof, while in the Fig. 2 is shown in detail the circuit arrangement of a portion of the ringing apparatus.

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' . Considerable advantages are secured by bridging the ringer arrangements of this invention across the line L by the conductors 1 and 2 and 1' and 2' instead of connecting it in series with the circuit as has heretofore been the practice as relay and jack contacts are eliminated from the telephone circuit and the wiring is greatly simplified.

In Fig. 2 are shown in detail the arrangements 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 receiving 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 voice frequency generator 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 thru the left-hand contact of relay 14. The inductance 15, together with capacity 16, tunes the oscillating circuit to be resonant at 800 cycles. 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 receiving arrangements are connected to line L_2 through transformer 19 and include a series resonant circuit 32 tuned to approximately 800 cycles. The series resonant circuit 32 is of low impedance as it is impracticable to construct such a circuit to have 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 an amplifier and 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 lower 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, coil 22, conductors 23 and 45, winding of relay 46, resistances 50, contact of relay 40 and conductors 42 and 43 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 operate under these conditions, discharging condenser 57 and re-establishing the current through the latter relay. When the relay 46 is released, the following circuit is closed: from ground, conductors 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, 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.

While the low frequency ringing current has been referred to as current of approximately 20 cycles, and the voice frequency current has been referred to as of approximately 800 cycles, it is pointed out that this invention is not limited to these frequencies but that other suitable frequencies may be utilized. Furthermore, while the arrangements of the invention have been disclosed in certain specific forms which are deemed desirable, it is understood that they are capable of embodiment in many and widely varied forms without departing from the spirit of the invention as defined in the appended claims.

What is claimed is:

1. A transmission line interconnecting two stations, means at one of said stations for generating current within the voice frequency range, means for applying said current to said line in a periodically interrupted manner according to a predetermined frequency, and receiving means at said other station exclusively responsive to currents periodically interrupted according to said predetermined frequency.

2. A transmission line interconnecting two stations, a low frequency signaling source at one station, signaling apparatus at said station comprising a vibrating relay controlled by the frequency of said signaling current from said station, an oscillating circuit controlled by said relay and tuned to a fre-

quency within the voice range whereby there will be generated trains of oscillations of a periodicity controlled by the frequency of vibration of said relay, and means for coupling said circuit to said line.

3. A transmission line interconnecting two stations, a low frequency signaling source at one station, signaling apparatus at said station comprising a vibrating relay controlled by said low frequency signaling current from said station, an oscillating circuit controlled by said relay and tuned to a frequency within the voice range whereby there will be generated trains of oscillations of a periodicity controlled by the frequency of vibration of said relay, and means for coupling said circuit to said line, and signaling apparatus at the other station comprising means exclusively responsive to trains of oscillations of the same periodicity as those generated at said first station.

4. A transmission line interconnecting two stations, signaling apparatus at one station comprising a vibrating relay controlled by low frequency signaling current from said station, an oscillating circuit controlled by said relay and tuned to a frequency within the voice range whereby there will be generated trains of oscillations of a periodicity controlled by the frequency of vibration of said relay, and means for coupling said circuit to said line, and signaling apparatus at the other station comprising relay means exclusively responsive to trains of oscillations of the same periodicity as those generated at the first station, a normally closed circuit controlled by said relay means, said normally closed circuit including electrically retarding means and a relay, and a signal controlling circuit controlled by said last mentioned relay.

5. A transmission line interconnecting two stations, signal apparatus at each of said stations comprising sending and receiving apparatus, said sending apparatus comprising a vibrating relay controlled by low frequency signaling current from the station, an oscillating circuit controlled by said relay and tuned to a frequency within the voice range whereby there will be generated trains of oscillations of a periodicity controlled by the frequency of vibration of said relay, and means for coupling said circuit to said line, said receiving apparatus comprising means exclusively responsive to trains of oscillations of the same periodicity as those generated by the sending apparatus at the other station, and means for preventing interference between the sending and receiving apparatus at the same station.

6. A transmission line interconnecting two stations, signaling apparatus at one station comprising a vibrating relay controlled by low frequency signaling current from said station, an oscillating circuit controlled

by said relay and tuned to a frequency within the voice range whereby there will be generated trains of oscillations of a periodicity controlled by the frequency of vibration of said relay, and means for coupling said circuit to said line, and signaling apparatus at the other station comprising a vacuum tube detector, a transformer in the output of said tube tuned to be efficient at the frequency of the aforementioned periodicity of said trains of oscillations, relay means in the output circuit of said tube exclusively responsive to trains of oscillations of the same periodicity as those generated at the first station, a normally closed circuit controlled by said relay means, said normally closed circuit including electrically retarding means and a relay, and a signal controlling circuit controlled by said last mentioned relay.

7. A transmission line comprising two line sections, each of said line sections being suitable for the transmission of signaling currents of different frequencies, a composite ringer comprising means responsive to signal currents of one of said frequencies and generating means controlled thereby for generating currents of the other of said frequencies, and a single pair of conductors associated with said transmission line whereby the incoming currents of one of said frequencies may be applied to said responsive means and whereby the generated currents from said generating means may be applied to said line.

8. A transmission line interconnecting two stations, means at one of said stations for generating current within the voice frequency range, means for applying said current to said line in a periodically interrupted manner according to a predetermined frequency, and signal receiving apparatus at the other station comprising means exclusively responsive to trains of oscillations of the same periodicity as those generated at the first station, a normally closed circuit controlled by said last mentioned means, said normally closed circuit including electrically retarding means, and a signal controlling circuit controlled by said last mentioned circuit.

9. A transmission line interconnecting two stations, means at one of said stations for generating current within the voice frequency range, means for applying said current to said line in a periodically interrupted manner according to a predetermined frequency; and receiving means at said other station, said receiving means comprising arrangements tuned to be exclusively responsive to said signaling currents, a signal, and electrical retarding arrangements for connecting said signal to said tuned arrangements.

10. A transmission line over which sig-

5 naling currents are transmitted, said signaling currents being of a relatively high frequency and being interrupted in a periodic manner according to a predetermined relatively low frequency, and receiving means associated with said line, said receiving means comprising a circuit tuned to be exclusively responsive to said signaling currents, a slow operating relay controlled by

said circuit, and signaling means controlled 10 by said relay.

In testimony whereof we have signed our names to this specification this 16th day of November 1921.

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