J. MILLS.

FOUR-WIRE CIRCUIT.

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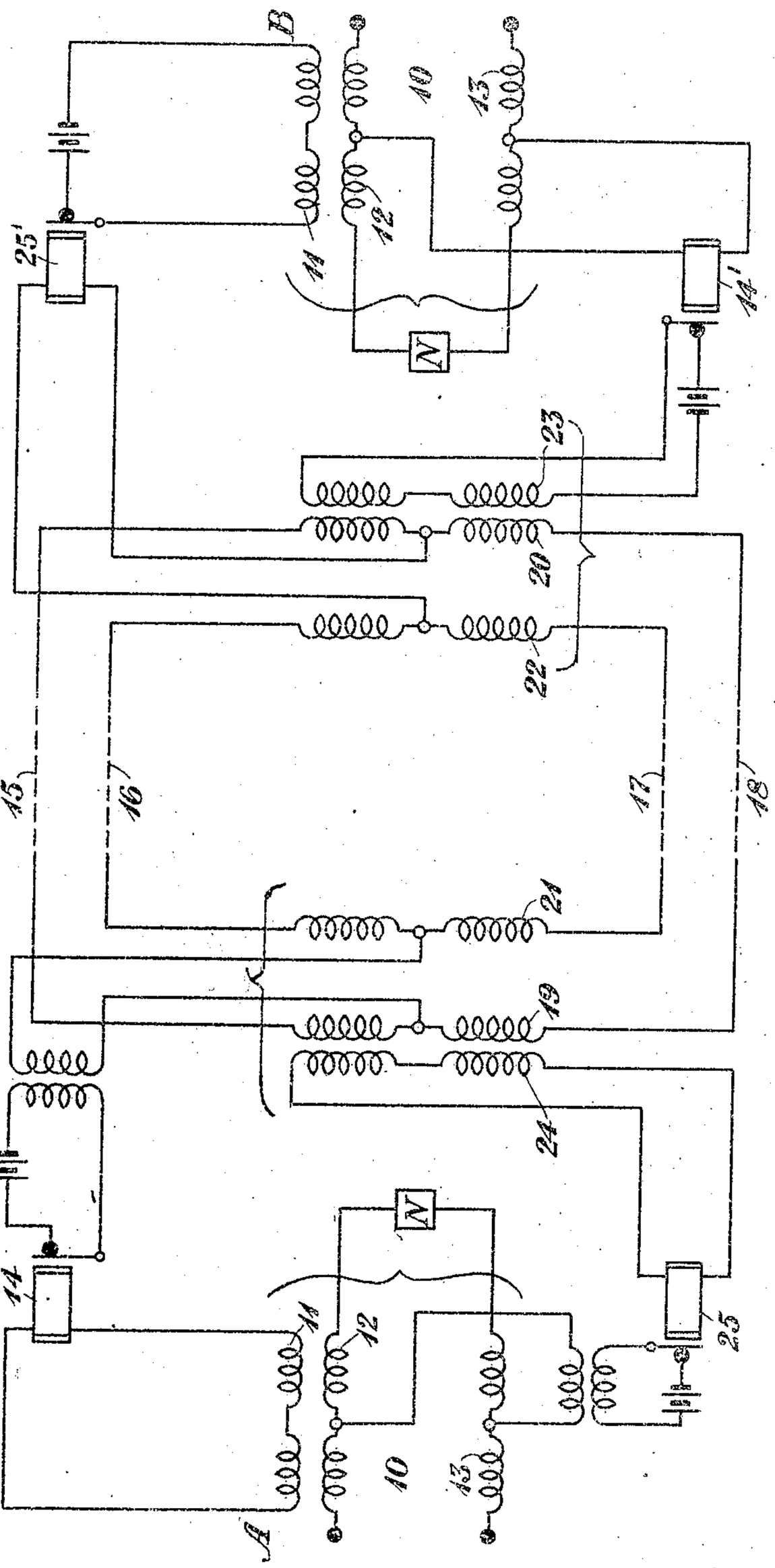
1,352,828.

Patented Sept. 14, 1920.



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Application filed June 7, 1918. Serial No. 238,715.

To all whom it may concern:

Be it known that I, JOHN MILLS, residing at Wyoming, in the county of Essex and State of New Jersey, have invented certain Improvements in Four-Wire Circuits, of which the following is a specification.

This invention relates to telephone transmission lines and especially to such as employ repeaters or amplifiers. One of its objects is to provide a circuit in which the total output of certain of the amplifiers is made available. Another object is to provide a circuit in which a greater degree of amplification than usual may be employed, and consequently a greater volume of voice currents, may be received without the introduction of the objectionable condition known as "singing" which limits the amplification in ordinary repeater circuits. Other objects of the invention will be apparent from the following description. In general the invention is characterized by the employment of four wires or conductors between two stations, and may be regarded as a variant of the four-wire circuit disclosed in the patent to Van Kesteren, 1,189,411, July 4, 1916, and that in the application of G. A. Campbell, Serial No. 72,606, filed January 17, 1916. It is, however, distinguished from other four-wire circuits by the fact that the talking currents in either direction travel over all four of the conductors of the circuit.

The invention will be more fully understood by reference to the accompanying sheet of drawings in which the single figure represents a system embodying my invention.

A and B represent telephone stations or terminals of the transmission line. In the embodiment of the invention here illustrated, there is provided at each station the ordinary transformer 10 used in connection with the usual two-way repeater sets, and here shown as having three windings 11, 12 and 13 in inductive relation. Network or artificial lines N are provided as usual in connection with these transformers to balance the telephone set or other apparatus connected to the terminals at A and B. This method of connection between the two-wire and four-wire parts of the circuit produce an advantage in the degree of amplification possible but is not essential to the practice of the invention, a simple parallel branching of the two-wire circuit such as shown in Van Kesteren above referred to being sufficient, as will appear hereinafter.

14 represents the outgoing repeater or amplifier at the station A, and 14′ the similar amplifier at station B. For convenience ordinary mechanical repeaters are here indicated, but it will be understood that amplifiers of any known description can be employed.

Between the two stations the line comprises four conductors, 15, 16, 17 and 18. Conductors 15 and 18 are joined to the terminals of transformer windings 19 and 20 located at opposite ends of the line so that with the windings they constitute the closed circuit. Conductors 16 and 17 are similarly connected to transformer windings 21 and 22. Transformer windings 20 and 22 may be regarded as secondary windings, both in inductive relation to the primary winding 23 located at station B, which receives the talking currents from that station through the amplifier 14′, and windings 19 and 21 may be regarded as primary windings both in inductive relation to the secondary winding 24 at station A which transmits the talking currents to that station through the auxiliary amplifier 25.

The outgoing connection from station A leads through the amplifier 14 to the four-wire circuit at the mid-points of the windings 19 and 21, and the incoming connection at station B leads from the mid-points of windings 20 and 22 to the auxiliary amplifier 25′ and to the station B in the well known manner. A given current impulse arising in station A will, then, pass to the center of the secondary winding 19 where it divides equally between the conductors 15 and 18. Traveling these in parallel and reuniting at the center point of transformer winding 20 the current passes through the repeater 16 back to the mid-point of winding 22, thence in parallel through the conductors 16 and 17 to the center point of winding 21 and to the source from which it started. A given current impulse emanating from the station B passes through the transformer winding 23 which induces like impulses in the windings 20 and 22. These impulses travel in separate circuits 16—17 and 15—18 respectively each passing through a transformer winding 19 or 21 at the opposite end of the line. These wind-

ings coöperate in inducing a corresponding impulse in the winding 24 whence it passes to the station A through the amplifier 25.

It will be observed from the circuits above traced that talking in either direction is accomplished over all four wires of the four-wire circuit.

In such a circuit as this, even without the use of the balancing networks N and the transformers 10, 11, 12 used in connection therewith, the amplification of the current may be made such as to produce at the receiving end nearly or quite as strong a talking current as is sent out at the opposite end of the line. The degree of amplification possible in the ordinary repeater circuit is very limited owing to the impossibility of accurately and fully balancing the line at the repeater station by the artificial network, and singing will result if the amplification is made unduly great. With the circuit hereinabove described, even disregarding the degree of balance obtained by networks N, there will be no singing if the total attenuation of the two circuits between A and B is greater in any degree than the sum of the gains of the one-way amplifiers. By using a fair degree of balance at N. N. an even high amplification may be had without "singing" so that stronger talking currents may be received than are emitted at the sending station.

What I claim is:

1. A transmission system comprising two pairs of conductors extending between stations a connection at one station delivering current substantially equally to said pairs in parallel, a connection at another station delivering current to two circuits in parallel each of which comprises one conductor of each of said pairs, means at each station for taking off current delivered by the other, and amplifiers for the currents traveling in either direction.

2. A transmission system comprising two pairs of conductors extending between two stations an amplifier at one station delivering current equally to said pairs in parallel an amplifier at the other station delivering current to two separate circuits in parallel each of which comprises one conductor of each of said pairs, and means at each station for taking off the current delivered at the other.

3. In a transmission system for connecting a plurality of stations a two-wire circuit at each station four conductors extending between the stations, an outgoing connection at each station for uniting the two-wire circuit with the four conductors in a definite relation, different at each station and an incoming connection at each station uniting the two-wire circuit with the four conductors in a relation corresponding at any station to the outgoing connection at another station whereby all four conductors transmit signals in either direction, and an amplifier in the circuit at each station.

4. A transmission line comprising four conductors extending between stations, a one-way amplifier at each station, electrically connected on one side to all four of said conductors and on the other side to the station and another connection from each station to said four conductors, the connection of said amplifiers to the four conductors being different at each station and each corresponding to the said other connection at a different station.

5. In a transmission system for connecting two signal stations, an incoming and an outgoing connection at each station, at least one amplifier at each station located in said connections, two complete loops extending between the stations and means, uniting said loops and said connections, for distinguishing between currents originating at different stations whereby signal impulses from the outgoing connection at one station enter only the incoming connection at the other station.

6. In a transmission system for connecting two signal stations, a two-wire circuit at each station, two pairs of conductors extending between the stations, transformer windings bridging the respective pairs at each station, an outgoing connection from one station having a conductor running to the mid-point of each of said transformer windings at that station and an incoming connection at the other station having similar connection to the transformer windings at that station, an outgoing connection from said other station having a winding in inductive relation to each of the said transformer windings at that station and an incoming connection at the first named station having similar relation to the transformer windings of said first named station, and one-way amplifiers located in said connections.

In testimony whereof, I have signed my name to this specification this 31st day of May 1918.

JOHN MILLS.