

Oct. 28, 1930.

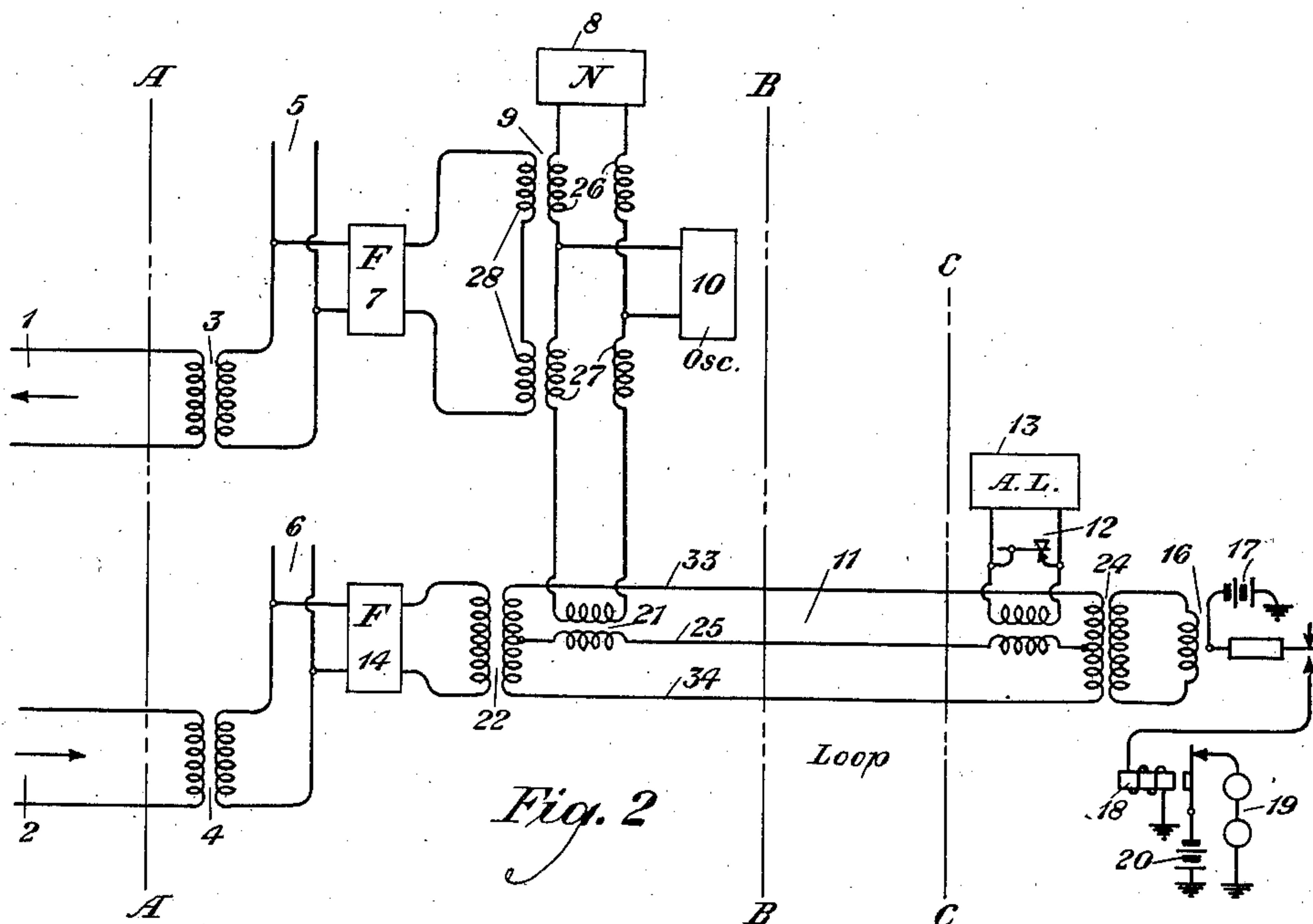
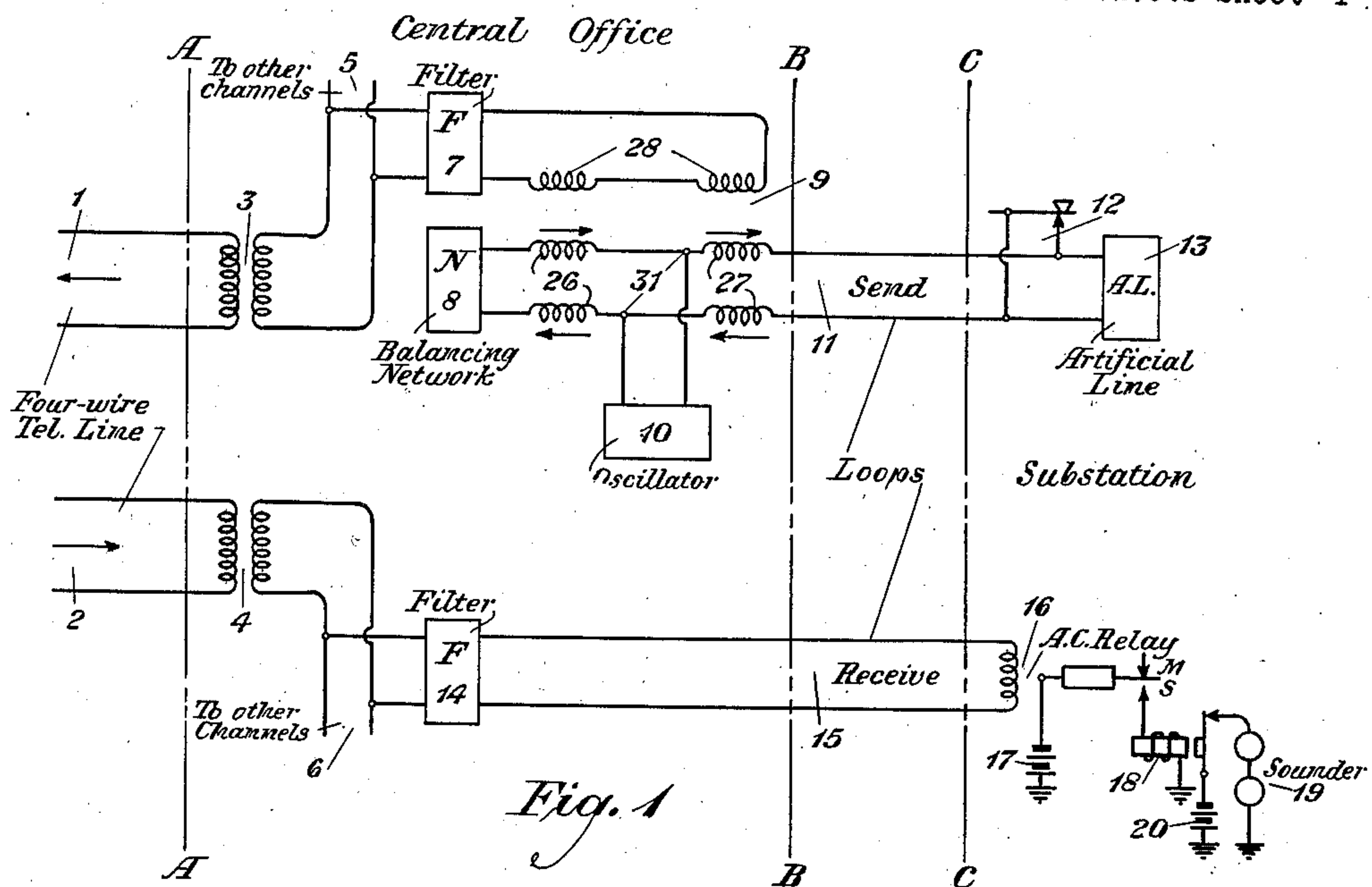
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1,779,493

CARRIER CURRENT TELEGRAPH SYSTEM

Original Filed March 7, 1929

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

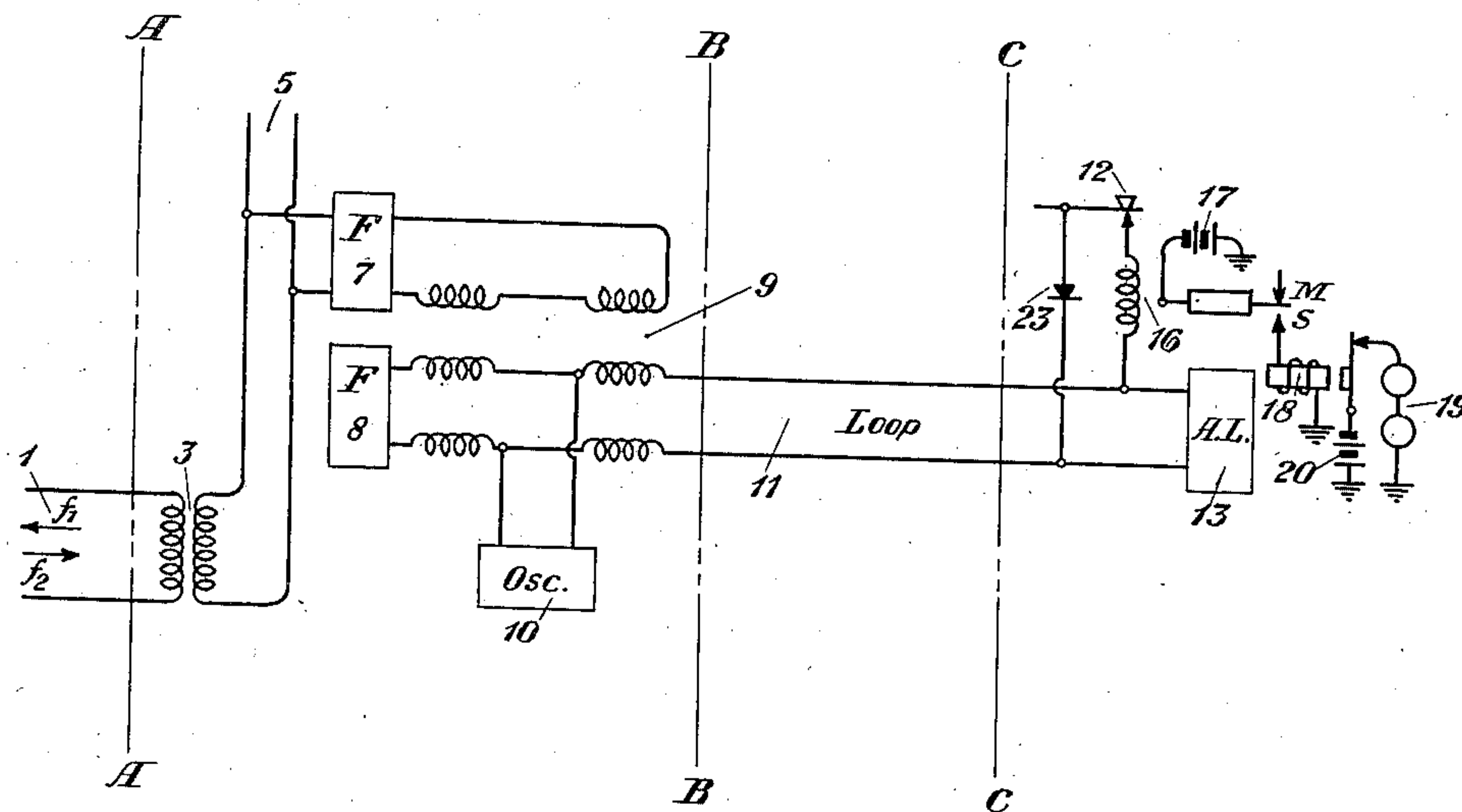


Fig. 3

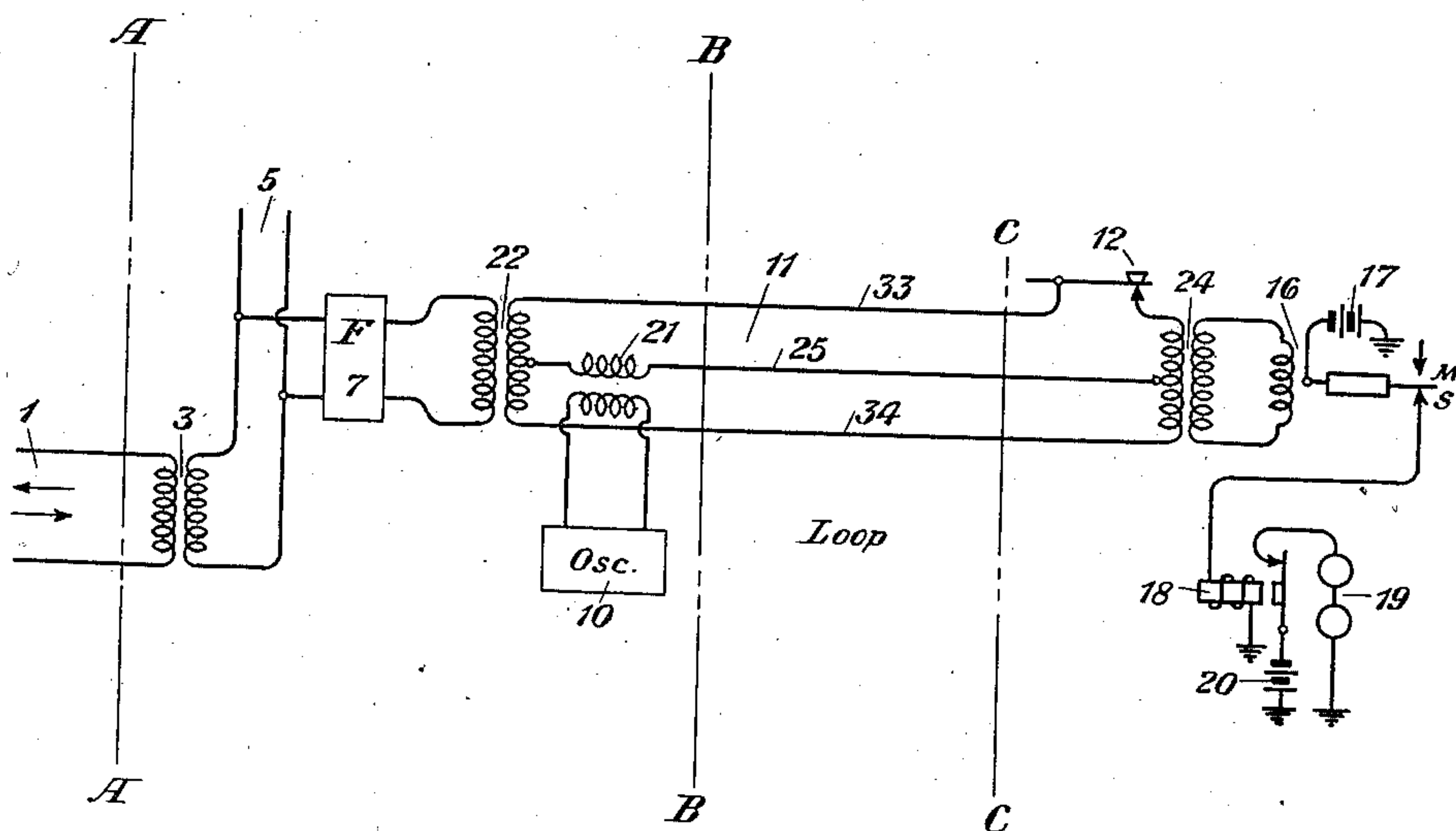


Fig. 4

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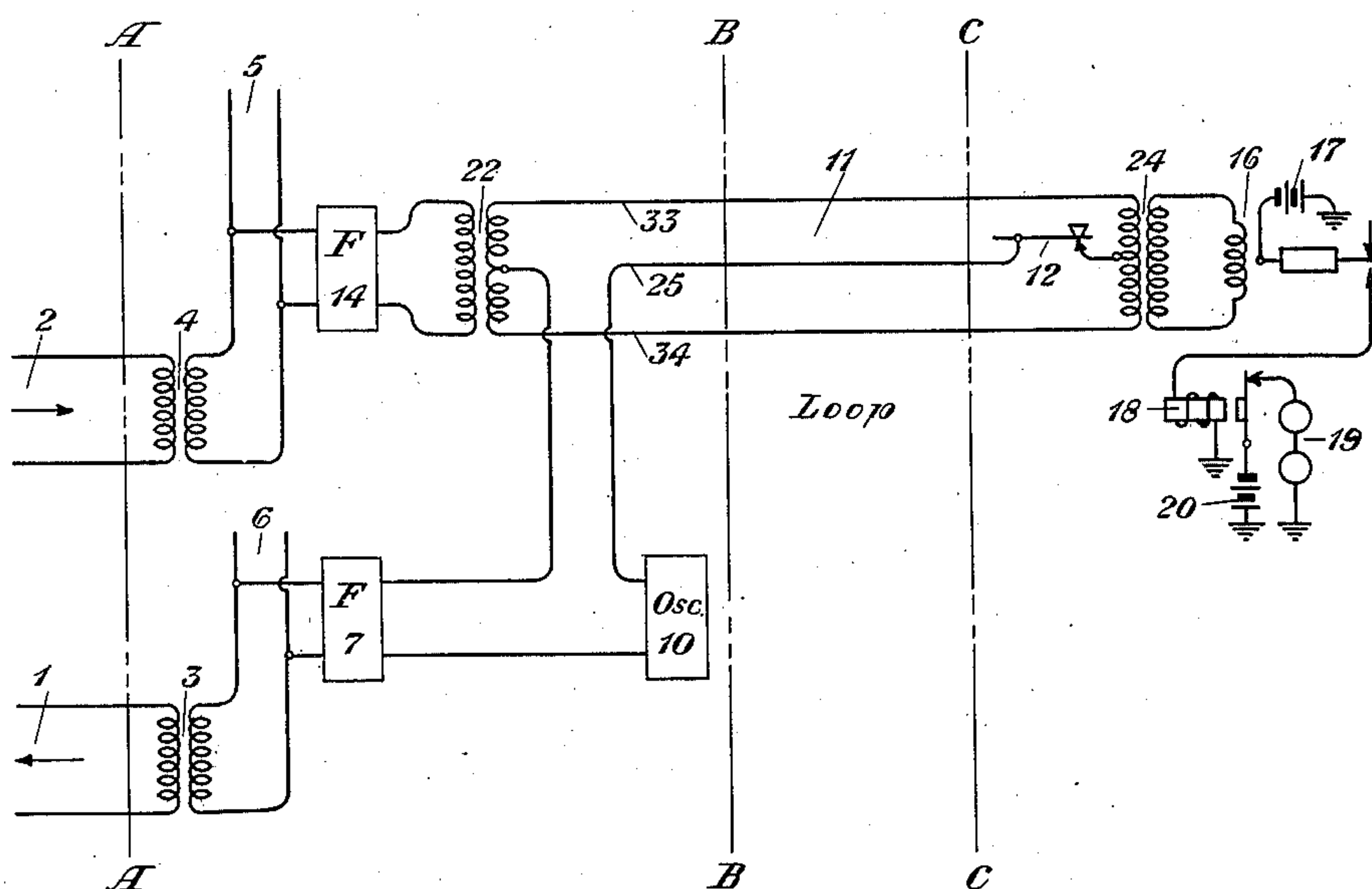


Fig. 5

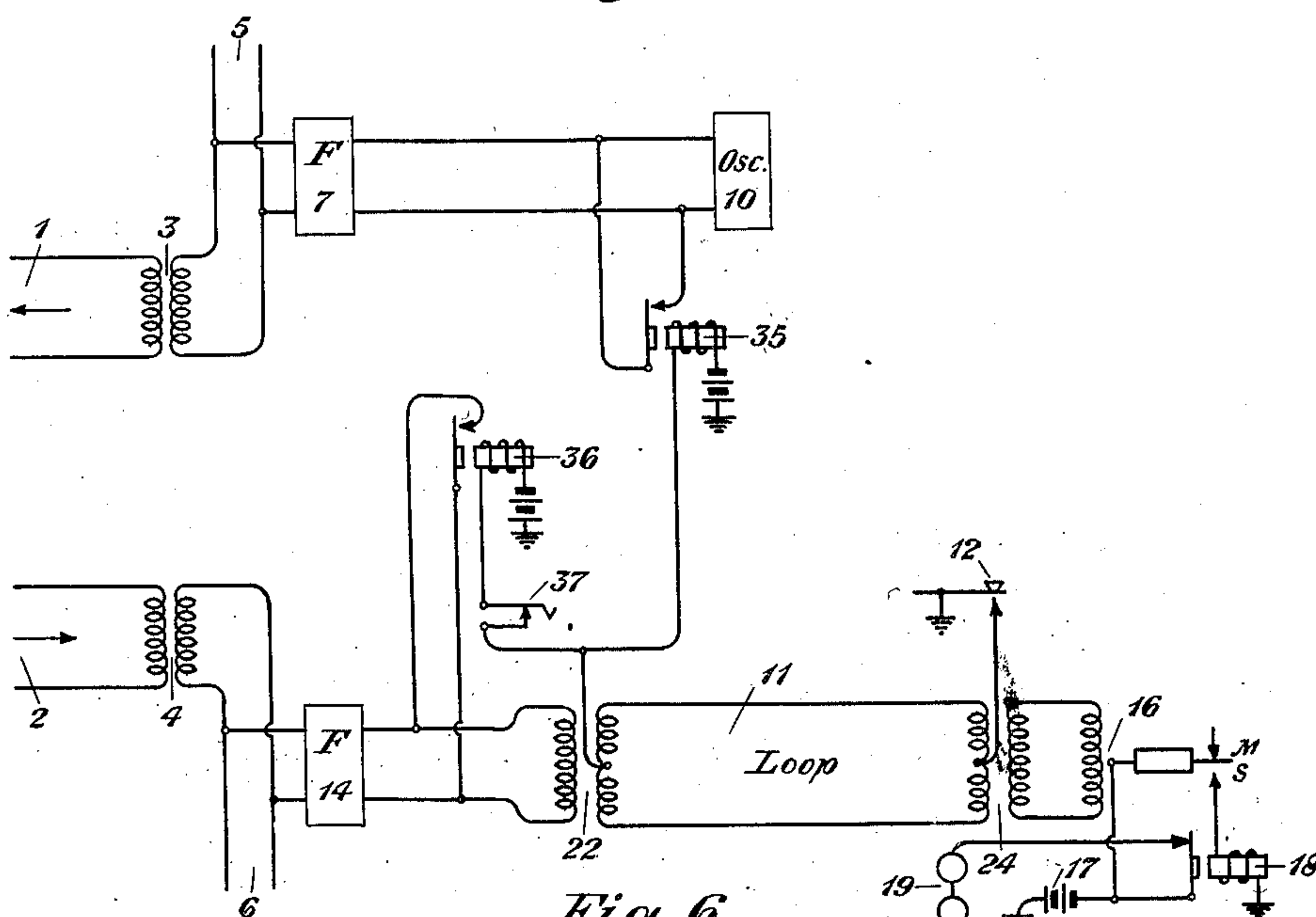


Fig. 6

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CARRIER-CURRENT TELEGRAPH SYSTEM

Original application filed March 7, 1929, Serial No. 345,057. Divided and this application filed April 11, 1930. Serial No. 443,429.

This invention relates to telegraph systems, and more particularly to telegraph systems which employ so-called "carrier currents" for transmitting signals, and discloses novel means applicable to such systems whereby the carrier current is transmitted directly to the subscriber's stations to operate telegraph means thereat without recourse to direct current signaling over the subscribers' loop circuits which is the method now in use.

As is well known, a carrier current telegraph system comprises means whereby a single telegraph line extending between two distant points or cities may be adapted to furnish a plurality of distinct telegraph channels such that a number of telegraph stations located in one city may communicate simultaneously with other stations individual thereto in the second city without interference between the various communications.

At each city, the carrier telegraph line terminates in a central office and is connected thereat through certain well-known filter arrangements to a number of loop circuits extending to the various subscribers' stations. Telegraph signaling is accomplished through the medium of pulses of alternating current of a distinct frequency for each channel, transmitted under control of sending means at a subscriber's station. The received pulses of carrier current in turn operate suitable receiving means at the proper subscriber's station. The filters associated with the loops serve the purpose of directing the various signaling frequencies along their proper channels.

In accordance with the present practice, the carrier signaling currents comprising the pulses of alternating current are transmitted only over the telegraph line proper which extends between the central offices. Signaling over the loop circuits has in the past been accomplished by means of well-known direct current operated telegraph equipment. The change from carrier current to direct current signaling, or vice versa, at the central stations requires the use of a considerable amount of expensive equipment which could be eliminated by transmitting the carrier current over the loop circuit directly to the sub-

scriber's station to operate suitable signaling means thereat.

In the present invention, a number of novel circuit arrangements are disclosed in which the carrier current signals are transmitted to the subscriber's station and control the operation of a suitable alternating current relay thereat. The source of carrier current is, in each case, located at the central station, but is controlled from sending means located at the corresponding subscriber's station.

This is a division of applicant's copending application Serial No. 345,057, filed March 7, 1929.

The various modifications disclosing the invention are best explained by reference to the drawings, of which:

Figure 1 shows a full duplex arrangement of a four-wire carrier current telegraph system in which the carrier current is transmitted directly between the subscribers' stations over the loop circuits. In this modification, each subscriber's station requires separate sending and receiving loops.

Fig. 2 shows a second modification employing alternating current signaling on the loops as applied to a full duplex four-wire system. In this case, the sending and receiving loops are combined in a three-conductor circuit.

Fig. 3 shows a half-duplex arrangement for a two-wire system. A single subscriber's loop is used for transmitting and receiving. In this modification, the carrier current comprises two distinct frequencies which are demodulated at the receiving station and the beat note utilized for operating the receiving relay.

Fig. 4 shows a half-duplex, two-wire system utilizing a three-conductor loop.

Fig. 5 shows a full-duplex, four-wire system which utilizes a three-conductor loop.

Fig. 6 shows a system applicable to a four-wire telegraph line, which may be operated full or half-duplex, as desired, by operating a key switch. In this modification, direct current signaling is utilized for the sending loop and alternating current for the receiving loop.

In all of the drawings, the same designa-

tion has been utilized for a given element throughout insofar as this is possible.

Referring to Fig. 1, a portion of a four-wire carrier telegraph line extending to a distant point is shown to the left of the line AA. The portion of the drawing between lines AA and BB represents a central office at which the near end of the carrier telegraph line terminates, and shows the manner in which the carrier line is connected through certain intermediate apparatus to a loop circuit extending to a local subscriber's telegraph station. The loop circuits comprise the portion between lines BB and CC, while the subscriber's station is shown to the right of line CC.

At the central station, an oscillator 10 is connected to the midpoints 31 of a hybrid coil 9, to windings 27 of which is connected a sending loop 11 extending to the subscriber's station. At the subscriber's station loop 11 is terminated in an artificial line 13 which simulates the characteristic or surge impedance of the loop. The left windings 26 of the hybrid coil 9 are connected to a balancing network 8 which matches the impedance of the loop circuit 11 as viewed from the central office, and with key 12 at the subscriber's station open. A band-pass filter 7, adapted to pass the frequency generated by oscillator 10, is connected to the secondary windings 28 of the hybrid coil. The primary windings of the hybrid coil 9 are connected series-aiding for currents flowing as shown by the arrows. The secondary windings of the coil are connected series-aiding. The output terminals of filter 7 are connected through transformer 3 to line 1 of the four-wire telegraph line, which constitutes the circuit for sending to the distant point, as indicated by the arrow.

The circuit for receiving from the distant point comprises line 2 which is connected through transformer 4 to the input terminals of a band-pass filter 14 adapted to transmit a suitable frequency transmitted from an oscillator located at the distant central office. The output terminals of filter 14 are connected to the receiving loop 15 which extends to the subscriber's station. At the subscriber's station, loop 15 terminates in a relay 16 which is operable by pulses of alternating current. Relay 16 controls the operation of receiving equipment at the subscriber's station as is explained below.

The operation of the telegraph system is as follows: Associated with the sending loop 11 at the subscriber's station is a sending key 12 which, with the key closed, connects a short circuit across the loop. When the key is open, however, the loop is terminated in its characteristic impedance by means of artificial line 13. With key 12 open, current supplied from oscillator 10 divides equally at terminals 31 with half of the current flowing into the net-

work 8 and the other half flowing into the loop circuit 11. The equal currents thus flowing in windings 26 and 27 set up equal and opposed fluxes with the result that no voltage is induced in windings 28, and hence no current is transmitted from oscillator 10 over line 1. With key 12 closed, the artificial line 13 is short-circuited and hence the loop impedance as seen from the terminals of windings 27 becomes considerably smaller than that of network 8. As a result, more current flows in windings 27 than in windings 26, thus producing a resultant effect in winding 28, which causes current of the oscillator frequency to be transmitted through filter 7 and over line 1 to the distant station.

At the distant point, line 1 will be terminated in a receiving circuit identical with that shown connected to line 2 of Fig. 1. It can be assumed, therefore, that current sent out as above over line 1 is received at the distant point over a line 2. The received current incoming over line 2 flows through transformer 4, through band-pass filter 14, and over the receiving loop 15, to the distant subscriber's station. At the subscriber's station, current received over loop 15 flows through the alternating current relay 16 and operates the same against its marking contact M, as shown on the drawing. When no current is being received, due to the opening of key 12 at the sending station, relay 16 will be operated against its spacing contact S.

With relay 16 in its marking position, as shown, a circuit is completed from battery 20 through the armature and back contact of relay 18, and through telegraph sounder 19 to ground, thus operating the sounder against its marking contact. When relay 16 is operated against its spacing contact S, current from battery 17 flows through the armature and spacing contact of relay 16 and the winding of relay 18 to ground, thus operating the latter. The operation of relay 18 disconnects battery 20 from sounder 19 and thus causes the sounder to be operated against its spacing contact.

From the above description, it is thus apparent that operation of the sending key 12, by unbalancing the hybrid coil bridge, causes pulses of alternating current to be transmitted over the telegraph line to a distant point and then over a receiving loop to a subscriber's station to operate an A. C. relay thereat in accordance with the pulses of current received. The A. C. relay in turn controls the operation of D. C. telegraph means at the subscriber's station.

In Fig. 1, only one subscriber's station has been shown, having the loops associated therewith connected through filters 7 and 14, respectively, to the telegraph line. It is to be understood, however, that a plurality of subscribers' stations would be similarly connected to telegraph lines 1 and 2. The sending loops

from the various subscribers' stations would all be connected in multiple to conductors 5, while the receiving loops would be similarly connected to conductors 6. Each sending loop would be equipped with a source of oscillating current 10 having a different frequency of oscillation for each such loop. A band-pass filter 7 would be inserted in each sending loop to transmit current of the frequency generated by the corresponding oscillator only. Each receiving loop would be equipped with a band-pass filter 14 adapted to transmit only the current transmitted from the distant sending loop associated therewith. Thus the filters divide the telegraph system up into a number of distinct channels which use the telegraph line in common.

The sending key 12 and the sounder 19 of Fig. 1 are shown merely for convenience. Any other type of telegraph sending and receiving means could, of course, replace them, such as a printing telegraph sending and receiving unit.

Relay 16 could, of course, be any suitable type of relay operable by alternating current of the carrier frequency. It is suggested, however, that a relay of the type disclosed in U. S. Patent No. 1,579,887, to E. J. Pratt, April 6, 1926, or that disclosed in U. S. patent application, Serial No. 320,799, filed November 21, 1928, by E. J. Pratt, would be best adapted for use in the present instance. The relays disclosed in the references cited are very sensitive types of relays which are operable by alternating current within the voice frequency range, and hence would fit in well with the well-known voice frequency carrier telegraph system.

The system disclosed in Fig. 1 operates full-duplex since for each station the sending circuit is independent of the receiving circuit.

In Fig. 1, four conductors were required for each subscriber's loop circuit. Fig. 2 shows a full-duplex system as applied to a four-wire carrier telegraph line which requires only three conductors for connecting each subscriber's station with the central office.

In Fig. 2, windings 27 of hybrid coil 9 are connected through transformer 21 to conductor 25, comprising one of three conductors 11 extending to the subscriber's station. At the subscriber's station, conductor 25 is connected through transformer 32 with sending key 12 and artificial line 13. Otherwise, the sending circuit is unchanged from Fig. 1.

The receiving circuit extends from line 2 through filter 14, through balancing coil 22 and over conductors 33 and 34 to the subscriber's station, and thence through balancing coil 24 to the receiving relay 16. Conductor 25 is connected to the midpoints of coils 22 and 24, as shown.

The balancing network 8 is so designed that with key 12 open, equal and opposed currents flow from oscillator 10 into windings 26 and 27, respectively, of coil 9, thus producing no resultant effect in the secondary windings 28. With key 9 closed, however, the current flowing in windings 27 becomes greater than in windings 26, thus inducing a voltage in windings 28.

The current flowing in windings 27 is transmitted through transformer 21 to lead 25. The current in lead 25 divides at the midpoints of transformers 22 and 24, respectively, so that half of the total current flows through the upper portion of the primary winding of each transformer and half through the lower winding. As a result, no voltages are induced in the secondary windings to operate relay 16 or to flow back through filter 14.

Signaling currents received over line 2 are transmitted through filter 14, transformer 22, over loop conductors 33 and 34 to the subscriber's station, and through transformer 24 to operate relay 16. The received signaling currents do not flow through transformer 21 into the sending circuit since conductor 25 is connected between equipotential points on transformers 22 and 24.

From the above, it will be seen that for a given subscriber's station, the sending and receiving channels are independent of each other and hence the system operates full duplex.

Fig. 3 discloses a two-wire half-duplex system with a two-conductor loop extending from the central office to a given subscriber's station. This system operates by modulating at the subscriber's station a pair of high frequency carrier currents and utilizing the difference frequency to operate the relay 16. Either current alone is too high in frequency to operate relay 16. Current of one frequency is supplied to the local relay 16 from the local oscillator while current of the second frequency is supplied from the distant oscillator.

Referring to the drawing, with key 12 open, the hybrid coil 9 is balanced so that no current from oscillator 10 gets out onto line 1, and also no current flows through the local relay 16 since its winding is in series with the contacts of key 12. With key 12 closed, current from the local oscillator is transmitted over line 1 and also through the winding of the local relay 16 and the modulator 23 in series therewith. The current from the local oscillator alone and the modulated components thereof are, however, of too high a frequency to operate the local relay 16.

The system of operation can best be explained by considering what is occurring simultaneously at both ends of a given carrier channel. For example, assume that the local oscillator 10 associated with a given

channel generates a frequency f_1 while the corresponding oscillator at the distant station generates a frequency f_2 . With keys 12 at both stations open, relays 16 at both stations are operated against their spacing contacts since no current can flow through the winding of either due to the open circuit at the contacts of the corresponding key 12.

With key 12 closed, say at the local station, and open at the distant station, relays 16 remain operated against their spacing contacts S, since the distant relay 16 receives no current, while the local relay 16 receives current of frequency f_1 only. If, however, keys 12 at both stations are closed, current of frequency f_1 from the local oscillator flows through the relays 16 at both stations, and simultaneously therewith, current of frequency f_2 from the distant station flows through both relays 16. The frequencies f_1 and f_2 are thus intermodulated by modulating elements 23, and the resulting difference frequency $f_3 = f_1 - f_2$ flowing through the winding of each relay 16 operates the same against its marking contact M.

In a specific case, the frequency of the local oscillator might be 4,000 cycles and that of the corresponding distant oscillator 4,500 cycles. In this case, the difference frequency which operates the relay 16 would be 500 cycles.

The system necessarily operates half-duplex since the position of relays 16 at both the local and distant stations depends on the operated condition of the sending keys 12 at both stations. Either station may "break" by holding key 12 open.

Fig. 4 shows a two-wire half-duplex system utilizing three-conductor loops to the subscribers' stations. The oscillator 10 is connected through transformer 21 to the central lead 25, which latter is connected to the mid-points of the primary windings on transformers 22 and 24, respectively.

With key 12 closed, no current is transmitted to the local relay 16 or over line 1, due to the balanced bridge arrangement of transformers 22 and 24. Assuming key 12 likewise closed at the distant station, both relays 16 thus are operated against their spacing contacts. With key 12 open, the bridge arrangement becomes unbalanced and currents are induced in the secondaries of transformers 22 and 24, the one being transmitted to the distant station over line 1 and the other operating the local relay 16 against its marking contact M. At the distant station, the current incoming over line 1 flows through transformer 22 and over loop conductors 33 and 34 and through transformer 24 to operate the relay 16 thereat against its marking contact. The received signaling current produces no effect in the oscillator circuit since conductor 25 is connected between equipotential points on transformers 22 and 24. If

keys 12 are open at both stations, current from the local and distant oscillators is transmitted to each of relays 16 operating the same against their marking contacts. The system is, of course, half-duplex since the opening of either key 12 "breaks" the message being transmitted.

Fig. 5 shows a full-duplex arrangement as applied to a four-wire system. The arrangement of the subscriber's loop is somewhat similar to Fig. 4. In Fig. 5, key 12 is connected in lead 25. The oscillator 10 is connected directly to filter 7, the upper conductor including the subscriber's loop circuit in series therewith. With key 12 closed at the local station, current from oscillator 10 flows out to the distant station over line 1. This current flows in the loop circuit at the local station but it does not affect the operation of the local relay 16 or cause current to be transmitted over line 2 due to the balanced bridge arrangement of transformers 22 and 24.

The current thus transmitted from the local station comes in over a receiving circuit 2 at the distant station and flows through filter 14 and over the loop circuit thereat to operate relay 16 against its marking contact, as shown. When key 12 at the local station is opened, it disconnects the oscillator from line 1, thereby interrupting the current transmission to the distant station which causes relay 16 thereat to move against its spacing contact. In the same manner, the operation of key 12 at the distant station controls relay 16 at the local station. Transmission in one direction is thus independent of that in the other and the system thus operates full-duplex. The received current produces no effect in the oscillator circuit since the latter is connected between equipotential points on transformers 22 and 24.

Fig. 6 shows a four-wire system which may be operated half-duplex or full-duplex, as desired, by suitably operating key 37. This system utilizes direct current telegraph equipment for sending over the loop circuit, but on receiving the carrier current is transmitted directly to the subscriber's station as before.

With key 37 in the position shown, the system operates half-duplex. With key 12 open, local oscillator 10 transmits current to the distant station to operate relay 16 thereat against its spacing contact. At the same time, with key 12 at the distant station open, current is transmitted therefrom which flows in over loop 11 and operates the local relay 16 against its marking contact.

If, now, local key 12 is closed, it completes direct current paths to ground at the key contacts traced over the loop circuit to operate relays 35 and 36. The operation of relay 35 short circuits the output of local oscillator 10 and thus interrupts the flow of current to the distant station, thereby causing relay 16 thereat to move against its spac-

ing contact. At the same time, the operation of relay 36 short circuits the input to loop 11, and thus interrupts the flow of current transmitted from the distant station to the local relay 16 thereby causing this relay also to move against its spacing contact. In a similar manner, operation of key 12 at the distant station controls the relays 16 at both stations. The system thus operates half-duplex.

With key 37 operated, relay 36 is disconnected from the local key 12 and hence no longer operates in accordance therewith. Thus, local key 12 now controls only the operation of the distant relay 16, while key 12 at the distant stations controls only relay 16 at the local stations. The system thus operates full-duplex.

What is claimed is:

1. A telegraph system comprising in combination, a transmission circuit, a loop circuit associated with said transmission circuit at a certain point and extending to a telegraph station, a source of alternating signaling current associated with said transmission circuit at said point, and a direct current circuit including a sending means at said station, both sides of said loop circuit parallel and relay means at said point, for controlling the transmission of signals from said source to said transmission circuit.

2. A telegraph system comprising in combination, a transmission circuit, a loop circuit connected to said transmission circuit at a certain point and extending to a telegraph station, a source of alternating signaling current associated with said transmission circuit at said point, and a direct current simplex circuit including a sending means at said station, said loop circuit and relay means at said point, for controlling the transmission of signals from said source to said transmission circuit.

3. A telegraph system comprising in combination, a transmission circuit, a loop circuit connected thereto at a central office and extending to a branch telegraph station, telegraph receiving means at said branch station, impedance elements bridging said loop circuit at said central office and at said branch station, respectively, direct current sending means connected to the midpoint of said impedance element at said branch station, a source of alternating current at said central office for transmitting alternating current signals over said transmission circuit, and relay means at said central office controlled by said sending means for controlling the output of said current source.

4. A telegraph system comprising in combination, a transmission circuit connecting a plurality of central offices, a plurality of loop circuits connected thereto at each central office and extending to telegraph stations, telegraph receiving means at each station, means at each station responsive to al-

ternating signaling current for operating said receiving means, impedance elements bridging each loop at each central office and at each telegraph station, respectively, relay means connected to the midpoint of each impedance element at each central office, direct current sending means for controlling said relay means connected to the midpoint of the impedance element at each telegraph station, a source of alternating signaling current for each loop circuit associated with said transmission circuit at each central office, and means at each central office responsive to said relay means for controlling the output of the corresponding current source thereat.

5. A telegraph system comprising in combination, a transmission circuit, a loop circuit connected thereto at a central office and extending to a telegraph station, a filter interposed between said transmission circuit and said loop circuit at said central office for transmitting received signaling current of a definite frequency, a relay terminating said loop at said station and responsive to alternating signaling current, telegraph receiving means thereat responsive to said relay, direct current conductive impedance elements bridging said loop at said central office and at said telegraph station, respectively, relay means connected to the midpoint of said impedance element at said central office, direct current sending means for controlling said relay means connected to the midpoint of said impedance element at said station, a current source of definite frequency connected to said transmission circuit through filter means for transmitting said current, and means responsive to said relay means for controlling the output of said current source.

6. A telegraph system comprising a transmission circuit, a loop circuit connected thereto at a central office and extending to a telegraph station, a filter interposed between said transmission circuit and said loop for transmitting received signaling current of a definite frequency, a relay terminating said loop at said station responsive to alternating signaling current, telegraph receiving means thereat responsive to said relay, direct current conductive impedance elements bridging said loop at said central office and telegraph station, respectively, relay means connected to the midpoint of said impedance element at said central office, direct current sending means for controlling said relay means connected to the midpoint of said impedance element at said station, a current source of definite frequency connected to said transmission circuit through filter means for transmitting said current, means responsive to said relay means for controlling the output of said current source, means responsive to said relay means for

controlling the loop reception of said received signaling current whereby said system operates half-duplex, and a key switch associated with said relay means for preventing said last mentioned operation whereby said system operates full-duplex.

In testimony whereof, I have signed my name to this specification this 10th day of April, 1930.

WILTON T. REA.