

June 10, 1930.

R. C. MATHES

1,763,169

SOUND RECORDING

Filed Sept. 23, 1926

3 Sheets-Sheet 1

Fig. 1.

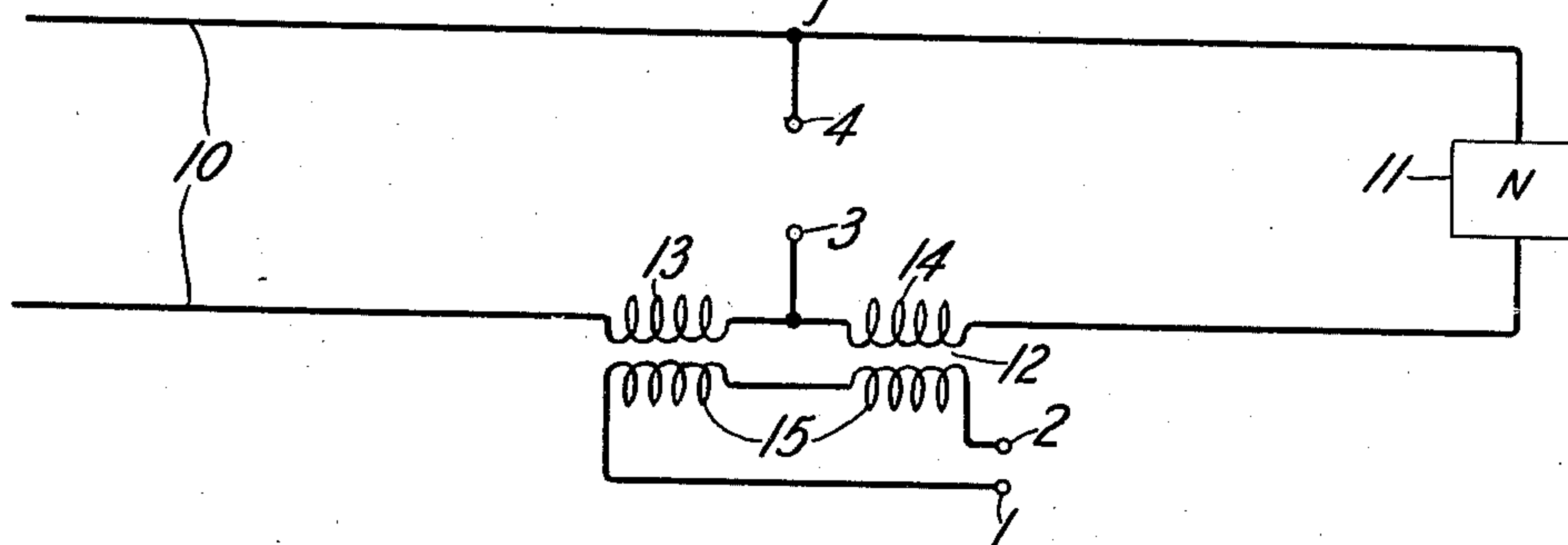


Fig. 2.

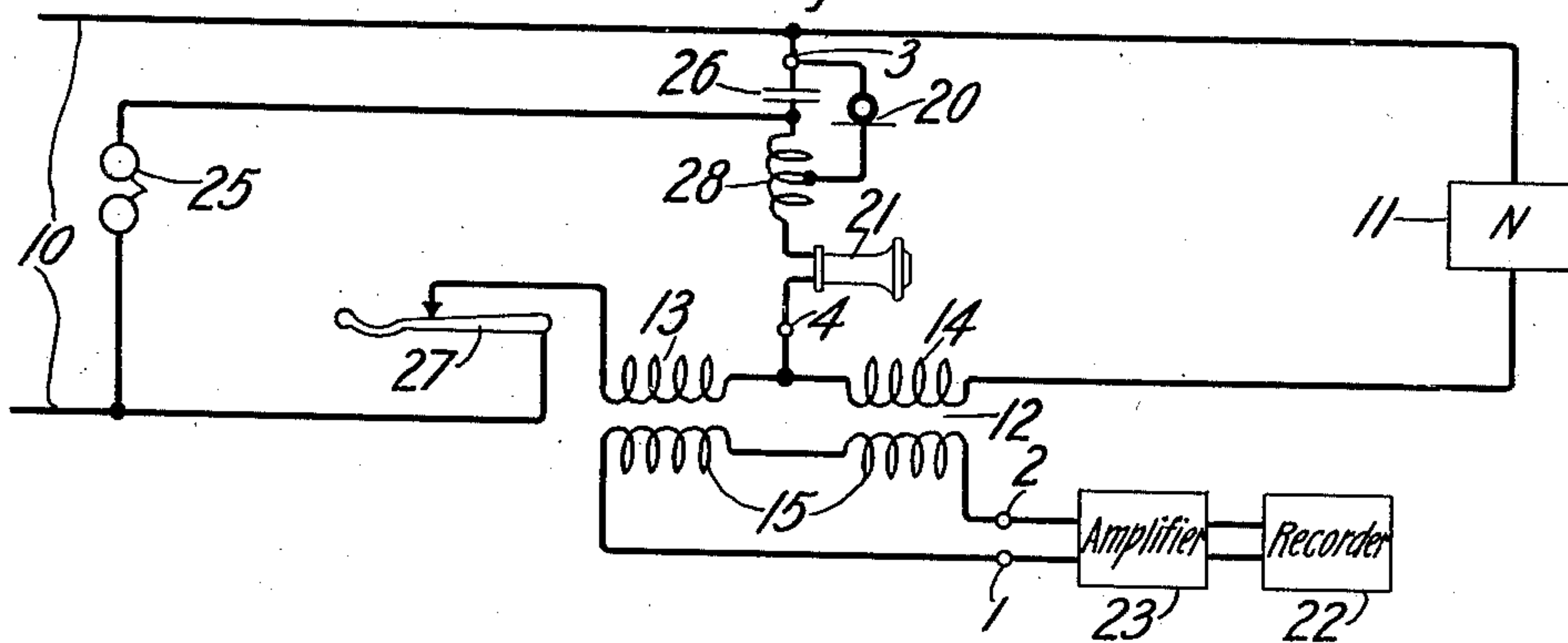
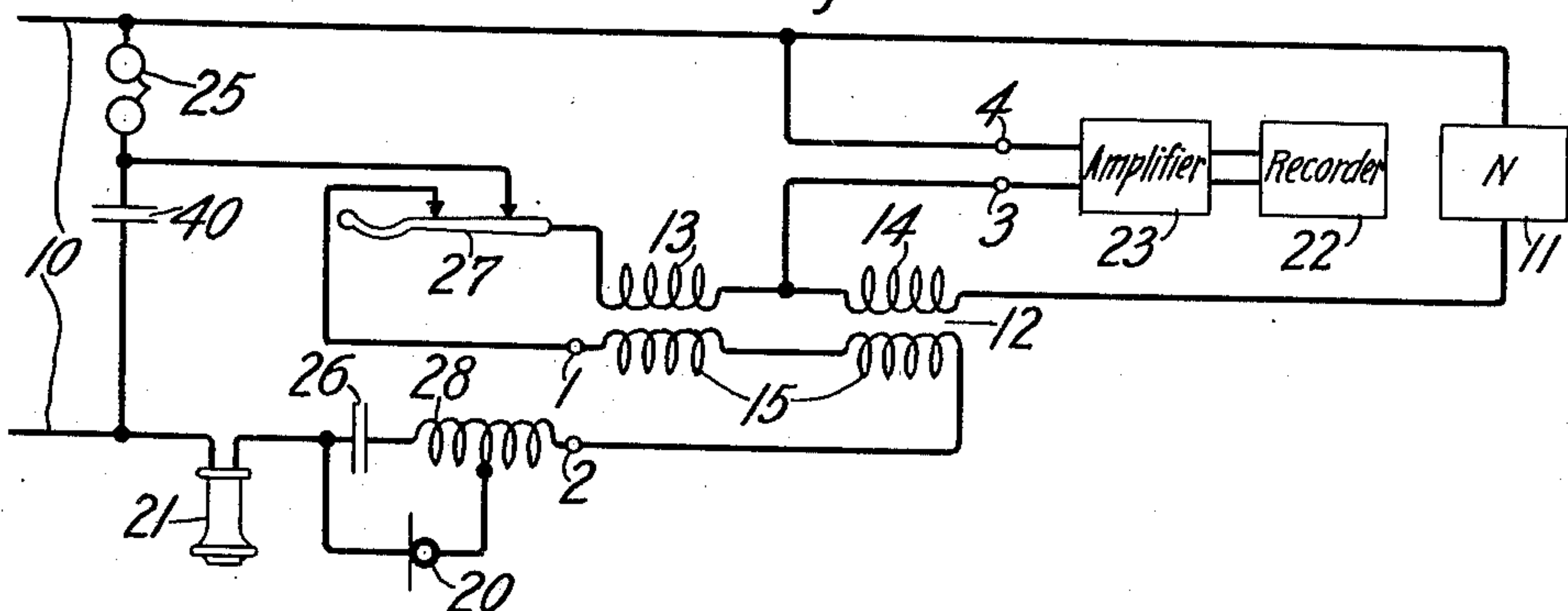


Fig. 3.



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Fig. 4.

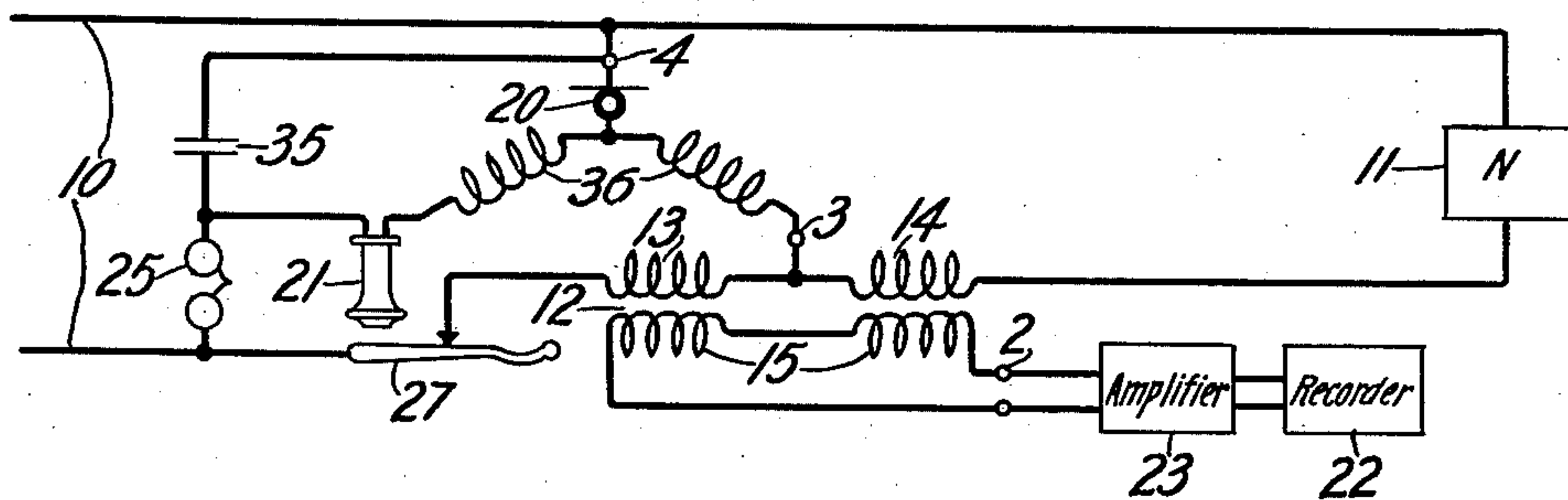


Fig. 5.

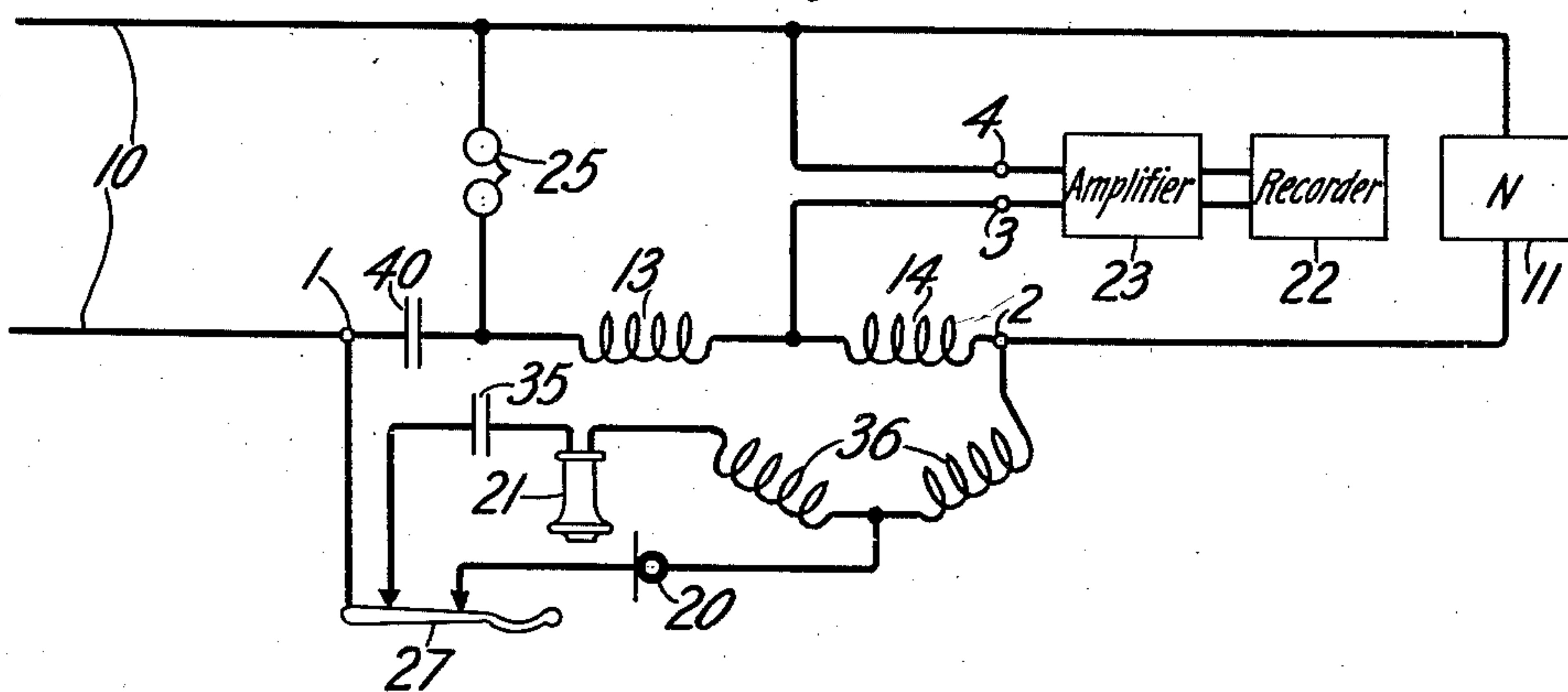
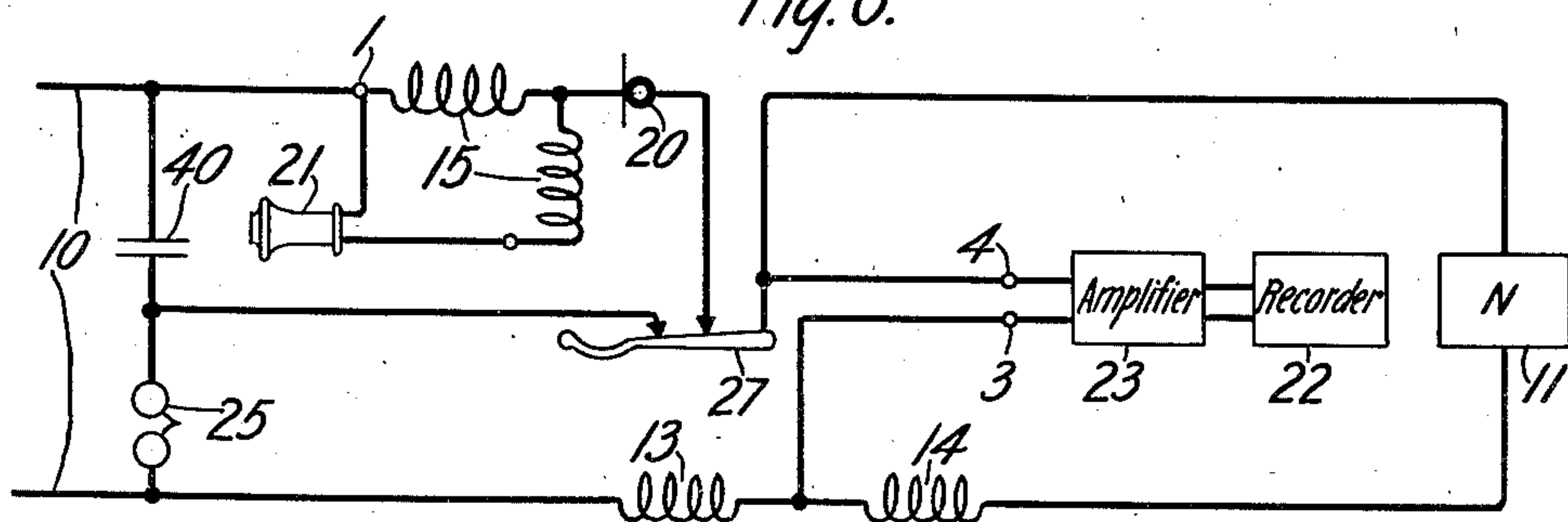


Fig. 6.



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3 Sheets-Sheet 3

Fig. 7.

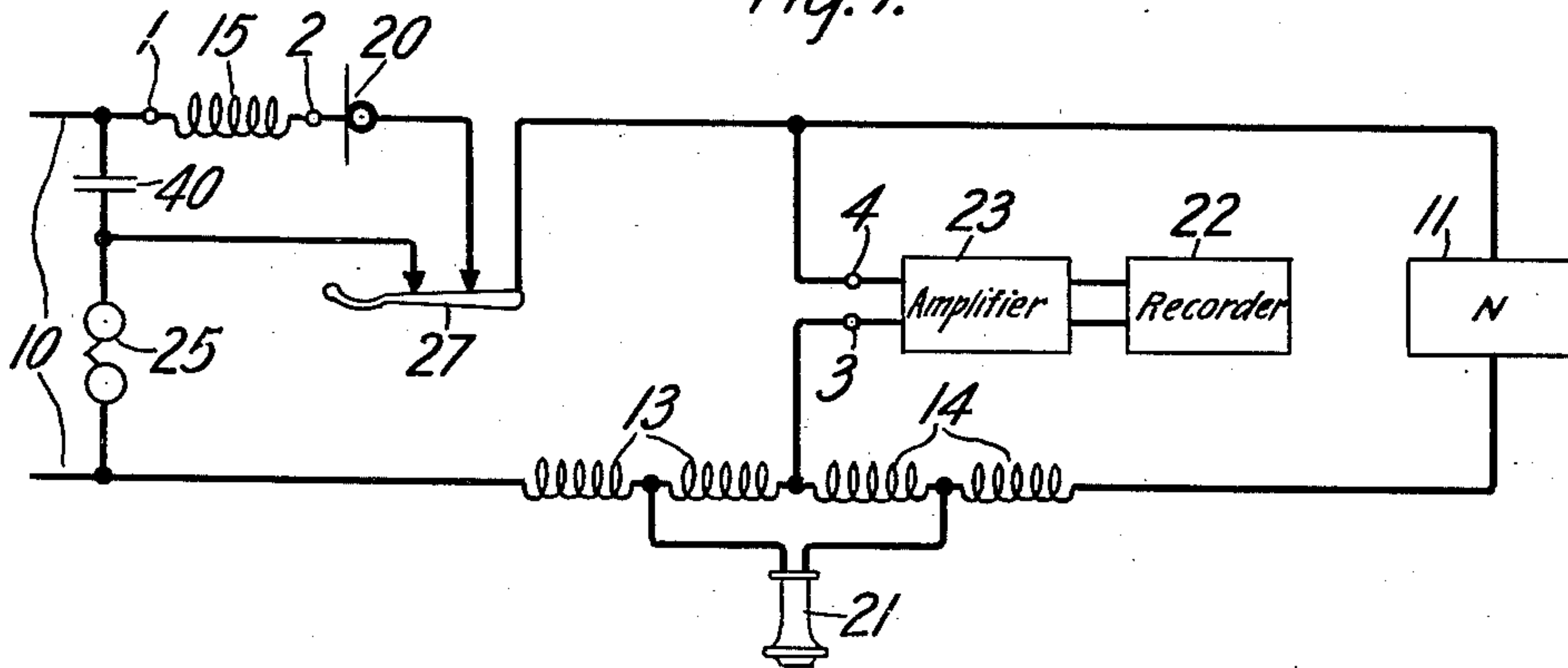
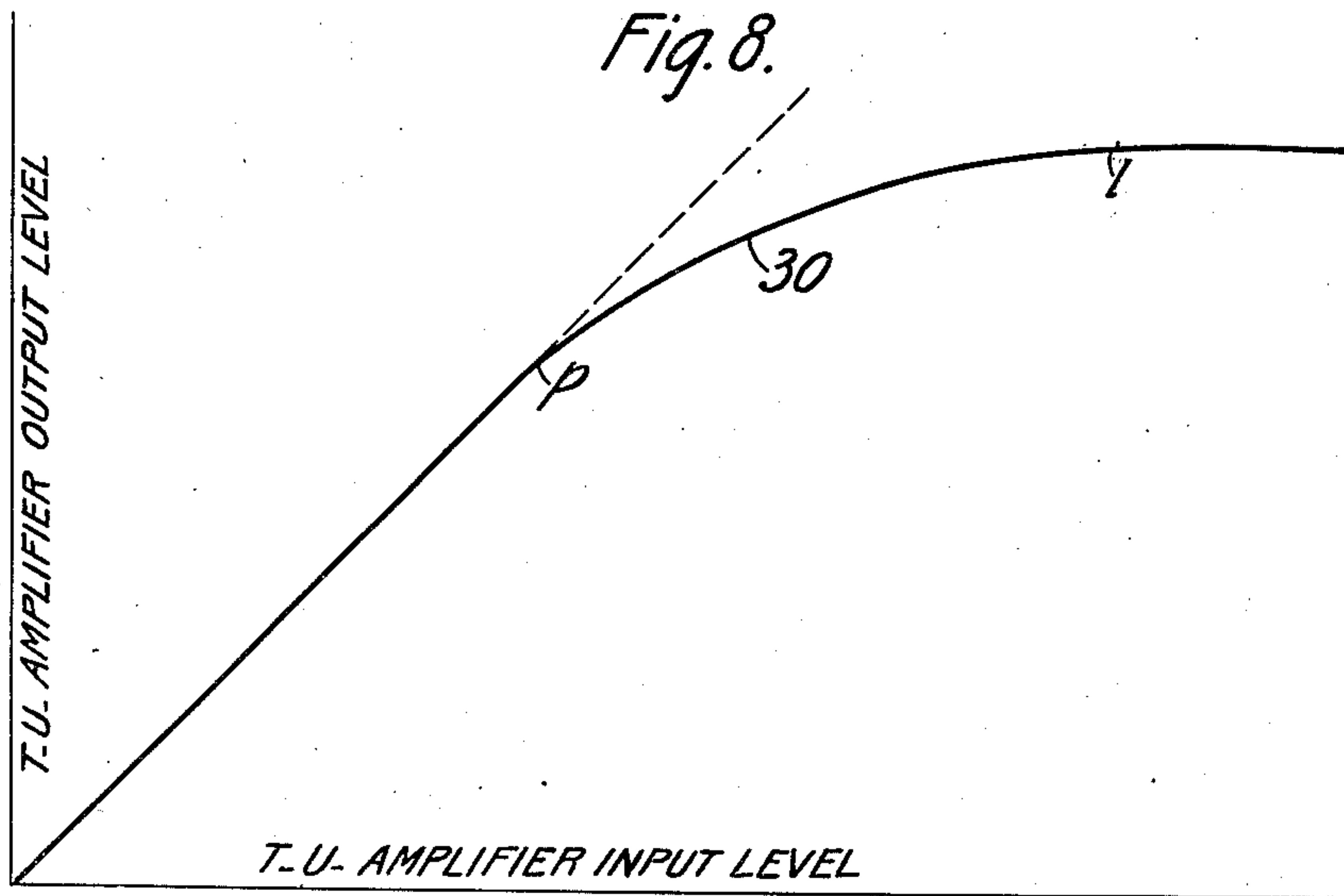


Fig. 8.



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UNITED STATES PATENT OFFICE

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SOUND RECORDING

Application filed September 23, 1926. Serial No. 137,274.

This invention relates to systems for recording variations, as for example, variations corresponding to sound, and aims to avoid excessive changes in the amplitude of the variations applied to the recorder in the system.

As a specific example of applications of the invention, there are described hereinafter systems for recording incoming and outgoing speech at a telephone station, such as a subscriber's or operator's telephone set, the recorder being of phonographic or any other desired type. One of the problems to be met in such systems is that of making the minimum power input into the recorder sufficient to yield a satisfactory record, and preventing the maximum power input to the recorder from unduly overloading the recorder. The input volume encountered may be large due to a loud voice at the local transmitter, and may be low due to currents originated by a weak voice at the distant end of a long toll connection. For reducing the tendency of the current generated in the local transmitter to overload the recorder, the recorder may be connected in conjugate or anti-side tone relation to the local transmitter, the adjustment of the circuit being made sufficiently different from that required for the condition of conjugacy to give the desired amount of side tone in the recorder. Egerton Patent 1,548,028, August 4, 1925, discloses an anti-side tone type of substation circuit or telephone set, in which a recorder has the place of the usual receiver and in which the receiver is in series with the line in order that the side tone produced in the receiver may cause the talking subscriber to soften his tones and thereby lead the responding subscriber to talk forcefully and consequently increase the energy level at the input of the recorder. The adjustment of the circuit is sufficiently different from that required for conjugacy of the transmitter and the recorder so that the transmitter can operate the recorder.

In specific embodiments of the instant invention shown in the drawing, a sound recorder and a telephone set which includes a transmitter and a receiver are coupled to a line and a line balancing network by a hybrid

coil, with the line and its balancing network in conjugate relation to each other and with the recorder and the telephone set in conjugate relation to each other. Either the recorder or the telephone set can occupy either the bridged circuit or the series circuit position in this bi-conjugate system, or in other words, can be effectively connected to either the bridge points or the series terminals of the hybrid coil. The telephone set can be of any desired type. For example, the transmitter can be either effectively in series or effectively in shunt with the receiver, with respect to the circuit faced by the telephone set, or can have any desired relation to the receiver as regards transmission of side tone from the transmitter to the receiver. Enough unbalance is used in the hybrid coil connection of the elements of the bi-conjugate system to give any desired amount of side tone in the recorder.

Preferably, an electric space discharge amplifier having a power limiting characteristic is connected in the input circuit of the recorder and adjusted to bring the minimum energy level of the variations to be recorded up to a level just sufficient for satisfactory recording but to overload when considerably higher levels are reached, so that the highest energy levels applied to the input of the recorder can not exceed the lowest energy levels at that point in the circuit by more than approximately the volume range over which the recorder can operate satisfactorily.

A feature of the invention relates to coupling a sound recorder and a telephone set which includes a transmitter and receiver to a line, with the recorder and the telephone set in conjugate relation to each other, the adjustment of the circuit being sufficiently different from that required for the condition of conjugacy to give the desired amount of side tone in the recorder.

Another feature of the invention is a sound recorder having a volume range limiting device in its input circuit.

A somewhat different aspect of the invention is the conjugate relationship of a sound recorder which has in its input circuit a volume range limited to a telephone trans-

mitter, the adjustment of the circuit being such that the recorder receives the desired amount of side tone from the transmitter.

Other objects and aspects of the invention will be apparent from the following description and claims.

Fig. 1 of the drawings is a circuit diagram for facilitating explanation of the circuits of Figs. 2 to 7; Figs. 2 to 7 show six different forms of the invention; and Fig. 8 is a curve for facilitating explanation of the operation of an amplifier preferably employed in the circuits of Figs. 2 to 7.

In Fig. 1, a telephone line 10 and a balancing impedance network 11 therefor are connected by a hybrid coil 12. The hybrid coil comprises a line winding 13, a network winding 14, and a series winding or arm 15. These windings are inductively related in the manner usual for hybrid coils, as employed in telephone repeater circuits, for example. Terminals 1 and 2 of the series arm 15 are the series impedance terminals of the hybrid coil. Terminals 3 and 4 are the bridge points or bridge terminals of the hybrid coil.

Each of Figs. 2 to 7 shows a subscriber's telephone set, including a transmitter 20 and a receiver 21, a sound or voice recorder 22 which preferably has an electric space discharge amplifier 23 in its input circuit, a telephone line 10, an impedance network 11 for balancing the impedance of line 10, and a hybrid coil connecting the telephone set and the recorder amplifier to the line 10 in conjugate relation to each other. As pointed out in more detail hereinafter, certain of these figures show the telephone set effectively connected to the bridge points of the hybrid coil, and the recorder amplifier connected to the series impedance terminals of the hybrid coil, whereas others of the figures show the telephone set effectively connected to the series impedance terminals of the hybrid coil and the recorder amplifier connected to the bridge points of the hybrid coil.

In Fig. 2 the telephone set is connected to the bridge points 3 and 4 of hybrid coil 12, and the recorder and amplifier are connected to the series impedance terminals 1 and 2 of the hybrid coil. The telephone set is shown in this figure as a series set, the transmitter 20 and receiver 21 being effectively in series with each other with respect to the line.

In the operation of the subscriber's station shown in Fig. 2 ringing current from line 10 passes through ringer 25 and large condenser 26. When the receiver operated switch 27 is closed direct current from line 10 energizes transmitter 20 over a circuit extending from the upper conductor of line 10 through transmitter 20, the lower portion of induction coil 28, receiver 21, and winding 13 of hybrid coil 12, and receiver oper-

ated switch 27, to the lower conductor of line 10. Condenser 26 prevents direct current from being by-passed around transmitter 20 through the upper portion of induction coil 28. Operation of transmitter 20 causes voice currents to flow through condenser 26 and the upper portion of induction coil 28 so that a corresponding electromotive force appears across the terminals of induction coil 28 and sends current through receiver 21 to line 10, through winding 13 of the hybrid coil 12, and to network 11, through winding 14 of the hybrid coil 12. Sufficient unbalance is used in the hybrid coil to give the desired amount of side tone for operating amplifier 23 and recorder 22. Voice currents transmitted to the substation over line 10 operate the receiver 21, over a circuit extending from lower conductor of line 10, through switch 27, winding 13, receiver 21, lower portion of coil 28 and upper portion of coil 28 and condenser 26 in parallel with transmitter 20, to the upper conductor of line 10. The flow of this current through winding 13 induces in winding 14 an electromotive force for causing operation of amplifier 23 and recorder 22. If desired, network 11 may include a condenser preventing flow of direct current through the network, or the upper network terminal may be moved down to the lower terminal of condenser 26, for the same purpose. In some cases induction coil 28 may be omitted and the transmitter 20 connected directly to the receiver 21.

Curve 30 of Fig. 8 is plotted between transmission levels at the input of the amplifier 23 as abscissae and transmission levels at the output of the amplifier as ordinates, the transmission level in each case being expressed in transmission units. The amplifier has a limited load capacity and is adjusted to bring the minimum speech levels at the input of the recorder up to a volume level just suitable for recording. For volume levels more than, say, 25 or 30 t. u. above the minimum level, the amplifier is overloaded, so that the loudest speech levels applied to the input are not recorded as more than about 25 t. u. greater in volume than the weakest levels. The amplifier thus functions as a volume range limiter. The point *p* of the curve at which the slope of the curve begins to decrease noticeably is controlled by the direct current voltages applied to the amplifier. The output level corresponding to the point *l* of the curve, which marks the beginning of the horizontal portion of the curve, indicates approximately the amplifier input and output levels at which noticeable overloading of the recorder begins.

In Fig. 3 the amplifier and recorder are connected to the bridge points 3 and 4 of hybrid coil 12 and the telephone set is connected to the series impedance terminals 1 and 2 of the hybrid coil. The telephone set

is shown in Fig. 3 as a series set, the transmitter 20 and receiver 21 being effectively in series with each other with respect to the line.

5 In the operation of the subscriber's station shown in Fig. 3 ringing current from line 10 passes through ringer 25 and large condenser 40. When the receiver operated switch 27 is closed direct current from line 10 energizes transmitter 20 over a circuit
10 extending from the upper conductor of line 10, through a low resistance primary winding of an input transformer (not shown) for amplifier 23, winding 13 of hybrid coil 12, switch 27, winding 15 of hybrid coil 12, right
15 hand portion of induction coil 28, transmitter 20, and receiver 21, to the lower conductor of line 10. Operation of transmitter 20 causes voice currents to flow through con-
20 denser 26 and the left hand portion of induction coil 28, so that a corresponding electromotive force appears across the terminals of induction coil 28 and sends current through receiver 21, condenser 26, switch 27,
25 and winding 15 of the hybrid coil 12. This current in winding 15 induces in windings 13 and 14 an electromotive force which sends current through switch 27, condenser 40, lower
30 conductor of line 10, upper conductor of line 10 and network 11. Sufficient unbalance is used in the hybrid coil to give the desired amount of side tone for operating amplifier 23 and recorder 22. Voice currents trans-
35 mitted to the substation over line 10 operate the amplifier and recorder over a circuit extending from the lower conductor of line 10, through condenser 40, switch 27, winding 13, the low resistance primary winding of
40 the input transformer (not shown) for amplifier 23, to the upper conductor of line 10. This current in winding 13 induces in winding 15 an electromotive force which operates the receiver 21 over a circuit extend-
45 ing from terminal 1, through switch 27, condenser 40, receiver 21, condenser 26 and left hand portion of coil 28 in parallel with transmitter 20, and right hand portion of coil 28 to terminal 2.

50 In Fig. 4 the telephone set is connected to the bridge points 3 and 4 of hybrid coil 12 and the recorder and amplifier are connected to the series impedance terminals 1 and 2 of the hybrid coil. The telephone set is shown in this figure as a standard series set, the
55 transmitter 20 and receiver 21 being effectively in series with each other with respect to the line.

60 In the operation of the subscriber's station shown in Fig. 4 ringing current from line 10 passes through ringer 25, and large condenser 35. When the receiver operated switch 27 is closed direct current from line 10 energizes transmitter 20 over a circuit
65 extending from lower conductor of line 10, through switch 27, winding 13 of hybrid coil

12, right hand winding of induction coil 36 and transmitter 20, to upper conductor of line 10.

The operation of transmitter 20 causes voice current to flow through condenser 35, receiver 21 and left hand winding of induc-
70 tion coil 36, and also through right hand winding of induction coil 36 and thence through winding 13, switch 27 and line 10 in parallel with winding 14 and network 11. Sufficient unbalance is used in the hybrid
75 coil connection between the telephone set and the amplifier 23 so that this current through windings 13 and 14 will operate the amplifier and the recorder. Voice currents coming into the substation over line 10 pass through
80 the circuits traced above for the transmitter direct current, and cause voice current to flow through left hand winding of induction coil 36, receiver 21 and condenser 35. The voice
85 current from the line in passing through winding 13 of hybrid coil 12 induces in winding 15 an electromotive force for causing the operation of amplifier 23 and recorder 22.

90 In Fig. 5 the hybrid coil has no series winding in addition to the line winding and network winding 14, and the series impedance terminals 1 and 2 of the hybrid coil are at the junction points of the line and network
95 windings with the line and the network, respectively. The telephone set is a standard series subset connected to the series input terminals 1 and 2, the transmitter and the receiver being effectively in series with each
100 other with respect to the lines. The amplifier and the recorder are connected to the bridge points 3 and 4 of the bi-conjugate circuit. Ringing currents from line 10 pass through ringer 25 and large condenser 40.
105 When switch 27 is closed, direct current for the transmitter is supplied through a circuit extending from the lower conductor of line 10, through switch 27, transmitter 20, right
110 hand winding of induction coil 36, winding 14, and a low resistance primary winding of an input transformer (not shown) for amplifier 23, to the upper conductor of line 10. Op-
115 eration of the transmitter 20 causes voice current to flow through the left hand winding of coil 36, receiver 21, condenser 35 and switch 27, and also causes current to flow through
120 right hand winding of coil 36, coils 14 and 13, in parallel with network 11 and line 10, and through switch 27. Sufficient unbalance is used in the conjugate connection between
125 the telephone set and the amplifier 23 to enable the transmitter to operate amplifier and recorder. Voice current received at the substation energizes receiver 21 over a circuit extending from the lower conductor of line 10,
130 through condenser 40, winding 13 and the primary winding of the input transformer (not shown) for amplifier 23, to the upper conductor of line 10. This current in winding 13 causes current to flow through wind-

ing 14, right hand winding of coil 36 and the circuits including the left hand winding of coil 36, receiver 21 and condenser 35, and transmitter 20 and switch 27, through condenser 40.

In Fig. 6 the telephone set is a shunt sub-set forming the series impedance or the bi-conjugate circuit, the amplifier and the recorder being the bridged impedance. As in the preceding figures the windings 13, 14 and 15 are all on one core, windings 13 and 14 being the line and network windings respectively of the hybrid coil and winding 15 being the series winding of the hybrid coil. Winding 15 forms an auto-transformer winding for connecting transmitter 20 and receiver 21, the receiver being connected across the entire winding 15, whereas the transmitter is in effect connected across the horizontal portion of winding 15, since condenser 40 is large. Ringing current from line 10 passes through ringer 25 and condenser 40. Direct current for energizing transmitter 20 is supplied from line 10 over a circuit extending from the upper conductor of line 10, through the horizontal portion of winding 15, in parallel with receiver 21 and the vertical portion of winding 15. Transmitter 20, switch 27, the low resistance primary winding of the input transformer (not shown) for the amplifier 23, and winding 13 to the lower conductor of line 10. Operation of transformer 20 causes voice current to flow through conductor 40 and the horizontal portion of winding 15, and therefore, causes current to flow through the vertical portion of winding 15 and receiver 21, to energize the receiver 21. The current in winding 15 induces electromotive force in windings 13 and 14, causing a current to flow through windings 13 and 14, network 11, switch 27, and condenser 40 to line 10. Sufficient unbalance is used in the hybrid coil connection between the telephone set and the amplifier and the recorder to enable the transmitter to operate the amplifier and recorder. Voice current coming into the substation over line 10 passes through a circuit extending from lower conductor of line 10, through winding 13, primary winding of the input transformer (not shown) for amplifier 13, switch 27, and condenser 40 to upper conductor of line 10. This current flowing in winding 13 induces in winding 15 an electromotive force for causing operation of the receiver 21.

Fig. 7 shows a modified form of the circuit of Fig. 6. As was the case in Fig. 6 the telephone set is a shunt sub-set forming the series impedance of the bi-conjugate circuit, the amplifier 23 and the recorder 22 being the bridged impedance. The windings 13, 14 and 15, as in the preceding figures are all on one core, windings 13 and 14 being the line and network windings respectively of the hybrid coil and winding 15 being the

series winding of the hybrid coil. The receiver 21 is connected across a portion of winding 13 and an equal portion of winding 14, so that the winding 15 and these portions of windings 13 and 14 serve as a transformer for connecting the receiver to the circuit connected to terminals 1 and 2 of the series winding 15 of the hybrid coil. Ringing current from line 10 passes through ringer 25 and condenser 40. Direct current for energizing the transmitter 20 is supplied from line 10 over a circuit extending from the upper conductor of line 10 through winding 15, transmitter 20, switch 27, low resistance primary winding of an input transformer (not shown) for amplifier 23 and winding 13, to the lower conductor of line 10. Operation of transmitter 10 causes voice current to flow through winding 15, condenser 40 and switch 27. This current in winding 15 induces an electromotive force in windings 13 and 14. This electromotive force in windings 13 and 14 sends current through a circuit extending from the right hand end of winding 14, through network 11, switch 27, condenser 40 and line 10 to the left hand end of winding 13. The electromotive force in the portion of windings 13 and 14 across which receiver 21 is connected causes operation of the receiver. Sufficient unbalance is used in the hybrid coil connection between the telephone set and the amplifier 23 to cause operation of the amplifier and recorder. Voice currents coming into the substation over line 10 pass through a circuit extending from the lower conductor of line 10, through winding 13, the primary winding of input transformer (not shown) for amplifier 23, switch 27 and conductor 40 to the upper conductor of line 10, thus causing operation of the amplifier 23 and the recorder 22. This current in winding 13 also causes operation of receiver 21.

If desired, the amplifier 23 may be omitted from any of the circuits of the Figs. 2 to 7. If the amplifier be omitted the input circuit of the recorder may be made of low impedance to direct current where that is advisable, in order to facilitate the energization of the transmitter.

What is claimed is:

1. A system comprising a telephone set including a transmitter, a line, a recorder adapted for recording electrical variations within a limited amplitude range, means coupling said telephone set and said recorder to said line and in conjugate relationship to each other, said system being so adjusted that said recorder is supplied with a portion of the electrical variations received over said line and from said transmitter, and means comprising a single space discharge amplifying device connected between the recorder and said coupling means, and automatically responsive to received electrical variations to

maintain the amplitude range of the electrical variations supplied to said recorder within the recording limits thereof.

2. A system comprising a telephone set including a transmitter, a line, a network for balancing said line, a recorder for recording electrical variations within a limited amplitude range, said telephone set, said line, said network and said recorder being connected in a Wheatstone bridge circuit so that said line and said network are in conjugate circuit relationship to each other and said telephone set and said recorder are in conjugate relationship to each other, said bridge circuit being so adjusted that a portion of the electrical variations received over said line and a portion of the electrical variations received from said transmitter are supplied to said recorder, and means connected in the input of said recorder and comprising a single electron discharge amplifying device with a power limiting characteristic, for maintaining the amplitude range of the electrical variations supplied to said recorder within the recording limits thereof.

3. A system comprising a recorder adapted for recording electrical variations within a limited amplitude range, a telephone set including a transmitter, an incoming line, a balancing network for said line, a hybrid coil for connecting said recorder and said telephone set to said line and to each other, said hybrid coil having a pair of series terminals and a pair of bridge terminals, said recorder being connected effectively to one pair of terminals and said telephone set being connected effectively to the other pair of terminals, said system being adjusted so that said recorder is supplied with the electrical variations received over said line and with the electrical variations received from said transmitter, and means connected between said hybrid coil and said recorder and comprising a single vacuum tube amplifying device with a power limiting characteristic determined by the upper recording limit of said recorder and an amplification factor determined by the lower recording limit of said recorder for maintaining the amplitude of the electrical variations supplied to said recorder within the recording limits thereof.

4. In combination with a recorder for recording electrical variations between definite upper and lower amplitude limits having an input circuit, a source of electrical variations of a wide range of amplitudes; a single space discharge amplifying device fed from said source and feeding said input circuit, for amplifying the received variations of amplitudes below the lower recording limit of said recorder, and having an energy input versus energy output characteristic with a slope decreasing rapidly above a point in the region of the maximum energy input which the recorder can satisfactorily record.

5. A system comprising a line and a subscriber's telephone set connected thereto, a transmitter in said set, a recorder of received electrical waves over a limited amplitude range, in substantially anti-side tone circuit relation to said transmitter, and an amplifier comprising a single space discharge device connected between said transmitter and said recorder and adjusted to amplify the received waves of amplitudes below the range of said recorder, and to overload for received waves of amplitudes above the range of said recorder so as to limit the input to the recorder to a range over which the recorder can record satisfactorily.

6. A system according to claim 1, in which said single space discharge amplifying device connected between said coupling means and said recorder is adjusted to amplify the received variations of low energy level so as to bring them within the recording range of said recorder, and to overload for received variations of a level higher than can be recorded satisfactorily by said recorder.

7. In combination, a recorder of electrical waves of amplitudes lying only within a definite upper limit and a definite lower limit, a source of electrical waves having an amplitude range extending beyond said upper limit and said lower limit, and means comprising a single space discharging amplifying device for automatically producing and supplying to said recorder electrical waves corresponding to the waves from said source but having amplitudes lying only between said upper limit and said lower limit.

8. In combination, a recorder of electrical waves of amplitudes lying only within a definite upper limit and a definite lower limit, a source of electrical waves having an amplitude range extending beyond said upper limit and said lower limit, and a vacuum tube amplifier comprising a single stage fed from said source and feeding into said recorder, said amplifier being adjusted to raise the amplitude of all received waves of amplitudes below said lower limit to an amplitude level between said upper and lower limit, and to saturate for all received waves of amplitudes exceeding said upper limit.

In witness whereof, I hereunto subscribe my name this 21st day of September, A. D. 1926.

ROBERT C. MATHES.