

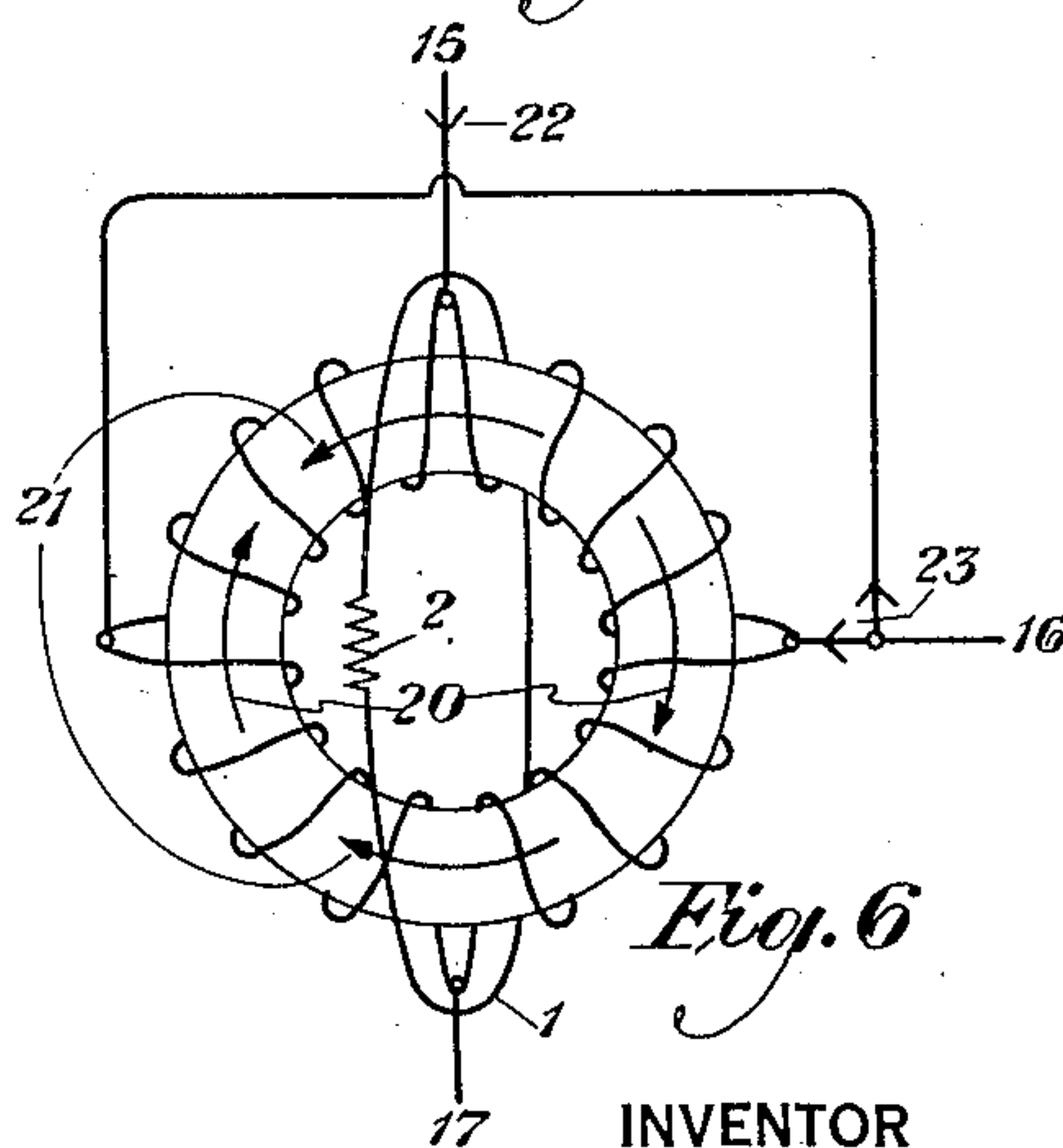
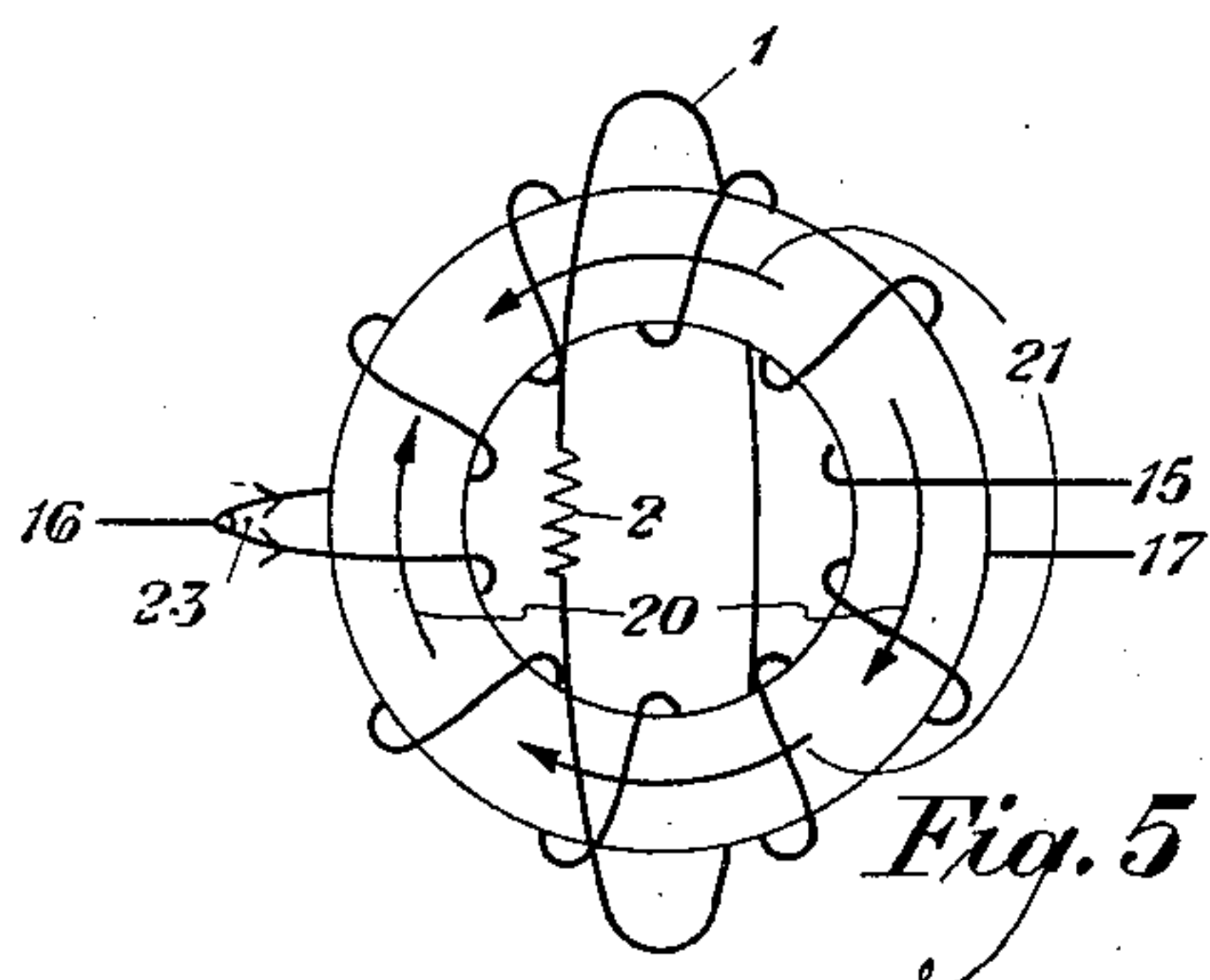
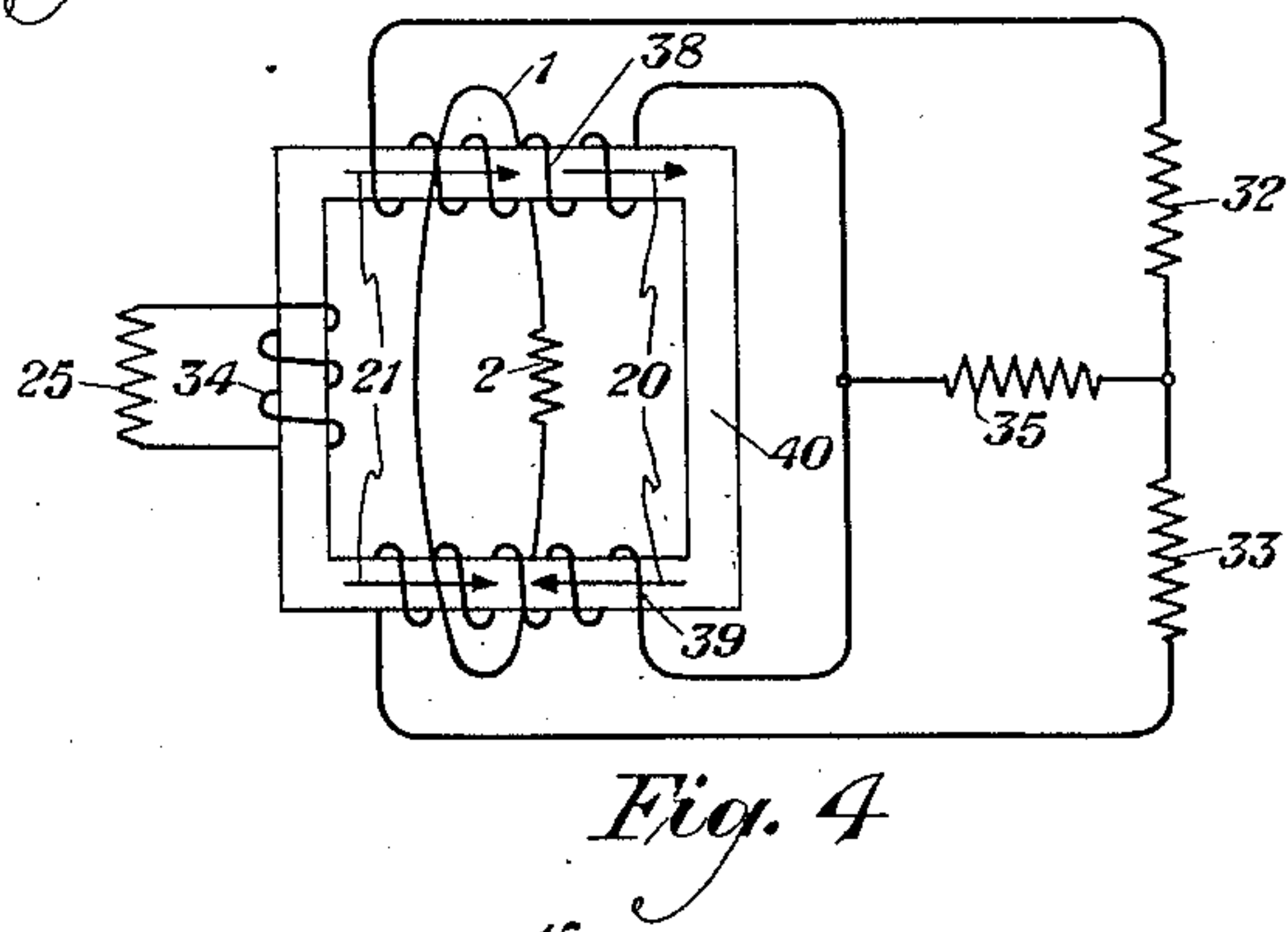
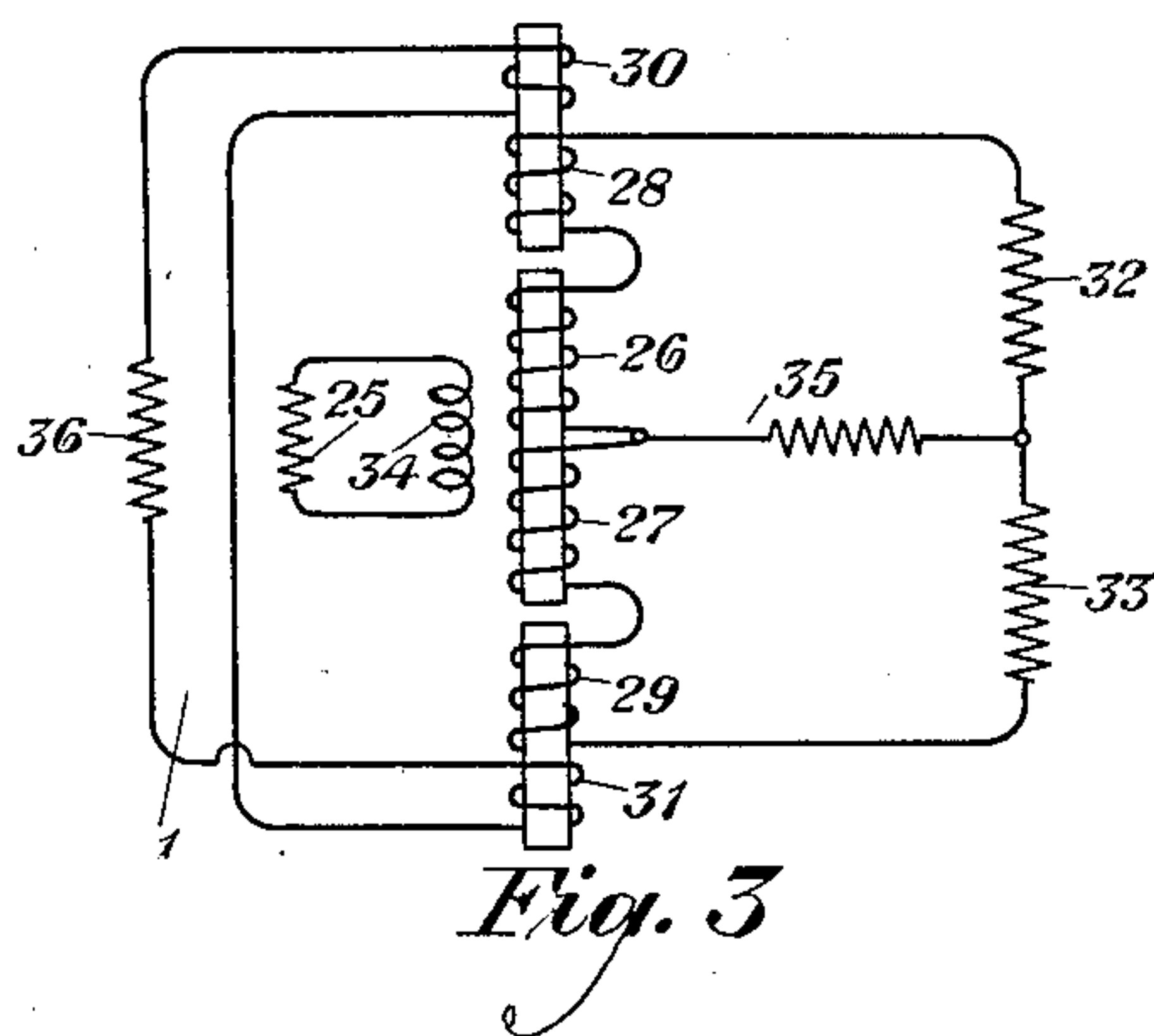
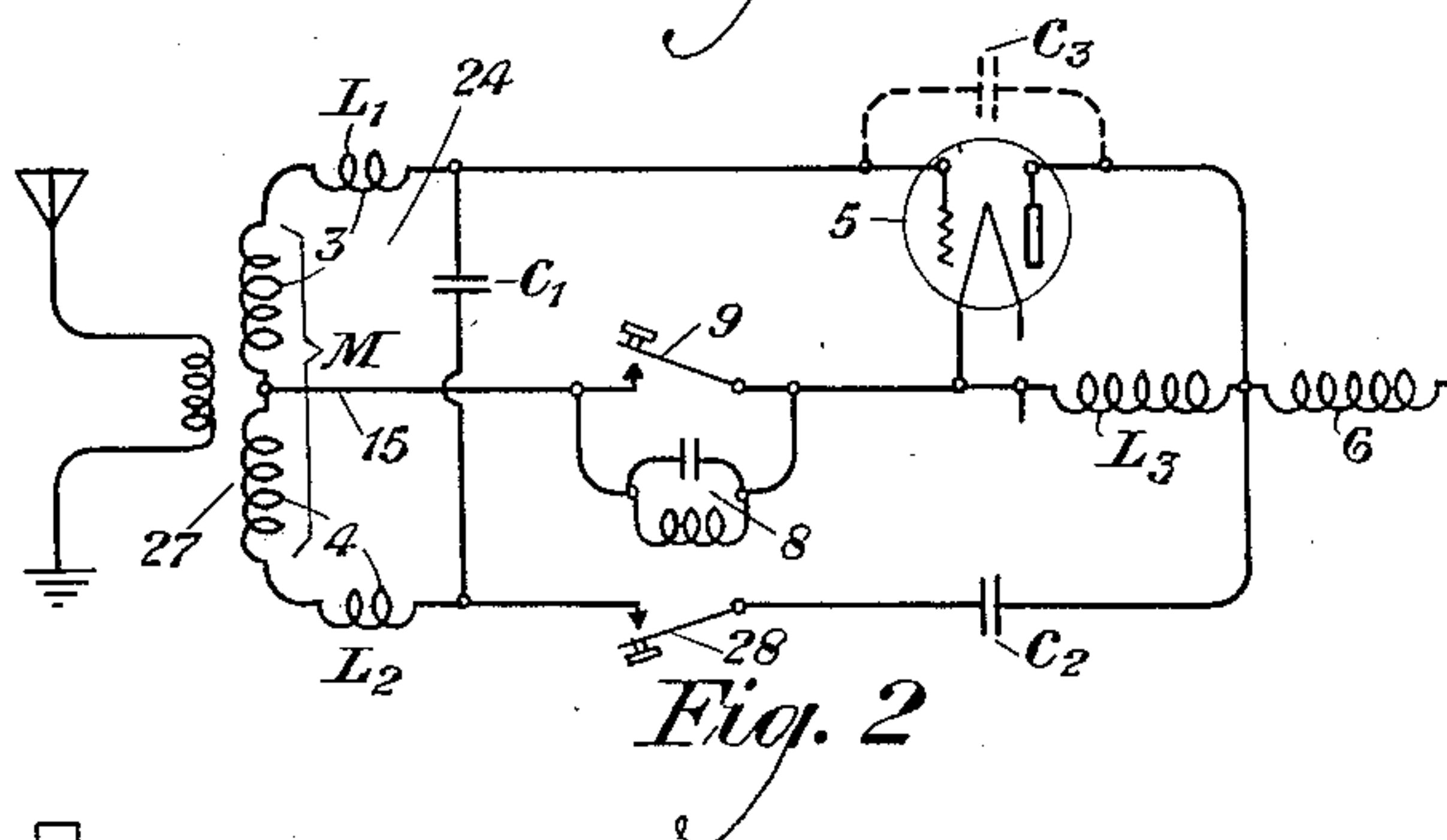
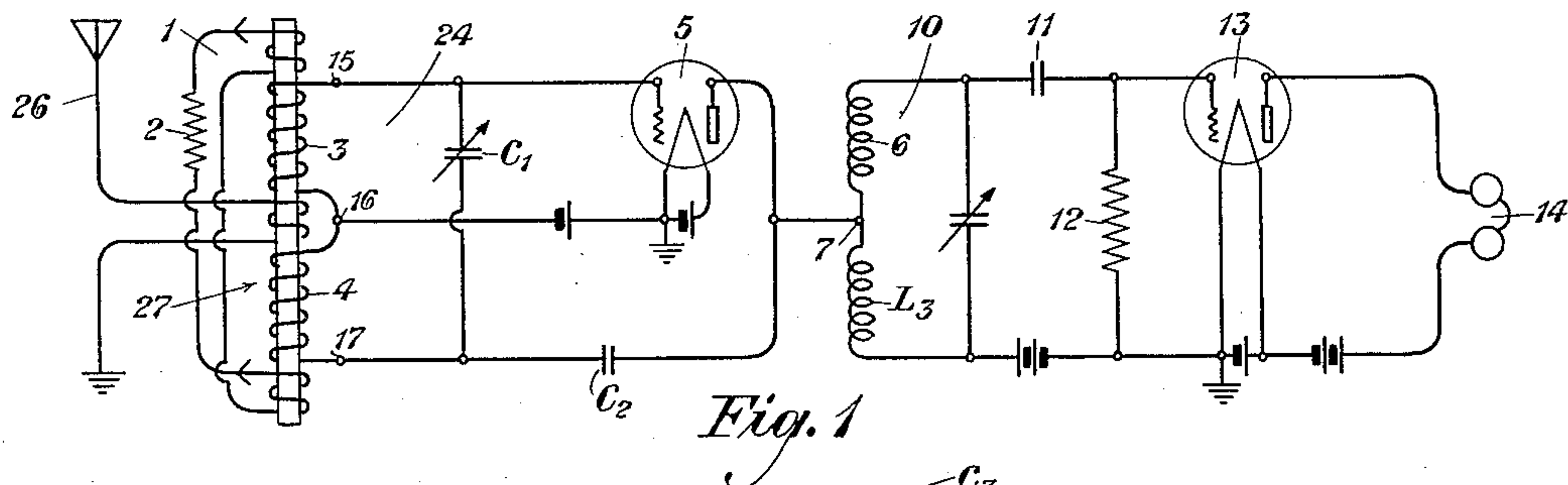
Dec. 23, 1930.

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1,785,819

PREVENTION OF PARASITIC OSCILLATIONS

Filed Nov. 9, 1928



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PREVENTION OF PARASITIC OSCILLATIONS

Application filed November 9, 1928. Serial No. 318,194.

This invention relates to improvements in the art of radio communications, and more specifically discloses improved means for damping out parasitic oscillations such as occur in certain types of radio circuits.

The nature of the problem involved and the application of the proposed improvements will best be understood by immediate reference to the drawings, of which Figure 1 discloses in schematic form a certain well-known type of radio receiving circuit embodying the improved damping feature, while Fig. 2 discloses a portion of the circuit of Fig. 1 in a form better adapted to explain the circuit operation. Figs. 3 and 4 show schematic circuits adapted to better disclose the broad principle underlying the invention. Figs. 5 and 6 indicate the method of adapting the damping circuit to certain closed core types of coils.

Fig. 1 discloses a radio receiving circuit having one stage of tuned radio frequency amplification, a detector and head-phones for reception of the signal. The waves impinging upon the antenna 26 are impressed upon the amplifier tube 5 by means of the tuned circuit 24. The output of the amplifier tube is impressed upon the detector tube 13 by means of autotransformer 7 associated with tuned circuit 10 in the grid circuit of tube 13. The head-phones 14 for reception are connected in the plate circuit of detector tube 13, as shown.

As is well known for a circuit of the type shown in Fig. 1, in the absence of any neutralizing means, there is a tendency for sustained high frequency oscillations to be set up in the amplifier stage due to the interaction between the plate and grid circuits of tube 5 resulting from the coupling effect through the grid-plate capacity of tube 5. To avoid this tendency to oscillate at high frequency, the neutralizing condenser C_2 is connected in the circuit of Fig. 1 as shown.

Fig. 2 furnishes a clearer picture for comprehending the action by which the sustained oscillations are set up and neutralized. Fig. 2 shows only the amplifier stage of Fig. 1, omitting the D. C. batteries utilized for obtaining the grid and plate potentials and

for lighting the tube filaments. In Fig. 2, windings 3 and 4 of coil 27 are drawn schematically to show the mutual inductance between windings and also the leakage inductances L_1 and L_2 of these windings. The grid-plate capacity of tube 5 is shown in dotted lines by condenser C_3 . Assuming for the moment that switch 9 is closed and that the neutralizing condenser C_2 is disconnected from the circuit by opening switch 28, as shown, winding 3 in the grid circuit of tube 5, the capacity C_3 , and the inductance L_3 in the plate circuit comprise a tuned circuit adapted to oscillate at a high frequency. And, since a voltage induced in the plate circuit will produce an interactive effect in the grid circuit and vice versa, sustained oscillations will be set up, provided the total loss in the circuit is sufficiently low. For example, if a voltage be induced in L_3 , it will set up a current flowing through winding 3 and condenser C_3 . The potential drop thus set up in winding 3 will impress a voltage on the grid circuit of the tube, thus permitting the building up of sustained oscillations. If, however, the neutralizing condenser C_2 is connected in the circuit of Fig. 2, as for example, by closing switch 28, conditions are no longer favorable for sustained oscillations, provided the leakage inductances L_1 and L_2 are negligible and C_2 is of suitable capacity. For example, if conductor 15 is connected to the midpoint of winding 27 and capacity C_2 is made equal to C_3 , no oscillations will occur, provided, as assumed, L_1 and L_2 are negligibly small. This is due to the fact that with such an arrangement there is no interactive effect between the plate and grid circuits, i. e., a voltage in the plate circuit will produce no potential in the grid circuit of tube 5, or vice versa, through the medium of tube capacity. This statement is easily demonstrated by considering again a voltage induced in L_3 . With switch 9 closed, such a voltage will cause a current to flow in conductor 15 through winding 3 and condenser C_3 back to the plate circuit. At the same time, an equal and opposite current will flow in winding 4 and through condenser C_2 back to the plate circuit. The opposing currents flowing in windings 3 and

4 will set up equal and opposing fluxes which will annul one another and hence no voltage will be impressed between the grid and filament of tube 5 as a result of the voltage induced in L_3 , on the assumption stated that L_1 and L_2 are practically zero. Thus, a voltage induced in the plate circuit can produce no effect in the grid circuit and hence conditions are not favorable to sustain oscillations. Correspondingly, a current flowing in the oscillatory circuit 24 will produce no interactive effect in the plate circuit of tube 5. A current oscillating in circuit 24 will induce equal voltages in the same direction in windings 3 and 4. These voltages will cause a circulating current to flow in the series circuit comprising windings 4 and 3 and capacities C_3 and C_2 . This circulating current, however, will produce no effect in the plate circuit of tube 5, since one side of the inductance L_3 is connected between windings 3 and 4 and the other side is connected between capacities C_2 and C_3 . An inspection of the circuit will show that the arrangement constitutes a balanced bridge in which the inductance L_3 is connected across the equipotential points, with the result that the voltages induced in windings 3 and 4 produce no effect in the plate circuit inductance L_3 and hence an oscillatory current in tuned circuit 24 has no tendency to set up sustained oscillations in the tube.

The above method of neutralization, however, is satisfactory only when the leakage inductances L_1 and L_2 are negligible. If these leakage inductances are considerable, as is frequently the case, the neutralization, while affecting the desired result at the frequency to which the circuit comprising coil 27 and condenser C_1 is tuned, may cause the circuit to break into violent sustained oscillations at very high frequency and thus interfere with perfect reception. To understand this, assume again a voltage induced in L_3 , causing equal and opposing currents to flow through windings 3 and 4. These currents flowing in the closely coupled portions of windings 3 and 4 indicated by M set up equal and opposing fluxes which produce no effect in the grid of tube 5. The current in winding 3, however, in flowing through the leakage inductance L_1 , does impress a voltage across the grid of tube 5 and, if the loss in the circuit is sufficiently small, sustained oscillations will thus be set up. In this case, there will be two circuits oscillating in unison, one comprising winding 3, condenser C_3 and inductance L_3 and the other comprising winding 4, capacity C_2 and inductance L_3 . The tube 5 supplies the power to overcome the loss in both these circuits for maintaining the oscillations.

One method of damping out these oscillations which are termed "parasitic oscillations" would be to insert a tuned circuit 8 in conductor 15, as is shown by opening switch

9. This circuit 8 is tuned to the frequency of sustained oscillations and, by introducing considerable loss in the oscillating circuits, renders conditions unfavorable for further oscillation. The circuit 8, however, by introducing an impedance into the conductor 15, reduces the degree of neutralization obtainable.

Referring now to Fig. 1, it is proposed by the present invention to damp out the oscillations set up in the circuit due to the leakage inductances of windings 3 and 4, by winding on the same core therewith circuit 1, in the manner shown. Circuit 1 comprises a few turns of wire placed near the upper end of coil 3 and likewise a few turns placed on the core near the lower end of winding 4, said windings being connected in the manner shown through a suitable resistance 2. This circuit 1 is adapted to damp out the tendency of the circuit to produce sustained oscillations but to have no effect on the signals impressed upon the circuit from the antenna 26. A wave train impinging on the antenna 26 will produce voltages in the same direction in windings 3 and 4 and will thus set up additive fluxes in the core of 27. Due to the connection of the upper and lower windings of circuit 1, the fluxes in the core of 27 will induce equal and opposite E. M. F.'s in circuit 1 and hence no current will flow therein. On the other hand, if an attempt is made to set up sustained oscillations in tube circuit 5, as by inducing a voltage in winding L_3 , equal and opposing currents will flow through windings 3 and 4, respectively. The mutual fluxes set up by these currents will annul each other but the leakage fluxes in windings 3 and 4, respectively, being now opposed in direction, will set up additive E. M. F.'s in the upper and lower windings of circuit 1 which will cause a current to circulate in this circuit and permit the dissipation of energy through the medium of resistance 2. By suitably selecting resistance 2, circuit 1 will thus introduce a sufficient loss in the circuits tending to set up sustained oscillations to prevent their occurrence.

Resistance 2 can, of course, be included as the resistance of the upper and lower windings of circuit 1, i. e., the windings themselves can be of sufficiently small gauge wire to introduce the proper resistance. The proper value of resistance 2 can best be determined by experiment, as it will not suitably damp out oscillations if too high or too low. For example, if the resistance were zero, circuit 1 could dissipate no energy. The same would be the case if the resistance 2 were so high as to constitute an open circuit.

The best location for the upper and lower windings of circuit 1 on the straight core type of winding, as shown in Fig. 1, is best determined by experiment for each different

type of coil. For experimental coils which have been tried out using this method of neutralization, the upper winding has been placed about one-sixteenth of an inch above winding 3, and the lower winding the same distance below winding 4. This has given satisfactory results although it is probable that optimum effects would be obtainable with the upper winding superimposed on winding 3 about one-third of the distance from the top and with the lower winding over winding 4 about one third of the distance from the bottom.

As was brought out above, the amplifier stage of Fig. 1 constitutes a balanced bridge with winding 3 and the grid plate capacity in one balancing arm, and with winding 4 and the neutralizing condenser C_2 in the opposite balancing arm. The circuit of Fig. 1 is therefore merely a specific application of the generalized circuit shown in Fig. 3.

Referring to Fig. 3, generalized impedances 32 and 33 replace the grid-to-plate capacity of the tube and the neutralizing condenser of Fig. 1, respectively. Windings 26 and 28 replace winding 3 of Fig. 1, and windings 27 and 29 replace winding 4. An antenna circuit of Fig. 1 is replaced in Fig. 3 by impedance 25 and input winding 34 inductively coupled to windings 26 and 27. The auxiliary circuit 1 is shown the same in both figures.

The leakage inductances of windings 3 and 4 of Fig. 1 are shown in Fig. 3 as separate windings 28 and 29 distinct from windings 26 and 27 as is indicated by the separate cores. This is merely to present the more generalized case, since the operation of the circuit of Fig. 3 is the same whether the auxiliary coils 30 and 31 couple separate coils 28 and 29, as shown, or whether they couple merely the leakage fluxes of the inductively coupled windings 26 and 27, in which latter case, of course, windings 28 and 29 would be omitted.

The circuit of Fig. 3, as will be seen by inspection, is a device for selectively transferring energy between certain branches of the network. For example, with the coils wound as shown, and, assuming the bridge to be balanced, a voltage active in series with impedance 25 produces no effect in impedances 35 and 36, but does deliver energy to impedances 32 and 33. On the other hand, a voltage active in 35 produces no effect in impedance 25, but does deliver energy to impedances 32, 33 and 36. For the final case, a voltage active in series with 36 delivers no energy to 25, but does deliver energy to impedances 32, 33 and 35.

It will thus be seen that in addition to the specific use pointed out in connection with Fig. 1, the generalized circuit arrangement of Fig. 3, involving the principle of operation of Fig. 1, will find general application where-

ever it is desired to selectively transmit energy between from three to five separate impedances.

Fig. 4 discloses the generalized circuit of Fig. 3 but with the difference that a closed core type of transformer is employed and the leakage inductance of the transformer windings in the balancing arms is utilized for transferring energy to the auxiliary circuit. The transformer windings in the balancing arms of the bridge are shown at 38 and 39. These windings are symmetrically placed on the core 40. The auxiliary circuit 1 in this case comprises a closed winding extending about the outer confines of the core, as shown.

The selective characteristics of this circuit are shown as follows: With a voltage active in series with impedance 25 equal currents are caused to flow in windings 38 and 39 in such direction that the fluxes are equal and additive, as shown by arrows 20. It will be seen from an inspection of Fig. 4 that for this case, the total flux cutting the auxiliary winding 1 is zero and hence no voltage is induced therein. On the other hand, with a voltage active in series with impedance 35 equal currents flow in windings 38 and 39, producing opposed fluxes in the core as shown by arrows 21. The mutual fluxes annul one another, but the leakage fluxes being now in the same direction through the auxiliary winding 1 as shown by the arrows 21, induce a resultant voltage in circuit 1, causing a current to flow therein.

A specific application of this generalized case may be pointed out by referring again to Fig. 1. Suppose in the circuit arrangement of Fig. 1, the received signal impinging on the antenna contained only the carrier side band and it were desired to introduce the carrier demodulating frequency into the receiving circuit in such manner that it would not be radiated from the antenna. This could be accomplished quite simply with the circuit arrangement shown by merely connecting a source of suitable carrier frequency in the auxiliary circuit 1. The carrier current thus applied to transformer 27 through the windings of the auxiliary circuit would set up equal and opposing currents in windings 3 and 4. The resultant mutual fluxes would annul each other and, hence, no voltage would be induced in the antenna circuits. On the other hand, the currents opposed in windings 3 and 4 would flow in the same direction through winding L_3 and would thus impress the carrier frequency upon the detector tube along with the received side band permitting effective demodulation.

Fig. 5 shows the location of the auxiliary circuit 1 for a toroidal core type of coil adapted for use in a circuit arrangement such as is shown in Fig. 1. The manner in which the coil of Fig. 5 would be connected in the circuit of Fig. 1 is indicated by the terminals 15,

16 and 17, which are the same as for the corresponding terminals of coil 27 of Fig. 1. The voltage impressed across the terminals 15 and 17 of Fig. 5 would produce additive fluxes in the core, as shown by the arrows 20, and thus the total flux linking the dissipative circuit 1 would be zero, and hence no energy would be dissipated by such circuit in this case. On the other hand, for currents flowing in at terminals 16, and out at terminals 15 and 17, or the reverse, opposing fluxes would be set up in the core, as indicated by the arrows 21. In this case, the mutual fluxes would annul one another, but the leakage fluxes would cut the dissipative circuit 1 and thus cause energy to be expended therein.

Fig. 6 shows a torusolenoid type of coil so-called, in which the connections 15, 16 and 17 are the same as indicated for coil 27 of Fig. 1. In this case, with a current flowing in over lead 15, and out over lead 17, the fluxes are additive, as shown by the arrows 20, and hence the total flux cutting the dissipative circuit 1 is zero and no loss is introduced thereby. On the other hand, for currents flowing in over lead 16 and out over leads 15 and 17, or the reverse, opposing fluxes are set up in the core, as indicated by the arrows 21, thus causing the resultant leakage flux to cut the dissipative circuit 1, thereby introducing a loss.

Each new type of winding, of course, presents its own problem as to the best location for the auxiliary winding. The general rule to be followed in all cases, however, is to so locate the neutralizing winding that it will be linked with the maximum possible leakage flux. Also, the auxiliary circuit should be symmetrically placed with respect to the coil windings so that it will be linked by the same portion of the main flux from each winding, thus insuring that it does not absorb energy from the main circuit.

It is to be understood, of course, that the application of the auxiliary circuit is not to be restricted to the circuit arrangement of Fig. 1, but may be used generally wherever applicable in accordance with the principles outlined in connection with Fig. 3.

In the claims the term "closed winding" signifies a winding, the terminals of which are connected together.

What is claimed is:

1. A transformer comprising a pair of inductively coupled principal windings, an auxiliary winding coupling the leakage flux of both said principal windings in such manner that equal and additive fluxes due to currents in the principal windings are ineffective in the auxiliary circuit but equal and opposed fluxes due to currents in the principal windings induce a resultant voltage in the auxiliary winding.

2. A closed core transformer having therein a pair of inductively coupled principal

windings, an auxiliary winding extending about the outer confines of said core and so coupling the leakage fluxes of both said principal windings that currents in said principal windings producing equal and additive fluxes are not effective in the auxiliary winding, but currents in said principal windings producing equal and opposed fluxes induce a resulting voltage in said auxiliary winding.

3. A transformer comprising a pair of inductively coupled primary windings, a secondary winding individual to each primary winding and coupling the leakage flux thereof, a series connection for said secondary windings such that for primary winding currents producing additive fluxes the induced secondary voltages are opposed, whereas for primary currents producing fluxes opposed, the induced secondary voltages resulting from said leakage inductances are additive.

4. A transformer comprising a pair of similar inductively coupled primary windings, a pair of similar secondary windings individual to said primary windings and coupling the leakage flux thereof, a series connection for said secondary windings such that equal primary currents producing additive fluxes induce equal and opposed voltages in the secondary circuit, whereas equal primary currents producing opposed fluxes induce equal additive voltages in said secondary circuit through the medium of said leakage inductances.

5. A transformer comprising a pair of inductively coupled principal windings, an auxiliary winding coupling the leakage flux of both said principal windings in such manner that equal and additive fluxes due to currents in the principal windings are ineffective in the auxiliary circuit but equal and opposed fluxes due to currents in the principal windings induce a resultant voltage in the auxiliary winding, and additional winding inductively coupling said primary windings.

6. A closed core transformer having wound thereon a pair of similar, inductively coupled and symmetrically placed coils, an auxiliary winding extending about the outer confines of said transformer and lying approximately in a plane of symmetry cutting across the core at right angles thereto and to the plane of symmetry of said coils, the arrangement being such that additive fluxes due to currents in said coils are ineffective upon the auxiliary winding whereas opposed fluxes due to currents in said coils induce additive voltage effects in said auxiliary winding through the medium of the leakage inductances of said coils.

7. A closed core transformer having wound thereon a pair of similar inductively coupled and symmetrically placed coils, a closed winding of relatively few turns extending about the outer confines of said transformer lying

approximately in a plane of symmetry cutting across the core at right angles thereto and to the plane of symmetry of the coils, said closed winding having included therein suitable resistance for dissipating energy, being ineffective for this purpose for currents in said coils producing equal and additive fluxes, but effective for currents in said coils producing equal and opposed fluxes.

8. A closed core transformer having on said core a continuous, closed, principal winding, a first pair of taps at opposite points thereon, and a second pair of taps at opposite points midway between the first pair, an auxiliary winding extending about the outer confines of the transformer, lying approximately in a plane cutting across the core at right angles thereto and passing through the first pair of tapping points, such auxiliary winding having no voltage induced therein by the additive fluxes resultant upon currents flowing in the principal winding between the first pair of tapping points, but having a voltage induced therein by the leakage inductance of the principal winding for equal currents flowing therein between the first pair of tapping points and the second pair producing equal and opposed fluxes.

9. A closed core transformer having wound thereon a pair of similar inductively coupled and symmetrically placed coils, a closed winding of relatively few turns extending about the outer confines of said transformer and lying approximately in a plane of symmetry cutting across the core at right angles thereto and to the plane of symmetry of the coils, said closed winding having included therein suitable resistance for dissipating energy, being ineffective for this purpose for currents in said coils producing equal and additive fluxes, but effective for this purpose for currents in said coils producing equal and opposed fluxes.

In testimony whereof, I have signed my name to this specification this 7th day of November, 1928.

HAROLD C. SILENT.