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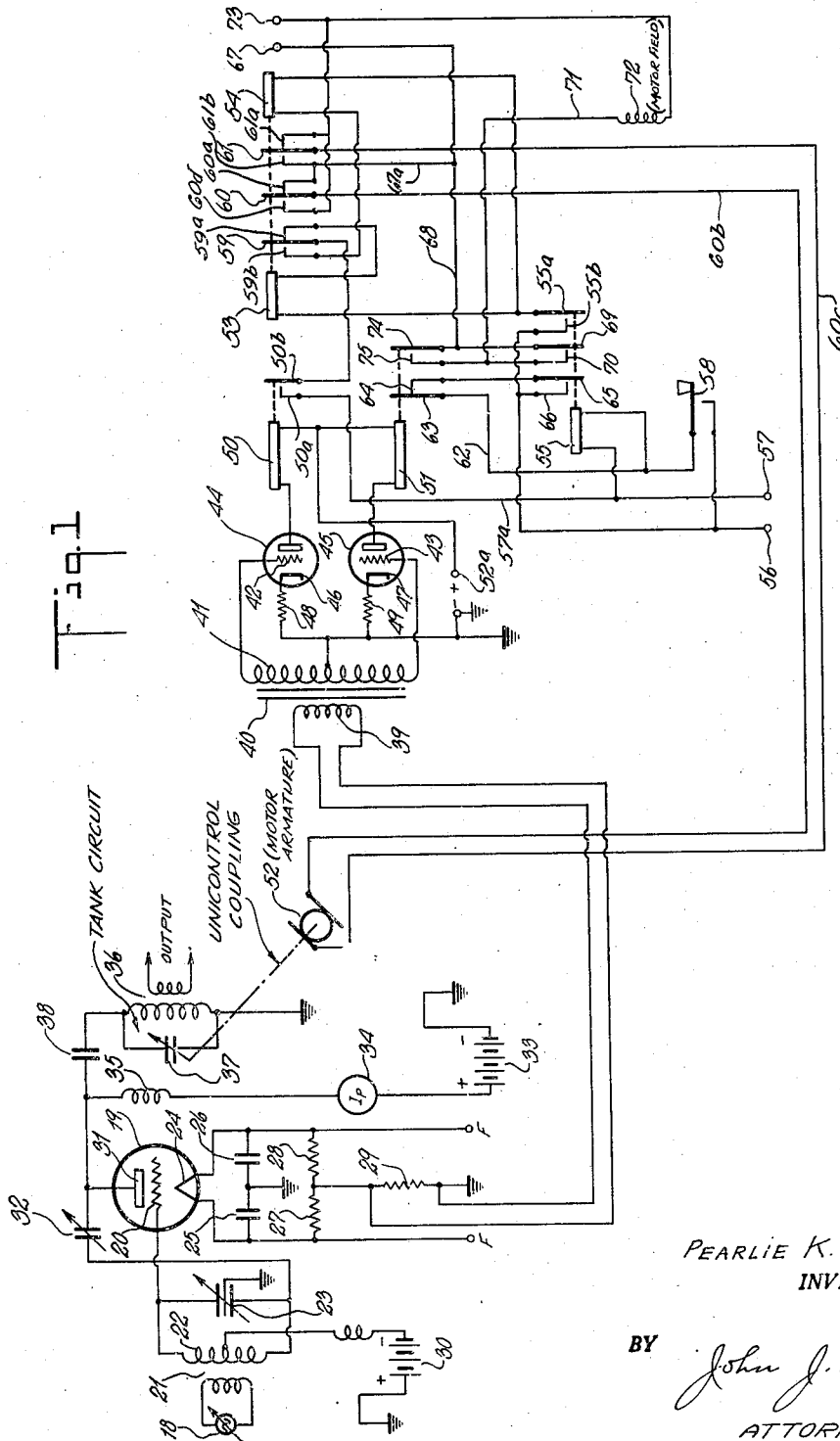
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2,476,897

AUTOMATIC MOTOR-CONTROLLED RESONATING SYSTEM

Filed Sept. 7, 1946

2 Sheets-Sheet 1



July 19, 1949.

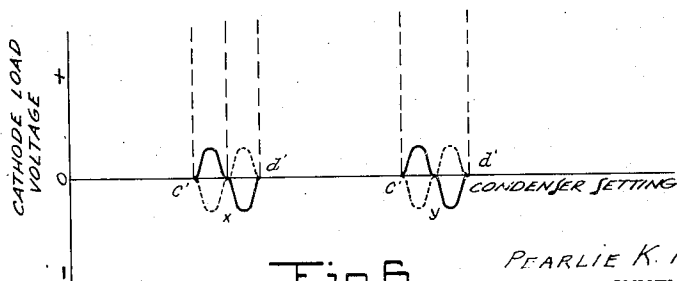
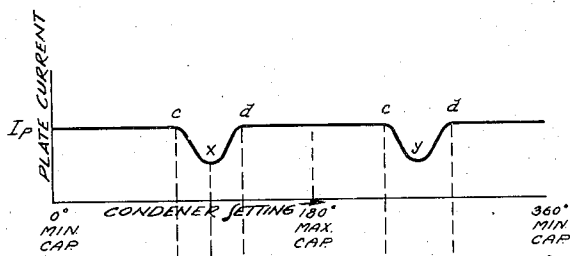
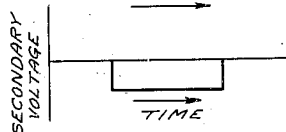
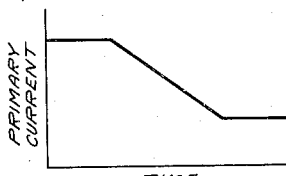
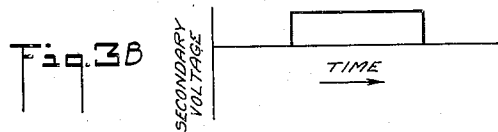
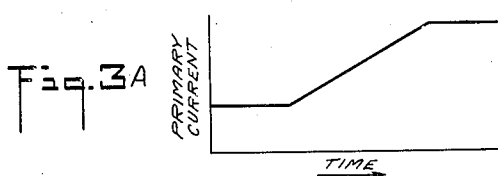
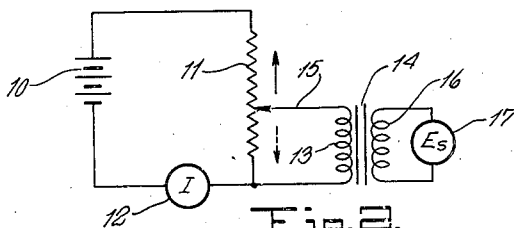
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AUTOMATIC MOTOR-CONTROLLED RESONATING SYSTEM

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2 Sheets-Sheet 2



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AUTOMATIC MOTOR-CONTROLLED
RESONATING SYSTEM

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9 Claims. (Cl. 250—40)

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This invention relates to radio systems and more especially to systems for automatically bringing a tuned circuit to resonance at a desired frequency.

A principal object of the invention is to provide an improved and simplified motor-controlled resonance-adjusting arrangement for tuned electric circuits.

Another object is to provide a simplified automatic tuning arrangement for resonant circuits wherein the tuning element e. g., a variable condenser, is of the 360° rotational type.

A feature of the invention relates to an arrangement comprising a pair of grid-controlled tubes which are selectively controlled by the plate current dips of a tuned radio frequency amplifier to determine the direction and extent of rotation of a tuning control motor.

A further feature relates to an automatic motor-controlled tuning arrangement which is particularly suited to class "C" amplifiers employing tuning condensers of the 360° rotational type.

A still further feature relates to the novel organization, arrangement and relative interconnection of parts which cooperate to provide an improved automatic motor-controlled tuning system.

In the drawing,

Fig. 1 is a schematic wiring diagram of a class "C" amplifier embodying the invention.

Fig. 2 is a simplified wiring diagram explanatory of Fig. 1.

Figs. 3A, 3B, 4A, 4B, are graphs used in explaining Figs. 1 and 2.

Fig. 5 is a graph of the plate current versus condenser setting of Fig. 1.

Fig. 6 is a graph of the cathode load voltage versus condenser setting of Fig. 1.

The electrical principle which is employed in the automatic resonating system of Fig. 1 is schematically shown in simplified form in Fig. 2, wherein a steady source of direct current such as battery 10 is connected across the potentiometer resistance 11 in series with ammeter 12. The primary winding 13 of a voltage transformer 14 is connected across an adjustable length of resistor 11, by means of contact slider 15, the secondary winding 16 being connected to a suitable voltage indicator 17. In a steady state, i. e., with slider 15 at rest, a constant current flows through the primary winding 13, therefore no voltage output appears at the secondary winding 16. If the slider 15 is moved in the direction of the full line arrow at a uniform rate, the current from primary 13 varies as shown in Fig. 3A and the corresponding secondary voltage is shown as a positive rectangular wave (Fig. 3B). If the slider 15 is moved in the direction of the dotted line arrow, the primary current and secondary voltage are as represented respectively

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in Figs. 4A and 4B. It will be noted that the voltage wave of Fig. 4B is negative with respect to the voltage wave of Fig. 3B. By suitable circuit connections therefore, it is possible to determine whether the current in a control circuit is increasing or decreasing.

Fig. 1 shows a typical automatic resonating control system employing the principle illustrated in Fig. 2. Numeral 18 represents any well-known source of radio frequency carrier waves adapted to be amplified by the tuned class "C" amplifier tube 19. While the drawing shows tube 19 of the triode type, it will be understood that any multi-grid amplifier tube may be employed. The source 18 is coupled to the control grid 20 of tube 19, through the coupling transformer 21, whose secondary winding 22 is tuned in the conventional manner by the condenser 23. The electron-emitting cathode 24 is returned to ground through a balancing network comprising the condensers 25, 26, and resistances 27, 28, and thence through the cathode load resistor 29. Since the tube 19 is to act as a class "C" amplifier, the control grid is negatively biased for example by battery 30, so that plate current flows only for a relatively small portion of the positive peaks of the excitation waves applied to grid 20. Preferably, and in accordance with standard practice, the plate or anode 31 is connected to the input circuit through an adjustable neutralizing condenser 32. The D. C. plate voltage is supplied from a suitable power supply represented schematically by the battery 33 in series with the plate current meter 34 and the radio frequency choke coil 35.

The output circuit comprising the output coupling transformer 36 tuned by variable condenser 37, is coupled to the plate 31 through the condenser 38. When the condenser 37 of the plate tank circuit is rotated from minimum to maximum and then back to minimum, that is, 360° of rotation, the relation between the condenser setting and the plate current as indicated on meter 34, is represented by the curve of Fig. 5. These dips in the plate current during the resonating ranges c—d produce a D. C. voltage drop across the cathode load resistor 29. Connected across the said resistor 29 is the primary winding 39 of an audio frequency transformer 40. The corresponding voltages induced in the secondary 41 of this transformer during the plate current dips, are represented by Fig. 6. The dotted line graphs in Fig. 6 represent the voltages at the secondary 41 when the rotation of condenser 37 is from minimum capacity to maximum and then again to minimum. As the condenser is passing through the resonating range, the plate current first decreases c to x (Fig. 5), thus giving rise to a negative output voltage c'—x (Fig. 6). The plate current then increases x—d (Fig. 5) giving rise to a positive voltage

d'—*x*. On the other hand, if the capacitor is at maximum capacity and rotated in either direction toward minimum capacity, the voltage at the secondary 41 will be indicated by the full line graphs in Fig. 6.

The secondary winding 41 is connected in divided balanced relation to the control grids 42, 43, of respective triodes 44, 45, the cathodes 46, 47, of which are returned to ground through the respective cathode resistors 48, 49. Likewise, the electrical midpoint of secondary 41 is returned to ground. Connected in the plate circuit of each of the tubes 44, 45, are respective electromagnetic directional control relays 50, 51, through the windings of which the positive potential terminal 52 of the D. C. plate power supply is connected to the plates of tubes 44, 45. It will be understood that the tubes 44 and 45, while shown as triodes, may be of any well-known multi-grid type. Relays 50 and 51 are control relays which are actuated depending upon whether the grid 42 or the grid 43 has a more positive potential applied thereto with respect to ground as determined by the current flow through the primary winding 39. The rotor element of the condenser 37 is suitably coupled to a tuning motor 52 whose power supply is controlled by a set of snap-acting relay contacts controlled respectively by relays 53, 54. The start circuit for the motor 52 is controlled by a relay 55, the winding of which is connected to the relay current supply terminals 56, 57, through a push button switch 58. The relay windings 53 and 54 actuate the movable contacts 59, 60, 61, in either direction depending upon which of the windings 53, 54, is energized. The movable contacts 59, 60 and 61, however, are operated, from relay windings 53, 54, through a toggle action (not shown) so that they stay put in their last operated position even though the previously energized winding 53 or 54 is in the meanwhile deenergized.

Assume for purposes of explanation that it is desired automatically to tune the tank circuit of amplifier 31 to a new resonance setting. The push button 58 is actuated closing a circuit traceable from terminal 56 through the contacts of button 58, winding of relay 55 to terminal 57. A holding circuit for relay 55 is thereupon completed from terminal 57 through the relay winding, conductor 62, armature 63 and back contact 64 of relay 51, armature 65 and front contact 66 of relay 55 to terminal 56. When relay 55 operates, it closes the motor power circuit traceable from power supply terminal 67, conductor 68, armature 69, front contact 70, conductor 71, motor winding 72 to terminal 73. The tuning motor 52, 72 thereupon begins to turn the rotor of condenser 37 in a clockwise or counterclockwise direction depending upon the position of the contacts 59, 60 and 61. As the condenser 37 reaches the resonance range, a positive voltage appears on the control grid 43, which causes sufficient plate current to flow through tube 45 to operate the relay 51. Relay 51 in operating, opens the previously described holding circuit of relay 55 which thereupon releases. However, the motor power supply circuit is maintained closed through the armature 74 and front contact 75 of relay 51. When the rotor of condenser 37 is in a position corresponding to *x* or *y* (Figs. 5 and 6), the voltage on the grid 43 drops to zero and relay 51 releases thus opening the power circuit to the motor which thereupon stops. This completes the tuning cycle for this condition of operation.

It is important to note that the polarity of the transformer 40, that is, the connection of the ends of its windings, is so related to the grids 42 and 43, that the grid 43 becomes positive with decreasing current through the primary winding 39. On the assumption that the condenser 37 was in a position corresponding to the rotation between *c* and *d*, that is, close to resonance, the following operations will occur. When the starting button 58 is operated, the tuning motor 52 starts to rotate, but if the rotation is in such a direction as to drive the condenser 37 away from resonance, the grid 42 becomes positive resulting in the operation of relay 50. The operating circuit for relay 50 may be traced from the positive D. C. terminal 52a, winding of relay 50, through the plate-cathode conduction path of tube 44 to ground, it being understood of course that the terminal 52a is the conventional positive D. C. terminal of the usual high voltage plate power supply such as is conventionally used with electron tubes. The operation of relay 50 results in the energization of either winding 53 or 54, depending upon the previously operated snap-action setting of the contacts 59, 60 and 61. For purposes of explanation, it will be assumed that the contacts 59, 60, 61 had been previously moved to the position shown in Fig. 1 under control of relay 54, and that they had been snapped and held in that position. Consequently when relay 50 energizes, it completes a circuit from the terminal 57, conductor 57a, relay contacts 50a, 50b, relay contacts 59, 59a, winding of relay 50, relay contacts 55a, 55b, to terminal 56. It will be observed that the directional rotation of the motor is controlled by the direction of current flow through the armature 52 which in turn is controlled by the movable contacts 60, 61, and their associated contact sets. Thus when the contacts 60 and 61 are in the position shown in Fig. 1 prior to the energization of relay 53, current flows from the terminal 67, conductor 67a, contacts 60a, 60, conductor 60b, armature 52, conductor 60c, contacts 61, 61a, to terminal 73. When the relay 53 is energized as above described, it closes contact 60 on contact 60d, and it also closes contact 61 on contact 61b. This results in reversing the direction of current flow through the motor armature 52. As soon as this reversal of direction begins, relay 50 releases and relay 51 operates as above described, by reason of the fact that the potential on grid 42 changes from a positive to a negative phase and the potential on grid 43 changes from a negative to a positive phase. The operating circuit for relay 51 is traceable from the positive D. C. plate power supply terminal 52a, winding of relay 51, and thence through the tube 45 to ground. Relay 51 therefore remains operated until condenser 37 reaches a position corresponding to point *x* or *y* (Figs. 5 and 6) at which time it releases, completing the tuning cycle with condenser 37 at a resonant position. When relay 51 operates as above mentioned, it breaks the previously described holding circuit for relay 55. However, as above mentioned, a circuit is maintained through the motor winding 72 which circuit is traceable from terminal 67, conductor 68, contacts 74, 75, conductor 71, motor field winding 72, to terminal 73. When resonance is reached, relay 51 releases and the motor circuit is opened. It will be observed however that because of the toggle action on the contacts 59, 60 and 61, they remain in their positions wherein they engage their respective front contacts 59b, 60d and 61b. Conse-

quently during a subsequent automatic tuning cycle when the relay 50 operates, instead of resulting in the energization of relay 53, it results in the energization of relay 54, this circuit being traceable from terminal 57, conductor 57a, contacts 50a, 50b, contacts 59, 59b, relay 54, contacts 55a, 55b, and terminal 56. This therefore provides the proper direction of motor rotation to complete the subsequent tuning cycle. It will be understood of course, that during the foregoing described automatic operations, the input circuit 21 is being excited by the radio frequency signals from the source 18 at a frequency to which the new setting of condenser 37 is to be automatically obtained. Furthermore, while the arrangement is illustrated for tuning an oscillatory tank circuit, it will be understood that any other tuned electrical network can be resonated by the motor 52.

While one specific embodiment has been described herein, it will be understood that various changes and modifications may be made without departing from the spirit and scope of the invention.

What is claimed is:

1. An automatic resonating control system for radio apparatus of the type having a source of radio frequency, a grid-controlled amplifier tube excited from said source and having an adjustable resonating element for resonating with said source comprising, a motor for moving said element, a pair of directional control motor relays and an electrical network selectively and automatically responsive to the polarity of the plate current dips of said amplifier tube as said element is being moved through the resonating range to cause corresponding selective operation of said relays and thereby adjusting said element to a resonating position.

2. An automatic resonating control system for radio apparatus of the type having a source of radio frequency a grid-controlled amplifier excited from said source and having an adjustable resonating element for resonating with said source, comprising a motor for moving said element, an electrical network which is selectively and automatically responsive to the relative polarity change of the plate current dips of said amplifier as said element is passing through a resonating range, and a pair of directional motor control relays controlled by the currents from said network for causing said motor to adjust said element to a resonating position.

3. An automatic resonating control system for radio apparatus of the type having a radio frequency source, a grid-controlled amplifier excited from said source and having an adjustable resonating element for resonating with said source, comprising a motor for moving said element, a pair of grid-controlled tubes selectively and automatically responsive to the relative polarity change of the dips in the plate current of said amplifier tube as said element is moving through a resonating range, and a pair of motor control relays selectively controlled by said pair of tubes and thereby adjusting said element to a resonating position.

4. An automatic resonating control system for radio apparatus of the type having a radio frequency source, a grid-controlled amplifier excited from said source and having a tuning element of the 360° rotational type for resonating with said source, comprising a motor for rotating said element, a pair of grid-controlled tubes selectively and automatically responsive to the relative

polarity of the dips in the plate current of said amplifier as said element is moving through a resonating range, a pair of motor control relays controlled respectively by said grid-controlled tubes, a set of motor reversing switch contacts, a pair of electromagnets controlled by said relays for operating said switch contacts to either of two positions, said contacts when operated to one position remaining "stay-put" until operated by the other electromagnet and even though the previously energized electromagnet becomes deenergized.

5. An automatic resonating system for radio apparatus of the type having a radio frequency source, a grid-controlled amplifier tube excited from said source and having an adjustable resonating element for resonating with said source, comprising a motor for moving said element, a pair of grid-controlled tubes, a phase-sensitive network for selectively and automatically exciting the control grids of said pair of tubes in accordance with the relative polarity changes of the dips in the plate current of said amplifier tube as said element is moving through a resonating range, a pair of relays each controlled respectively by the plate current of one of said pair of tubes, a motor start control relay, manual switch means to close the circuit of said motor start relay, a holding circuit for said motor start relay controlled by the normally closed contacts of one relay of said pair of relays, a motor reversing switch having a contact set of the "stay-put" type, a pair of electromagnets for moving said contact set from one position to the other to reverse the direction of the motor, the energization of both said electromagnets being controlled by a normally open contact of said motor start relay and by a normally open contact of the other relay of said pair of relays.

6. An automatic resonating control system according to claim 5 in which the circuit of one of said electromagnets is closed through a normally open contact of the other electromagnet.

7. An automatic resonating control system according to claim 5 in which an alternative energizing circuit is provided for said motor start relay which is controlled by the normally open contacts of both of said electromagnets to cause said motor to continue rotating even when said resonating element is out of the resonating range, said alternative energizing circuit being broken when said element reaches the resonance position.

8. An automatic resonating control system according to claim 3 in which said pair of grid-controlled tubes are coupled to the cathode load circuit of said amplifier tube through a phase-sensitive coupling transformer.

9. An automatic resonating control system according to claim 3 in which said pair of grid-controlled tubes are coupled to the cathode load circuit of said amplifier tube through a push-pull input transformer.

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