The 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 resonating 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 S39 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 S90 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 16 is connected across the potentiometer resistance 11 in series with ammeter 12.

The primary winding 13 of a 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 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. Numerals 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 condenser 25, 26, and resistances 21, 28, and thence through the cathode lead resistor 29.

The output circuit comprising the output coupling transformer 35 is 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 range c—a produce a D.C. voltage drop across the cathode load resistor 23. Connected across the said resistor 23 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 a (Fig. 5), thus giving rise to a negative output voltage e—x (Fig. 6). The plate current then increases x—d (Fig. 5) giving rise to a positive voltage...
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 arnament 72 of 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 opened, 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 circuits 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 in radio 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 is 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 59a, 59b, 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 57, conductor 57a, contacts 59a, 59b, conductor 60b, armature 52, conductor 60c, contacts 61a, 61c, 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 61d. This results in reversing the direction of current flow through the armature 52 as above described, 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 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 59a, 59b, contacts 59a, 59b, relay 54, contacts 59a, 59b, 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 51 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 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 of said amplifier as said element is passing through a resonating range, and a pair of directional 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 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 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 control 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 phasesensitive 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 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 5 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 5 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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