

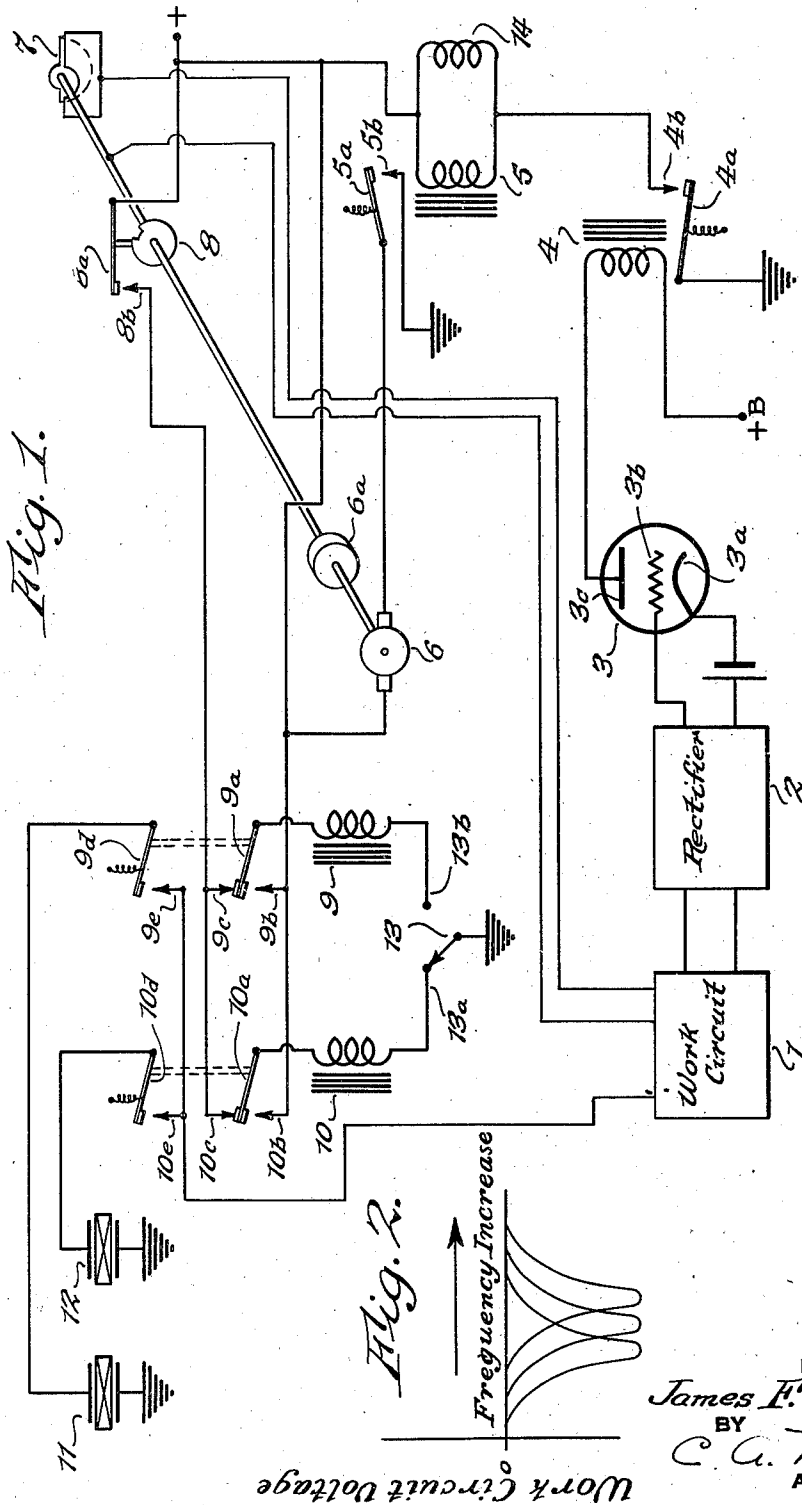
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AUTOMATIC TUNING CONTROL CIRCUIT

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AUTOMATIC TUNING CONTROL CIRCUIT

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8 Claims. (Cl. 250—40)

This invention relates to an automatic tuning control circuit, and more particularly to automatic crystal controlled radio transmitters or receivers, although it will be understood that my invention may be applied in other apparatus where automatic tuning of a circuit to any one of a series of predetermined frequencies is desired. Various forms of circuits of this type have been described and claimed in a co-pending application of William S. Winfield, Serial No. 463,775. In apparatus of this type, the circuits are automatically tuned by a motor to desired frequencies determined by crystals, but do not require the setting of mechanical elements, such as pins, contactors, selecting cams, rocker bars, or the like. The voltage developed in the circuit to be tuned is utilized to control a relay which opens the motor circuit. Since this voltage is zero except over the resonance range of the circuit and is a maximum only at the resonant frequency or very close thereto, very accurate tuning can be obtained in this way.

In experimental work with apparatus such as that described in the above application, it has been found that, while the system described operates as contemplated when the resonance curves of the circuits controlled are separated or do not overlap to any considerable extent, difficulties may be encountered when the channels desired to be tuned are so close to each other that the resonance curves overlap to a considerable extent. Under such conditions the apparatus, when tuned to one frequency, may remain tuned to that frequency although the controls are operated to change the frequency.

It is an object of this invention to provide apparatus of the class described in which these difficulties are eliminated and reliability of operation is assured, even though a number of channels are provided so closely adjacent in frequency that the resonance curves of the apparatus for various channels overlap.

It is a further object of my invention to provide apparatus which will be closely tuned to the desired channel even though other channels are closely adjacent to the desired channel.

It is a still further object of my invention to provide improved apparatus of the class described having improved operational characteristics such that the apparatus will function and tune properly even where channels are as closely spaced as tuning selectivity permits.

It is still a further object of my invention to provide apparatus of the class described so arranged that when the selecting switch is oper-

ated to change the frequency channel, the crystal corresponding to the former channel is immediately disconnected from the circuit, but the second crystal corresponding to the new channel desired is not immediately connected into the circuit, thereby assuring that the motor which drives the tuning instrumentality will be set into operation without the possibility of failure.

Still other objects and advantages of my invention will be apparent from the specification.

In the drawing,

Fig. 1 is a circuit diagram of automatic tuning apparatus in accordance with my invention.

Fig. 2 is a family of resonance curves illustrating conditions which may be encountered when it is desired to provide a number of channels closely spaced in frequency.

Referring now more particularly to Fig. 1, reference numeral 7 designates a variable tuning instrumentality such as a variable condenser, variometer, or the like, driven by a suitable operating means, such as motor 6, through suitable reduction gearing 6a, and serving to tune one or more circuits, which may be oscillator circuits, antenna circuits, or, in fact, any tunable circuit required to be tuned, herein diagrammatically shown and described as work circuit 1.

The tuning instrumentality, which, for sake of simplicity, is referred to as a condenser, although it may be another instrumentality, may be a single or gang condenser, and may tune one or more circuits, as may be desired, if two or more circuits are desired to be simultaneously tuned.

The tuning instrumentality is arranged for continuous rotation; i. e., no stop is provided limiting its rotation to 180° as is sometimes the case in condensers. For purposes of simplicity, the remainder of the tuning circuit or circuits is not shown, but it will be understood that condenser 7 may be part of work circuit 1. A voltage derived from this circuit may be first rectified by rectifier 2 and then impressed between the cathode 3a and control electrode 3b of relay control tube 3.

The control tube 3 controls the operation of motor 6 through relays 4 and 5 connected in tandem. The biasing and plate voltages of control tube 3 and its operating characteristics are so chosen and related to each other that when the voltage derived from work circuit 1 reaches a predetermined magnitude, the grid bias on tube 3 is such as to considerably reduce or stop the flow of plate current in tube 3. This permits the armature 4a (which may be spring biased to open

position) to move away from fixed contact 4b, thereby opening the energizing circuit of motor relay 5 and likewise opening the circuit of clutch coil 14 operating mechanism (not shown) to immediately declutch the motor 6 from con-

5 denser 7 and prevent the condenser from coasting past the resonance position due to the inertia of the motor and gearing. Opening of the circuit of the motor relay coil 5 permits the armature 5a, which may be spring biased to open position, to
10 move away from fixed contact 5b, thereby de-energizing the motor.

It may be noted at this point that the use of re-

lays 4 and 5 in tandem is of no significance with respect to my invention, but is desirable in case the motor current is so large that it cannot be properly handled by a relay operated by the plate current of tube 3. If this motor current is small enough, the relay winding 5 might be substituted for relay winding 4 without changing the principle of operation.

Selection of the various channels or frequencies to which the apparatus may be tuned is made by selecting switch 13, herein shown as movable from fixed contact 13a to fixed contact 13b.

It will be understood, however, that while I have shown only two positions, corresponding to two channels, any desired number of channels may be provided, each with its individual fixed contact and associated apparatus, as will now be described.

In the position 13a, a circuit is prepared from ground through switch 13, fixed contact 13a, and the energizing coil of relay 10, through armature 10a, fixed contact 10c, to the fixed contact 8b, of cam switch 8. The circuit is open at the cam switch except at one position, through which it passes once in each tuning cycle. The cam is synchronized with tuning condenser 7 so that closure of movable contact 8a against fixed contact 8b occurs once in each tuning cycle, preferably at the point where the circuits are tuned to the lowest frequency at which the apparatus is capable of operating.

It will be noted that in the position shown, neither of the crystals 11 and 12 are connected to the work circuit because neither relays 9 or 10 have yet been energized, and no voltage is produced in the work circuit, no voltage is impressed on control tube 3, normal plate current flows, relays 4 and 5 are closed, and the motor circuit is energized. The motor will continue to operate until a voltage is produced in the work circuit sufficient to stop or substantially reduce the plate current to cause operation of relays 4 and 5. This occurs as follows:

On closure of cam switch 8, the circuit previously prepared through relay winding 10 is closed to the power source indicated as +, the opposite side of which may be grounded. This closes armatures 10a and 10d against fixed contacts 10b and 10e and opens the former connection between 10a and 10c. Closure of 10a against 10b locks relay 10 in, as it will be observed that this circuit no longer includes cam switch 8, and the opening of the cam switch will not open relay 10. In the closed position of the relay 10, it will be observed that the crystal 12 is connected through armature 10d and fixed contact 10e to the work circuit.

When the tuning of this circuit approaches the resonance frequency as determined by crystal 12, a voltage will be generated in the work circuit, rectified by rectifier 2, and will serve to reduce the plate current of tube 3 to the point where relay 4

opens, in turn opening relay 5, and thereby the motor circuit, and de-energizing clutch coil 14. The motor is stopped, and likewise condenser 7 and cam 8, and the apparatus will remain in this position.

If the clutch coil 14 and its associated mechanism is not provided, it will be understood also that when the motor circuit is opened, the condenser will not instantaneously stop its rotation because of the inertia of the parts. In general, the time required for the motor to stop and the angular distance through which the condenser turns after the motor circuit is opened will be substantially constant for any particular apparatus, and may be measured and allowed for in such a manner that the coasting which intervenes between the opening of the motor circuit and the final position of rest is just sufficient to carry the apparatus to the peak of the resonance curve.

If the operator desires to switch to the second channel, he will move the selecting switch 13 from position 13a to position 13b. This first opens the circuit of relay 10, permitting armatures 10a and 10d to move to back contact position, thereby disconnecting crystal 12 from the work circuit. Since no voltage is now being produced by the work circuit, relay 4 will be energized, closing relay 5, energizing clutch coil 14, and starting the motor. A circuit through relay 9 is now prepared through armature 9a, back contact 9c, to the cam switch fixed contact 8b; but this circuit will not be completed until the cam switch 8 has completed a cycle.

While this cycle is being completed, condenser 7 is likewise rotating through a complete cycle. When the cycle is completed, cam switch 8 is closed, and the winding or relay 9 energized, thereby closing armature 9d against front contact 9e, and armature 9a is moved from back contact 9c to front contact 9b. This locks in relay 9, since the energizing winding is now connected through contacts 9a and 9b directly to the source of power, and also connects crystal 11 to the work circuit.

The motor will continue to operate as before until the voltage produced by the work circuit is sufficient to reduce the plate current of the tube 3 to the point where relay 4 opens, thus operating the motor circuit, whereupon rotation of condenser 7 stops as already explained, the apparatus now being tuned to the second frequency channel.

In the operation of the circuit described, careful adjustment of both relays 9 and 10 is necessary because, as will be noted, each of these relays disconnects its own power in switching from back contact position to front contact position, in the latter of which it is locked in. While careful adjustment of these relays is required, I have found that it is entirely feasible to arrange the apparatus to operate as described.

This assures positive operation under the condition shown by Fig. 2, where the three resonance curves shown represent three channels overlapping closely, and under which conditions the voltage impressed on the control tube might be sufficient to prevent the motor from starting when the controls are operated to change from one of the channels to another.

In the specification I have explained the principles of my invention and the best mode in which I have contemplated applying those principles, so as to distinguish my invention from other inventions; and I have particularly pointed out and distinctly claimed the part, improve-

ment, or combination which I claim as my invention or discovery.

While I have shown and described certain preferred embodiments of my invention, it will be understood that modifications and changes may be made without departing from the spirit and scope of my invention, as will be apparent to those skilled in the art.

I claim:

1. In automatic tuning apparatus, in combination, a frequency determining element, a work circuit including a power source for delivering energy limited to a frequency determined by said element, said work circuit having a variable tuning instrumentality operable through successive tuning cycles, power means for varying said instrumentality, energy responsive means receiving energy from said work circuit for interrupting operation of said power means in response to delivery by said work circuit to said energy responsive means of a predetermined level of energy, and means for causing operation of said power means to move said tuning instrumentality through completion of one tuning cycle irrespective of the level of energy of said work circuit, said last mentioned means comprising a relay for closing a circuit to connect said frequency determining element to said work circuit, a normally open switch interposed in circuit with the energizing winding of said relay, and means for closing said switch once only in each tuning cycle.

2. In automatic tuning apparatus, in combination, a frequency determining element, a work circuit including a power source for delivering energy limited to a frequency determined by said element, said work circuit having a variable tuning instrumentality operable through successive tuning cycles, power means for varying said instrumentality, energy responsive means receiving energy from said work circuit for interrupting operation of said power means in response to delivery by said work circuit to said energy responsive means of a predetermined level of energy, and means for causing operation of said power means to move said tuning instrumentality through completion of one tuning cycle irrespective of the level of energy of said work circuit, said last mentioned means comprising a relay for closing a circuit to connect said frequency determining element to said work circuit, a normally open switch interposed in circuit with the energizing winding of said relay, and means synchronized with said tuning instrumentality for closing said switch once only in each tuning cycle.

3. In automatic tuning apparatus, in combination, a frequency determining element, a work circuit including a power source for delivering energy limited to a frequency determined by said element, said work circuit having a variable tuning instrumentality operable through successive tuning cycles, power means for varying said instrumentality, energy responsive means receiving energy from said work circuit for interrupting operation of said power means in response to delivery by said work circuit to said energy responsive means of a predetermined level of energy, and means for causing operation of said power means to move said tuning instrumentality through completion of one tuning cycle irrespective of the level of energy of said work circuit, said last mentioned means comprising a relay for closing a circuit to connect said frequency determining element

to said work circuit, a normally open switch interposed in circuit with the energizing winding of said relay, means for closing said switch once only in each tuning cycle, and a circuit completed by said relay on closure for energizing said relay independently of said normally open switch.

4. In automatic tuning apparatus, in combination, a frequency determining element, a work circuit including a power source for delivering energy limited to a frequency determined by said element, said work circuit having a variable tuning instrumentality operable through successive tuning cycles, power means for varying said instrumentality, energy responsive means receiving energy from said work circuit for interrupting operation of said power means in response to delivery by said work circuit to said energy responsive means of a predetermined level of energy, and means for causing operation of said power means to move said tuning instrumentality through completion of one tuning cycle irrespective of the level of energy of said work circuit, said last mentioned means comprising a relay for closing a circuit to connect said frequency determining element to said work circuit, a normally open switch interposed in circuit with the energizing winding of said relay, means synchronized with said tuning instrumentality for closing said switch once only in each tuning cycle, and a circuit completed by said relay on closure for energizing said relay independently of said normally open switch.

5. In automatic tuning apparatus, in combination, a frequency determining element, a frequency selecting switch for selecting said frequency determining element, a work circuit including a power source for delivering energy limited to a frequency determined by said element, said work circuit having a variable tuning instrumentality operable through successive tuning cycles, power means for varying said instrumentality, energy responsive means receiving energy from said work circuit for interrupting operation of said power means in response to delivery by said work circuit to said energy responsive means of a predetermined level of energy, and means for causing operation of said power means to move said tuning instrumentality through completion of one tuning cycle irrespective of the level of energy of said work circuit, said last mentioned means comprising a relay for closing a circuit to connect said frequency determining element to said work circuit, a normally open switch interposed in circuit with the energizing winding of said relay, means for closing said switch once only in each tuning cycle, and a circuit completed by said relay on closure for energizing said relay independently of said normally open switch, said circuit including said frequency selecting switch.

6. In automatic tuning apparatus, in combination, a frequency determining element, a frequency selecting switch for selecting said frequency determining element, a work circuit including a power source for delivering energy limited to a frequency determined by said element, said work circuit having a variable tuning instrumentality operable through successive tuning cycles, power means for varying said instrumentality, energy responsive means receiving energy from said work circuit for interrupting operation of said power means in response to delivery by said work circuit to said energy responsive means of a predetermined level of energy, and means for causing operation of said power means to move said tuning instrumentality through completion of one tuning cycle irrespective of the level of

energy of said work circuit, said last mentioned means comprising a relay for closing a circuit to connect said frequency determining element to said work circuit, a normally open switch interposed in circuit with the energizing winding of said relay, means synchronized with said tuning instrumentality for closing said switch once only in each tuning cycle, and a circuit completed by said relay on closure for energizing said relay independently of said normally open switch, said circuit including said frequency selecting switch.

7. In automatic tuning apparatus, in combination, a plurality of frequency determining elements, a frequency selecting switch for selecting one of said frequency determining elements, a work circuit including a power source for delivering energy limited to a frequency determined by the selected frequency determining element operable through successive tuning cycles, said work circuit having a variable tuning instrumentality, power means for varying said instrumentality, energy responsive means receiving energy from said work circuit for interrupting operation of said power means in response to delivery by said work circuit to said energy responsive means of a predetermined level of energy, and means for causing operation of said power means to move said tuning instrumentality through completion of one tuning cycle irrespective of the level of energy of said work circuit, said last mentioned means comprising a relay for each frequency determining element for closing a circuit to connect said frequency determining element to said work circuit, a normally open switch interposed in circuit with the energizing winding of each of said relays, means for closing said switch once only in each tuning cycle, and a circuit for each relay,

completed by the relay on closure for energizing said relay independently of said normally open switch, each of said circuits including said frequency selecting switch.

8. In automatic tuning apparatus, in combination, a plurality of frequency determining elements, a frequency selecting switch for selecting one of said frequency determining elements, a work circuit including a power source for delivering energy limited to a frequency determined by the selected frequency determining element operable through successive tuning cycles, said work circuit having a variable tuning instrumentality, power means for varying said instrumentality, energy responsive means receiving energy from said work circuit for interrupting operation of said power means in response to delivery by said work circuit to said energy responsive means of a predetermined level of energy, and means for causing operation of said power means to move said tuning instrumentality through completion of one tuning cycle irrespective of the level of energy of said work circuit, said last mentioned means comprising a relay for each frequency determining element for closing a circuit to connect said frequency determining element to said work circuit, a normally open switch interposed in circuit with the energizing winding of each of said relays, means synchronized with said tuning instrumentality for closing said switch once only in each tuning cycle, and a circuit for each relay, completed by the relay on closure for energizing said relay independently of said normally open switch, each of said circuits including said frequency selecting switch.

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