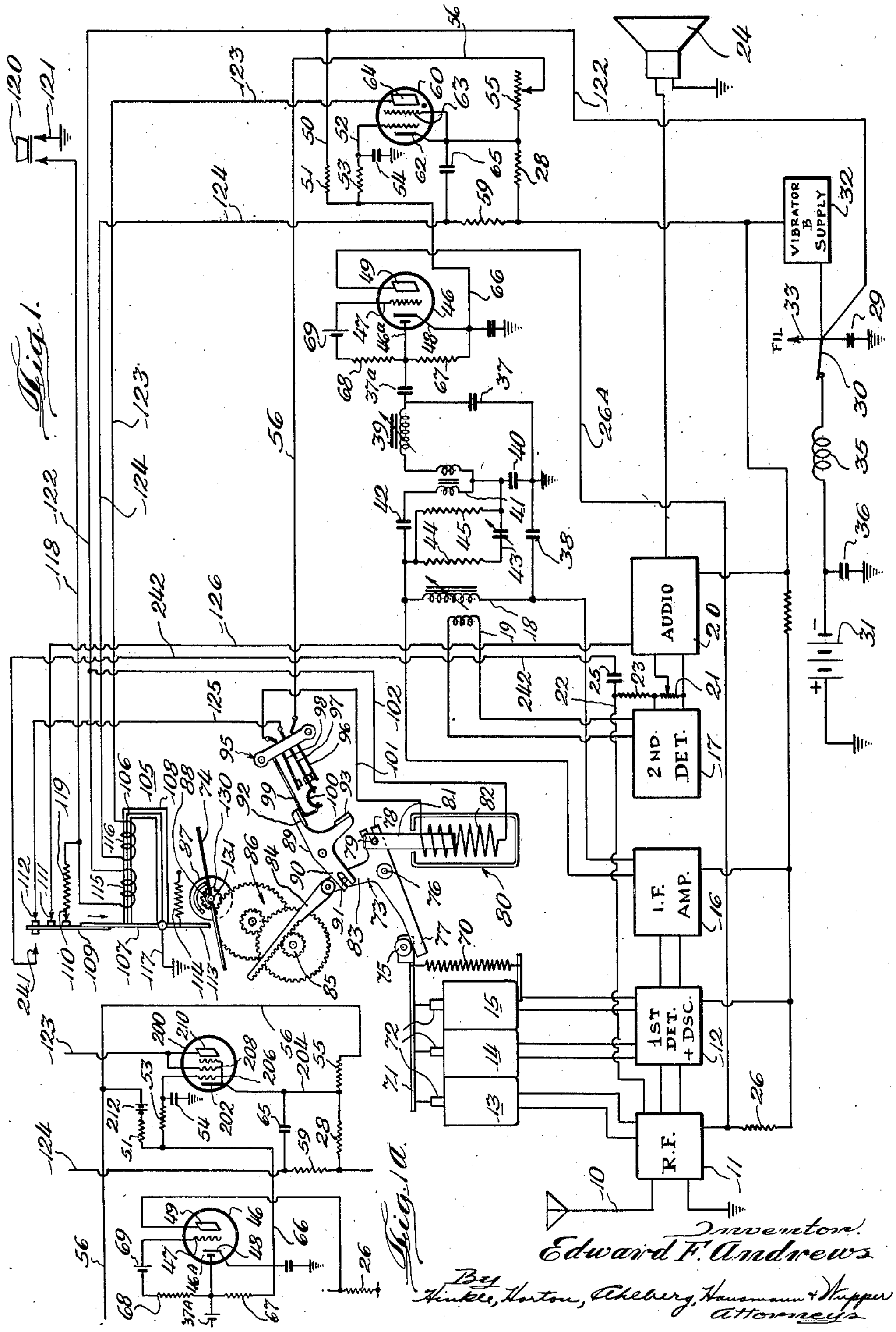
Feb. 13, 1951 E. F. ANDREWS 2,541,018

STOP-ON-SIGNAL RADIO APPARATUS

Filed Nov. 1, 1946 2 Sheets-Sheet 1



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STOP-ON-SIGNAL RADIO APPARATUS

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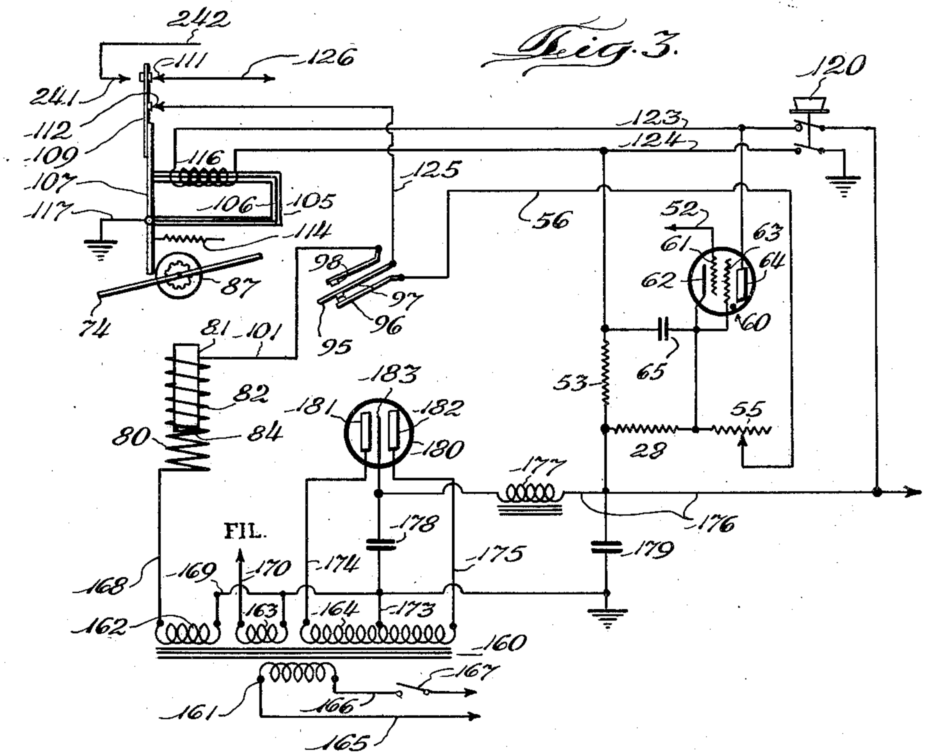
Fig. 3.



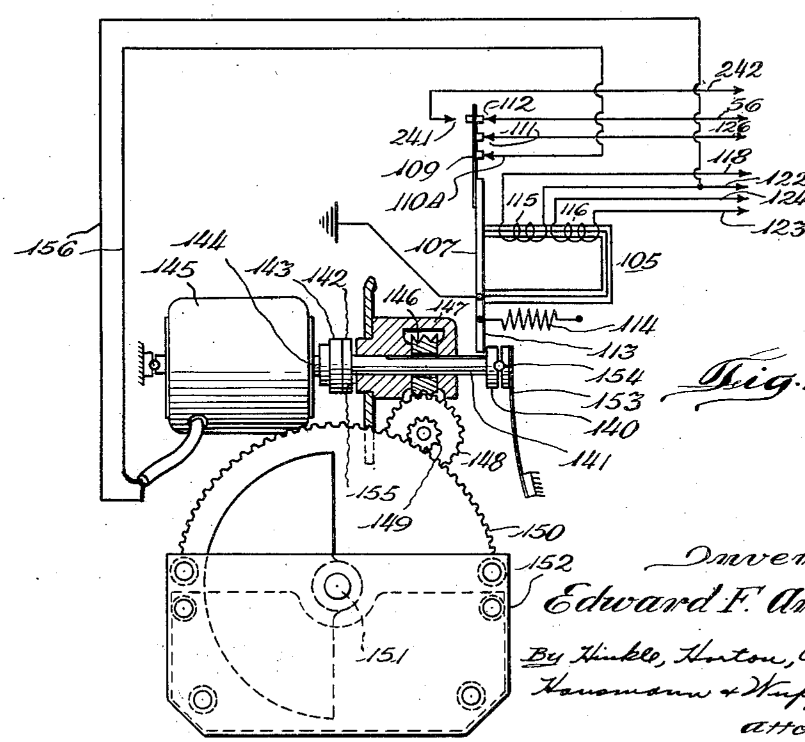


Fig. 2.

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STOP-ON-SIGNAL RADIO APPARATUS

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Application November 1, 1946, Serial No. 707,219

20 Claims. (Cl. 250—40)

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This invention relates to radio apparatus of the self-tuning type. More particularly, it relates to "stop-on-signal" apparatus, especially receivers, requiring no manual presetting to tune in progressively the stations within their range of sensitivity. Such receivers, although having broad utility, are particularly advantageous for use as automobile receivers because the frequent changes in geographical position of the vehicle cause different stations to be within range for reception at different times. This feature of stop-on-signal receivers makes them also especially applicable to all types of automotive vehicles including watercraft and aircraft.

Receivers of this type have been known in the art as "stop-on-carrier" or "signal-seeking" receivers. Although "stop-on-carrier" is substantially the same in meaning as "stop-on-signal," I now prefer the use of the term "stop-on-signal" receiver for this class of device. Receivers of this general type have been described in previous patents and patent applications, such as those of Edward F. Andrews, Patent No. 2,326,738, issued August 17, 1943, and Patent No. 2,262,218, issued November 11, 1941; also in the presently pending application of William J. O'Brien, Serial No. 605,397, filed July 16, 1945, and Patent No. 2,442,430, issued June 1, 1948.

Certain features of the apparatus disclosed in this application are disclosed and claimed in the above-mentioned application and patent of William J. O'Brien, my Patent No. 2,493,741 issued January 10, 1950 and Patent No. 2,494,235, issued January 10, 1950 to Olgierd Gierwiatowski.

Although the invention to be described is especially adapted for use with stop-on-signal receivers for broadcast reception, its use is not necessarily restricted to this field, for stop-on-signal devices may also find application in radio transmitters, in the field of electronic control, and in other resonance responsive electronic apparatus.

One of the objects of my invention, therefore, is to provide improved stop-on-carrier, signal-seeking, or stop-on-signal tuning apparatus for all varieties of tunable radio circuits.

Another object of my invention is to provide an improved stop-on-signal radio receiver.

A further object of the present invention is to provide new and improved stop-on-signal radio apparatus including an electron tube having a plate circuit and a magnetically or flux latched tuning means controlling relay having a coil in the plate circuit of the tube which is energizable to unlatch the relay.

Another object of the present invention is to provide a new and improved stop-on-signal radio apparatus wherein the means for stopping variation of tuning means in response to a signal includes flux-latched relay means unlatched by

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signal responsive means and brake means applied when said relay means is unlatched.

A further object of the present invention is to provide a new and improved stop-on-signal radio apparatus including an electron tube having a plate circuit and a tuning means brake controlling relay in the plate circuit energizable to unlatch the relay and wherein said relay also is adapted to open the plate circuit of the tube, thereby to insure that the tuning means will not vary the tuning until the plate circuit is again reclosed.

A further object of the present invention is to provide a new and improved stop-on-signal radio apparatus comprising a gas tube adapted to be rendered conductive in response to a signal and a tuning means controlling relay energized from the plate circuit of the tube which is adapted to open the plate circuit, thereby to render the tube nonconductive to prevent variation of the tuning means until the plate circuit is again reclosed.

A further object of the present invention is to provide a new and improved stop-on-signal radio apparatus comprising variable tuning means, a plurality of electron tube means and a relay controlled thereby adapted to be energized to terminate variation of the tuning means and, preferably, simultaneously to open the plate circuits of one or more or all of the electron tube means, thereby to cut down the current consumption during such time as the stop-on-signal means is not tuning in a signal.

Another object of the present invention is to provide a new and improved stop-on-signal radio apparatus wherein variable tuning means are stopped by a flux-latched relay having coil means in the plate circuit of an electron tube and arranged to buck the relay latching flux.

A further object of the present invention is to provide a stop-on-signal radio apparatus wherein the tuning means is controlled by a relay having coil means energized by direct current in opposite directions to effect magnetic latching and unlatching of the relay.

A further object of the present invention is to provide a new and improved, and especially simplified, stop-on-signal control comprising variable tuning means and means including a single coil relay energizable in opposite directions to initiate and terminate operation of the tuning means.

A still further object of the present invention is to provide stop-on-signal radio apparatus having novel means for initiating and stopping variation of tuning means to tune in signals, which means includes electromagnetic means having two windings and means for energizing one of said windings with direct current to initiative variation and the other with direct current to stop variation.

A further object of the present invention is to provide a new and improved stop-on-signal tuning means comprising a magnetically latched relay wherein the magnetic latching is effected by the residual magnetism of the relay and by a small current providing additional holding flux.

A further object of the present invention is to provide a new and improved stop-on-signal relay.

Another object of the present invention is to provide new and improved stop-on-signal radio apparatus including a flux-latched relay having a coil energizable to buck the latching flux and means associated therewith to limit the current through the coil to a value which will not effect relatching of the relay means.

A further object of the present invention is to provide a new and improved stop-on-signal radio apparatus having an audio amplifier in which the stopping means is coupled to the apparatus ahead of the audio amplifier and includes relay means in the plate circuit of a tube adapted to be energized by an increase in current in the plate circuit and which, when energized, releases resiliently operated means to stop the tuning means.

Another object of the present invention is to provide a new and improved stop-on-signal radio apparatus energized from an alternating current source of power, wherein the power storage means is charged by means energized by alternating current and both the initiation and termination of the variation of the tuning means is controlled by means energized from a rectifier also energized from the said source of power.

Further objects, advantages and capabilities of my invention will become apparent upon study of the following description and accompanying drawings in which:

Fig. 1 is a schematic illustration of an embodiment of my invention as applied to automobile receivers;

Fig. 1A is a fragmentary schematic representation of another embodiment of the invention;

Fig. 2 is a schematic illustration of further embodiment of my invention utilizing motor driven tuning means and relay operated clutch means for starting the tuning means; and

Fig. 3 is a schematic illustration of a still further embodiment of my invention.

Fig. 1 illustrates an embodiment of my invention applied to automobile radio receivers. More particularly, it represents an automobile radio receiver of the superheterodyne type, including an antenna 10; a tuned radio frequency amplifier 11 and its associated variable tuning means 13; a first detector and oscillator 12 and the variable tuning means 14 and 15 associated therewith; an intermediate frequency amplifier 16 which may have a plurality of stages; a second detector 17; a transformer having a primary 18 and a secondary 19 coupling the intermediate frequency amplifier 16 to the second detector 17; an audio frequency amplifier 20; a volume control voltage divider 21; an automatic volume control circuit 22; and a loudspeaker 24.

Power is preferably supplied to the apparatus by the vehicle storage battery 31 which serves directly as a source of filament supply for the tubes, as well as to energize a relay and solenoid forming part of the stop-on-signal means to be described shortly. The power supply includes a high voltage "B" supply 32, which may be a standard vibrator unit of the type commonly used in vehicular radios. The filament supply, indicated at 33 and which is connected to the filaments (not shown) of all the tubes, and current to the "B" supply is controlled by an "on-and-off" switch 30, which may be physically connected to the volume control 21. A choke coil 35 connected to the ungrounded negative terminal of the battery serves to isolate high frequency currents from the battery circuit, and capacitors 29 and 36 further serve to ground high frequency currents.

The variable tuning means 13, 14 and 15 are illustrated as being of the variable permeability type having movable powdered iron cores 72. However, it should be understood that variable condensers may be employed. The cores are arranged for slidable movement by means of the spring 70 which pulls a yoke 71 to which the several cores 72 are attached from the high frequency end of core travel whereat the cores are outside their associated coils to the low frequency end where the cores are within the coils. An arm 77 of the pivoted lever 73 cams a roller 75 affixed to the yoke 71 against the pull of spring 70. A slotted arm 78 extending in a direction opposite to that of arm 77 is engaged by a pin 79 secured to the end of the plunger 81 of an electromagnetic solenoid 80, which has been illustrated in its unretracted position.

In order to prevent short circuiting of the flux produced by the solenoid, the arm 73 should be made of some nonmagnetic material such as brass, or it should be magnetically insulated from the plunger 81.

The power storage means for operating the tuning means may take forms other than the spring. Other resilient or gravity type power storage means could be used. The solenoid 80 constitutes electromagnetic means for charging the spring and it is energized to charge the spring in a manner which will be described in detail hereinafter. For the present it will suffice to state that it is supplied with power from the battery through conductors 102 and 122, the circuit being completed through ground and, more particularly, through conductor 101, a position limit switch 95 when the latter is in the position into which it is operated when the tuning means reaches its low frequency end, and through switch means controlled by what is termed the stop-on-signal relay 105, and which is magnetically or flux-latched in operated position and the physical construction of which is illustrated in the contemporaneously filed applications referred to above.

When the energizing circuit for the solenoid is completed it effects movement of its plunger downwardly, as indicated in Fig. 1, thereby to tension the spring 70 and to move the cores back to their high frequency positions.

The spring 70 is, in effect, a power means which tends to accelerate beyond a desired speed in so far as movement of the tuning means is concerned. Its speed is restrained by a suitable restraining means, such as a wind vane 74, which is driven by the spring through a variable mechanical advantage transmission means constructed and arranged to apply an increasing torque to the wind vane as the tuning means is moved in the tuning direction, i. e., from the high frequency to the low frequency end, and also to decrease the gear ratio of the transmission means, whereby the restraining means and the tuning means are driven at a speed which increases as a result of the increased torque applied to the wind vane and the decrease in gear ratio as the cores are moved toward the low frequency end.

The variable advantage mechanical transmission means illustrated diagrammatically in Fig. 1 is described in greater detail and also claimed in the copending application of Olgierd Gierwiatowski referred to above and it will, therefore, not be described in any greater detail here than is necessary for an understanding of the present invention.

The pivoted lever 73 includes a third extending arm 83 pivoted at its extremity to a rack 84. The teeth of rack 84 engage the first pinion 85 of a speed amplifying gear train 86. The gear train drives a light disc-shaped brake drum 87 rotating upon a common shaft 131 with a pinion 130 at the high speed end of the gear train. The wind vane 74 or an equivalent speed regulating means is journaled for rotation independent of but coaxially with the brake drum 87. The brake drum 87 drives a sensitive spring type one-way drive including a spring 88 which engages and drives the wind vane 74 only when it is turning under the influence of spring 70. The driving spring 88 disengages from the wind vane and slips past it when the brake drum is rotating in the opposite direction, thereby permitting rapid retensioning of the spring 70 by the solenoid 80 unrestrained by the wind vane 74.

The limit switch includes a pivotally mounted operating lever 89 having a slotted arm 90 engaged by a pin 91 set near the extremity of arm 83 of the pivoted lever 73. The configuration of the pivoted lever 89 is chosen such that the lugs 92 and 93 mounted upon the two other extending arms of the lever 89 operate the contacts of a snap-action limit switch 95 when the solenoid and tuning means reach either limit of their strokes. The limit switch 95 comprises contact springs 96, 97 and 98, a resilient yoke 99, and a toggle link 100, compressed between yoke 99 and contact spring 97. The operation of this switch is such that when the end of the toggle link nearest the yoke is slightly displaced in one direction, then the other end of the toggle link imparts a very rapid snap-action displacement to contact 97 in the opposite direction. Contact 96 is connected by lead 56 to a resistor 55 in the cathode circuit of a tube 60 comprising part of the stop-on-signal means. Contact 97 is connected to contact 112 of the stop-on-signal relay 105 by lead 125. Contact 98 is connected to solenoid 80 by lead 101.

The stop-on-signal relay 105 includes a magnetic circuit comprising a ferromagnetic core 106, a pivoted ferromagnetic armature 107, and a ferromagnetic yoke 108 for completing the flux path from the core 106 to the pivot point of the armature 107. The relay is provided with three normally open independently and resiliently mounted contacts 110, 111, and 112, and with one normally closed resiliently mounted contact 241 which cooperate with a contact strip 109 extending from one end of the armature 107. The contact strip 109 is connected to ground through the armature and a ground lead 117.

The short depending portion 113 of the stop-on-signal relay armature 107 is employed as a brake shoe and is positioned to cooperate with the brake drum 87. A fairly strong spring 114 urges the brake shoe 113 against the surface of the brake drum 87 and serves to bias the armature toward the open position. By the term "open position" I mean the position of the relay armature in which the magnetic circuit is interrupted because there is an air gap between the armature 107 and the core 106. This position corresponds also to what I term the non-operated position of the relay. In this position the brake shoe 113 is applied to the brake drum 87 by the pull of the spring 114, the contact 241 is closed, and the contacts 110, 111, and 112 are open. The short depending brake arm enables the spring 114 to exert a powerful pressure with a short motion against the brake drum 87, and the long, oppositely extending portion of the armature provides a longer stroke of the contact strip 109 for obtaining the necessary contact clearance.

The flux within the magnetic circuit of the relay 105 is established by means of a relay operating winding 115 providing enough magnetizing force to close the magnetic circuit of the relay by attracting the armature 107 into close contact with the core 106 against the pull of spring 114 when the winding 115 is energized by current from the battery 31. When the winding is no longer energized, the flux passing through the magnetic circuit of the relay is not rapidly dissipated. A residual flux remains which is sufficient to maintain the armature 107 in the closed position, i. e., the relay is magnetically latched. Better to magnetically latch the armature in operated position, the relay construction is such that the magnetic path is substantially without an air gap in operated position, as illustrated diagrammatically in Fig. 1. Additionally to insure magnetic latching, as well as to permit the use of a strong spring 114, I prefer, in accordance with a feature of this invention, to pass a small bleeder current through the closing winding 115 when the relay is operated. This is accomplished by completing the circuit from the positive lead 118 of the winding 115 to ground through a current limiting resistor 119 when the relay is closed. This bleeder circuit permits sufficient current to flow through the holding winding 115 when the relay is closed to maintain a holding flux in the magnetic circuit of the relay sufficient to overcome the pull of spring 114. The relay is thus magnetically latched in operated position by the residual flux and the additional flux resulting from the small bleeder current. If a hardened steel core 106 is employed and the spring 114 is not too strong, this bleeder circuit may be omitted. On the other hand, the bleeder circuit may be energized continuously by eliminating contact 110 and permanently grounding the contact end of the resistor 119. This simplified arrangement may be employed if the slight additional current drain is not objectionable. The small steady bleeder current suffices to hold the armature 107 in the closed position but is not strong enough to permit it to close unaided once it has opened.

The relay is manually controlled to initiate the tuning operation by a manually operable contacting bar or push button 120 adapted to connect the operating winding 115 across the battery through a circuit including conductors 118 and 121. Push button 120 is the main tuning control of the receiver which starts the tuner to tune in the next signal. The negative lead 122 of the closing winding 115 runs to the storage battery 31 via the on-off switch 30. Manual operation of the push button 120 energizes the relay operating winding 115 to operate the relay and the latter remains magnetically latched in its operated position by the holding flux and/or the residual flux maintained within its magnetic circuit.

Contact 111 is connected to the grid of the first tube of audio amplifier 20 by lead 126. When the relay 105 operates and contact 111 is closed, the grid is grounded to "mute" the receiver during the tuning operation. As soon as relay 105 is returned to nonoperated position in response to a signal, contact 111 opens, and once again permits normal audio amplification.

Contact 112 connects contact 97 of limit switch 95 to ground via lead 125 when the relay is closed, and disconnects contact 97 from ground potential and prevents operation of the solenoid 80 and gas tube 60, under the selective control of the limit switch 95, when the relay is open. The reason for this mode of operation will become apparent subsequently.

Contact 241 connects the automatic volume control circuit 22 to ground through a time delay condenser 25 which is connected between resistor 23 and contact 241 by lead 242. When the relay is open, contact 241 is closed and the time delay condenser 25, charged through resistor 23, provides normally slow automatic volume control. When the relay is closed, during the tuning operation, contact 241 is open and the condenser is disconnected. The AVC is therefore fast during the tuning operation. This prevents a decrease in sensitivity because the fast AVC permits an actuating voltage (to be described in greater detail shortly) to build up to its full value while the tuning mechanism is traversing the signal. With slow AVC the actuating voltage would not build up to its full value until the originating signal had been passed.

The leads 123 and 124 from a second winding 116, called a bucking winding, of the stop-on-signal relay are energized under the control of the stop-on-signal means, in this case by current controlled by the electron tube 60, which may be and is shown as a gas tube, which ionizes responsive to conditions of resonance in the tuned circuits of the receiver. When the gas tube 60 is ionized, current is passed through winding 116 in a direction creating a bucking flux opposing the holding or residual flux in the magnetic circuit of the relay to permit spring 114 to reopen armature 107 and to break the magnetic circuit of the relay. The current producing the bucking flux should not be large enough or of long enough duration to reverse the flux and close the armature again after it has once been opened.

The intermediate frequency balanced bridge circuit supplies a restraining voltage to prevent ionization of the gas tube except exactly at or close to the intermediate frequency, thus providing the sharp, precise response desired for exact tuning. The balanced bridge circuit is similar in many respects to the one disclosed and claimed in the application of William J. O'Brien, Serial No. 387,907, filed April 10, 1941 now U. S. Patent No. 2,426,580 granted August 26, 1947. It comprises a primary circuit and a secondary circuit which are inductively coupled by the mutual inductances 41 and capacity coupled by the capacitor 40. The primary circuit includes the adjustable primary inductance 18, the condensers 42 and 38, and a resistance phasing or neutralizing arrangement consisting of the adjusting capacitor 43 and resistors 44 and 45. The secondary circuit includes the adjustable secondary inductance 39 and a capacitor 37. The inductances 18, 19, 39, and 41, the condensers 37, 38, 40, 42, 37A, and 43, and the resistors 44 and 45 are included within a shielded metal container and form part of what is preferably referred to as a "balanced bridge transformer."

The circuit constants of the primary and secondary circuits are arranged so that they resonate at or near the intermediate frequency. The inductive reactance of the mutual inductances 41 is also adjusted to equal the capacitive reactance of the capacitor 40 at the intermediate frequency. The phasing network comprising the capacitor 43 and the resistors 44 and 45 serves to balance out the resistive coupling which exists between the primary and secondary circuits so that the total coupling between the primary and secondary circuits may approach zero at the intermediate frequency. This results in a response curve with two negative voltage peaks, one on either side of the resonance center and a very steep depression therebetween going down to or nearly to zero voltage. The resonance of the secondary circuit with capacitor 37 tuned by inductance 39 causes these two peaks to be higher in voltage.

The restraining voltage derived from the balanced bridge circuit passed through capacitor 37A is rectified by the diode plate 46A of an electron tube 46 which may be a 6SQ7G or 6Q7 tube. The rectified negative restraining voltage appears across resistor 67 and is applied to the grid 47 of tube 46. A biasing cell 69 maintains a sufficient negative bias through resistor 68 upon the grid 47 to keep the plate current relatively low when there is no signal on the grid 47. The plate 49 of tube 46 is connected to a point between the plate of the radio frequency amplifier 11 and the resistor 26. Variations in plate current of the radio frequency amplifier 11 will therefore create a variable voltage drop across the resistor 26 which is applied to the plate of tube 46 through conductor 26A and which serves as the actuating voltage for operating the gas tube 60. A signal at resonance will produce a large increase in voltage across the voltage divider 21 and a correspondingly large negative voltage upon the automatic volume control lead 22. This causes the plate current of the radio frequency amplifier 11 to decrease, resulting in a smaller voltage drop across resistor 26. This places a higher positive potential upon the plate 49 of tube 46 which would result in a larger plate current through the tube. However, the actual plate current through tube 46 is restrained by the effect of the restraining voltage from the balanced bridge circuit on the grid 47 so that although the plate voltage response curve due to the action of the automatic volume control voltage is quite broad, the two high negative peaks and the sharp depression between them in the negative restraining voltage response curve provide a very steep sided narrow positive signal to the grid 61 of gas tube 60, as shown more fully in the copending applications of William J. O'Brien.

In order that the normal time delay of the AVC may not delay the actuating voltage from reaching its peak before the signal to be tuned in passes the narrow valley of the restraining voltage, contact 241 disconnects the AVC time delay condenser 25 from the AVC circuit 22 during the tuning operation, while relay 105 is closed.

The plate-cathode circuit of the tube 46 is completed to the negative terminal of battery 31 through the cathode lead 66 and a resistor 51. Due to this negative voltage from battery 31, the cathode 48 may be at about zero voltage when normal plate current is flowing in tube 46. The positive voltage drop across resistor 51 at resonance is applied to the grid 61 of the tube 60 which may be a gas tube of the 2051 or 2050 type.

A small time delay network consisting of a resistor 53 and a condenser 54 leading to ground may be inserted in the grid lead 52 in order to prevent extremely short pulses or other disturbances from prematurely ionizing the gas tube.

The cathode 62 and shield grid 63 of the gas tube 60 are connected to ground by means of a variable resistor 55, and the limit switch 95 and relay operated switch 109, 112. A bleeder 28 associated with resistor 55 forms a potentiometer to provide the desired negative grid bias relative to the cathode and to constitute a sensitivity control, although other types of sensitivity control may be used. The limit switch opens the cathode circuit of tube 60 when solenoid 80 is energized and thus insures that the gas tube cannot ionize in response to a signal and apply the brake shoe 113 to brake drum 87 while solenoid 80 is retensioning spring 70.

The cathode to ground connection from contact 97 is also interrupted by contact 112 when the stop-on-signal relay opens. The cathode side of the gas tube plate circuit is therefore disconnected at all times except during the short interval after the relay is operated by operating push button 120 and before it is released by the bucking winding 116 to stop on a signal. This method of operation is an especially valuable feature of my invention because it is stable, dependable, and economical. When operating according to my invention, the gas tube is energized only during the brief interval within which tuning is accomplished and no provision for maintaining stable ionization for long periods is required as in some gas tube devices. This method of operation is also economical because the plate circuit of the gas tube is opened and the flow of plate current stopped while a station is being listened to.

The plate 64 is concerned directly to one terminal of the bucking winding 116 of the relay 105 by lead 122. The other terminal of the bucking winding 116 is connected by means of lead 123 to a capacitor 65 connected to the cathode, and adapted to be charged from the "B" supply through a current limiting resistor 59. The size of capacitor 64 and of resistor 59 are so chosen that when the plate circuit is closed, the voltage required to ionize the gas tube does not build up across the capacitor 65 immediately, but only after an interval of time sufficiently long to permit the spring 70 to move the tuning inductance cores 72 enough to detune the receiver from the last station received. This arrangement avoids a second stoppage of the receiver upon the same station or stoppage too close thereto which might occur especially if the selectivity is low. It also provides a means by which the tuner may be made to travel a predetermined distance before stopping to tune in the next station.

The capacitor 65 also functions to give a larger surge of current through the busking coil, although requiring only the relatively small charging current flowing through resistor 59 providing time for charging is allowed. The impedance of the plate circuit of the tube is such, however, that the current through the bucking coil is limited to a value which will not effect the relatching of the relay.

The operation of the stop-on-signal receiver described above proceeds as follows: Assume the solenoid 80 to be in deenergized condition and the driving spring 70 to be at least partly tensioned and ready to vary the tuning means by driving the inductance cores 72. The relay 105 is in nonoperated position and the depending brake portion 113 is securely held in engagement with the brake drum 87 by the spring 114 and prevents movement of the speed amplifying gear 86, the rack 84, the pivoted lever 73, and the yoke 71 to which the three slidable inductance cores 72 are attached.

When the push button 120 is depressed to select another station, the circuit from the battery 31 through the stop-on-signal relay operating winding 115 to ground is completed, causing the armature 107 to be attracted to close the magnetic circuit of the relay. This closes the contacts 110, 111, and 112, and opens contact 241. Contact 112 completes the ground return circuit from the gas tube cathode 62 through limit switch contacts 97 and 96 and conditions for operation the stop-on-signal means. Contact 110 closes the bleeder circuit 119, which permits just enough current to pass through the winding 115 to maintain a holding flux within the relay sufficient to keep the relay in the closed position after the push button 120 is released, even when a strong spring 114 is employed. Closing contact 111 grounds the grid of the first tube of audio amplifier 20 and "mutes" the receiver during the tuning operation. Contact 241 opens and disconnects the time delay condenser 25 from the AVC circuit 22 and provides fast AVC during the tuning operation, as described above.

The closing of the relay armature retracts brake shoe 113 from the brake drum 87 and permits movement of the tuning inductance cores by the driving spring 70, thereby changing the tuning of the receiver. Excessive tuning speed is prevented by the action of the wind vane 74 which encounters sufficient air resistance as the tuning speed increases to keep the tuning speed within the limits of good operation of the stop-on-signal circuit.

As the receiver is detuned from the previous signal by the motion of the tuning inductance cores the automatic volume control voltage drops because moving off resonance results in a decrease in voltage across the voltage divider 21 from the second detector 17. The decrease in automatic volume control voltage increases the plate current of the radio frequency amplifier and produces a relatively large voltage drop across resistor 26 which causes a reduction in the positive plate potention applied to tube 46. A substantial decrease does not take place until some distance from exact resonance. The balanced bridge circuit, however, imposes a negative restraining voltage upon the grid of tube 46 when the receiver has been detuned as little as one kilocycle from exact resonance. This limits the plate current through the tube and lowers the grid potential applied to the gas tube 60 to a value prohibiting ionization thereof.

The time delay provided by resistor 59 in the charging of capacitor 65 provides a short time delay during which the tuning means is moved out of resonance with the previous station. As already described in greater detail, this delay insures that the apparatus will not stop twice on the same station or signal.

The motion of the tuning inductance cores under the influence of the driving spring 70 continues until another station or signal is encountered producing a condition of resonance in the tuned circuits at the receiver. This builds up a voltage in the automatic volume control lead 22 which decreases the plate current through the radio frequency amplifier and increases the plate voltage applied to the tube 46. The broad action of the automatic volume control results in an increased plate voltage some appreciable distance from the point of exact resonance. However, not until a point within about one kilocycle or less of exact resonance is attained does the balanced bridge circuit suddenly reduce the negative bias upon the grid of tube 46 to permit increased current to flow in the plate circuit of the tube.

Current through the plate circuit of tube 46 at resonance flows through the resistor 51 and produces a positive voltage drop which is applied to the grid 61 of the gas tube 60 and causes it to ionize.

The capacitor 65 was charged by the "B" supply through the resistor 59 when the relay contact 112 was closed as a result of operation of the push button 120. Ionization of the gas tube now produces a sudden surge-like discharge of the capacitor 65 through the bucking winding 116, which bucks the holding flux through the magnetic circuit of the relay, causing armature 107 to be pulled into the open position by spring 114. This breaks the magnetic circuit of the relay which then remains in the open position and applies the brake 113 to the brake drum 87. Further movement of the tuning means is checked immediately and the receiver consequently remains tuned to the signal which initiated operation of the stop-on-signal circuit. When the relay opens, it closes contact 241, which connects the time delay condenser 25 to the AVC lead 22, and re-establishes the normally slow AVC which is desired during listening.

The gas tube does not remain ionized after response to a signal because the plate circuit lead 56 to ground is immediately broken by the opening of contact 112 when the relay opens. This insures that no voltage changes or oscillations can reionize the gas tube and prematurely restart the tuner. In the very unlikely event of the bucking winding 116 failing to open the relay and thus interrupting the plate circuit of the gas tube, the gas tube will nevertheless not remain ionized. The capacitor 65 and resistor 59 in the gas tube plate circuit will reduce the plate voltage and cause the gas tube to deionize.

To tune in another station, the procedure described is repeated.

When the spring has almost completely retracted the tuning coil cores 72, however, the pivoted levers 73 and 89 are in a position shown in Fig. 1. permitting the lug 92 to trip the limit switch 95, which is illustrated at the moment just before tripping. This opens the gas tube cathode circuit through contacts 96 and 97 and closes the circuit of the solenoid winding 82 through contacts 97 and 98. The solenoid thereupon retracts plunger 81 and retensions spring 70, and withdraws the cores 72 from the tuning inductances the full extent of their movement. While the spring 70 is being retensioned, no ionization of the gas tube and consequent operation of brake 113 is possible because the gas tube cathode circuit through contacts 96 and 97 remains open. When the spring 70 is completely retensioned, the pivoted lever 89 is once more in a position to actuate switch 95 by means of lug 93. This opens the solenoid circuit and stops further tensioning of the spring 70. The gas tube circuit is reclosed at the same time, but unless a signal is received at that time, the tuning coil cores resume their motion under the influence of spring 70.

The wind vane 74 is engaged and driven by ratchet 88 when the brake drum is turning in tuning direction under the influence of spring 70, and serves to regulate the speed of the tuning means as previously described. The first signal of sufficient strength encountered ionizes the gas tube and applies the brake 113 and stops the tuning means precisely on the signal as before described.

Push-button 120 need be depressed only momentarily in the selection of another station. If it is desired to traverse the entire tuning range of the receiver, however, or to skip a substantial portion thereof, the push button may be depressed longer and when it is released, the next signal encountered will stop the tuning device. If the push-button is held depressed indefinitely, the spring 70 will cause the tuning inductance cores to traverse their entire tuning range, after which the solenoid 80 will retension the spring.

The principles of the present invention are applicable also to apparatus employing a high vacuum tube in place of the more costly gas tube in the stop-on-signal means. Also, in order to cut down the consumption of current by the stop-on-signal means when the latter is not in use, i. e., during normal audio reception, the stop-on-signal relay, in accordance with another feature of the invention, may be utilized to open the plate circuits of one or more or all of the tubes of the stop-on-signal system. An embodiment of the invention incorporating the foregoing desirable features is illustrated fragmentarily in Fig. 1A.

The apparatus illustrated in Fig. 1A may be substituted for a portion of the apparatus of Fig. 1 and like elements in Fig. 1A have been indicated by the reference characters used in Fig. 1. The main differences between the embodiment of Fig. 1A and that of Fig. 1 resides in the use of a high vacuum tube 200 in place of the gas tube 60 and a change in the connection of the resistor 51 across which the stop-on-signal control voltage appears when the receiver is tuned to a signal or station, the change in connections enabling the stop-on-signal relay 105 to open not only the plate circuit of the tube 200 but also of the tube 46, whereby during normal audio reception neither of the tubes is supplied with plate current.

The high vacuum tube 200 may be of suitable type. It is preferred that it be a pentode of the type having a high plate transconductance, such as the 6SH7 or 6AK5 tubes. Tubes of this type are particularly advantageous when a large change in plate current is desired with a small change in grid voltage or when only limited gain is available. The change in plate current is substantially increased by connecting the screen grid to the plate, as hereinafter described. The conductivity of the tube is varied from a normal low value to a high value in response to the application of the stop-on-signal control voltage to its grid. This is in contrast to the operation of a gas tube which is varied from a nonconductive to a conductive condition. The tube could, if desired, be biased to cut off and the similarity to the gas tube arrangement would then be greater. However, this arrangement would not be as sensitive.

The tube 200 includes a cathode 202 which is connected by conductor 204 to the capacitor 65 and the junction of resistors 28 and 55 just as the cathode of the gas tube. Its control grid 206 is connected to the conductor 66 through the time delay circuit, including resistors 53 and 54, just as the control grid of the gas tube. The screen grid 208 is connected to the plate 210 and both of these elements are connected to the conductor 123, which leads to the bucking coil 116 in the same manner as the like numbered plate connection of the gas tube.

The plate-cathode circuit of the tube 200 is completed through the limit switch 95 and the stop-on-signal relay switch in the same manner as heretofore, the connection to the switch and relay including the conductor 56. The plate-cathode circuit of the tube 46 is likewise connected to the conductor 56, the connection being made through the previously referred to resistor 51 and a small biasing cell 212 providing a bias supplied by the battery 31 in the previous embodiment. In view of the fact that the plate circuits of both tubes 46 and 200 are connected to and completed through conductor 56, the stop-on-signal relay 105 is effective to open both the plate circuits when it returns to its nonoperated position as a result of the tuning in of a signal. In its nonoperated position, the plate circuits of the tubes are broken as a result of disengagement of contact 112 and the armature carried movable contact 109.

It may be mentioned also that the change in circuit connections also results in the limit switch rendering both tubes of the stop-on-signal means ineffective during the time the spring 79 is being charged by solenoid 80. This also results from the fact that the plate circuits of the two tubes are connected to and completed through the conductor 56.

When the apparatus is conditioned to tune in a station by the closure of the manually operable switch 120, the plate circuits for both tubes are completed, as described above, through the stop-on-signal relay. Under these conditions the tube 200 is only slightly conductive—as its grid is biased so that the tube draws only small plate current. The tube 46 also draws some plate current at this time. When a station is tuned in the conductivity of, the tube is sharply increased, with the result that capacitor 65 discharges through it and the bucking coil 116, thereby to effect release of the stop-on-signal relay so that it is returned to its nonoperated position and the brake applied by the spring 114 just as in previously described embodiments of the invention.

When the relay returns to its nonoperated position, the plate circuits of tubes 46 and 200 are both broken, with the result that they do not draw any plate current during reception, thereby providing a more economical arrangement in that no drain is placed upon the apparatus by the stop-on-signal means during the time it is not in operation. While these two tubes do not draw very much plate current during operation, they do draw some and it should be noted that the principles of this feature of the invention may be applied to apparatus using more tubes than two and some of which may draw considerable current during operation, as for instance, an amplifier tube which might be placed ahead of tube 46. The tube 200 would also draw considerable current if the capacitor 65 was not used, and the value of resistor 59 consequently reduced. In this case the tube would have to draw more plate current to unlatch the relay, this current being supplied by the capacitor 65 in the illustrated embodiment.

The stop-on-signal relay and circuit described can be applied to other types of tuning mechanisms than that illustrated in Fig. 1. It may be readily applied to motor driven stop-on-signal tuning mechanisms, such for instance, as illustrated in Fig. 2. The illustration is fragmentary, and is intended to be taken in conjunction with a portion of Fig. 1, with which it cooperates and to which reference is made by the use of like identifying numerals.

The embodiment of the invention illustrated in Fig. 2 indicates the further adaptability of the principles of the present invention. Primarily it applies the invention to a capacitor type tuning means driven by an electric motor which is adapted to be clutched to the capacitors to drive them and to be declutched therefrom under the control of the stop-on-signal relay, which also applies a brake to the capacitors to reduce undesirable overrun even more.

In this embodiment the depending portion 113 of the stop-on-signal relay armature 107 acts upon the flange 140 of a slidably mounted splined shaft 141 journaled within a stationary supporting yoke 147. A driven clutch plate 142 at the other extremity of the shaft 141 normally engages a driving clutch plate 143 driven by the shaft 144 of a small motor 145. The splined shaft 141 passes through and has driving engagement with a worm gear 146 (preferably irreversible) rotatable within the yoke 147. The worm 146 engages a gear 148 which drives the pinion 149 which, in turn, drives the spur gear 150. If a slower speed motor is employed the worm 146 may engage the gear 150 directly and in this case the gear 150 would be a worm wheel. The spur gear 150 turns the rotor 151 of a variable capacitor type tuning means 152 which may be of a continuously rotating type not requiring reversal of the motor 145 when the point of minimum capacitance has been attained. Thus, a limit switch is not required. A spring 153 pressing against an anti-friction ball thrust bearing 154 at the end of the shaft 141 urges the clutch plates 142 and 143 into engagement. Movement of the armature 107 into the open position under the influence of spring 114 causes the depending portion 113 of the armature to bear against flange 140 and retract shaft 141 and clutch plate 142 from engagement with the clutch plate 143. The amount of movement may be adjusted so that clutch plate 142 frictionally engages a braking surface 155 when the shaft 141 is completely retracted, thereby enhancing quick and positive stoppage of the tuning means.

The motor is controlled by means of contact 110A of the relay 105, which connects the motor across the battery through conductors 156 and the relay armature when the relay is operated by push button 120. The motor is maintained energized upon release of the push button by the relay which is magnetically latched by the residual flux only—the bleeder circuit not being used.

The operation of this embodiment of my invention is similar to that of the first embodiment described. The radio receiver circuit and the balanced bridge and gas tube circuits operate substantially as before, the differences being the result of using a motor drive for the tuning means, and of substituting the combined clutch and brake for the brake of Fig. 1. When the relay is operated to its operated position by pressing button 120 and held in the closed position by the residual flux in the magnetic circuit, motor 145 is energized to drive the tuning means. When the relay is released by a pulse of current from the gas tube 60 through the bucking winding 116, the motor circuit is interrupted by the opening of contact 110A, and the clutch 142 is quickly disengaged, thus preventing any overrunning due to the motor inertia. At the same time, the braking surface 155 effectively brakes further motion of the tuning condenser, and causes the receiver to remain stopped in tune with the signal. The braking and locking effect is further enhanced by the irreversibility of the worm 146.

In view of the fact that the motor 145 rotates in one direction only, no limit switch is required. For this reason the conductor 56 through which the cathode of the gas tube is connected to ground, is connected directly to contact 112 whereby, when the relay is in operated position, the tube circuit is completed and broken when the relay is in nonoperated position.

A stop-on-signal latching relay having only one winding may be employed if desired. The embodiment of my invention illustrated in Fig. 3 utilizes such a relay in which, in accordance with a further feature of this invention, the relay operating current is taken from the "B" supply. Only the portion of the circuit diagram that differs from the preferred embodiment has been shown. Like numerals refer to the corresponding parts in Fig. 1.

The relay 105 in this embodiment is provided with only one winding 116 similar to the bucking winding 116 of the two coil relay. The contacts 111, 112, and 241 are identical with those of the two coil relay. The contact 110 shown in Fig. 1 is omitted, however, because no bleeder circuit is employed as the residual flux within the magnetic circuit of the relay alone is utilized for latching the relay. To increase the residual flux, the core 106 or some other part of the magnetic circuit may be made of more or less hard steel having greater retentivity.

The push button 120 is of the double pole single throw type in this embodiment and closing of the push button serves to connect the leads 124 and 123 from the winding 116 to the "+B" supply and to ground, respectively, thereby to energize the winding with one polarity of current to actuate the relay to its operated position. Once the relay has been closed by depressing push button 120 it is held in the closed position by the resulting residual flux. When the potential applied to grid 61 of gas tube 60 becomes positive as a result of resonance in the tuned circuits, the gas tube ionizes and permits the charge built up within condenser 65 to surge through the winding 116. The current surge is of opposite polarity and it bucks the residual flux within the relay. It is to be noted that current flows through the winding 116 from the condenser 65 in the opposite direction to the current flowing through winding 116 from the push button switch 120. This creates the bucking flux for which a separate bucking winding of opposite polarity is used in the relay shown in Fig. 1.

It may be mentioned that operating the relay 105 from the "B" supply is especially advantageous in stop-on-signal tuning apparatus operating from alternating current power lines, because a separate source of direct current would otherwise have to be used to establish a holding flux that will be counteracted by the surge of current produced by the stop-on-signal operation.

The "B" supply for the embodiment of Fig. 3 comprises a multiple winding power transformer 106. The primary winding 161 of the transformer is energized from the alternating current power line leads 165 and 166, one lead 166 of which may be conveniently broken by an on-off switch 167. The transformer is shown with a separate low voltage secondary winding 162 for energizing the winding 82 of solenoid 80, to which it is connected by lead 168. The other lead 169 of winding 162 is grounded. The solenoid 80 may be a low voltage A. C. type solenoid preferably fitted with a copper shading ring 84 on the lower end of its plunger 81. Its ground return lead 101 goes to contact 98 of the limit switch 95 as in Fig. 1. The foregoing arrangement of the separate transformer and control of the energization of the solenoid by the relay and limit switch is one of the features disclosed and claimed in the copending application of Olgierd Gierwiatowski.

Another low voltage secondary winding 163 is used for filament voltage supply. One lead 170 thereof may serve all of the filaments of the tubes used in the stop-on-signal receiver, as indicated schematically by the arrow on lead 170.

The high voltage secondary winding 164 is center-tapped and grounded by lead 173. The two sides of the winding are connected to the plates 181 and 182 of a full wave rectifier 180 by leads 174 and 175. The cathode 183 of the rectifier tube is connected to the "+B" supply lead 176 through a filter choke coil 177 in the conventional manner. Two large filtering capacitors 178 and 179, connecting the cathode 183 and the "+B" lead respectively to ground, complete the "B" supply filter.

The operation of a stop-on-signal receiver employing the above described modification of my invention is similar to the operation of the receiver employing the two coil relay shown in Fig. 1. An important difference is the manner in which the push button switch 120 reverses the polarity of the "B" supply potential applied to the winding 116, so that the residual flux remaining after the push button 120 is released is opposed by the bucking flux created by the surge of current from the plate circuit of the gas tube 60 through the winding 116. This releases armature 107 and opens the relay and applies brake 113 to stop the movement of the tuning means upon the actuating signal as in Fig. 1.

The several embodiments of my invention that have been described in detail above were chosen to represent typical forms of the invention but are in no way intended to limit the invention to the embodiments disclosed for purposes of illustration, except in so far as set forth in the accompanying claims. For instance, it should be understood that many of the features of the present invention may be utilized in stop-on-signal radio apparatus wherein the tuning means may take different forms and wherein various drives and transmissions may be used for driving the tuning means and the speed restraining means.

Having thus described my invention, what I claim as new and desire to secure by United States Letters Patent, is:

1. Stop-on-signal radio apparatus having a source of alternating current power, radio apparatus supplied with power from said source and including variable tuning means, power storage means for varying said tuning means in one direction, means including a solenoid energizable by alternating current from said power source for charging said power storage means and varying said tuning means in an opposite direction, means for terminating variation of said tuning means by said power storage means in response to the tuning in of signals, said last mentioned

means including relay means, and means including rectifying means for supplying said relay means with unidirectional current to control operation of said relay means to initiate and terminate the variation of said tuning means.

2. Stop-on-signal radio apparatus having a source of alternating current, radio apparatus including a rectifier supplying direct current energized from said source and including also variable tuning means to tune said apparatus, power storage means for varying said tuning means in one direction, means including a solenoid energizable by alternating current from said power source for charging said power storage means, and means for terminating variation of said tuning means by said power storage means, said last mentioned means including relay means adapted magnetically to be latched in operated position, means for supplying said relay with current from said rectifier to produce flux of one polarity to move said relay to its operated position, and stop-on-signal control means energized from said rectifier and supplying said relay with current to produce flux of opposite polarity to terminate variation of said tuning means.

3. In stop-on-signal radio apparatus, variable tuning means, and means for initiating and stopping variation of said tuning means to tune in signals, said last mentioned means including electro-magnetic means having two windings, an electron tube having a plate circuit in which one of said windings is included, means for energizing the other winding to initiate variation, and means for causing an increase of the plate current in said electron tube sufficient to energize the first mentioned winding thereby to stop variation when the tuning means is in tune with a signal.

4. Stop-on-signal radio apparatus having variable tuning means, means including a motor and a disengageable clutch for moving said tuning means, resilient means normally engaging said clutch, and means for stopping movement of said tuning means, said last mentioned means including an electron tube having a plate circuit and rendered more conductive in response to the tuning in of a signal, relay means in said plate circuit energized in response to increased conductivity of said electron tube, and resiliently applied brake means and clutch disengaging means released by the energization of said relay means.

5. In a stop-on-signal radio apparatus, a variable tuning means, and means for controlling the variation of said tuning means including relay means having a starting position and a stopping position, a source of plate voltage, manual means operable to energize said relay means with current of one polarity derived from said source for moving said relay means into said starting position, and means effective when said manual means is not operated and responsive to the transmission of a signal through said tuning means to energize said relay means to cause it to move to said stopping position by supplying thereto current of opposite polarity from said source.

6. Stop-on-signal radio apparatus having variable tuning means, means including a motor and a resiliently disengageable clutch for starting and stopping said tuning means, a resiliently applied brake to stop movement of the tuning means, a relay having a moving part, effective when the relay is energized for starting, to prevent application of the brake and to prevent disengagement of the clutch by the resilient means, said relay having connected to its moving part means operable, when the relay is not energized for starting, to effect the disengagement of the clutch and the application of the brake.

7. In a stop-on-signal tuning apparatus, variable tuning means, mechanical power storage means for varying the tuning means, brake means controlling the said tuning means, a spring forming part of the brake means providing the force for applying the brake means, electromagnetic means for controlling the operation of the brake means, means for energizing said electromagnetic means to provide magnetic flux of one polarity to effect release of said brake means and thereby to initiate variation of the tuning means, and stop-on-signal means operable upon the tuning-in of a signal by the tuning means to energize said electromagnetic means to provide magnetic flux of opposite polarity and cause application of said brake means by the spring.

8. In stop-on-signal radio apparatus, variable tuning means, means for varying the tuning means, a member connected for movement with said tuning means, stopping means resiliently engaged with said member for stopping said tuning means, a latching relay having a movable armature operatively associated with said resiliently engaged stopping means, means for moving and latching said armature in a position preventing the resilient engagement of said stopping means, a thermionic tube having a grid and plate circuit, means for applying a signal tuned by said tuning means to said grid, and a coil on said relay coupled to said plate circuit energized in response to a signal applied to said grid to unlatch said armature and stop said tuning means.

9. In stop-on-signal radio apparatus, variable tuning means, power storage means for varying the tuning means, means for charging the power storage means, a member connected for movement with said tuning means, stopping means resiliently engaged with said member for stopping said tuning means, latching relay means having a movable armature operatively associated with said resiliently engaged stopping means, means for moving and latching said armature in a position preventing the resilient engagement of said stopping means, a thermionic tube having a grid and a plate circuit, means for applying a signal tuned by said tuning means to said grid, and a coil on said relay means coupled to said plate circuit energized in response to a signal applied to said grid to unlatch said armature and stop said tuning means.

10. In stop-on-signal radio apparatus, variable tuning means, means for varying the tuning means, means for stopping said tuning means, a flux-latched relay having an armature movable to change the air gap operatively associated with said stopping means, means for moving said armature to reduce the air gap and to magnetically latch the armature in a position preventing stoppage by said stopping means, a thermionic tube having a grid and a plate circuit, means for applying a signal tuned by said tuning means to said grid, and a coil on said relay in series with said plate circuit and energized in response to a signal applied to said grid to buck out the latching flux and stop said tuning means.

11. In stop-on-signal radio apparatus, variable tuning means, means for varying the tuning means, means for stopping said tuning means, a latching relay having a movable member operatively associated with said stopping means, means for moving and latching said movable member in

a position preventing stoppage by said stopping means, a stop-on-signal tuning tube having a grid and a plate circuit, switch means in said plate circuit operated by said movable relay member to open said plate circuit, means for applying a signal tuned by said tuning means to said grid, and a relay coil in said plate circuit energized in response to a signal applied to said grid to unlatch said movable relay member, stop said tuning means, and open said plate circuit.

12. In stop-on-signal radio apparatus, variable tuning means, means for varying the tuning means, means for stopping said tuning means, a latching relay having a movable member operatively associated with said stopping means, means for moving and latching said movable member in a position preventing the stoppage by said stopping means, a plurality of stop-on-signal tuning tubes having grids, and plate circuits, switch means in the plate circuits of said tubes operated by said movable relay member to open the plate circuits of a plurality of said tubes, means for applying a signal tuned by said tuning means to said grids, and a relay coil in the plate circuit of one of said tubes energized in response to a signal applied to said grids to unlatch said movable relay member, stop said tuning means, and open said plate circuits.

13. In stop-on-signal radio apparatus, variable tuning means, means for varying the tuning means, means for stopping said tuning means, a flux-latched relay having an armature, movable to change the air gap, operatively associated with said stopping means, means for moving said armature to reduce the air gap and magnetically latch the armature in a position preventing stoppage by said stopping means, a thermionic tube having a grid, a cathode, and a plate, a plate current source, means for applying a signal tuned by said tuning means to said grid, a coil on said relay in series with said plate and current source and energized in response to a signal applied to said grid to buck out the latching flux and stop said tuning means, a resistance in series between said coil and said current source of such value as to prevent the current through said coil from said source from moving said armature to said reduce air gap position, and a condenser shunted between said coil and said cathode receiving its charge through said resistance and discharging through said coil without passing through said resistance.

14. In stop-on-signal radio apparatus, variable tuning means, means for varying the tuning means, means for controlling the variation of said tuning means, including a flux-latched relay having an armature movable to a starting position with small air gap and a stopping position with large air gap, coil means on said flux-latched relay, means for moving said armature to said starting position, flux-latching means including means for passing a small current of one polarity through said coil means strong enough to latch but not strong enough to move said armature to starting position, a thermionic tube having a plate circuit and a grid, means coupling said relay coil means to said plate circuit, and means for applying a signal to said grid to supply an unlatching current of opposite polarity to said coil means, cause said armature to move to stopping position, and stop said tuning means.

15. In stop-on-signal radio apparatus, variable tuning means, means for varying the tuning means, means for controlling the variation of said tuning means including a flux-latched relay having an armature movable to a starting position with small air gap and a stopping position with large air gap, coil means on said flux-latched relay, means for moving said armature to said starting position, flux-latching means including means for passing a small current of one polarity through said coil means strong enough to latch but not strong enough to move said armature to starting position, a switch operated by said armature for interrupting said small current, a thermionic tube having a plate circuit and a grid, means coupling said relay coil means to said plate circuit, and means for applying a signal to said grid to supply an unlatching current of opposite polarity to said coil means, cause said armature to move to stopping position, stop said tuning means, and cause said switch to interrupt said small current.

16. In stop-on-signal radio apparatus, variable tuning means, means to vary said tuning means, means for starting and stopping variation of said tuning means to tune in signals including relay means having an armature movable to starting and stopping positions, a starting switch, a coil associated with said relay energizable with one polarity in response to operation of said starting switch to cause said armature to move into said starting position, latching means tending to maintain said armature in said starting position, and means responsve to a signal tuned by said tuning means to energize said coil with the opposite polarity and cause said armature to move to said stopping position to effect stoppage of said tuning means.

17. In a relay controlled device started by the application of relatively large manually controlled energy and stopped by small automatically controlled energy, stopping means for stopping the operation of said device, a flux-latched relay having a magnetic circuit including an armature operably associated with said stopping means movable to open or close said magnetic circuit, a coil on said relay, resilient means biasing said armature to open position, manually controlled means briefly actuated to move said armature to closed position, charge said resilient means with potential energy, and start operation of said device, means for maintaining a holding flux in said closed magnetic circuit, after termination of the application of said manually controlled energy, in an amount sufficient to maintain closure but insufficient to effect closure of said magnetic circuit, a small power amplifying tube having a grid, and a plate circuit including said coil, means operated automatically during the operation of said device to apply a small voltage to said grid and produce a current surge, of smaller energy than said potential energy, in said coil of proper polarity to buck said holding flux and permit the energy stored in said resilient means to open said magnetic circuit and stop the operation of said device.

18. In a relay controlled device having moving parts started by manually controlled energy and stopped by small automatically controlled energy; a motion stopper disengageable to start and engageable with a moving part to stop said device; a flux-latched relay having a magnetic circuit including an armature, operably associated with said stopper, and movable to open or close said magnetic circuit; a coil on said relay; resilient means biasing said armature to open position; manually controlled means briefly actuated to move said armature to closed position, charge said resilient means with potential energy, and

retract said stopper to start operation of said device; means for maintaining a holding flux in said closed magnetic circuit, after termination of said manually controlled energy, in an amount just sufficient to maintain closure but insufficient to effect closure of said magnetic circuit; a small power amplifying tube having a grid and a plate circuit; means coupling said plate circuit to said coil; and means operated automatically during the operation of said device to apply a small voltage to said grid and produce a current surge of smaller energy than said potential energy in said coil of proper polarity to buck said holding flux and permit the energy stored in said resilient means to open said magnetic circuit, to engage said stopper with said moving part and to stop the operation of said device.

19. In stop-on-signal radio apparatus, variable tuning means; means for varying the tuning means; a member connected for movement with said tuning means; a tuner stopper retracted for starting and moved into engagement with said member for stopping; a flux-latched relay operatively associated with said stopper having an armature movable to a stopper retracted position in which the air gap is small and to a stopper engaged position in which the air gap is large; means for moving and flux-latching said armature in said small air gap stopper retracted position; a thermionic tube having a plate circuit and a grid; means for applying a signal tuned by said tuning means to said grid; and a coil on said relay coupled to said plate circuit and energized in response to a signal applied to said grid to buck out the latching flux, cause said armature to move to said stopper engaged position, and effect stoppage of said tuning means.

20. In stop-on-signal radio apparatus, variable tuning means; power storage means for varying the tuning means; means for charging said power storage means; a stopper operable to start and

stop tuner variation; a flux-latched relay having a magnetic circuit including an armature operably associated with said stopper and movable to open or close said magnetic circuit; resilient means biasing said armature to open position; manually controlled means briefly actuated to move said armature to closed position, charge said resilient means with potential energy, and retract said stopper to start tuner variation; means for maintaining a holding flux in said closed magnetic circuit, after starting, just sufficient to maintain closure; a thermionic tube having a grid and a plate circuit; a coil on said relay coupled to said plate circuit; and means for applying a signal tuned by said tuning means to said grid to produce a current surge in said coil of proper polarity to buck said holding flux and permit the energy stored in said resilient means to open said magnetic circuit, engage said stopper, and stop the variation of said tuner by said power storage means.

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