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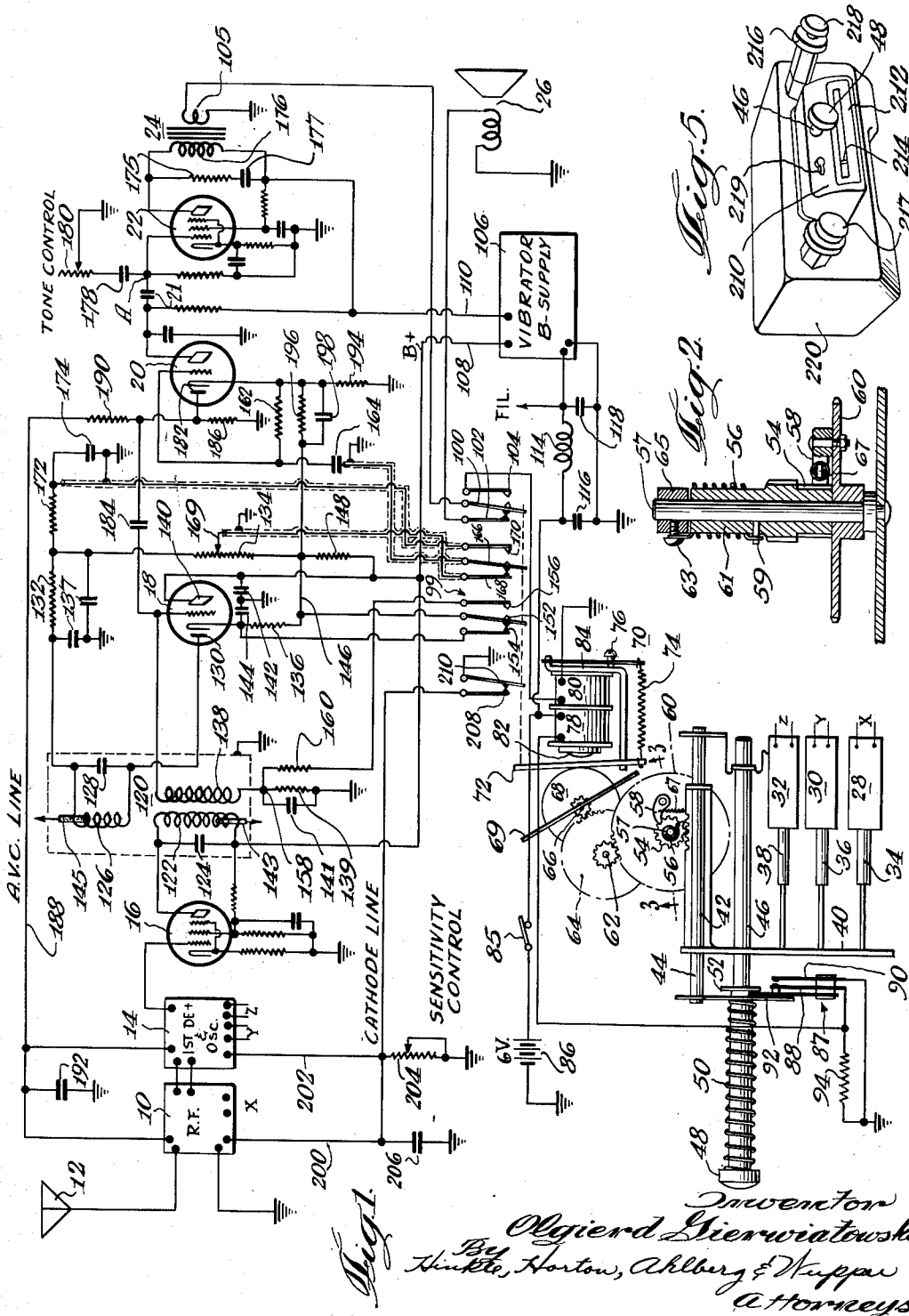
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2,622,202

SIGNAL TUNED RADIO APPARATUS

Filed Dec. 15, 1950

3 Sheets-Sheet 1



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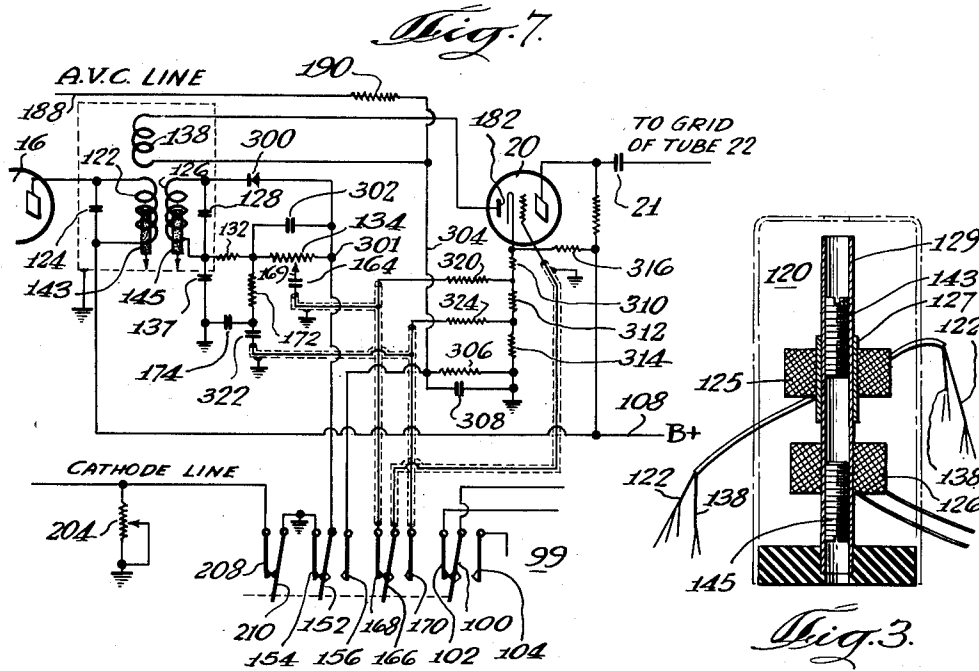
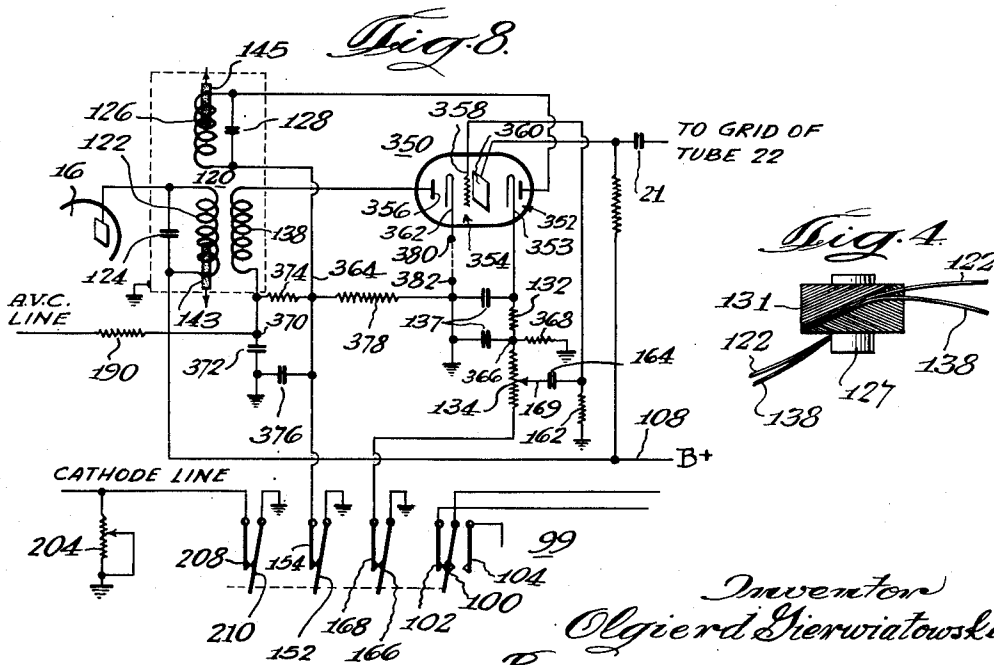
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3 Sheets-Sheet 2



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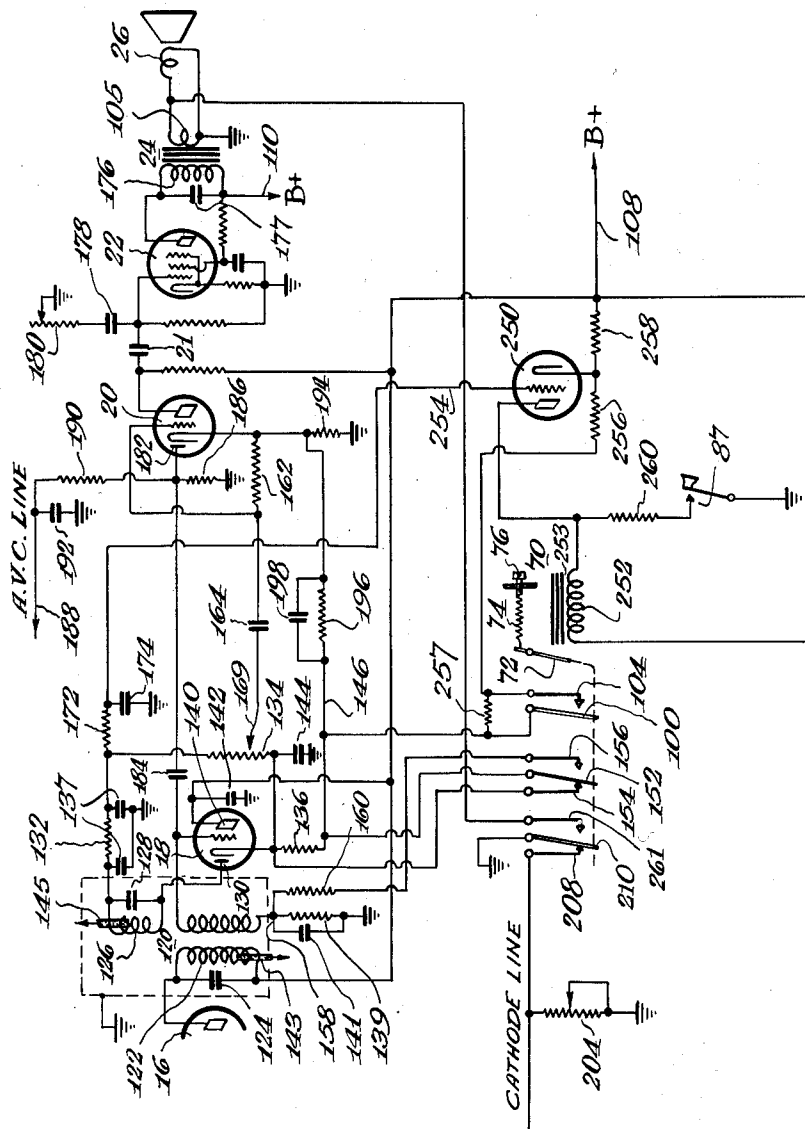
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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

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SIGNAL TUNED RADIO APPARATUS

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Application December 15, 1950, Serial No. 200,911

16 Claims. (Cl. 250—40)

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This invention relates to signal tuned radio apparatus. Signal tuned radio receivers require no manual presetting to tune in progressively all transmitted signals of sufficient strength within the frequency tuning range of the receiver. Signal tuned radio apparatus has broad utility and is applicable to home receivers and other radio apparatus as well as automobile receivers and other receivers which are subject to frequent changes of geographical position.

Signal tuned receivers have also been known in the art as stop-on-signal, stop-on-carrier, or signal seeking receivers. Signal tuned apparatus of this general type has been described and claimed in other patents, such as those of E. F. Andrews Patent No. 2,493,741 and O. Gierwiatowski Patent No. 2,494,235, and in U. S. Patent No. 2,541,018, granted February 13, 1951, to E. F. Andrews. The present invention is applicable generally to resonant responsive electronic apparatus, but relates especially to improvements in signal tuned radio devices.

An object of this invention is to provide improved signal tuned devices.

Another object is to provide improved signal tuned radio receivers.

A further object is to provide an improved radio apparatus in which a utilization device is operated when a variable frequency signal comes within a narrow frequency band.

Another object is to provide signal tuned radio receivers having improved ability to tune in weak stations.

Another object is to provide simple and inexpensive signal tuned radio receivers having improved ability to tune in satisfactorily stations having widely varying strength.

Another object is to provide simple and inexpensive signal tuned radio receivers which are improved so that stopping more than once on even the strongest stations is unlikely.

Another object is to provide signal tuned radio receivers embodying improvements in simplicity and economy as well as performance.

Another object is to provide signal tuned radio receivers having improved ability to produce large restraining voltages and thereby to utilize relatively large actuating voltages.

Another object is to provide an improved signal tuned radio receiver having improved restraining voltage producing means including a triode restraining voltage rectifier having high input impedance.

Another object is to provide a signal tuned radio receiver having improved restraining volt-

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age producing means including a tuned primary, a secondary having a large number of turns and inductively coupled very closely to the primary, and a triode rectifier supplied by the secondary.

Another object is to provide a signal tuned radio receiver having improved operating voltage producing means including a tuned primary, a secondary coupled very closely to the primary, an infinite impedance restraining voltage rectifier supplied by the secondary, a tuned secondary coupled to the primary, an actuating voltage rectifier supplied by the tuned secondary, means interconnecting the rectifiers in opposition, and means providing a delay bias on the restraining voltage rectifier.

Another object is to provide an improved signal tuned radio receiver in which equal, oppositely polarized restraining and actuating voltages are derived from primary and secondary windings of a single transformer.

Another object is to provide an improved signal tuned radio receiver in which equal, oppositely polarized restraining and actuating voltages are derived from two secondaries of a single transformer.

Another object is to provide an improved signal tuned radio receiver in which equal, oppositely polarized restraining and actuating voltages are derived respectively from an untuned secondary and a tuned secondary of a single transformer having a tuned primary.

Another object is to provide an improved signal tuned radio receiver having a tuner operating system responsive to voltages of both polarities, and in which a restraining voltage biases an actuating voltage rectifier so that only signals having the polarity of the actuating voltage are impressed upon the tuner operating system.

Another object is to provide an improved signal tuned radio receiver in which signals for operating the tuner mechanism are amplified by the audio system of the receiver, and in which a restraining voltage biases an actuating voltage rectifier so that no restraining voltage is impressed upon the audio system.

A further object is to provide an improved signal tuned radio receiver having means for producing a negatively polarized operating signal which is the resultant of a negatively polarized actuating voltage and a positively polarized restraining voltage, and tuner operating means including an amplifying tube responsive to negatively polarized signals for utilizing the operating signals.

Another object is to provide an improved signal tuned radio receiver having a restraining voltage rectifier and an actuating voltage rectifier, at least one of which is a crystal rectifier, and means to connect the outputs of the rectifiers in series opposition.

Another object is to provide an improved signal tuned radio receiver in which restraining and actuating voltage rectifiers have respective output resistors connected in series opposition, and in which tuner operating means, responsive effectively only to signals having the polarity of the actuating voltage, is coupled to the series connected resistors by a capacitor and a resistor having sufficiently large values to prevent spurious reversals.

Another object is to provide a signal tuned receiver having in a large measure the qualities desired in such a receiver by utilizing to the fullest extent the apparatus present in an ordinary radio receiver with the addition of the minimum amount of further apparatus to effect signal tuning of the receiver.

Another object is to provide a signal tuned receiver by the addition to the ordinary receiver of simple tuner moving and stopping means, utilizing the audio amplifier for operating these means, and adding a single rectifier to increase the selectivity and the uniformity of the tuning signal.

Another object is to provide a signal tuned receiver in which the effective tuning voltage is confined to a narrow band of frequencies close to the tuning frequency and in which the width of this band does not increase substantially with the strength of the signal which is being signal tuned.

Another object is to provide a signal tuned receiver, possessing the above qualities, which is low in cost and in which the minimum addition of apparatus is made for effecting signal tuning.

Another object is to provide signal tuned apparatus in which selectivity and tuning uniformity are obtained without undue signal attenuation.

Another object is to provide an economical signal tuned apparatus having sensitive stopping means which will respond to a relatively low voltage tuning signal.

Still another object is to provide a signal tuned radio receiver in which the same tuned circuit and the same rectifier provide the actuating voltage during tuning and the detector voltage during listening.

Further objects, advantages and features of this invention will be apparent from the following description of several illustrative embodiments taken with the drawings in which:

Fig. 1 is a diagrammatic representation of an illustrative signal tuned radio receiver constructed in accordance with the invention;

Fig. 2 is a sectional view on an enlarged scale illustrating the mounting of a spring which drives the tuner of the receiver;

Fig. 3 is a sectional view of a transformer which couples the last intermediate frequency amplifier to the tube which functions as a detector for listening and as an actuating voltage rectifier for tuning;

Fig. 4 is a fragmentary elevational view illustrating a modification of the transformer of Fig. 3;

Fig. 5 is a perspective view illustrating the external appearance of the receiver;

Fig. 6 is a fragmentary diagrammatic view of a modified signal tuned receiver;

Fig. 7 is a fragmentary diagrammatic view of another modified receiver; and

Fig. 8 is a diagrammatic view of still another modified receiver.

Certain features of the receivers disclosed in this application, relating for example to the tuning mechanism, are disclosed and claimed in the copending application of Edward F. Andrews, Serial No. 195,161, filed November 13, 1950. Other features disclosed herein will be claimed in other copending applications.

The signal tuned radio receiver illustrated in Fig. 1 has many of the components of the usual superheterodyne receiver. It has a radio frequency amplifier 10 with an input to which an antenna 12 may be connected. A superheterodyne converter stage 14 is coupled to the output of the R. F. amplifier 10. The converter 14 may include a first detector, an oscillator, and an I. F. input transformer for coupling the output of the first detector to an intermediate frequency amplifier tube 16.

The output of the I. F. tube 16 is coupled to a diode-triode tube 18 which functions as the detector for listening and as the operating voltage rectifier for signal tuning. The output of the detector tube 18 is coupled to a first audio amplifier comprising a triode section of a second diode-triode tube 20, the diode section providing automatic volume control voltage. The output of the triode section of the tube 20 is coupled by a capacitor 21 to a second audio amplifier tube 22 having an output transformer 24 in its plate circuit. The tubes 20 and 22 function as amplifiers during both listening and signal tuning. A speaker 26 is provided for listening.

The receiver includes a radio frequency tuning inductance 28, a first detector tuning inductance 30, and an oscillator tuning inductance 32 which are connected with the corresponding portions of the circuit by means of pairs of leads X, Y and Z, respectively. For convenience and clarity only the end portions of the leads are shown. The inductance coils 28, 30 and 32 are mounted with their axes parallel. The coils are tunable by means of cores or slugs 34, 36 and 38 which are movable in an axial direction.

The cores may be moved by any suitable moving means, such as a motor or a spring which is charged periodically, either manually or by power operated means, such as a solenoid. A variable condenser or other tuning means may be employed in place of the tuning coils and cores. A suitable tuning arrangement including a manually chargeable spring is shown in Figure 1.

The tuning cores 34, 36 and 38 are mounted on a crosspiece 40 which is supported by a rack member 42. The rack 42 is slidably mounted on a supporting rod 44. The crosspiece is slidably guided by a pushrod or control plunger 46 to restrain the rack from rotation on the supporting rod 44 and to maintain alignment between the cores 34, 36 and 38 and the coils 28, 30 and 32. A knob 48 is provided on the front end of the pushrod 46 for manually pushing the rod inwardly, and a helical return spring 50 is positioned around the pushrod to urge it outwardly. A C-washer or abutment 52, mounted on the pushrod 46, is engageable with the front of the crosspiece 40 when the pushrod is pushed inwardly.

If desired, the crosspiece 40 may be folded downwardly to bring the coils 28, 30 and 32 un-

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derneath the rack 42. Such a modification provides a more compact tuning mechanism. However, for clarity the coils and the rack are shown on the same level in Fig. 1.

The rack 42 meshes with a pinion 54. A torsional coil spring 56 produces a clockwise torque on the pinion so as to urge the rack outwardly.

As best shown in Fig. 2, the pinion 54 is rotatably carried on a stationary upright shaft 57. The lower end of the torsional coil spring 56 is hooked on a radial pin 59 fixed to the pinion 54. The spring 56 is coiled around the outer periphery of a sleeve 61 which may be formed integrally with the pinion and extending upwardly therefrom. The upper end of the coil spring may be hooked on a setscrew 63 which is threaded into a collar 65 positioned above the sleeve 61, or the spring may be attached directly to the collar by other appropriate means. The collar 65 may be attached to the shaft 57 by tightening the setscrew 63. The spring 56 may be given an initial torsional strain by loosening the setscrew 63, twisting the collar 65 and tightening the setscrew again.

A pawl 58 is pivoted on a gear wheel 60 rotatably carried on the shaft 57 below the pinion 54. A tension coil spring stretched between the pawl 58 and the gear 60 urges the pawl into engagement with the pinion 54. The gear 60 meshes with a pinion 62 fixed to a second gear wheel 64 which meshes with a pinion 66. A wind vane 69, in the form of a paddle wheel, preferably having two or more arms, is mounted on the stop-
 30 member 68.

A relay 70 has an armature 72 which is urged toward the brake disc 68 by means of a spring 74. The tension exerted by the spring 74 may be adjusted by means of a screw 76.

The relay 70 has a pair of oppositely polarizable windings 78 and 80, the winding 78 operating to attract the armature 72 and the winding 80 operating to release the armature. The relay has a core 82 mounted in a frame 84. The magnetic circuit formed by the core 82, the frame 84 and the armature 72 has considerable retentivity so that the armature may be retained in attracted position by residual magnetism, once it has been moved to attracted or closed position by energization of the winding 78. Energization of the winding 80 releases the armature by buck-
 45 ing the residual magnetism.

The receiver is powered by a battery 86 which may be an automobile battery. A switch 85 is in series with the battery lead. The battery is utilized to energize the winding 78 for attracting the armature 72 to commence tuning. The attracting winding 78 of the relay 70 is connected across the battery 86 through a starting switch 87 comprising a pair of contact springs 88 and 90. The contacts 88 and 90 are normally held open by engagement of the washer 52 on the pushrod 46 with a spring member 92 mechanically connected with the contact spring 88 but electrically insulated therefrom. When the knob 48 on the pushrod is pushed inwardly, the washer 52 is disengaged from the spring member 92 and the spring member closes the contacts 88 and 90. The contacts are shunted by a bleeder resistor 94 which permits a small current to flow through the attracting winding 78 when the contacts are open to augment the residual magnetism and to provide an adjustment of the force tending to hold the armature in attracted or closed position. If the bleeder current or the retentivity of the magnetic material is suitably
 65 70 75

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increased, the relay armature may be moved to closed position by a directly applied manual movement if desired. Under these circumstances the closing winding and the starting switch would be eliminated.

The relay 80 operates switch means 99 including a number of movable contacts. A movable contact 100 is movable between stationary contacts 102 and 104 for connecting a secondary winding 105 of the output transformer 44 with the speaker 26 when the armature 72 is released and with the releasing winding 80 when the armature 72 is attracted. Thus the output transformer is connected with the speaker for listening and with the releasing winding for tuning.

Plate voltage for the receiver is supplied by a vibrator B supply 106 having two B+ output conductors 108 and 110. The B supply 106 is connected with the battery 86 through a switch 85 and an interference filter comprising a series inductance 114 and a pair of shunt capacitors 116 and 118.

An I. F. output transformer 120 couples the intermediate frequency amplifier pentode 16 with the detector tube 18. The transformer 120 has a primary winding 122 connected between the anode of the pentode 16 and the B supply conductor 108. The primary 122 is shunted by a capacitor 124 to form a tuned circuit.

A secondary tuned circuit comprising a secondary winding 126 in parallel with a capacitor 128 is coupled with the primary winding 122. One end of the tuned secondary winding 126 is connected to the anode 130 of the diode section of the tube 18. The diode section may be termed the actuating voltage rectifier and the winding 126, the actuating voltage winding. The other end of the secondary winding 126 is connected with the cathode of the diode-triode tube 18 through a series circuit including an intermediate frequency filtering resistor 132, a volume control and diode load resistor 134, and a cathode load resistor 136. Two intermediate frequency bypass capacitors 137 are connected respectively between the ends of the filtering resistor 132 and ground.

The I. F. output transformer 120 has an untuned secondary winding 138 which is closely coupled to the primary winding 122. The winding 138 may be termed the restraining voltage winding. The windings 122 and 138 may constitute a single winding of multiple strand Litz wire, some of the strands being used for the primary winding 122 and others being used for secondary winding 138. A ferromagnetic core 143 axially movable within the winding 122 may be provided to tune the primary circuit, comprising the winding 122 and capacitor 124, to resonance. The secondary winding 126 may be carried in axially spaced relation to the winding 122 and 138. A second ferromagnetic core 145 may be provided to tune the secondary circuit, comprising winding 126 and capacitor 128, to resonance. The coupling between the primary winding 122 and the secondary winding 126 may be changed, for instance, by adjusting the axial spacing of the two windings.

Fig. 3 illustrates details of the I. F. transformer 120. As indicated above, the tuned primary winding 122 and the untuned secondary winding 138 may be wound as a single coil 125 of multiple strand Litz wire in order to obtain the closest possible coupling. As shown in Fig. 3, the Litz wire may have five independently insulated strands. Three of the strands may be used for the primary
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winding 122, and the other two strands for the untuned secondary 138. The individual strands must be adequately insulated to isolate the plate voltage.

The coil 125 may be wound on a short insulating tube 127 which is slidably carried on the outside of a longer insulating tube 129. The tuned secondary winding 126 may be wound on the insulating tube 129 below the coil 125. The cores 143 and 145 are threaded into the opposite ends of the tube 129. The coupling between the coils 125 and 126 may be adjusted by sliding the short tube 127 along the tube 129 to move the coil 125. The positions of the cores 143 and 145 may be adjusted by screwing the cores in or out.

Fig. 4 illustrates a modification of the transformer of Fig. 3. If desired, the primary 122 and the secondary 138 may be formed as shown from two separate wires, wound side by side or twisted together to form a single coil 131, the coil 131 corresponding to the coil 125 of Fig. 3. The coil 131 may be wound on the short tube 127 which is slidably carried on the tube 129 as before.

The constructions shown in Figs. 3 and 4 provide nearly unity coupling between the windings 122 and 138. Close coupling is employed to obtain the highest possible restraining voltage. A high restraining voltage is desirable because it permits the use of a high actuating voltage.

One end of the untuned secondary 138 is connected with the grid of the diode-triode tube 18, and the other end is connected to ground through a resistor 139 shunted by a bypass capacitor 141. The triode section of the tube 18 is connected as an infinite impedance rectifier. The triode anode 140 of the tube 18 is connected directly with the B supply conductor 108 and is bypassed to ground by a capacitor 142. The resistor 136 serves as a load resistance for the triode section of the tube 18. This resistor also provides resistance coupling between the triode and diode circuits of the tube 18. The cathode is by-passed to ground through an intermediate frequency bypass capacitor 144. In order to furnish cathode bias voltages the conductor 146 which connects the volume control resistor 134 and the cathode load resistor 136 is connected with the B supply conductor 108 through a resistor 148.

A movable contact 152 operated by the relay armature 72 engages a stationary contact 154 to short out the cathode load resistor 136 when the armature is in its listening position in engagement with the brake disc 68. When the armature is in its tuning position the movable contact 152 engages a stationary contact 156 to connect the conductor 146 with the junction 158 of the secondary winding 138 and the resistor 139 through a resistor 160. When the relay armature 72 is in listening position there is a large positive voltage on the cathode of the tube 18 supplied from lead 108 through the resistor 148, while the grid, which is connected to ground through resistor 139, is maintained substantially at ground potential.

When the relay armature is in the tuning position the cathode load resistor 136 is in the circuit. A delay bias for the triode section of the tube 18 is developed by the voltage drop across the resistor 160, which now establishes bias on the grid relative to the cathode by raising the voltage at junction 158 above ground. The current flowing from the B supply conductor 108 through the resistor 160 provides delay bias for the triode restraining voltage rectifier section of the tube 18.

The grid of the first audio amplifier triode section of the tube 20 is shunted to the cathode by a resistor 162. The grid is connected through a coupling capacitor 164 to a movable contact 166 operated by the relay armature 72. When the relay armature is in listening position, the movable contact 166 engages a stationary contact 168 connected with the slider 169 of the volume control 134. When the relay armature 72 is in the tuning position, the movable contact 166 engages a stationary contact 170 connected with the diode plate end of the volume control resistor 134 by an interference filtering resistor 172 and shunted to ground by an interference bypass capacitor 174. Thus different adjustments of the volume control have no effect during tuning.

The tube 22 is connected as a power amplifier. The output transformer 24 has a primary winding 176 which connects the anode of the tube 22 with the B supply conductor 110. A resistor 175 and a capacitor 177 in series are connected across the primary winding 176.

A series circuit comprising a tone control capacitor 178 and a variable tone control resistor 180 is connected between the grid of the tube 22 and ground.

The tube 20 has a diode anode 182 which is coupled to the untuned secondary 138 through an intermediate frequency coupling capacitor 184. The anode 182 is connected to ground through a load resistor 186 and to an automatic volume control line conductor 188 through an automatic volume control filtering resistor 190. A bypass capacitor 192 connects the AVC line 188 to ground. The AVC line is connected with the R. F. amplifier 19, the first detector forming a part of the converter stage 14, and through the I. F. input transformer with the grid of the I. F. pentode 16.

It is advantageous for both listening and tuning to prevent operation of the AVC on weak signals. This may be accomplished by providing a delay bias to prevent operation of the AVC rectifier at low signal inputs. By this means the full sensitivity of the receiver is available at low signal inputs while at high signal inputs the AVC operates in the usual manner to hold the output at a substantially constant level.

A cathode resistor 194 is connected between the cathode of the diode-triode tube 20 and ground. The cathode is connected through a voltage dividing resistor 196 shunted by a capacitor 198 to the conductor 146 and thence through the resistor 148 to the B supply conductor 108. The voltage drop across the resistor 194 provides an AVC delay bias.

The cathodes of the radio frequency amplifier tube and the first detector tube are brought out by conductors 200 and 202 which are connected to ground through a variable sensitivity control resistor 204 shunted by a bypass capacitor 206. The conductors 200 and 202 are connected with a stationary contact 208 on the relay 70 which is shunted to ground by a movable contact 210 when the relay armature 72 is in listening position so that the sensitivity control is effective only during tuning.

In the operation of the receiver, the spring 56 is charged manually to store energy for tuning the receiver. The spring 56 may be charged by manually pushing the knob 48 on the push-rod 46 inwardly. This produces inward movement of the rack 42 and rotates the pinion 54 counterclockwise to tension the coil spring 55. The cores 34, 36 and 38 are carried along with the rack and are moved into their respective coils

28, 30 and 32. During the inward movement of the rack, the pawl 58 ratchets over the teeth of the pinion 54 so that the gear wheel 60 does not have to rotate while the spring is being charged.

The inward movement of the pushrod 46 permits the spring member 92 to close the contacts 88 and 90 of the starting switch 87. Closure of the starting switch energizes the attracting winding 78 of the relay. The relay armature 72 thereby is attracted against the core 82 and the stopping member 68 is released.

The knob 48 is promptly released after it is moved inwardly to charge the spring 56. The spring 50 returns the push-rod 46 and opens the contacts 88 and 90 of the starting switch by overcoming the force of the spring member 92. Except for the current through the bleeder resistor 94, the attracting winding 78 is deenergized when the starting switch 87 is opened but the armature 72 is retained in attracted position by residual magnetism, the magnetic field produced by the current passing through the bleeder resistor 94 and the winding 78, or both.

When the stopping member 68 is released, the spring 56 rotates the pinion 54 and thereby moves the rack 42 forwardly. Since the cores 34, 36 and 38 are moved out of their respective coils, the receiver is tuned toward the high frequency end of the tuning range.

When the pinion 54 is being rotated by the torsional spring 56, the pawl 58 forms a positive driving connection between the pinion 54 and the gear 60. Consequently the pinion 54 drives the entire gear train, comprising the gear 60, the pinion 62, the gear 64, the pinion 66, the stopping member 68, and the wind vane 69. The wind vane controls and stabilizes the tuning speed by providing rapidly increasing resistance to the rotation of the stopping member 68 as the speed of the wind vane increases. Because of the high gear ratio between the pinion 54 and the stopping member 68, the wind vane rotates at a considerable speed during tuning and the speed regulation produced by the small wind vane is quite effective.

As indicated above, the spring 56 may be initially tensioned or loaded by twisting the collar 65 with respect to the shaft 57 and the pinion 54. The spring is initially loaded to such an extent that the change in the tension of the spring, caused by the movement of the rack 42 over its entire range, is relatively small with respect to the initial tensioning. Consequently the torque exerted by the spring upon the pinion 54 is relatively constant over the entire range of motion of the pinion and the rack. This constructional feature provides adequate torque or force for starting and running the tuner over the entire tuning range, with a minimum force and movement required for recharging the spring and a minimum restraining force for regulating the speed.

When a signal of sufficient strength is tuned in, the tube 18 produces an operating voltage impulse across the volume control resistor 134. The exact manner in which the impulse is produced will be discussed in detail below. The impulse is transmitted to the grid of the first audio triode section of the tube 20 through the interference filtering resistor 172, the contacts 170 and 166, and the coupling capacitor 164.

The impulse is amplified by the first audio triode and the power amplifier tube 22 and is supplied to the relay releasing winding 80 by the secondary 105 of the output transformer 24. This operating voltage impulse is of relatively low fre-

quency and, therefore, it is desirable that the output transformer be constructed to provide effective power output at low frequencies. For similar reasons, the coupling capacitor 21 should have sufficient capacitance. The resistor 175 and the capacitor 177 are provided to improve the sensitivity and to promote proper relay action.

The secondary 105 of the output transformer 24 and the releasing winding 80 are polarized with respect to the attracting winding 78 so that the first signal impulse through the releasing winding bucks the residual magnetism and the magnetism produced by the current through the attracting winding and the bleeder resistor 94. As previously stated, residual magnetism or bleeder current may be utilized separately or together to latch the relay armature in its tuning position. If the impulse in the releasing winding is of sufficient strength, the relay armature 72 is released and tuning is discontinued by engagement of the armature with the brake disc or stopping member 68.

The magnitude of the holding current through the bleeder resistor 94 is one of the factors determining the sensitivity of the relay 70. The sensitivity generally is increased if the bleeder current is decreased. The retentivity of the core 82, the armature 72 and the frame 84, as well as the strength or adjustment of the armature spring 74, also affect the sensitivity.

The adjustment of the sensitivity control resistor 204 determines the strength of the signal necessary for stopping the tuning of the receiver on a signal. The operation of the tuning mechanism is not affected by the setting of the volume control resistor 134 because the slider 169 of the volume control is disconnected during tuning, and the signal output is taken through the interference filtering resistor 172 from the end of the volume control resistor connected with the diode anode 130. During tuning, the resistor 172 and the capacitor 174 provide additional filtering to minimize the possibility of the tuner being stopped by static or other interference. This filter does not appreciably affect the audio response during listening.

When the relay armature 72 has been released to stop the tuning, the movable relay contacts shift to their listening position. The movable contact 210 shorts out the sensitivity control resistor 204 so that the full sensitivity of the receiver controlled by the AVC is available for listening.

During listening the movable contact 152 shorts out the cathode load resistor 136 to prevent any signal voltages from developing across this resistor, and to permit the full signal voltage to develop across the volume control resistor 134. The triode section of the tube 18 is cut off by disconnecting the resistor 160 from the positively charged conductor 146, thus permitting the grid of the triode section to drop to ground potential. The conductor 146 is at a positive potential high enough to effectively prevent rectification in the triode restraining voltage rectifier with the strongest signal input.

For listening, the movable contact 166 connects the input of the first audio tube 20 to the slider 169 of the volume control resistor so that the slider may be adjusted to vary the volume.

It will be seen that both the tuning and the listening signals come from the same diode plate 130 and also from the same tuned circuit consisting of the secondary winding 126 and the capacitor 128. For tuning, the signal from the diode

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section of the tube 18 follows the path through the interference filter resistor 172, but, for listening, the signal passes through the volume control resistor 134 and the slider 169, as determined by the position of the switch contact 166. As a result, the last tuned circuit which establishes the frequency for signal tuning is also the last tuned circuit which establishes the frequency of the signal during listening. During tuning, the width of the response of this tuned circuit is narrowed by the restraining voltage, particularly to strong signals. However, the center frequency is the same as during listening. This arrangement eliminates any possible error in tuning which might occur if different tuned circuits were employed for tuning and listening, since one of the circuits could get out of tune with respect to the other.

The operation of the signal tuning circuits will now be described in detail. As stated above, the coupling between the primary winding 122 and the tuned secondary 126 may be adjusted by moving one of the coils to increase or decrease the axial distance between them. A degree of coupling between these coils which gives very good results may be secured in the following manner.

First, the delay bias on the restraining voltage rectifier is reduced to zero by adjusting the grid-cathode bias of the tube 18 to the value which is just sufficient to produce plate current cut-off in the triode with zero signal input. The grid-cathode bias may be adjusted by varying the relative values of the resistors 139 and 160. Then a signal of moderate strength is supplied to the receiver. The signal may be derived from a signal generator operating at the central intermediate frequency and may be applied, for example, to the grid of the intermediate frequency amplifier tube 16. The coupling between the primary 122 and the secondary 126 is then adjusted so that there is an appreciable voltage output from the actuating voltage diode rectifier section of the tube 18, measured, for instance, across the volume control resistor 134. The coupling is then reduced until this measured voltage substantially disappears. At this point the restraining voltage developed by the triode section of the tube 18 across the cathode resistor 136, and applied to the diode plate 130 through the volume control resistor, is substantially equal to the peak I. F. actuating voltage applied to the plate 130 by the coil 126.

Next, the relative values of the resistors 139 and 160 are changed to increase the voltage between the cathode and the grid of the tube 18 to provide a delay bias. The amount of delay bias that should be used will be discussed below. The receiver is now adjusted for its normal operation. If the delay bias were not provided, the restraining voltage developed by the triode section of the tube 18 would always bias the diode section of the tube so that it would pass substantially no current during tuning. With the additional delay bias applied to the restraining voltage triode rectifier, an operating voltage appears across the volume control resistor 134 whenever a signal is supplied to the transformer 120.

If the strength of the applied signal increases from zero, the operating voltage across the resistor 134 increases from zero until the peak voltage developed across the untuned winding 138 approximately equals the delay bias. Up to this point the delay bias prevents the restraining voltage rectifier from conducting. Any further

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increase in the applied signal strength does not substantially increase the operating voltage developed across the resistor 134 because the restraining voltage developed across the cathode resistor 136 increases the bias on the diode plate 130 approximately as fast as the voltage developed across the winding 126 increases. The restraining voltage thus prevents any further substantial increase in the operating voltage. Thus strong signals do not produce substantially greater operating voltages than weaker signals. For this reason both strong and weak signals are tuned closely to the center intermediate frequency, and the effective width of a signal in terms of frequency does not increase substantially with increasing signal strength.

Thus the operating voltage increases toward a maximum value which does not greatly exceed the value produced by a signal which is just sufficient to overcome the delay bias. This maximum operating voltage depends upon the value of the delay bias, and is of the same order as the delay bias. Raising the delay bias increases the maximum operating voltage, and vice versa.

In tuning through a station, the operating voltage rises to a peak at the center intermediate frequency. The operating voltage must attain or exceed a predetermined value in order to stop the tuning of the receiver. The minimum operating voltage that will stop the tuning mechanism may be termed the operating level. A station, when tuned in, stops the tuning mechanism or not according to whether or not the operating signal produced across the resistor 134 exceeds or at least reaches the operating level. The magnitude of the operating level depends upon the sensitivity of the relay and the amount of amplification between the resistor 134 and the relay.

The delay bias should be great enough to provide a maximum operating voltage which equals or exceeds the operating level. It is desirable to stop the tuning of a station near the center of the channel which the station occupies. Consequently the operating voltage produced by a station signal preferably should exceed the operating level near the peak of the operating voltage. This should be the case for relatively strong as well as relatively weak stations. For this reason the maximum operating voltage preferably should not greatly exceed the operating level. If the maximum operating voltage is raised too high with respect to the operating level, the tuner will tend to stop on strong signals before the receiver is correctly tuned. Moreover, the tuner will tend to stop twice or more on strong signals when the starting switch is operated, instead of moving on to the next station.

The strength a received signal must have to produce an operating voltage at least equal to the operating level depends upon the setting of the sensitivity control resistor 20. Thus the sensitivity control may be adjusted so that a greater or smaller number of stations will stop the tuning. With a setting of the sensitivity control providing high gain in the R. F. and I. F. stages, relatively weak as well as relatively strong stations will be signal tuned. Progressively reducing the gain will prevent signal tuning of progressively more stations which are then too weak to produce operating voltages at least as great as the operating level.

The relationship of the operating level and the delay bias may be such that signals may

be received which will stop the tuning but fail to overcome the delay bias. If the spring driven tuning mechanism of the receiver tunes in such a signal, the triode section of the tube 18 does not conduct, and a restraining voltage is not produced. As such a signal enters the frequency band to which the tuned winding 126 responds, a voltage begins to develop across the winding 126. This voltage is rectified by the diode section of the tube 18 and produces an operating signal across the volume control resistor 134. After the signal reaches the operating level, the tuning is stopped near the center intermediate frequency. This assumes that the signal must develop nearly its peak voltage before it reaches the operating level.

A restraining voltage is produced by signals which are sufficiently strong to overcome the delay bias. As soon as a restraining voltage is produced it biases the diode plate 130 and thereby tends to reduce the output of the diode so that the operating voltage across the resistor 134 tends to exceed the operating level nearer the center intermediate frequency than would be the case without the restraining voltage. Consequently the restraining voltage has a narrowing effect, in terms of frequency, on the signal tuning action. The restraining voltage improves the tuning accuracy and tends to prevent stopping before the center I. F. frequency is reached and stopping more than once on a station, especially on strong signals.

The tuning response characteristic of the untuned secondary winding 138 is like that of the primary 122 and is somewhat broader than the response characteristic of the secondary tuned circuit comprising the winding 126 and the capacitor 128. The response of the untuned circuit should not be narrower and preferably should be wider than that of the tuned circuit.

If the spring driven tuning mechanism tunes in a signal having a strength sufficiently exceeding the value required to overcome the delay bias, a restraining voltage is produced which tends to narrow the response of the diode actuating rectifier. As such a strong signal, applied to the transformer 120, approaches the center intermediate frequency, a substantial voltage develops across the untuned secondary 138 before any substantial voltage develops across the tuned secondary 126. Such a strong signal developing across the untuned secondary 138 overcomes the delay bias before any substantial voltage develops across the tuned secondary 126. When the delay bias has been overcome, the triode section of the tube 18 develops a restraining voltage across the cathode resistor 136. This voltage biases the diode plate 130 negatively with respect to the cathode of the tube 18 and thus restrains conduction in the diode section until the peak voltage developed by the tuned secondary winding 126 exceeds the restraining voltage.

Once a voltage starts to develop across the tuned secondary 126 it rises at a more rapid rate than the voltage across the untuned secondary 138, due to the steeper slope of its voltage versus frequency response. When the signal applied to the transformer 120 closely approaches the center intermediate frequency, the voltage across the tuned secondary 126 begins to exceed the restraining voltage and the diode section of the tube 18 begins to conduct. This produces an operating impulse across the volume control resistor 134 for stopping the tuning mechanism in the manner described above.

If the restraining voltage were not provided, a strong signal would produce an impulse of sufficient strength to stop the tuning mechanism at a frequency farther removed from the center intermediate frequency than in the case of a weak signal. It will be apparent that the restraining voltage prevents strong stations from producing a tuning signal higher and wider than produced by weaker stations. Together with the delay bias the restraining voltage provides relatively uniform response of the actuating circuit to signals of varying magnitude.

The flux latched relay may be adjusted to be particularly sensitive and the audio amplifying system provides relatively great amplification of the operating signals. As a result, the operating level may be made quite low. Less than one volt of operating voltage may be employed. In such a case the delay bias on the restraining voltage rectifier may be in the order of two or three volts. This provides a narrower operating voltage signal. However, if a larger operating voltage is employed, the operating level can be made higher by adjusting the relay for lower sensitivity or employing less gain in the relay amplifier. With a less sensitive relay arrangement the operating level may be raised. In this case the delay bias on the restraining voltage rectifier may be increased and the maximum operating voltage raised thereby. For the reasons explained previously, the maximum operating voltage should be greater than but comparable with the operating level. When the delay bias is raised, the variation of the operating voltage with changing signal strength will be greater for signals of insufficient strength to overcome the delay bias. With an increased delay bias there will be more difference between strong signals and relatively weaker signals which are insufficiently strong to overcome the delay bias.

For best operation the weakest desired station signals should produce adequate I. F. actuating voltage in the tuned winding 126. The highest I. F. actuating voltage is produced when the spacing between the primary 122 and the tuned secondary 126 is adjusted to provide approximately optimum coupling. However, to avoid broad tuning on strong signals, sufficient restraining voltage should also be provided. The arrangement of Fig. 1 provides a high restraining voltage because of the large number of turns in the untuned secondary 138 and its tight coupling to the primary 122. This may be done when an infinite impedance triode rectifier is employed to obtain the restraining voltage. The load imposed upon the secondary 138 by the infinite impedance rectifier is very low. Consequently the secondary 138 may be coupled very closely to the primary 122 without appreciable loss of voltage due to loading of the primary.

To produce the highest actuating voltage, the resistor 134 should have a high value relative to the resistor 136. However, the resistor 136 must have a great enough value to supply sufficient restraining voltage.

The great mechanical advantage provided by the gear train between the stopping member 68 and the pinion 54 increases the effectiveness and accuracy of the braking action of the armature 72 when it engages the stopping member 68. Thus excessive tension is not required of the spring 74.

Very positive holding of the stopping member can also be had by providing the stopping mem-

ber with teeth, and the armature with an abutment to engage the teeth. However, the teeth must be spaced so that the distance between adjacent teeth is small enough so that it has no important effect on the tuning.

When a different station is desired, the starting switch 87 is closed momentarily by tapping the knob 48. The relay winding 78 is energized and the armature 72 is attracted into its tuning position. Thus the stopping member 63 is released. The spring 56 drives the tuning mechanism until another signal of sufficient strength is tuned in, or until the high frequency end of the tuning range is reached. If a signal is tuned in, the relay armature 72 is released to arrest the movement of the stopping member 66.

When the high frequency end of the tuning range is reached, the spring 56 is recharged by manually pushing the knob 48 inwardly. Recharging is not required frequently since several stations spaced across the tuning range will ordinarily have sufficient strength for signal tuning in most localities.

The spring 56 may be partially recharged at any time in order to tune in a particular station, for example. The amount the tuning cores are moved and the amount the spring is recharged are determined by the extent of the inward movement of the control knob. The knob may be pushed in to move the tuner to the low frequency side of a desired station, and the station may be tuned in by tapping the control knob. The receiver dial may be observed during this procedure to establish visually the position of the desired station.

Fig. 5 illustrates the external appearance of the receiver. The pushrod or control plunger 46 protrudes through a panel 210 enclosing the front of the receiver. A tuning dial or scale 212 having an indicator 214 is positioned immediately below the pushrod 46. The volume control resistor 134 and the battery switch 85 may be controlled by a knob 218, and the tone control resistor 180 may be controlled by a ring 216. The sensitivity control may be controlled by a knob 217 and the receiver may be conditioned for manual or signal tuning by means of a lever 219. The receiver may be enclosed in a housing 220 and may be adapted for mounting on the dash of an automobile.

The above mentioned application of Edward F. Andrews, Serial No. 195,161, should be consulted for a description of further mechanical features of the receiver. For example, this copending application contains a description of the linkage by which the rack 42 operates the dial indicator 214 and the mechanism for manual tuning which is controlled by the lever 219.

Fig. 6 illustrates a signal tuned receiver which is different in some respects from the receiver of Figs. 1-5. The modifications embodied in the receiver of Fig. 6 will now be described in detail. In other respects the receiver may be similar to the receiver of Figs. 1-5.

In the receiver of Fig. 6, an additional triode 250 is used for stopping the tuning mechanism on a signal instead of employing the audio amplifying system for this purpose. In this modified receiver it is unnecessary to change the volume control connections for tuning. Consequently the switch contacts 166, 168 and 170 are omitted and the grid of the audio amplifier tube 20 is connected directly to the slider 169 of the volume control resistor 134 through the blocking capacitor 164. The tube 250 may be a high trans-

conductance pentode such as a 6AU6 connected as a triode.

The relay 70 is provided with a winding 252 which replaces the windings 78 and 80. The winding 252 is connected between the anode of the tube 250 and the B+ conductor 108. Since the winding 252 is controlled by the plate current in the tube 250, the winding has a considerably greater number of turns than either of the windings 78 and 80 of the receiver of Fig. 1. The relay 70 of Fig. 6 has a soft iron core 253 having the smallest obtainable retentivity, unlike the flux latched relay of Fig. 1. The armature 72 is also made of soft iron.

The grid of the relay operating tube 250 is connected by a conductor 254 to the junction of the resistor 172 and the capacitor 174. The lower end of the volume control resistor 134 is connected to the cathode of the tube 18. The cathode of the relay operating tube 250 is connected through a resistor 256 in series with a resistor 257 to the junction conductor 146 and thence through the cathode resistor 136 to the cathode of the tube 18. Cathode bias for the tube 250 is provided by the resistors 256 and 257 as well as a resistor 258 connected between the cathode and the B+ conductor 108.

The starting switch 87 is connected in series with a resistor 260 between the plate of the tube 250 and ground.

The switch contacts 100 and 104 are utilized in this receiver but they are connected differently than in the receiver of Fig. 1. The contact 102 is omitted. The movable contact 100 is connected to one end of the resistor 257 and the contact 104 to the other end, so that during tuning the resistor 257 is shorted out.

The contacts 208 and 210 are connected the same as in Fig. 1 so that during listening they short out the sensitivity control resistor 204. The speaker 26 is connected directly across the output transformer secondary 105, one terminal of the secondary being grounded. During tuning the speaker is shorted out because the grounded movable contact 210 engages a stationary contact 261 connected to the ungrounded side of the speaker.

Since the tuning impulses are transmitted to the relay by the tube 250 rather than by the audio amplifying system, it is not so important that the amplifying system have an adequate low frequency response.

The distinctive features of the operation of the receiver of Fig. 6 will now be explained. It will be assumed that initially the spring 56 is at least partly charged and the tuning is stopped on a signal. The relay armature 72 then is engaged with the stopping member 68 and the relay contacts are in their listening positions.

A current flowing from the B supply conductor 108 through the bleeder resistor 258 and the cathode resistors 256 and 257 produces a voltage drop across the resistors which is sufficient to bias the tube 250 far beyond cut-off. Consequently, no plate current flows in the tube during listening regardless of any signals impressed on its grid from the conductor 254.

When a new station is desired, the starting switch 87 is closed momentarily by tapping the knob 48 in the same manner as in the receiver of Fig. 1. When the starting switch is closed, a current flows from the B supply conductor 108 through the relay winding 252, the resistor 260 and the starting switch to ground. The magnetic flux produced by the current is sufficiently strong to at-

tract the relay armature 72 into its tuning position out of engagement with the stopping member 68.

The armature moves the relay contacts to their tuning positions and the contacts 100 and 104 short out the resistor 257. The grid-cathode bias on the tube 250 thereby is reduced to such an extent that plate current flows in the tube, assuming that an operating signal is not being developed. The plate current of the tube 250 passes through the relay winding 252. The plate current through the tube is sufficient to hold the relay armature 72 in attracted position when the starting switch 87 is opened.

When a signal of sufficient strength is tuned in, an operating signal is developed across the series circuit of the volume control resistor 134 and the cathode resistor 136 and is impressed upon the grid of the tube 250 by the resistor 172 and the conductor 254. If the operating signal on the grid of the tube 250 has sufficient strength, it reduces the plate current through the relay winding 252 to such an extent that the relay armature 72 is moved to its listening position by the spring 74. The relay armature engages the stopping member 68 and stops the tuning mechanism on the signal.

The relay of Fig. 6 is different from the flux latched relay of Fig. 1. Among other things, the magnetic circuit of the relay of Fig. 6 is made of soft relay iron in order to minimize residual flux. The relay of Fig. 6 also may have an air gap between the armature and the core when the former is in attracted position.

In the receiver of Fig. 6 the actuating voltage is developed across the volume control resistor 134 and the restraining voltage, across the cathode resistor 136. The ends of the resistors 134 and 136, having positive operating polarity, are connected together so that the restraining voltage bucks the actuating voltage. The resultant operating voltage across the resistors in series is applied between the grid and the cathode of the relay tube 250. The grid is connected through the resistor 172 to the negative end of the volume control resistor so that the plate current in the tube is reduced when the actuating voltage exceeds the restraining voltage. If the plate current is reduced sufficiently, the relay armature 72 is released and the tuning is stopped.

The operating level depends upon the sensitivity of the relay 70 and the amount of amplification provided by the relay tube 250. The operating level is likely to be higher than in the receiver of Fig. 1 because the sensitivity of the relay of Fig. 6 may be less than that of the flux latched relay of Fig. 1, and because the single relay tube may provide less gain than the audio system used in the relay amplifier in Fig. 1.

When the operating voltage is derived from the restraining and actuating voltages connected in series, both positive and negative voltages are present in the operating output from the two rectifiers. However, with the relay and relay tube system shown in Fig. 6, only the negative component in excess of the positive component can produce the reduction of plate current of the tube 250 required to release the relay armature. For this reason the series connection of the actuating and restraining voltage resistors may be combined advantageously with the relay system of Fig. 6.

Referring to the adjustment of the coupling between the primary 122 and the secondary 126 as described in connection with Fig. 1, it should

be noted that the operating or resultant voltage develops across the resistors 134 and 136 connected in series opposition instead of across the resistor 134 by itself. Therefore, in this embodiment the effective operating voltage should be measured across the resistors 134 and 136 in series. With no signal the voltage at this point is zero. With a moderate signal applied as in Fig. 1 a voltage appears across these resistors. When the adjustment of the coupling is being made, the delay bias should be removed from the restraining voltage rectifier as described in relation to Fig. 1. The coupling is then adjusted with the input signal still present so that the voltage across the two resistors is substantially zero. This shows that the restraining voltage is now equal to the actuating voltage and has neutralized it. When the delay bias is restored, the same input signal will again produce a voltage across these two resistors. The voltage remains substantially constant with increasing signal strength for signals having sufficient strength to overcome the delay bias.

The series arrangement of the resistor across which the actuating and restraining voltages develop, as shown in Fig. 6, may be advantageous where a single triode is employed between the relay and the source of the operating voltage, as here shown. Where the outputs of the restraining and actuating voltage rectifiers are connected in series opposition, as in Fig. 6, a somewhat higher operating voltage may be obtained than with certain arrangements where the restraining voltage rectifier biases the actuating voltage rectifier. This may be of some advantage where a less sensitive relay system having a higher operating level is employed, as in Fig. 6. With the higher operating level of Fig. 6 a correspondingly higher delay bias preferably is employed so that the restraining voltage develops in response to any signal exceeding the operating level by a small margin. This relation between the operating level and the delay bias is generally desirable.

Fig. 7 illustrates a modified signal tuned receiver. The differences between the receiver of Fig. 7 and the receiver of Fig. 1 will now be described. In other respects the receiver of Fig. 7 may be similar to the receiver of Fig. 1.

In the receiver of Fig. 7 a crystal rectifier 300 is employed as a signal detector for listening and as the actuating voltage rectifier for signal tuning. The diode plate of the tube 20 is employed to obtain the restraining voltage as well as the automatic volume control voltage. Consequently the tube 18 is omitted from the receiver of Fig. 7.

The crystal rectifier 300 may be of the germanium crystal type. A series circuit comprising the crystal rectifier 300, a junction conductor 301, the volume control resistor 134 and the intermediate frequency filtering resistor 132 is connected across the terminals of the secondary tuned circuit comprising the transformer winding 126 and the capacitor 128. The volume control resistor is shunted for intermediate frequencies by a bypass capacitor 302. As in Fig. 1, the by-pass capacitor 137 is connected between one end of the winding 126 and ground.

One end of the untuned secondary winding 138 is connected to the diode plate 182 of the tube 20 and the other end is connected to a junction conductor 304. The conductor 304 is connected through a load resistor 306 to ground, the load resistor being shunted by an intermediate frequency bypass capacitor 308. The conductor 304 is also connected to the automatic volume control

line 163 by the filtering resistor 190. A delay bias between the cathode of the tube 20 and the diode plate 162 is produced by three resistors 310, 312 and 314, connected in series between the cathode of the tube and ground, together with a bleeder resistor 316 connected between the B supply conductor 153 and the cathode.

All of the relay switch contacts 99 are employed in the receiver of Fig. 7 but some of them are connected differently than in the receiver of Fig. 1. The movable contact 152 is connected to the junction conductor 301 between the crystal rectifier 300 and the volume control resistor 134. When the relay contact 152 is in its listening position it engages the movable contact 154 which is connected to ground. When the movable contact 152 is in its tuning position it engages the contact 156 which is connected to the junction conductor 304 and thus to ground through the load resistor 306.

The movable contact 166 is connected directly to the grid of the triode section of the tube 20. In its listening position the contact 166 engages the contact 168 which is connected through the blocking capacitor 164 to the slider 169 of the volume control resistor 134. The contact 168 is also connected through a grid return resistor 320 to the junction of the cathode resistors 310 and 312. In its tuning position the movable contact 166 engages the stationary contact 170 which is connected through a blocking capacitor 322 and the interference filtering resistor 172 to the junction of the resistor 132 and the volume control resistor 134. The interference bypassing capacitor 174 is connected between the junction of the resistor 172 and the capacitor 322 and ground. The contact 170 is also connected through a grid return resistor 324 to the junction of cathode resistors 312 and 314. The connections to the contacts 160, 162, 166, 200 and 210 are the same as in Fig. 1.

As in Fig. 1, the anode of the triode section of the tube 20 is connected through the coupling capacitor 21 to the grid of the second audio amplifier tube 22.

In the receiver of Fig. 7 the transformer 120 is ordinarily constructed somewhat differently than in Fig. 1. As in the receiver of Fig. 1, the untuned secondary winding 138 is coupled as closely as possible to the primary winding 122 in order to secure the maximum obtainable restraining voltage. In the receiver of Fig. 7 the restraining voltage rectifier is a diode and not an infinite impedance rectifier employing a triode. Consequently the restraining voltage rectifier imposes an appreciable loading effect upon the secondary winding 138. In order to avoid excessive loading of the primary winding 122, the untuned secondary winding 138 ordinarily has a smaller number of turns than the primary winding in the receiver of Fig. 7.

In order to secure a maximum obtainable coupling between the primary winding 122 and the untuned secondary winding 138, the two windings may be formed as one coil. The windings may be wound from separate wires laid side by side or twisted together until the secondary winding 138 is completed. Then the end of the secondary winding may be anchored and brought out and the remaining turns of the primary winding may be wound to complete the coil.

The receiver may be modified to employ capacitance-resistance coupling between the primary 122 and the restraining voltage rectifier instead of inductive coupling. However, such capaci-

tance-resistance coupling can be expected to provide somewhat less restraining voltage than the inductive coupling, and so the inductive coupling is generally preferable.

In the receiver of Fig. 7 the load resistors of the actuating voltage rectifier and the restraining voltage rectifier are connected in series opposition during signal tuning. The end of one resistor is connected to the end of the other resistor having like operating polarity so that the outputs of the rectifiers buck each other. The scheme exemplified by Fig. 1 of utilizing the restraining voltage to bias the actuating voltage rectifier is not employed in Fig. 7 because ordinary crystal rectifiers may not give satisfactory operation with a reversely polarized biasing voltage.

The restraining voltage develops across the load resistor 306 and the actuating voltage develops across the volume control resistor 134. The operating voltage which is the resultant of combining the actuating and restraining voltages, develops across the resistors 306 and 134 in series. When the relay contacts 99 are in their tuning position, the resistors 134 and 306 are connected in series by the contacts 152 and 156. The operating voltage impulse is transmitted to the grid of the triode section of the tube 20 along a path including the interference filtering resistor 172, the capacitor 322, and the contacts 170 and 166. During tuning the resistor 324 serves as a grid return resistor. Consequently the voltage drop across the resistors 310 and 312 biases the grid of the tube 20 with respect to the cathode. This voltage is sufficient to bias the triode section of tube 20 toward or to cut-off. Consequently the triode responds effectively to only the positively polarized portions of the signal impressed on its grid during tuning. This biasing is desirable so that a tuning impulse is transmitted to the relay 70 only when the actuating voltage across the volume control resistor 134 exceeds the restraining voltage across the load resistor 306. The crystal is polarized to produce a positive actuating signal upon the grid of the tube 20, while the diode section of the tube 20 is polarized to produce a negative restraining voltage.

In order to prevent the negative restraining voltage from producing spurious positively polarized signals on the grid of the tube 20, the capacitor 322, and the resistor 324 should be sufficiently large so that the impulse signals produced during tuning are transmitted to the grid without substantial spurious reversals of polarity.

During signal tuning, the voltage drop across the resistors 310, 312 and 314 produces a delay bias on the diode section of the tube 20. The diode acts as the restraining voltage rectifier. A suitable delay bias may be arrived at in accordance with the considerations pointed out in the description of the receiver of Fig. 1. The coupling between the primary 122 and the tuned secondary 126 may be adjusted in substantially the same manner described in connection with the receiver of Fig. 6. Impulses for stopping the tuning mechanism are produced in much the same manner as in the receiver of Fig. 1. However, the restraining voltage is connected to buck or neutralize the actuating voltage rather than to bias the actuating voltage rectifier as in Fig. 1. Tuning signals representing the combination of the actuating and restraining voltages are supplied to the grid of the tube 20. These tuning signals have an excess of the positively polarized

actuating voltage over the negative restraining voltage. During tuning the triode section of the tube 20 is biased to or nearly to cut-off so that only the positive components can produce effective plate current in the triode and thereby stop the tuning mechanism.

As in the receiver of Fig. 1, the relay winding 80 has an operating polarity with respect to the winding 78 such that the initial tuning impulse, applied to the winding 80 by the output transformer secondary 105, tends to buck the flux which latches the relay armature 72. However, in the receiver of Fig. 7, the relative polarity of the winding 80 and the output transformer secondary 105 is the reverse of the polarity in the receiver of Fig. 1. This is true because positively polarized tuner stopping impulses are applied to the grid of the tube 20 in the receiver of Fig. 7 instead of the negatively polarized impulses applied to the grid in the receiver of Fig. 1.

In Fig. 7 the grid of the first audio triode in the tube 20 is biased at or near cut-off during tuning to prevent it from responding to the negative restraining voltage. This biasing raises the operating level, but the operating voltage is also relatively high because of the series connection of the restraining and actuating voltage rectifiers. In any event, adjustment of the operating level can be effected by adjusting the bleeder current, the tension of the relay spring 74, or both.

When the relay contacts 99 are in their listening position, the circuit including the crystal rectifier 300 operates as the signal detector. The junction conductor 301 connected with one end of the volume control 134 is grounded by the contacts 152 and 154. Signals are transmitted from the slider 169 of the volume control resistor to the triode grid of the tube 20 through the capacitor 164 and the contacts 168 and 166. For listening, the resistor 320 is the grid return resistor. Consequently only the drop across the resistor 310 is impressed between the grid and the cathode. This drop provides the usual bias for utilizing the triode section of the tube 20 as an audio amplifier.

During listening, the restraining voltage has no effect since the load resistor 306 for the restraining voltage rectifier is disconnected by the contacts 152 and 156 from the crystal rectifier circuit.

The contacts 100, 102, 104, 208 and 210 operate in the same manner as in the receiver of Fig. 1.

The differences between the modified receiver of Fig. 8 and the receiver of Fig. 1 will now be described. In other respects the receiver of Fig. 8 may be similar to the receiver of Fig. 1.

In the receiver of Fig. 8 the tubes 18 and 20 are replaced by a single tube 350 having an independent diode section 352 and a diode triode section 354 having a diode plate 356, a triode grid 358, a triode plate 360 and a common cathode 362 for the diode plate 356 and the triode section. The independent diode 352 has a separate cathode 353.

One side of the tuned secondary winding 126 is connected to the plate of the independent diode 352 and the other side of the winding is connected to a junction conductor 364. The cathode of the independent diode 352 is connected through the intermediate frequency filtering resistor 132 to a junction conductor 366. The junction conductor 366 is connected through a load resistor 368 to ground. The ends of the fil-

tering resistor 132 are bypassed to ground for intermediate frequencies by the bypass capacitors 137.

The movable relay contact 166 is grounded. In its listening position the contact 166 engages the contact 168 which is connected to one side of the volume control resistor 134. The other side of the volume control resistor is connected to the junction conductor 366. The contact 170 is omitted from the receiver of Fig. 8.

The slider 169 of the volume control resistor 134 is connected through the blocking capacitor 164 to the grid 358 of the triode section of the tube 350. The anode 360 of the triode section is connected through the coupling capacitor 21 to the grid of the second audio tube 22.

One side of the untuned secondary winding 138 is connected to the diode plate 356, and the other side is connected to a junction conductor 370 which is bypassed to ground for intermediate frequencies by a capacitor 372. The junction conductor 370 is connected through an intermediate frequency filtering resistor 374 to the junction conductor 364. The junction conductor 364 is bypassed to ground for intermediate frequencies by a capacitor 376. The junction conductor 364 is connected through a load resistor 378 to ground. A source of delay bias may be connected between terminals 380 and 382, respectively connected to the cathode 362 of the tube 350 and ground. The source is indicated by a dotted line between the terminals in Fig. 8. The delay bias source may be a battery, a suitable power supply, or a resistor having a suitable voltage drop across its terminals. For example, a delay bias may be obtained by a circuit similar to the arrangement of Fig. 1 in which the drop across the resistor 160 furnishes the delay bias.

In the receiver of Fig. 8 the movable relay contact 152 is grounded. In its listening position, the movable contact 152 grounds the contact 154 which is connected to the junction conductor 364. The contacts 100, 102, 104, 208 and 210 are connected in the same manner as in Fig. 1.

In the receiver of Fig. 8 the diode plate 356 and the cathode 362 function as the restraining voltage rectifier. Consequently the restraining voltage rectifier imposes an appreciable load upon the untuned secondary winding 138. In order to avoid loading the primary winding 122 excessively, the secondary winding 138 ordinarily will have a smaller number of turns than the primary winding. The windings 122 and 138 may be wound as one coil as described in connection with Fig. 7.

In the receiver of Fig. 8 the independent diode 352 is the actuating voltage rectifier and the diode comprising the plate 356 and the cathode 362 is the restraining voltage rectifier. During signal tuning the operating voltage develops across the output resistor 368 of the actuating voltage rectifier and the restraining voltage develops across the load resistor 378. When the relay contacts 99 are in their tuning position, the contact 154 is disconnected from ground and the restraining voltage is impressed upon the plate of the independent diode 352 through the secondary winding 126. The restraining voltage is negatively polarized so that it tends to restrain rectification by the diode 352.

The operating voltage impulse for stopping the tuning mechanism is transmitted from the junction conductor 366 to the grid 358 of the tube 350 through the volume control resistor 134 and the capacitor 164. During signal tuning the vol-

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ume control resistor is disconnected from ground by the contacts 166 and 168 so that the position of the volume control slider 169 has no effect upon the magnitude of the tuner stopping impulse.

The delay bias on the restraining voltage rectifier and the coupling between the primary 122 and the tuned secondary 126 may be adjusted in the manner described in connection with the receiver of Fig. 1. Consequently a tuning impulse is produced in the receiver of Fig. 8 in essentially the same manner as in the receiver of Fig. 1. The use of an independent diode with separate cathode for the actuating voltage rectifier in a single tube also containing a diode triode is a distinguishing feature of the receiver of Fig. 8 over the receiver of Fig. 1. Moreover, the same independent diode produces a positive detector listening signal as well as a positive actuating voltage.

As in Fig. 1, the same tuned circuit, comprising the winding 126 and the capacitor 128, and the same rectifier 352, produce the actuating voltage during tuning and the detector voltage during listening. In Fig. 8 both the actuating voltage and the detector voltage have positive polarity, while in Fig. 1 both have negative polarity.

While I have shown and described several preferred embodiments of my invention, it will be apparent that numerous variations and modifications thereof may be made without departing from the underlying principles of the invention. I therefore desire, by the following claims, to include within the scope of the invention all such variations and modifications by which substantially the results of my invention may be obtained through the use of substantially the same or equivalent means.

I claim:

1. In signal tuned radio apparatus, variable tuning means, means for varying said tuning means, means for stopping the variation of said tuning means in response to an operating voltage tuned by said tuning means, a circuit coupled to receive signal voltage from said apparatus, a first rectifier coupled to said circuit, a tuned circuit coupled to receive signal voltage from said apparatus, a second rectifier coupled to said tuned circuit, means for deriving a voltage from the first rectifier and applying it as a bias to an element of said second rectifier to reduce the output of the second rectifier, means to prevent rectification of said first rectifier in response to signal voltage below a predetermined value, and means coupling said second rectifier to said stopping means.

2. In signal tuned radio apparatus, variable tuning means, means for varying said tuning means, means for stopping the variation of said tuning means in response to an operating voltage tuned by said tuning means, a circuit coupled to receive signal voltage from said apparatus, a high impedance triode rectifier coupled to said circuit, a tuned circuit coupled to receive signal voltage from said apparatus, a second rectifier coupled to said tuned circuit, means interconnecting said two rectifiers whereby the effective output of the second rectifier is reduced by the operation of the high impedance triode rectifier, and means coupling said second rectifier to said stopping means.

3. In signal tuned radio apparatus, variable tuning means, means for varying said tuning

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means, means for stopping the variation of said tuning means in response to an operating voltage tuned by said tuning means, a circuit coupled to receive signal voltage from said apparatus, a first rectifier coupled to said circuit, a tuned circuit coupled to receive signal voltage from said apparatus, a second rectifier coupled to said tuned circuit, bias means connected to prevent operation of said first rectifier until said signal voltage overcomes the bias, means for deriving a voltage from the first rectifier and applying it as a bias to an element of said second rectifier to prevent substantial increase of said operating voltage by said second rectifier with increase of said signal voltage after the bias preventing the operation of said first rectifier is overcome, a low frequency amplifier, means coupling said second rectifier to the input of said low frequency amplifier, and means coupling the output of said low frequency amplifier to said stopping means.

4. In signal tuned radio apparatus, variable tuning means, means for varying said tuning means, means for stopping the variation of said tuning means in response to an operating voltage tuned by said tuning means, a tuned primary circuit coupled to receive signal voltage from said apparatus, a triode rectifier tightly coupled to said tuned primary circuit, a tuned secondary circuit coupled to said tuned primary circuit, a second rectifier coupled to said tuned secondary circuit, bias means connected to prevent operation of said triode rectifier until said signal voltage overcomes the bias, means connecting the triode rectifier to the second rectifier to prevent substantial effective increase of said operating voltage with increase of said signal voltage after the bias is overcome and said triode rectifier operates, and means coupling said second rectifier to said stopping means.

5. In signal tuned radio apparatus, variable tuning means, means for varying said tuning means, a high frequency transformer having a tuned primary and a tuned secondary winding, a triode rectifier having a grid, coupling means supplying a high frequency signal from said primary winding to the grid of said triode rectifier, a second rectifier, coupling means supplying a high frequency signal from said secondary winding to said second rectifier, a resistor in the circuit of said triode rectifier, a resistor in the circuit of said second rectifier, an electron tube having a grid and plate circuit, means coupling the negative side of said second rectifier resistor to the grid of said electron tube, means for terminating variation of said tuning means in response to a signal tuned by said tuning means coupled to the plate circuit of said electron tube, and means connecting the positive end of said triode rectifier resistor to said second rectifier to reduce the effective voltage of said second rectifier applied to the grid of said electron tube.

6. In signal tuned radio apparatus, variable tuning means, means for varying said tuning means, means for stopping the variation of said tuning means in response to an operating voltage tuned by said tuning means, a circuit coupled to receive signal voltage from said apparatus, a first rectifier coupled to said circuit, a tuned circuit coupled to receive signal voltage from said apparatus, a contact rectifier connected to said tuned secondary circuit, means coupling said contact rectifier to said stopping means, bias means connected to prevent opera-

tion of said first rectifier until said signal voltage overcomes the bias, and means connecting said first rectifier to said contact rectifier whereby the additional operating voltage developed by said contact rectifier is neutralized by the voltage output of said first rectifier after the bias preventing the operation of the first rectifier is overcome.

7. In signal tuned radio apparatus, variable tuning means, means for varying said tuning means, a high frequency amplifier coupled to said variable tuning means, rectifying means connected to said high frequency amplifier, including a first resistor across which a rectified voltage develops, a second resistor connected to the high voltage end of said first resistor, an electron tube having a grid and plate, a slider on said second resistor coupled to said grid, reproducing means coupled to said plate, relay means coupled to said plate, contact means operated by said relay to connect and disconnect the low voltage end of the second resistor to the corresponding end of the first resistor, whereby the position of said slider controls the strength of the signal applied to said reproducer when said contact is closed but does not control the strength of said signal to said relay means when said contact is open during tuning.

8. In signal tuned radio apparatus, variable tuning means, means for varying said tuning means, means for stopping the variation of said tuning means in response to an operating voltage tuned by said tuning means, a circuit coupled to receive signal voltage from said apparatus, a first rectifier coupled to said circuit, a tuned circuit coupled to receive signal voltage from said apparatus, a second rectifier coupled to said tuned circuit and adapted to supply an operating voltage, bias means connected to prevent operation of said first rectifier until said signal voltage overcomes the bias, means connecting said first rectifier to said second rectifier whereby the additional operating voltage developed by said second rectifier is neutralized by the voltage output of said first rectifier after the bias preventing the operation of the first rectifier is overcome, a low frequency amplifier, means coupling said second rectifier to the input of said low frequency amplifier, and means coupling the output of said low frequency amplifier to said stopping means.

9. In signal tuned radio apparatus, variable tuning means, means for varying said tuning means, means for stopping the variation of said tuning means in response to an operating voltage tuned by said tuning means, a circuit coupled to receive signal voltage from said apparatus, a first rectifier coupled to said circuit, a tuned circuit coupled to receive signal voltage from said apparatus, a second rectifier coupled to said tuned circuit, means to prevent rectification of said first rectifier in response to signal voltage below a predetermined value, means connecting the first rectifier to the second rectifier whereby the operating voltage developed by the second rectifier is reduced by the voltage output of the first rectifier, an audio amplifier, means associated with the input of said audio amplifier including means coupling said input to said second rectifier adapted to respond only to a voltage having the polarity of said second rectifier, and means coupling the output of said audio amplifier to said stopping means.

10. In signal tuned radio apparatus, variable tuning means, means for varying said tuning

means, means for stopping the variation of said tuning means in response to an operating voltage tuned by said tuning means, a circuit coupled to receive signal voltage from said apparatus, a first rectifier coupled to said circuit, a tuned circuit coupled to receive signal voltage from said apparatus, a contact rectifier coupled to said tuned circuit, means interconnecting said two rectifiers whereby the effective output of the contact rectifier is reduced by the operation of the first rectifier, and means coupling the output of said contact rectifier to said stopping means.

11. In signal tuned radio apparatus, variable tuning means, means for varying said tuning means, means for stopping the variation of said tuning means in response to an operating voltage tuned by said tuning means, a tuned primary circuit coupled to receive signal voltage from said apparatus, a secondary circuit including a coil coupled to said primary circuit, a first rectifier connected to said secondary circuit, a tuned secondary circuit coupled to said tuned primary circuit, a second rectifier coupled to said tuned secondary circuit and adapted to function for tuning and for detection, means interconnecting said two rectifiers whereby the effective output of the second rectifier is reduced by the operation of the first rectifier, means coupling said second rectifier to said stopping means, an audio amplifier, and means coupling said second rectifier functioning as a detector to said audio amplifier.

12. In signal tuned radio apparatus, variable tuning means, means for varying said tuning means, means for stopping the variation of said tuning means in response to an operating voltage tuned by said tuning means, a tuned primary circuit coupled to receive signal voltage from said apparatus, a secondary circuit including a coil coupled to said primary circuit, a first rectifier connected to said secondary circuit, a tuned secondary circuit coupled to said tuned primary circuit, a second rectifier coupled to said tuned secondary circuit, means interconnecting said two rectifiers whereby the effective output of the second rectifier is reduced by the operation of the first rectifier, means to prevent rectification of said first rectifier in response to signal voltage below a predetermined value, and means coupling said second rectifier to said stopping means.

13. In signal tuned radio apparatus, variable tuning means, means for varying said tuning means, a circuit coupled to receive signal voltage from said apparatus, a first rectifier coupled to said circuit, a tuned circuit coupled to receive signal voltage from said apparatus, a second rectifier coupled to said tuned circuit, means interconnecting said two rectifiers whereby the effective output of the second rectifier is reduced by the operation of the first rectifier, an electron tube having a plate and a grid, means connecting said grid to said second rectifier, and relay means connected to said plate for stopping the variation of said tuning means.

14. In radio apparatus, means supplying a signal of variable frequency, a utilization device, means to effect operation of said utilization device in response to a certain narrow frequency band of said variable frequency signal, including a circuit coupled to receive signal voltage from said apparatus, a first rectifier coupled to said circuit, a tuned circuit coupled to receive signal voltage from said apparatus, a second rectifier coupled to said tuned circuit, means to prevent

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rectification of said first rectifier in response to signal voltage below a predetermined value, means interconnecting said two rectifiers whereby the effective output of the second rectifier is reduced by the operation of the first rectifier, and means coupling said second rectifier to said utilization device.

15. In a signal tuned radio apparatus, variable tuning means, means for varying said tuning means, means for stopping the variation of said tuning means in response to an operating voltage tuned by said tuning means, a tuned primary circuit coupled to receive signal voltage from said apparatus, a first rectifier coupled to said tuned primary circuit, a tuned secondary circuit coupled to said tuned primary circuit, a second rectifier coupled to said tuned secondary circuit, bias means connected to prevent operation of said first rectifier until said signal voltage overcomes the bias, means connecting the first rectifier to the second rectifier to prevent substantial effective increase of said operating voltage with increase of said signal voltage after the bias on said first rectifier is overcome, and means coupling said second rectifier to said stopping means.

16. In signal tuned radio apparatus, variable tuning means, means for varying said tuning means, means for stopping the variation of said

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tuning means in response to an operating voltage tuned by said tuning means; a circuit coupled to receive signal voltage from said apparatus, a triode rectifier having a grid, plate and cathode coupled to said circuit, a tuned circuit coupled to receive signal voltage from said apparatus, a second rectifier coupled to said tuned circuit, means to prevent rectification of said first rectifier in response to signal voltage below a predetermined value including bias means connected between said cathode and grid whereby said grid is made negative with respect to said cathode by a predetermined amount, means interconnecting said two rectifiers whereby the effective output of the second rectifier is reduced by the operation of the triode rectifier, and means coupling said second rectifier to said stopping means.

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