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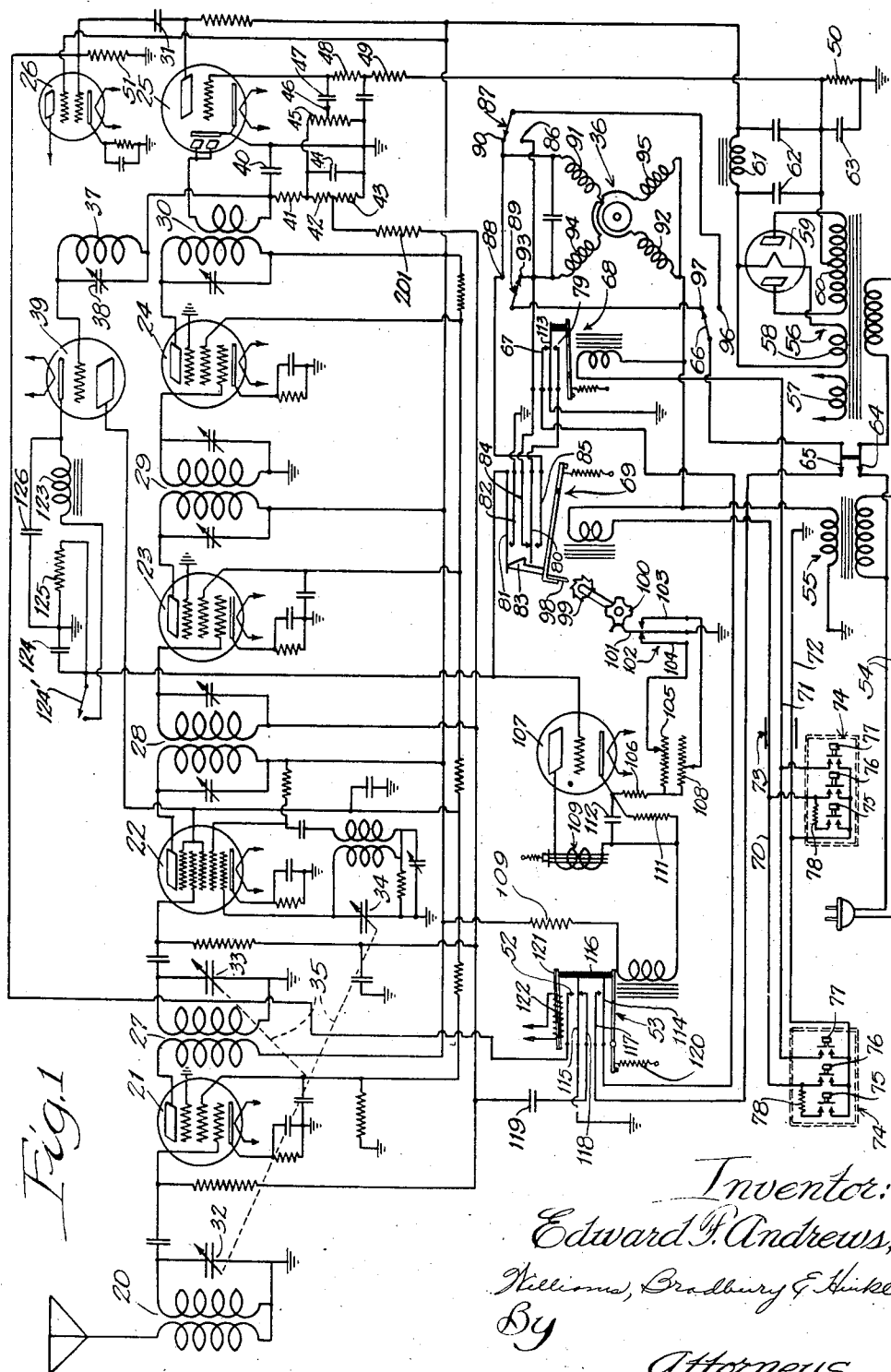
E. F. ANDREWS

2,326,738

RADIO RECEIVER

Original Filed May 24, 1939

8 Sheets-Sheet 1



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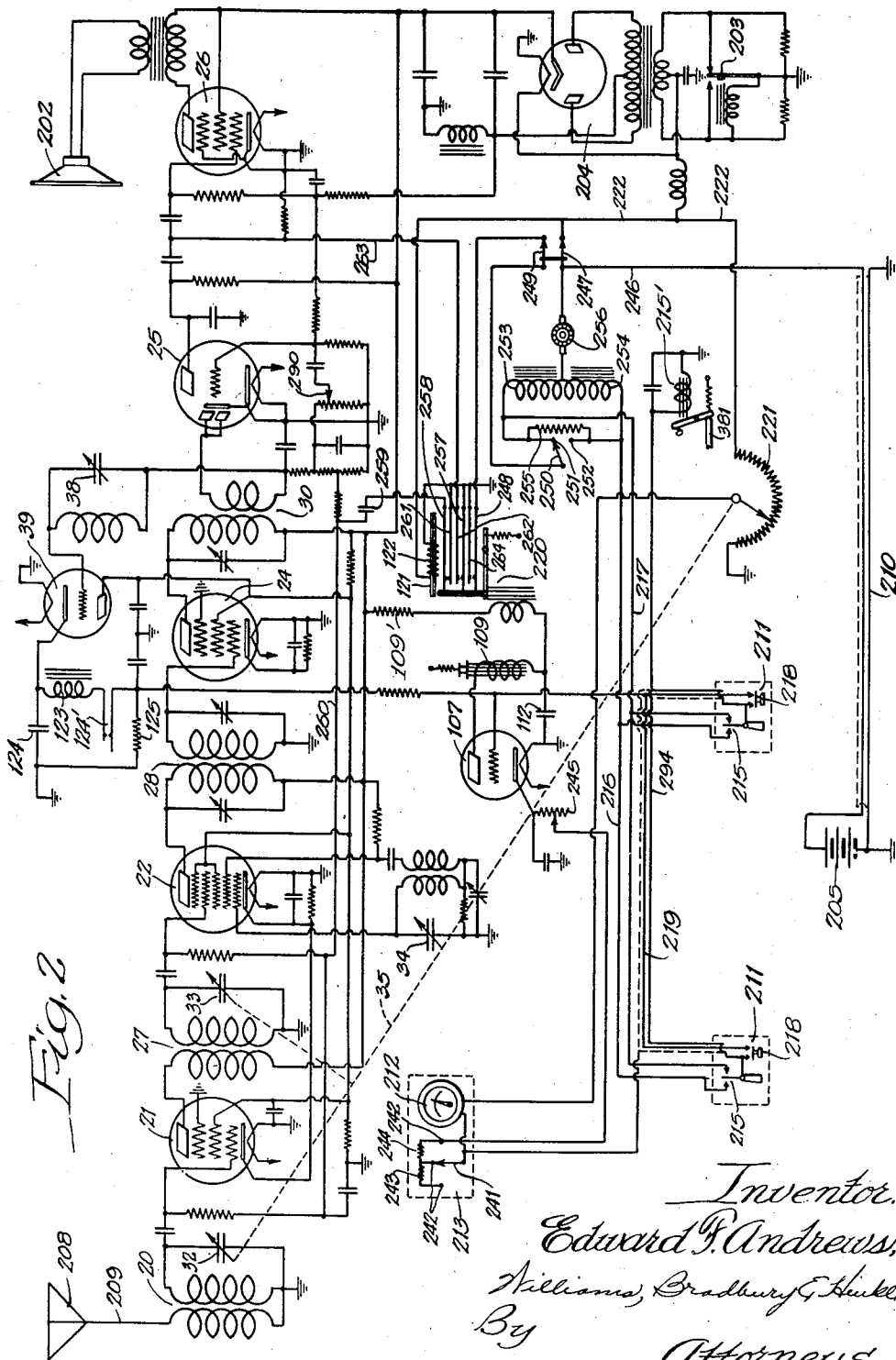
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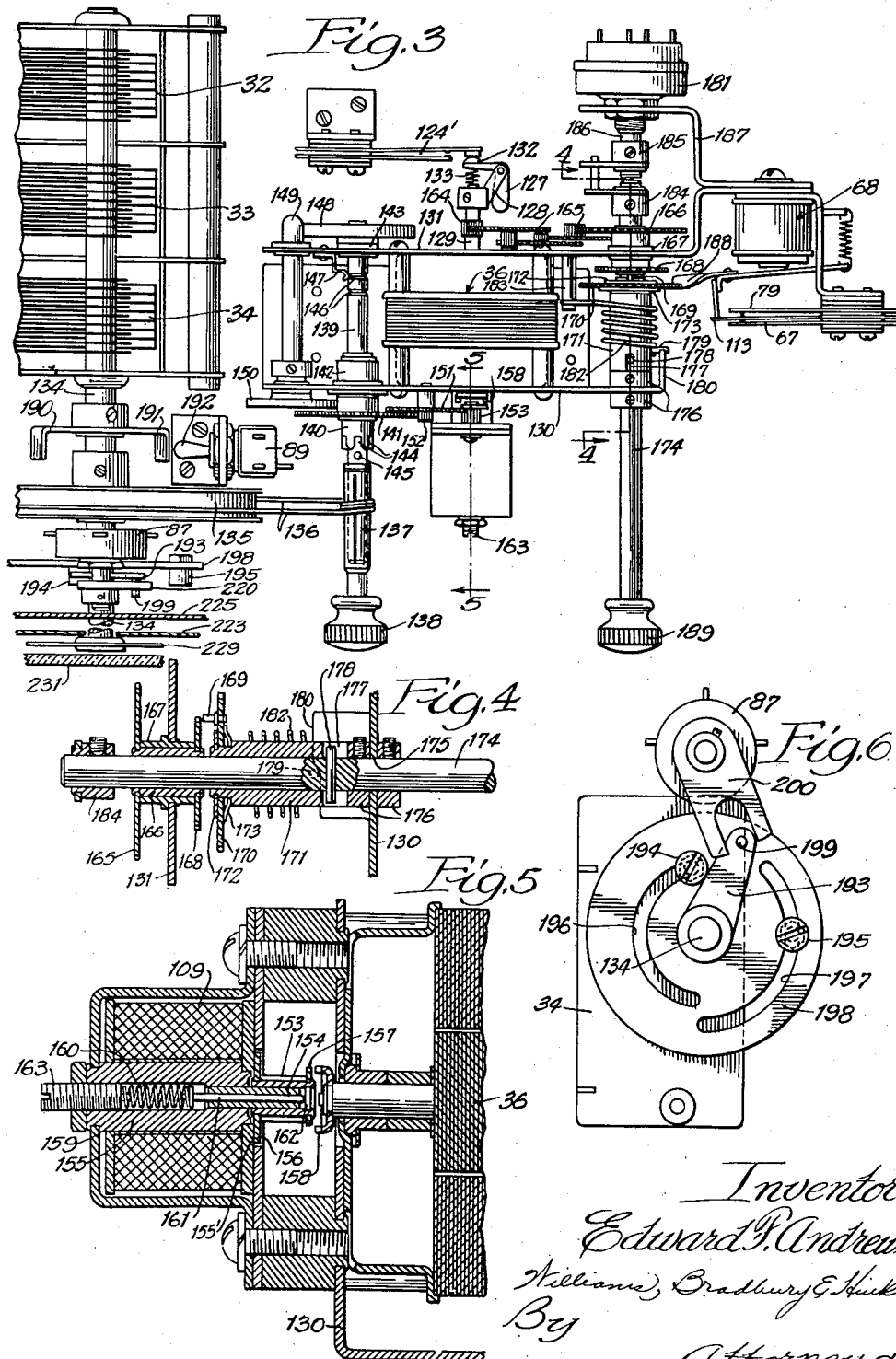
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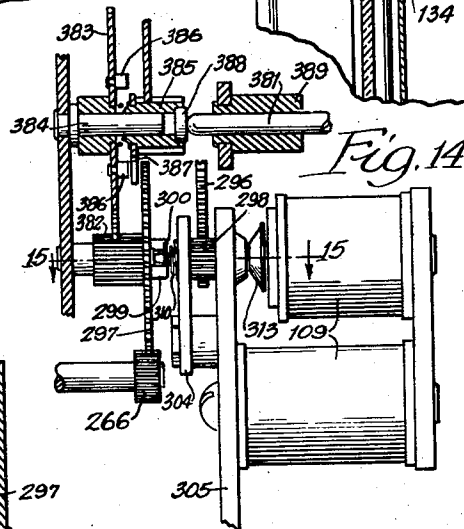
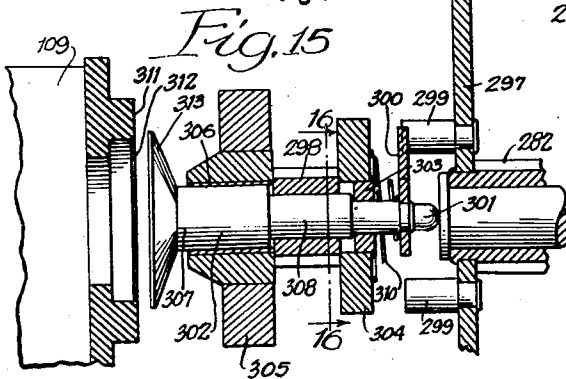
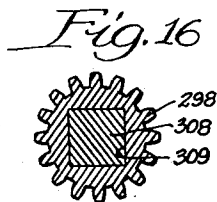
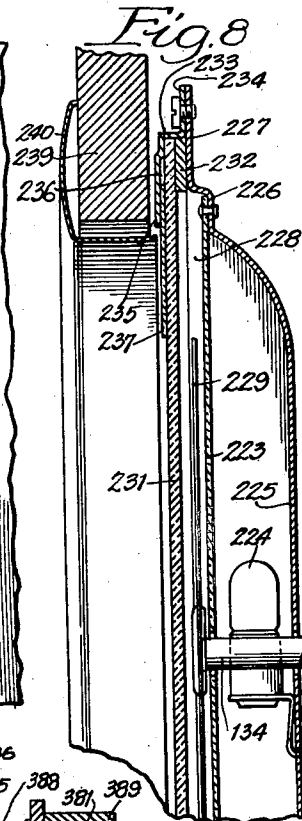
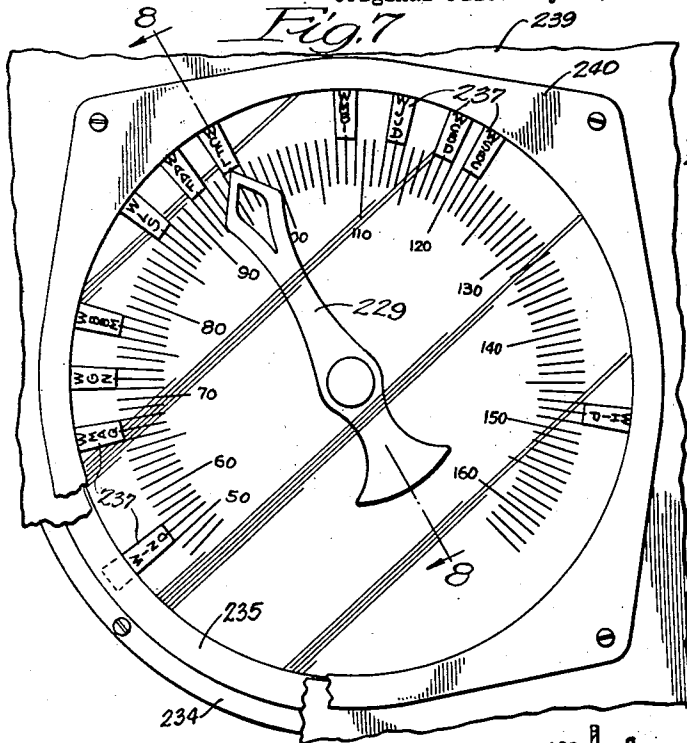
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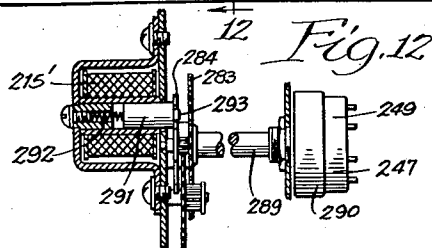
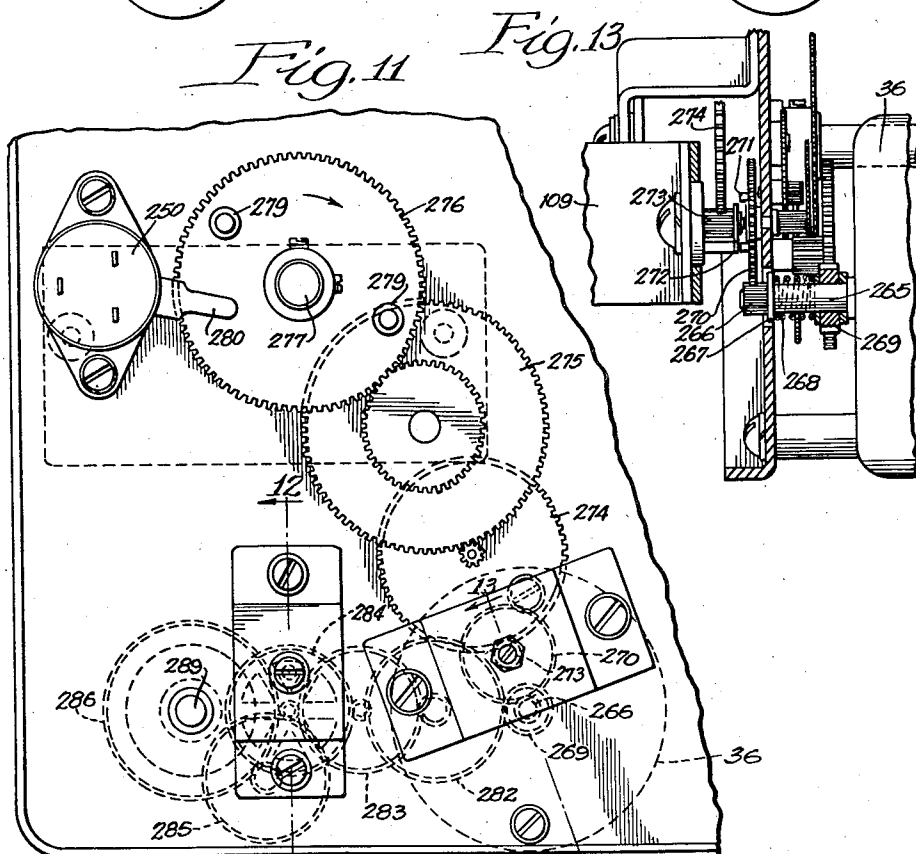
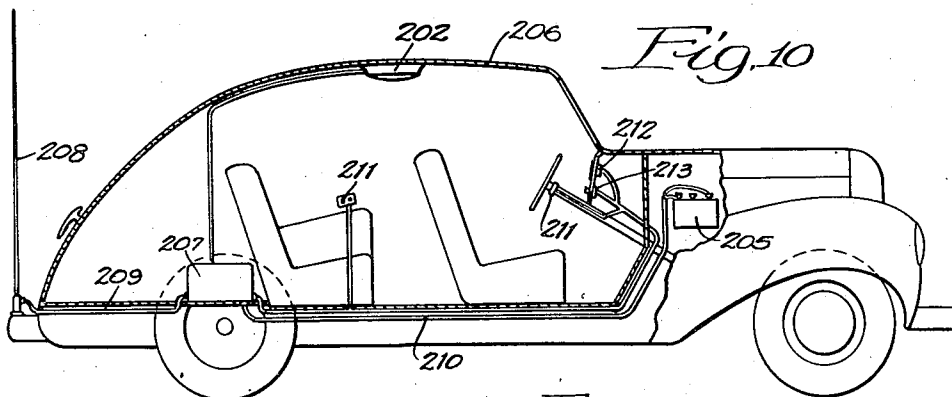
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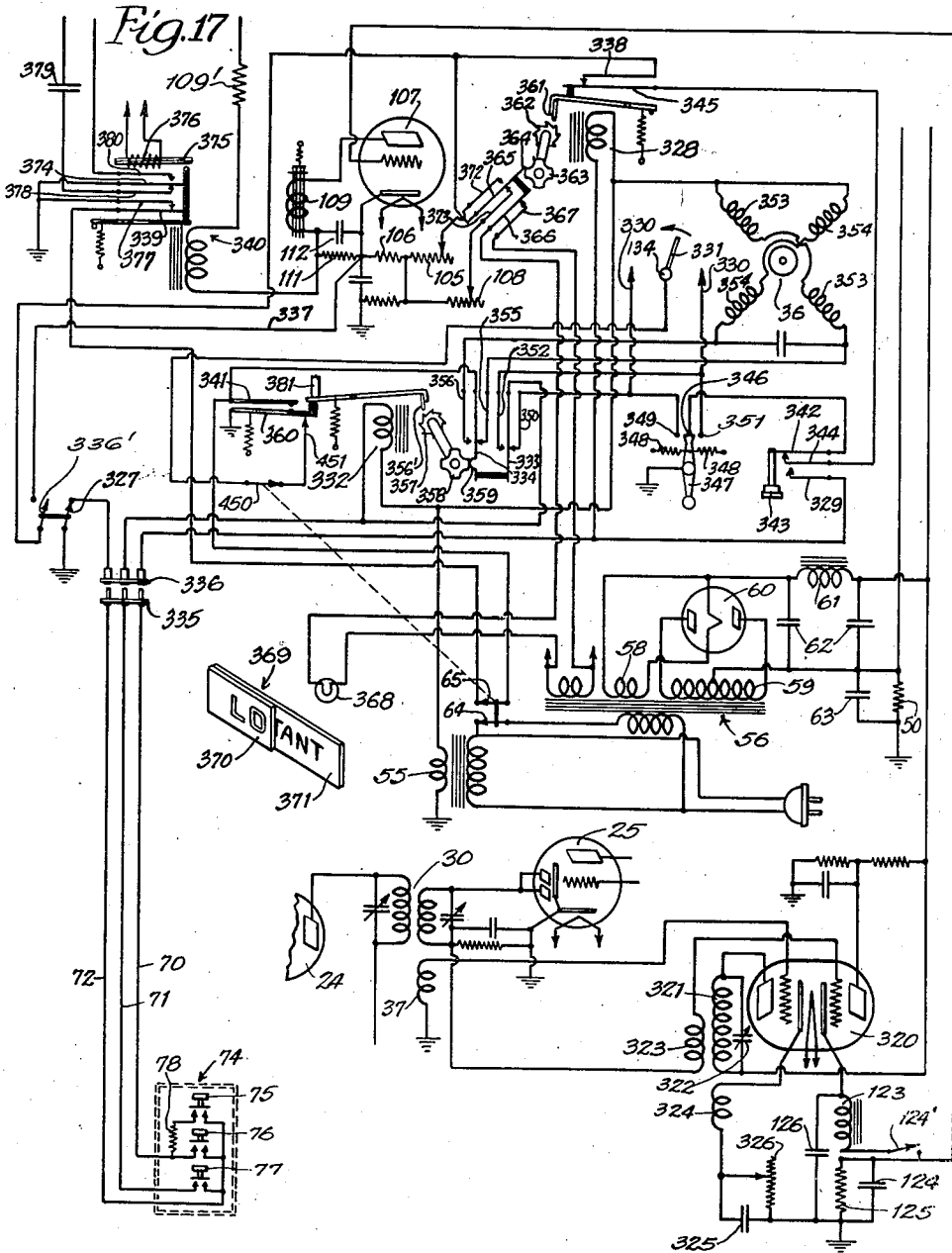
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8 Sheets-Sheet 6



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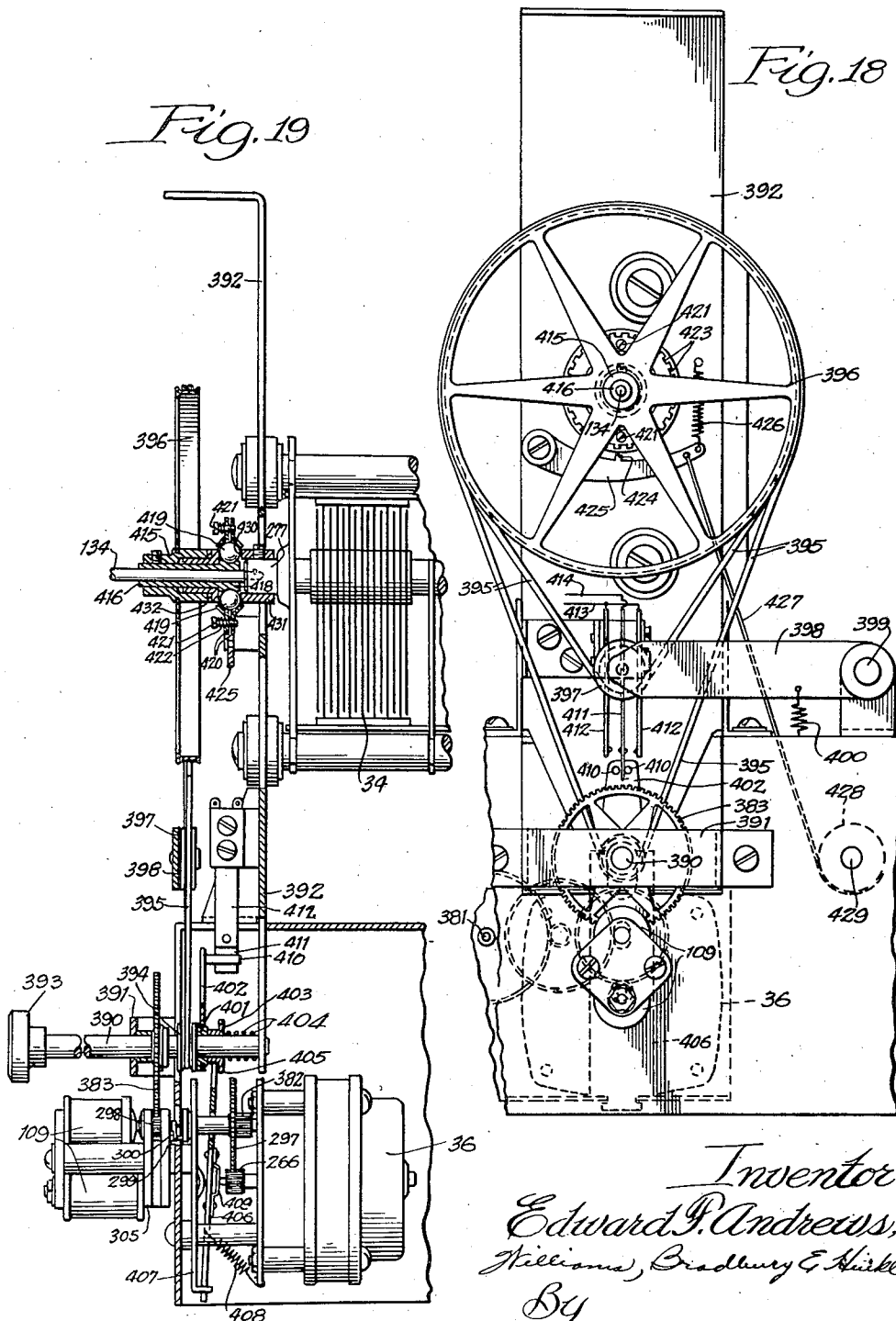
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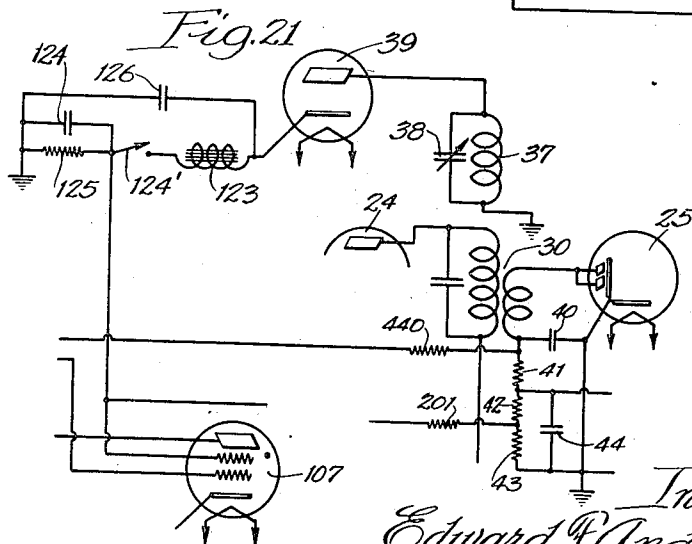
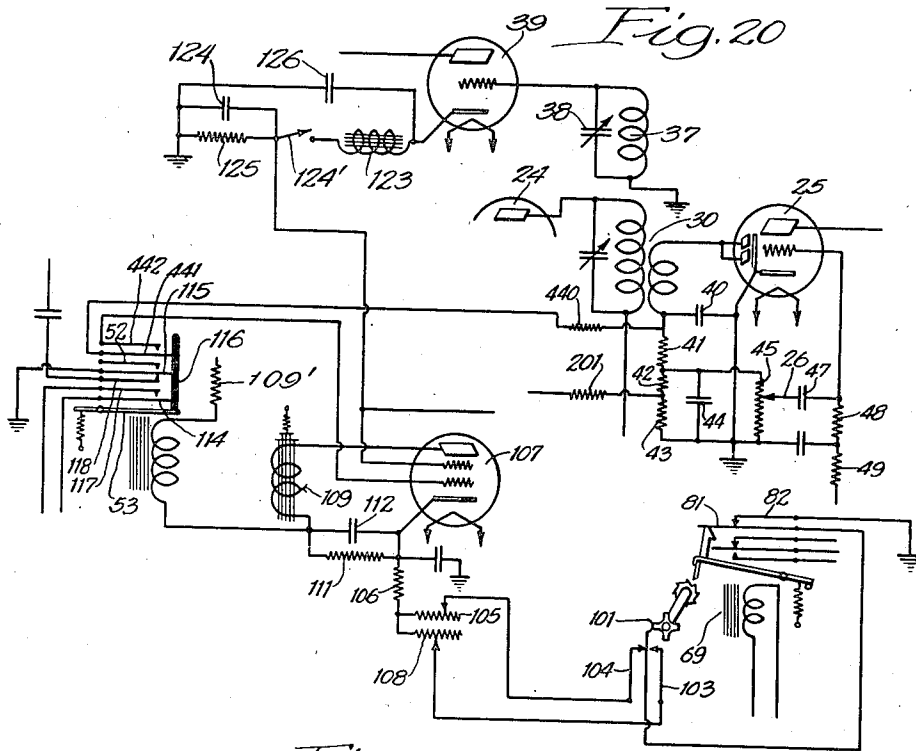
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UNITED STATES PATENT OFFICE

2,326,738

RADIO RECEIVER

Edward F. Andrews, Chicago, Ill.

Original application May 24, 1939, Serial No. 275,437. Divided and this application July 19, 1941, Serial No. 403,094

18 Claims. (Cl. 250—40)

This invention relates to radio receivers and particularly to radio receivers embodying tuning devices of the "stop-on-carrier" type, and this application is a division of my application Serial No. 275,437, filed May 24, 1939, on Radio receivers. Such devices have been described and claimed in Patent No. 1,700,281 and Patent No. 1,700,282, issued January 29, 1929, to Elmer E. Burns and Theodore Cohen, and in my co-pending application Serial No. 219,713, filed July 13, 1938 (now Patent No. 2,262,218, granted November 11, 1941). In receivers of this type, tuning is effected by power means adapted to be set in operation by manually actuated means and adapted automatically to effect the quick stoppage of the tuning means when the receiver has been tuned to the carrier wave of a broadcasting station received with sufficient strength. The manually actuated means suitably comprises means controlling the change of an electric current or voltage, and may be located at a point remote from the receiver, from which point control may be effected by means of a simple cable, or by other communicating means.

One of the objects of the present invention is to provide an improved radio receiver of this type.

A further object of the invention is to provide means whereby the effect of static and other undesired electrical disturbances are minimized or prevented, thus avoiding automatic stoppage where there is no desired signal.

A further object of the invention is to provide an improved mechanism whereby the tuning device may be arrested more precisely at positions of more exact resonance.

A further object is to provide a receiver of this type in which the sensitivity of the automatic tuning means may be readily controlled (from a remote point, if desired), whereby the set can be adapted for tuning in a relatively small number of the strongest stations or a greater number of stations, including distant stations, the signals from which are comparatively weak.

A further object of the invention is to provide an improved arrangement whereby vacuum tube means operate gas tube means connected to magnetic means for quickly stopping the tuning device.

A further object is the provision of condenser storage means cooperating with the gas tube to produce faster stoppage of the tuning means.

A further object of the invention is to produce an improved type of stop-on-carrier stopping relay.

improved means for securing the greatest automatic control of the set with a small number of simple controls.

A further object of the invention is to provide simple and effective means for de-ionizing a gas triode employed for these purposes.

A further object of the invention is to provide an improved automobile radio set and an improved installation thereof in an automobile.

A further object of the invention is to provide an improved means of increasing the sharpness of the circuit controlling automatic stoppage.

Other objects, advantages and capabilities of the invention will appear from the following description of preferred embodiments thereof, taken in conjunction with the accompanying drawings in which:

Fig. 1 is a wiring diagram of a radio receiver embodying the invention and intended primarily for alternating current operation in the home;

Fig. 2 is a similar diagram of a radio receiver embodying my invention and intended primarily for operation in an automobile from the automobile storage battery;

Fig. 3 is a fragmentary sectional plan view showing the arrangement of certain mechanism of the radio receiver shown in Fig. 1;

Fig. 4 is a fragmentary sectional detail, the section being taken on the line 4—4 of Fig. 3;

Fig. 5 is a fragmentary section on a larger scale, the section being taken on the line 5—5 of Fig. 3;

Fig. 6 is an elevational detail showing a modified form of operating means for the reversing switch;

Fig. 7 is a front elevational view of an indicator dial which may be employed in radio receiving sets embodying my invention;

Fig. 8 is a fragmentary sectional detail view therethrough, the section being taken on the line 8—8 of Fig. 7;

Fig. 9 is a perspective view of a station indicating tab which may be employed in connection with the dial shown in Figs. 7 and 8;

Fig. 10 is a diagrammatic view showing the manner in which the receiver illustrated in Fig. 2 may be mounted in an automobile;

Fig. 11 is a fragmentary sectional view of one end of the receiver shown in Fig. 10 showing the relative relation of certain of the control elements of the receiver;

Fig. 12 is a sectional detail view therethrough, the section being taken on the line 12—12 of Fig. 11;

Fig. 13 is a sectional detail view therethrough,

the section being taken on the line 13—13 of Fig. 11 and illustrating the construction of the stop-on-carrier clutch-brake relay embodied in the receiver;

Fig. 14 is a fragmentary elevational view of another form of stop-on-carrier clutch-brake relay which may advantageously be employed in either of the embodiments of the invention;

Fig. 15 is a fragmentary sectional elevation therethrough on a larger scale, the section being taken on the line 15—15 of Fig. 14;

Fig. 16 is a section detail taken on the line 16—16 of Fig. 15;

Fig. 17 is a wiring diagram of an automatic control system embodying my invention, similar to that of Fig. 1;

Fig. 18 is a fragmentary front elevation showing part of the tuning and volume control mechanism mounted on a chassis;

Fig. 19 is a side elevation and partial cross sectional view of Fig. 18;

Fig. 20 is a fragmentary wiring diagram showing certain modifications which may be made in the wiring diagram of Fig. 1; and

Fig. 21 is a similar fragmentary wiring diagram showing further modifications which may be incorporated in this wiring diagram.

Referring to the drawings and particularly to Fig. 1, the radio set illustrated therein is a super-heterodyne set comprising an antenna circuit 22, a radio frequency tube 21, an oscillator and demodulator tube 22, intermediate frequency tubes 23 and 24, a diode detector and first audio tube 25, and a power tube 26 which is connected to a loud speaker (not shown) in known manner. Tube 21 may suitably be a 6K7 tube, the tube 22, a 6A3 tube, tubes 23 and 24, 6K7 tubes, and tubes 25 and 26 a 6Q7G and 6L6G tube, respectively. The tubes 21, 22, 23, 24 and 25 are coupled together in cascade by transformers 27, 28, 29, and 30. The output of the tube 25 is resistance coupled through a condenser 31 to the grid of the power tube 26. The set is tuned by condensers 32, 33 and 34, which are connected together in a gang, as indicated by the dotted lines 35. These condensers are adapted to be tuned by a reversible motor 36.

The transformer 30 comprises a winding 37 which is loosely coupled to the primary of the transformer. This winding is sharply tuned by the condenser 33 and has one end connected to the grid of the stop-on-carrier triode 39. The other end of the winding 37 is connected to one end of the secondary of the transformer 29, which is connected through resistor 41, resistor 42, and resistor 43 to ground and to the cathode of the rectifier elements of the tube 25. The connected ends of the winding 37 and of the secondary of the transformer 29 are by-passed through condenser 40. The other end of the secondary of the transformer 30 is connected to the diode plates of the tube 25. The triode 39 may be so biased as to draw plate current at all times and to produce a sharp rise in its plate current, as the alternating current signal in the coil 37 impressed on its grid substantially exceeds the negative bias, also impressed on its grid, from the diode plate of the tube 25. This sharp rise in plate current produces a voltage across a resistance in the cathode circuit which constitutes the stop-on-carrier signal. The resistances 42 and 43 are paralleled by a condenser 44 and the winding 45 of a potentiometer which, together with the slider 46, constitutes the volume control of the set. The slider 46 is connected

through a condenser 47 to the grid of the triode elements of the tube 25. The condenser 47 and said grid are connected through resistances 48, 49, and 50 to ground.

The grid of the tube 26 is connected to ground through a resistance 51 and to a contact 52 of a relay 53.

Power is supplied to the set by means of power leads 54, which are connected through the primaries of transformers 55 and 56. A secondary 57 of the transformer 56 supplies current for the filaments of the various tubes, as indicated. Another secondary 58 is connected to supply heating current to the cathode of the full-wave rectifier 59, the plates of which rectifier are connected to a third high voltage center-tapped secondary 60 of the transformer 56. The cathode of the rectifier 59, which is a 5Z3 tube, is connected through a choke coil 61 to the plates of the tubes 21, 22, 23, 24, and 25 for the supply of B current thereto. Opposite ends of the choke coil 61 are connected through condensers 62 to the ungrounded end of the resistance 59, which resistance is bridged by a condenser 63 and connected to the center tap of winding 60.

The power supply to the primary of the transformer 55 is adapted to be completed or interrupted by a switch 64 which is located between the primaries of the transformers 55 and 56. This switch is physically united to a switch 65 so that they open and close simultaneously. One side of the switch 65 is connected to the pole of a switch 66. The other side is connected to contact 117 of a relay 53.

One side of the secondary of the transformer 55 is grounded. The other end is connected through the winding of a step relay 69 to a conductor 70. The ungrounded side of the secondary of the transformer 55 is also connected through the winding of the relay 69 to a conductor 71. The conductors 70 and 71, together with a third conductor 72, constitute a cable 73 of any desired length. This cable may be connected to any desired number of remote control units 74, two of which are shown by way of example in Fig. 1. It is, of course, to be understood that the cable 73 may comprise as many units 74 and as many branches as may be desired. Each unit 74 comprises three switches 75, 76, and 77, one side of each switch being grounded to the conductor 72. The other side of the switch 77 is connected to the conductor 71. The other side of the switch 76 is connected directly to the conductor 70. The other side of the switch 75 is connected through a resistance 78 to the conductor 70. It will readily be understood that when the switch 77 is closed, the electro-magnet of the relay 69 is energized and the pole of the relay 69 moves away from engagement with the contact 67 and into engagement with the contact 79. The contact 79 is connected to one of the poles 80 of the relay 69. The relay 69 includes a second pole 81 which is normally maintained out of engagement with a grounded contact 82 by a hook-like projection 83 on the armature. When the relay 69 is energized, the armature is moved so as to allow the contact 81 to become grounded, and the projection 83 moves the armature 82 out of engagement with the contact 84 and into engagement with the contact 85. The contact 84 is connected to a contact 86 of a switch 87. The contact 85 is connected to a contact 88 of the switch 87, to a contact 89 of the switch 87, and also to windings 91 and 92 of the motor 25. A con-

tact 93 of the switch 89 is connected through the windings 94 and 95 of the motor 36. The windings 92 and 95 are connected to the ungrounded side of the secondary of the transformer 55. The pole of the switch 87 is connected to the contact 96 of the switch 66. The other contact 97 of this switch is connected to the pole of the switch 89. The pole of the switch 66 is connected to one side of the switch 65. The other side of this switch is connected to the contact 117 of the relay 53. It will be understood that when the switch 66 is in engagement with contact 96, the motor 36 is controlled by the switch 87, and when the switch 66 engages the contact 97, the switch 89 controls the motor.

When the switch 75 is closed, the circuit through the relay 69 is completed through the resistance 73. Owing to the presence of this resistance, the energization of the relay 69 is somewhat limited and the responsive movement of the armature of this relay is limited by the engagement of a projection 98 carried thereby with a ratchet wheel 99. The ratchet wheel 99 is rigidly connected to a cam wheel 100, which engages the pole 101 of a switch 102.

When the control switch 76 is closed, the relay 69 is energized quite strongly, with the result that the projection 98 engages the ratchet wheel 99 with sufficient force to turn it a distance corresponding to one tooth. When the switch 75 is closed, the cam wheel 100 is not affected, and only the contact 81 is grounded. When, however, the switch 76 is closed, not only are the poles 80 and 81 moved from their normal position, but the cam wheel 100 is rotated a distance corresponding to one tooth on the ratchet wheel 99. The pole 101 of the switch 102 is in engagement with one of the contacts 103, 104. It will be understood that each time the button 76 is pressed, the contact 101 is moved from one of the contacts 103, 104 to the other one. The contact 104 is connected through an adjustable resistance 105 and a fixed resistance 106 to the cathode of the gas tube 107, which may be an 834 tube or a gas tube known as R6071 or R. C. A. 2051. The contact 103 is connected through a variable resistance 108 to the fixed resistance 106. It will thus be seen that each movement of the cam wheel 100 merely results in the grounding of the cathode of the tube 107 and the resistance 106 through a variable resistance 105 or 108. Ordinarily, these last two resistances are set at considerably different values. Thus, if the resistance 105 is greater than the resistance 108, the set will have a lower sensitivity when connected through the resistance 105 than it has when connected through the resistance 108. Consequently, the sensitivity of the set may be varied by pressing the button 76. Whenever either of the buttons 75 or 76 is pressed, the poles 80 and 81 are moved from their initial positions with results hereinafter to be more fully described.

The plate of the tube 107 is connected to the winding of the stop-on-carrier relay 109. This winding is connected in series with the winding of the relay 53 and through a suitable resistance 109' for limiting the steady current flowing through both relays from the B supply. The end of the winding of the relay 109 which connects to the winding of the relay 53 is also connected through a resistance 111 to the cathode of the tube 107, and this resistance is bridged by a condenser 112 adapted to supply a large surge of current through the relay 109 when

the gas tube is ionized, the operation of which will hereinafter be more fully described.

The contact 67 of the relay 68 is connected to one of the poles 114 of the relay 53. The other pole 115 of this relay is grounded and is mechanically attached to the pole 114 by a bar 116 of insulating material. When the relay 53 is energized, the armature is moved downwardly, as viewed in Fig. 1, and the pole 114 is moved away from the contact 117, which connects to one pole of the switch 65. At the same time, the pole 115 is moved away from the contact 52 and is moved into engagement with the contact 118. This contact is connected to a condenser 119. The capacity of this condenser may, for example, be about 0.1 microfarad. When the switch 64 is open, that is, when the set is not operating, the armature of the relay 53 is biased towards the winding against the action of a spring 120 by a thermostat 121. This is a strip of bimetal which is provided with a heater coil 122 in parallel with the filaments with the result that after the filament current is turned on for a short time, the strip 121 becomes heated and moves away from the bar 116. The cathode of the tube 39 is connected through a choke coil 123, a switch 124', and resistance 125 to ground. The coil 123 and resistance 125 are by-passed by a small radio frequency by-pass condenser 126. One side of the switch 124' and the adjacent side of the resistance 125 are connected to the grid of the tube 107. The switch 124' is actuated by a minimum time device, two types of which will be described in connection with other figures.

The minimum time switch 124' is best shown in Fig. 3. It may be operated by a weighted bell crank lever 127, which is pivotally mounted on a bracket 128 carried on the end of the shaft 129 of the reversible motor 36. The motor 36 is mounted between two plates 130 and 131, which may be mounted on the chassis of the receiver. One arm of the bell crank lever 127 terminates in an engaging member 132 in alignment with the shaft 129. The engaging member 132 is normally biased by a spring 133 so as to open the switch 124'. When the motor 36 attains sufficient speed, the weighted end of the lever 127 swings radially outwards with the result that the engaging member 132 is moved away from the switch 124'. When the motor stops, the spring 133 returns the lever 127 to the position shown in Fig. 3, thereby opening the switch 124'.

The gang of condensers 32, 33, and 34 are actuated by a common shaft upon which is mounted a drum 135. A cord 136 extends around the drum and around a split sleeve 137 upon which is mounted a manually operable knob 138. The split sleeve 137 has a frictional engagement with a shaft 139. The cord 136 extends around the sleeve 137 several convolutions so that this sleeve is normally compressed against the shaft 139. Means (not shown) are provided for preventing the axial movement of the sleeve 137 on the shaft 139. The shaft extends freely through a hub 140 of a gear 141 and through bearings 142 and 143 on the plates 130 and 131, respectively. The hub 140 is provided with a plurality of recesses 144, and the shaft 139 carries a pin 145 which is adapted to be introduced into one of the recesses 144 by merely pushing inwardly on the knob 138. The pin 145 may be disengaged from the hub 140 by merely pulling the knob 138 to its outermost position. The shaft 139 is

provided with two grooves 146 which are adapted to receive a spring element 147, so as to hold the shaft 139 in its inward or outward position, as the case may be. At its inner end, the shaft 139 carries a friction wheel 148. When the shaft 139 is in its outermost position, the friction wheel 148, which may have a peripheral portion or tire of rubber or the like, engages a shaft 149, which is also rotatably mounted on the plates 130 and 131. At its forward end, the shaft 149 carries a friction wheel 150 which is similar to the friction wheel 148. The friction wheel 150 engages the hub 140 of the gear 141. The gear 141 is connected through suitable speed reducing means, such as the gear and pinion 151 and 152 to a pinion 153, which is adapted to be driven by the motor 36.

The pinion 153 is shown on a large scale in Fig. 5. The pinion 153 is hollow and is slidably mounted on a sleeve 154 which extends inwardly towards the motor 36 from the core 135 of the relay 109. This relay is carried in front of the motor on the plate 130, with the sleeve 154 in axial alignment with the shaft of the motor. The pinion 153 carries at its outer end a disc 155 of magnetic material, which is adapted to be attracted by the relay 109 when its winding is energized. At its inner end the pinion 153 carries a clutch projection 157 which is adapted to engage corresponding projections 158 carried on the forward end of the shaft of the motor 36. The pinion 153 is normally biased inwardly by a spring 159 so that the clutch projections 157 and 158 tend to engage. The spring 159 is located in an axial recess 160 in the core 155. This spring applies pressure on a rod 161 which extends through the sleeve 154 and abuts against a hardened disc 162, which is located within the hollow pinion 153 adjacent its innermost end. The degree of compression exerted by the spring 159 is controlled by a screw 163. It will readily be understood that immediately the relay 109 is energized, the disc 155 is very strongly attracted and is moved to the left, as viewed in Fig. 5. The pinion 153 moves with it, and likewise the clutch projection 157. Consequently, these clutch members are withdrawn from the clutch elements 158, and the pinion 153 is completely freed of any connection with the motor 36. Owing to the small mass of the pinion 153 and the disc 155, this complete disengagement occurs very rapidly and the drive for the condenser is freed from the inertia of the motor armature. The magnetic force of the relay 109 also draws the disc 155 strongly against the friction surface 155', thus applying a strong braking action to effect the quick stoppage of the pinion 153. The elements of the drive between the condenser and the pinion 153 are driven relatively slowly and have small moments of inertia, so that their inertia is not a serious problem, as will hereinafter be more fully described.

When the knob 133 has been pressed inwardly, the shaft 139 is driven directly by the gear 141 through engagement of its hub 140 with the pin 145. This adjustment adapts the receiver for ordinary station reception. For short wave reception, it is preferred to adjust the drive of the gang of condensers so that it operates much more slowly. This object is obtained by pulling the knob 133 outward, whereupon the drive of the condenser occurs from the gear 141 through its hub, the friction disc 150, its shaft 149, and the friction disc 148.

The rear end of the motor shaft 129 is provided with a pinion 164 which is connected through speed reduction gearing 165 with a hub 166, which is rotatably mounted on a bearing 167. At its inner end the hub 166 carries a gear 168. The toothed wheel 168 is adapted to be engaged by a pin 169, which projects rearwardly from a detent wheel 170. The detent wheel 170 is carried on the rearward end of a hub 171, this hub being provided with a rigid abutment plate 172 which engages one side of the wheel 170, and a spring member 173 which resiliently forces the wheel 170 against the abutment plate 172. A shaft 174 extends through an opening 175 in the frame plate 130. The shaft 174 is held against axial movement by means of collars 176 rigidly mounted thereon on opposite sides of the plate 130.

The hub 171 is provided with opposed slots 177 which receive opposite ends of a pin 178 rigidly mounted in the shaft 174. A pin 179 projects radially from the hub 171 so as to cooperate with a cam member 180, which may suitably be formed from a rearwardly turned portion of the plate 130. The hub 171 is normally biased towards zero volume position of the volume control rheostat 181 by means of a spring 182. This spring is anchored to a stationary abutment 183 and to the pin 179. The shaft 174 extends freely through the hub 166 and carries at its innermost end one element 184 which cooperates with another element 185 of a universal joint mechanism. The member 185 is mounted on the shaft 186 of the volume control rheostat 181. This rheostat is supported by a bracket 187 from the frame member 131. The frame member 131 supports the elements of the relay 68, previously referred to. The armature of this relay is provided with a detent member 188 which is adapted to cooperate with the detent wheel 170. It will readily be understood that when the shaft 174 is manually actuated by the knob 133, the rheostat 181 is operated directly, the friction connection between the detent wheel 170 and the hub 171 enabling this wheel to stand still in the position in which it is held by the detent 188. It will be understood that when the relay 68 is energized the detent 188 is withdrawn from the wheel 170 and the spring 182 throws the shaft 174 around to zero volume position. Furthermore, if the knob 133 is rotated still further in the volume decrease direction, the switches 64 and 65, which are operated by the rheostat shaft 186, are opened. The friction connection between the wheel 170 and the hubs 171 and the engagement of the wheel 170 by the detent 188 insures the maintenance of any manual adjustment, until changed by further turning of the knob 133 or the energization of the relay 68. It may here be remarked that the detent 188 comprises a portion which overlies the wheel 170 and a tooth or detent portion which enters between the teeth of the detent wheel 170. It will likewise be understood that if the knob 133 is rotated in the opposite direction by hand, the switches 64 and 65 will be opened. The volume control rheostat 181 can, of course, be operated in either direction and the switches 64 and 65 turned on or off by the energization of the relay 68 so that it moves its armature upwardly as shown in Fig. 3.

Upon the shaft of the gang of condensers I provide two arms 190 and 191 which are adapted to cooperate with the operating arm 192 of the switch 89. These arms come into contact with

the arm 192 as the condenser shaft attains its extreme positions. The actuation of the switch 89 reverses the motor so that the same tends to operate in opposite directions while the condenser moves between extreme positions. In actual operation, this back and forth movement is terminated when a station is tuned in which has sufficient volume to energize the relay 109 and disconnect the motor. It is to be understood that the switch 87 and the switch 65 may be omitted, if desired, the switch 65 being connected directly to the pole of the switch 89. The switch 87 is preferably employed so as to enable a different adjustable range of tuning or range of condenser control between points of reversal to be employed. For this purpose, I loosely mount on the shaft 134 an arm 193. This arm is adapted to be engaged by two studs 194 and 195 which are adjustable to various positions in two arcuate slots 196 and 197 in a disc 198. This disc is rigidly mounted on the shaft 134. The arm 193 carries a pin 199, which is located in a slot formed by the forked end of an actuating arm 200 of the switch 87. It will readily be understood that the position of the condenser at which the arm 200 is actuated to reverse the motor can be controlled as desired by changing the position of the studs 194 and 195 on the disc 198. As has been previously described, the oscillation of the motor and the condenser may be controlled by either switch 87 or 89, control being transferred from one to the other by the mere actuation of the switch 65, which may be located at any desired position.

The dial 223 of the indicating device 230 is preferably translucent and carries suitable graduations and numbers which may correspond to the various frequencies of the broadcast band. The translucent dial 223 is illuminated by a plurality of lamps 224 on the reverse side of the dial. These lamps are mounted in a dish-shaped housing 225 which includes an annular shelf or flange 226 to which the periphery of the dial is secured in any suitable way. Beyond the flange 226, the housing 225 is provided with an outer flange 227. This flange is displaced forwardly of the flange 226 so as to provide a space 228 on the outer side of the dial 223 in which the pointer 229 is adapted to move. The pointer 229 is carried on the end of the shaft 134. The forward face of the housing 225 is enclosed by a glass window 231 which is separated from the flange 227 by a gasket 232. The window 231 is secured to the flange 227 by means of a securing ring 233, which includes an outer flange 234 adapted to be secured to the flange 227 by means of screws. The securing ring 233 is of step section, as best seen in Fig. 8. It includes a flange 234 which is adapted to bear against the window 231. The inner portion of the flange 234, which is indicated by the reference numeral 235, is displaced forwardly so that it is located out of contact with the window 231. Between the displaced portion 235 of the flange and the window 231 is provided a space 236 which is adapted to receive tabs 237. These tabs may be of transparent material, having a lighted background for opaque characters designating different broadcasting stations. The tabs 237 are preformed into concave shape as best seen in Fig. 9. To install a tab, it is merely necessary to apply it to the glass 231 and slide it radially in the proper direction until its outer end is located in the recess 236, as best shown in Fig. 8. The inner portion 235 of the flange 234 may be resilient and biased towards the window 231. As a result

of the curvature of the tabs or the inward biasing of the portion 235, or both, the tabs 237 are firmly held in position. To adjust the position of a tab for a particular broadcasting station, it is only necessary to tune in that station and slide the tab circumferentially so as to bring the opaque graduation at the inner end of the tab in radial alignment with the pointer 229. The tabs may be removed when desired and they may be replaced by other tabs. Owing to the initial convex form of the tabs 237, they lie quite flat against the window 231 when installed. It is of course to be understood that the window 231 is located in an opening in the front wall of the cabinet 238, which opening is finished by a suitable bezel 240.

The operation of this modification (as shown in Fig. 1) is as follows:

The set is put into operation by pressing the button 77. This results in the energization of the relay 68 and the withdrawal of the detent 188 from the detent wheel 170. The pole 113 of the relay 68 is moved into engagement with the contact 79. The motor circuit is then completed from ground through the pole 113, contact 79, pole 69 of the relay 68, contact 64, motor windings 54 and 55, and secondary of the transformer 56 to ground. When the motor is thus put into operation, the pin 179 resting on the elevated surface of the cam 189, the pin 169 is engaged with the wheel 165. Consequently, the motor drives the shaft 174 and consequently the shaft 186 in the volume increasing direction. The result of the initial movement of the shaft 186 in this direction results in the closing of the switches 64 and 65. The closure of the switch 64 immediately energizes the heater circuits, including the heating element 122. Until the cathodes of the tubes are heated up, the thermostatic element 121 holds the poles of the relay 53 in their downward position, as shown in Fig. 1. The motor 36 operates as long as the button 77 is pressed, and when the button 77 is released, the motor stops. When this occurs, the detent 188 withdraws the pin 169 from the wheel 165. The detent 188 locks the wheel 170 against rotation by the spring 182. The volume setting of the rheostat 181 is thus maintained until the relay 68 is again energized. It will be understood that when the relay 68 is deenergized, operation of the motor will have no effect upon the volume control. Under these conditions, the motor will merely drive the condensers. When the heater 122 has raised the thermostatic element 121 to a sufficient degree of temperature, the pole 114 engages the contact 117, and the motor circuit is completed from ground through the pole 113, contact 67, pole 114, contact 117, switch 66, switch 66, one of the switches 87 or 89 (depending on the position of switch 66), through one of the pairs of field coils 91, 92, or 94, 95 of the motor, and secondary of transformer 55 to ground. The motor will consequently start to operate in a direction depending upon the position of the switch 89 (or 87). Assuming that the switch 66 is in the relation shown in Fig. 1, the switch 89 will have control. It will be understood that if the switch 89 is in engagement with the contact 93, the motor will start to move in the same direction as it did when the button 77 was first pressed. If, however, the switch 89 is in engagement with the contact 88, the motor will operate in the reverse direction. If no signal is being received by the set, the motor would continue to operate alternately in opposite directions, the

arms 190 and 191 engaging the arm 192 of the switch 83 so as to reverse the motor for such operation. When, however, a signal of adequate strength is received, the operation of the motor will be terminated in a manner which will now be described.

When a signal is received by the receiver, intermediate frequency energy is transferred from the primary of the transformer 30 to the winding 37. It may here be pointed out that if signals on closely adjacent frequencies are to be tuned stop-on-carrier, it is desirable that there be the maximum difference in amplitude between the desired signal and other signals on closely adjacent channels. It is therefore preferable that the intermediate frequency transformer 30 from which the stop-on-carrier signal is obtained should be the last intermediate frequency transformer, that is, the one immediately ahead of the second detector. The coupling between the primary of the transformer and the winding 37 may be in the neighborhood of optimum coupling, or somewhat less. The coil 37 and the condenser 38 preferably form a high Q circuit sharply tuned to the intermediate frequency. An intermediate frequency signal in the tuned circuit of the coil 37 and condenser 38 is impressed upon the grid of the tube 39. The negative direct current voltage applied to the grid of the tube 39 is sufficiently high to cut off the broader base portion of the intermediate frequency signal in the tuned circuit 37, 38, so that the effective positive signal on the grid of the tube 39 is only as wide as that portion of the intermediate frequency signal which is of higher positive voltage than the negative voltage of the direct current signal. This produces an effective signal on the grid of the tube 39 which is extremely sharp. The sharpness of this signal is not substantially influenced by the coupling between the primary of the transformer 30 and the coil 37, and can be best increased by increasing the Q of the tuned circuit 37, 38. However, either too tight or too loose a coupling will undesirably affect the band pass characteristics of the transformer 30 and therefore the quality of the audible signal. This coupling should therefore preferably be adjusted so that the resonance curve has two peaks, with the single peak of the resonance curve of the tuned circuit 37 and 38 located midway between them, as shown in my copending application Serial No. 219,713 (Patent No. 2,262,218). It has been found that for best results, the peak voltage of the intermediate frequency signal applied to the grid of the tube 39 should have a ratio of around 3 to 2 compared to the negative direct current voltage applied to the same grid from the diode element of the tube 25. When the sharp, positive intermediate frequency signal is impressed upon the grid of the tube 39, the current in the plate circuit of the tube 39 increases sharply. This plate current flows from the cathode of the tube 39 through the choke coil 123, the switch 124', and the resistance 125 to ground. The ungrounded end of the resistor 125 is connected to the grid of the tube 107. The condenser 126 serves as a high frequency by-pass condenser. The choke coil 123 serves as an anti-static choke coil which is effective in greatly reducing the tendency of brief pulses, such as static, to ionize the gas tube 107. Sudden surges, such as static, have a short duration, and the choke coil 123, the resistance 125, and the condenser 124 constitute a low-pass filter which blocks rapid impulses of brief dura-

tion. At the same time, this filter passes sustained oscillations of longer duration or lower frequency which create a substantial voltage across the resistor 125 when a station of suitable strength is tuned in. This voltage being applied to the grid of the tube 107 ionizes this gas tube, with the result that the relay 109 is energized. This energization results in the immediate arrest of the gang of condensers and the breaking of the motor circuit which occurs when the relay 53 is energized and the pole 114 is withdrawn from the contact 117. The condenser 112 is normally charged, owing to the voltage across the resistor 111. When the tube 107 is ionized, the condenser 112 is discharged, with the result that a very large current flows through the winding of the relay 109 at the instant the plate current starts. Thus the condenser 112 materially aids in the instant arrest of the condenser.

It will be understood that when the condensers are thus arrested and the set is receiving a station, the relays 53 and 109 remain energized, due to the fact that the tube 107 remains in an ionized condition. When it is desired to tune in another station, the button 75 is pressed. The result is that the relay 69 is energized through the resistor 78. For the reasons previously described, this energization of the relay 69 does not affect the position of the ratchet wheel 99 and the cam wheel 100. The movement of the armature is, however, sufficient to bring the pole 61 into engagement with the pole 82, thereby grounding the grid of the tube 107. This de-ionizes and terminates the plate current of the tube 107, and the relays 53 and 109 are de-energized. The pole 114 moves upwardly into engagement with the contact 117 and thereupon the motor circuit is complete through the grounded pole 113, contact 67, pole 114, contact 117, switch 65, switch 66, and one or the other of the switches 87 or 89. Consequently, the motor operates until a new station is tuned in in the manner described above. If the button 75 is held depressed, the motor continues to operate the condensers until the button 75 is released. If the button 76 is depressed, the same action occurs as has just been described in connection with the button 75. In this case, however, the energization of the relay 69 is much stronger, and the cam wheel 109 is moved one position. The net result is that the grounded pole 101 is moved into engagement with the other contact 103 or 104. Consequently, the bias of the cathode of the tube 107 is altered and a different voltage is required on the grid of the tube 107 in order to initiate its operation. Thus, if the effective resistance 105 is larger than the effective resistance 108, then when the former is grounded through the pole 101, it will require a higher voltage on the grid of the tube 107 to put this tube into operation by effecting its ionization than when the resistance 108 is grounded. Consequently, when the resistor 105 is effective, the set is adapted to respond to a smaller number of stations giving the strongest signals, and the resistor 108 responds to a larger number of stations, which includes stations giving weaker signals.

When the button 77 and the button 76 are depressed, then the relays 68 and 69 are both energized and the motor circuit is completed through the grounded pole 113, contact 79, pole 89, contact 85, windings 91 and 92, and secondary of transformer 55 to ground. Owing to the energization of the relay 68, the detent 188 will

be withdrawn from the ratchet wheel 170. The spring 132 is now free to rotate the hub 171 to zero volume position, which results in its axial movement, owing to the engagement of the pin 179 with the most elevated portion of the cam 130. This axial movement brings the pin 139 into engagement with the gear 138. The simultaneous energization of the windings 91 and 92 effects the drive of the motor in a direction to carry the shaft 136 beyond zero volume position in the volume reducing direction, opening the switches 64 and 65. If the buttons 76 and 77 are held depressed after the final position of the shaft 136 is attained, the detent wheel 170 merely slips on the hub 171. When the buttons are released, the relays 68 and 69 are de-energized and the motor circuits are broken.

It may here be remarked that the minimum time switch 124 insures the movement of the condensers from one tuning position to another upon the depression of the buttons 75 or 76. If it were not for this switch, the buttons 75 or 76 might be depressed for a very short time and the gas tube 107 might be ionized again by the voltage derived from the station which it was desired to tune out. The centrifugal means which controls the switch 124 insures sufficient rotation for the condensers to tune out one carrier before they can be arrested by the gas tube 107, no matter how quickly the button 75 or 76 is actuated.

When the set is in operation, the depression of the button 77 results in the energization of the relay 68 and the elevation of the detent 133 from the detent wheel 170. When this happens, the spring 132 returns the shaft 174 and shaft 136 to zero volume control position of the rheostat 134. The cam 130 effects the axial movement of the hub 171 so as to engage the pin 139 with the gear 138. The energization of the relay 68 causes the motor circuit to be completed through the windings 93 and 95 so that the motor is put into operation in a direction to rotate the shaft 136 to increase the volume of the audible signal. During this operation of the motor, the tuning is unaffected because the relay 199 and relay 53 remain energized. When the button 77 is released, the desired volume having been reached, the motor circuit is immediately broken, and the detent 133 engages and arrests the detent wheel 170 and moves it away from the gear wheel 138. The desired volume setting is maintained by the engagement of the detent 133 with the detent wheel 170 until the relay 68 is again energized. It is to be noted that during normal reception, the relay 53 is energized and the pole 115 is separated from the contact 52. When, however, the set is being tuned, the pole 115 is in engagement with the contact 52, thus grounding the grid of the power tube 26 and muting the set. When the set is in normal reception, the condenser 119 is grounded through contact 113 and pole 115. Consequently, the automatic volume control voltage, which is applied on the grids of the tubes 21, 22 and 23 through the resistance 231, changes relatively slowly due to the time delay introduced by the resistance 201 and the capacity of the condenser 119. During tuning, however, at which time the relay 53 is de-energized, the ground connection of the condenser 119 is broken, with the result that the automatic volume control applied to the tubes just mentioned is substantially instantaneous, owing to the elimination of the capacity of the condenser 119, providing what I prefer to call fast automatic volume control. This fast auto-

matic volume control during tuning has several very remarkable advantages. In the first place, owing to its almost instantaneous effect, it demodulates received signals to a considerable degree and therefore reduces the difference between the maximum and minimum amplitude of the carrier frequency resulting from modulation. The result is that the signals are effective in arresting the condensers more on the average signal level of the carrier than on the peaks, due to modulation. In the second place, fast automatic volume control largely eliminates the passing over of a weak station after leaving a strong station close to it. Thus, if the condenser 119 were grounded during tuning, its charge might persist for sufficient time to prevent the stopping on a weak station, the frequency of which was close to that of the signal from a strong station, which had previously effected the charging of the condenser. Finally, fast automatic volume control, owing to its practically instantaneous action, reduces the tendency of static or other undesired disturbances of brief duration from stopping the condenser during tuning. Ordinary automatic volume control, notwithstanding its time lag, may decrease the amplification of a relatively long or continuous signal to a high degree, while reducing amplification very little in the case of pulses having sharp wave fronts or peaks of very brief duration.

The radio set illustrated in Fig. 2 is intended primarily for an automobile receiver. In general, the wiring diagram of the set is substantially similar to that illustrated in Fig. 1, with the omission of one of the intermediate frequency tubes 23 and the corresponding transformer 29. Consequently, corresponding numbers have been given to similar parts. It may be noted, however, that the connections to the loud speaker 202 are shown in Fig. 2, while they are omitted in Fig. 1.

The set comprises a vibrator 203 and associated transforming and rectifying means 204 adapted to provide the B supply for the tubes. Power is derived from a storage battery 205, which may be the battery of the automobile. As shown in Fig. 10, the loud speaker 202 may be located in the roof of an automobile 203. The main portion of the set 207 may be suitably located in the hamper of the car. This arrangement is particularly suitable for use with a rod type antenna 208. Thus, the antenna may be mounted at the rear of the car and may be connected by a relatively short cable 209 to the set 207. The set 207 may be supplied with electrical energy from the battery 205 through a cable 210, which may suitably include a grounded sheath. The arrangement of the set 207 remote from the engine and its high tension ignition system and adjacent the antenna 208 is remarkably suitable for satisfactory reception, since pick-up of objectionable disturbances from the electrical system of the car is substantially reduced. This is not only due to the distance of the antenna 208 from the ignition system, but also due to the fact that the metal body of the car acts as a shield between the ignition system and the antenna.

Suitable control devices 211 may be provided. One of these may suitably be mounted on the steering wheel column, preferably where it can be reached without removing the hand from the wheel. The other may suitably be located in the back portion of the car for use of the passengers in the rear seat. In addition to the control units 211, I provide an indicating device 212 on the

dashboard and a sensitivity control device 213, also on the dashboard. If desired, there may be included with these dash mounted devices a third control unit (not shown) for the convenience of the other occupant of the front seat. Each volume control unit comprises a single pole, double throw switch 215, which can be thrown one way or the other in order to ground a conductor 216 or a conductor 217 through the volume control relay 215'. It will be obvious that the switch 215 may be replaced by a pair of independent buttons or one-way switches. The remote control unit 211 also includes a button 218 which can be depressed temporarily in order to ground a conductor 219 through the volume control relay 215'. The conductor 219 is connected to the grid of the gas tube 107, which has the effect of de-ionizing the gas tube and de-energizing the relays 109 and 220.

On the common condenser shaft which carries the rotors of the condensers 32, 33, and 34, I mount the slider of a potentiometer 221. One end of the potentiometer is grounded, the other being connected to the conductor 222. The slider of the potentiometer 221 is connected to one terminal of the indicating device 212, which is a current responsive indicator graduated in the frequencies of the broadcasting band. It will thus be understood that while the slider of the potentiometer 221 is located in the housing 207 in the hamper of the automobile, the station to which the set is tuned is shown on the dial of the indicating means 212 on the dashboard.

The sensitivity control device 213 comprises a grounded arm 241 which is adapted to engage any of a plurality of contacts 242 on the dashboard. These stops are separated by resistances 243 and 244, and the latter is connected to an adjustable rheostat 245 which may be located in the housing 207. The rheostat is connected to the cathode of the gas tube 107. It will readily be understood from the description of the previously described embodiment that the sensitivity of the tube 107 may be given the proper general adjustment by the rheostat 245 and may be adjusted to receive local and distant stations, or only local stations, by the arm 241. The effect of this rheostat 245 and the arm 241 is, of course, to vary the relative grid bias of the tube 107. The windings of the relays 109 and 220 are arranged in series in the plate circuit of the tube 107, as were the windings of the relays 109 and 53 in the previously described embodiment.

The relay 220 may be associated with a thermostatic element 121 which is adapted to hold the armature and the poles in the position they occupy when the relay is energized. The thermostatic element 121 is provided with a heating coil 122 which is connected to the conductor 222, which supplies current to the filaments and also to the vibrator and rectifying unit when the conductor 222 is connected to the ungrounded side of the battery 206 by means of a switch 241. When the switch 241 is closed, the filaments begin to warm up, and at the same time the heater 122 warms up. When the filaments are warmed up, the thermostatic member 121 is moved away from the relay 220, with the result that this relay moves to its normal de-energized position under the action of the spring which is connected to its armature. The relay 220 comprises a pole 243 which is connected by a switch 249 to a switch 250. The switch 249 is physically connected to the switch 247 so that the two switches open and close simultaneously. The switch 250

is adapted to connect to either of two contacts 251 and 252 of the motor 36. The contact 251 is connected to one winding 253 of the motor 36, while the contact 252 is connected to the winding 254 of the motor 36. The two contacts 251 and 252 are bridged by a high resistance 255 which damps the commutator ripple produced by the motor 36. The two windings 253 and 254 are connected through the commutator 256 to the conductor 240. The relay 220 includes a pole 257. The relay 220 also comprises a pole 258 which is connected through a condenser 259 to the automatic volume control conductor 260. When the set is in receiving condition, the relay 220 is energized and the pole 258 is in engagement with the grounded contact 261. Consequently, the condenser 259, which is strictly analogous to the condenser 119 of the previously described embodiment, gives the necessary delay to the automatic volume control bias applied to the tubes 21 and 22. During tuning, that is, when the motor is driving the condensers in search of the next station to be tuned in, the pole 258 is moved away from the contact 261, with the result that "fast" automatic volume control is applied to these tubes. When the relay 220 is de-energized, the pole 257, which is ungrounded, engages a contact 262 which is connected to a conductor 263. The grounding of the conductor 263 renders the set mute. When a station is tuned in, the relay 220 is energized and the muting circuit is broken. The pole 248 is adapted to engage the grounded contact 264 when the relay 220 is de-energized. When this occurs when the set is turned on, the motor circuit is completed through grounded contact 264, pole 248, switch 243, switch 259, and either winding 253 or 254, commutator 256, conductor 243, and battery 206 to ground. The motor will be put into operation in a direction depending on the position of the switch 250. When the switch 256 is in one position, for example, the position in which it is shown in Fig. 2, the field winding 253 is energized and the motor turns in one direction. When the switch 250 is in engagement with the contact 252, the winding 254 is energized and the motor turns in the opposite direction. It will be understood that the switch 250, like the switch 87 or 89 of the previously described embodiment, is actuated or reversed by the gang of condensers when the same arrives at an extreme position. Consequently, the condensers will be moved from one extreme position to the other continuously until a carrier is received with sufficient signal strength to energize the gas tube 107, whereupon the relays 109 and 220 are energized, arresting the movement of the condenser and breaking the motor circuit established between the pole 248 and the contact 264. The device just described with respect to Fig. 2 will be understood more fully in its physical embodiment, as shown in Figs. 10, 11, 12 and 13. The motor 36 is provided with a shaft 265 which carries a pinion 266 on its outer end. On the inner side of the pinion 266, the shaft 265 is provided with a collar 267 which serves as an abutment for a spring 268 located around the shaft 265 and serving to apply friction, with the aid of suitable washers, to a pinion 269, otherwise freely rotatable on the shaft 265. The pinion 266 meshes with a gear 270, which is provided with projections 271. The projections 271 are adapted to be engaged by one or more projections 272 on a pinion 273, which is mounted for slight axial movement in alignment with the

gear 270. The pinion 273 is quite similar to the pinion 153 shown in Fig. 5, which pinion is actuated by the relay 109 in the manner described above in connection with the first embodiment. It is to be noted, however, that the relay 109 is located at an intermediate point of the gear train, which gear train comprises the elements 266, 270, 273, 274, 275, and 276, which is mounted on the shaft 277, which carries the gang of tuning condensers and the contact arm of the potentiometer 221. The element 276 carries projections 279 which are adapted to cooperate with the arm 280 of the reversing switch 250, previously described.

The pinion 269 is connected through a train of gear elements 282, 283, 284, 285, and 286, to a shaft 289 of the volume control 290. The shaft 289 also controls two switches 247 and 249 mounted on the back of the volume control 290, so that the set may be turned off by turning the volume control beyond the zero volume position in the volume decreasing direction. The train of gears 282 to 286 is adapted to be arrested in definite position by means of the relay 215'. The armature 291 is normally pressed outwardly by means of a spring 292 so that its reduced outer end 293 is adapted to project between the spokes of the gear element 284.

The operation of this embodiment is as follows: The two-way switch 215 is thrown to one side, for example, to the left, as viewed in Fig. 2, so as to complete a circuit from ground through the relay 215', conductor 294, switch 215, conductor 216, winding 254, conductor 246, and battery 295 to ground. This drives the shaft 289 in a direction to close the switches 247 and 249 and to increase the volume level. When the switch 215 is released, the motor is stopped. The battery now supplies current to the filaments through conductor 246, switch 247, and conductor 222. It may here be interposed that if the volume level is too high, it may be lowered by merely throwing the pole of the switch 215 into contact with the conductor 217, whereupon the motor is driven in the opposite direction until the volume level desired is attained. When the set is first turned on, the thermostat 121 is cold and maintains the poles 257, 258, and 243 in the position they occupy when the relay 220 is energized. Consequently, the motor cannot be actuated except by the switch 215, in which case the relay 215' is energized. When the relay 215' is energized and the motor circuit is completed, the projection 293 of the armature 291 of the relay 215' is withdrawn from the gear 284, and the motor starting, the gear train 282 to 286 is effective for driving the shaft 289. When the circuit of the motor through the volume control relay 215' is opened by releasing the switch 215, the de-energization of the relay permits the spring 292 to thrust the armature 291 outwardly so that its projection 293 engages and arrests the gear 284. At the same time, the motor is de-energized and the inertia of the armature is accommodated by the slippage of the shaft 265 relative to the pinion 269. The operation of the motor 36 changes the position of the gang of condensers and associated elements. If the gang of condensers is left so that no carrier wave is being received with sufficient strength to effect the ionization of the gas tube 107, then the relays 109 and 220 are not energized so that the clutch elements 271 and 272 are in cooperative relation. Consequently, the motor, when it starts, is adapted to drive the gang of condensers. The

motor goes into operation to drive the condensers when the heater 122 has raised the temperature of the thermostatic element 121 adequately. The motor circuit is completed from ground through the contact 264, pole 248, switch 249, switch 250, the motor 36, conductor 246, battery 205, and grounded conductor 210. During this operation, the condenser 259 is not grounded, and consequently, fast automatic volume control is applied to the grids of the tubes 21 and 22. When the condensers tune in a carrier wave of sufficient strength, the gas tube 107 is ionized and the relays 109 and 220 are energized. The energization of the relay 109 effects an immediate interruption of the drive of the gang of condensers, and the energization of the relay 220 interrupts the motor circuit and effects the grounding of the condenser 259. It will, of course, be understood that when the relay 220 is de-energized, the set is muted through the engagement of the pole 257 with the contact 262. When the relay 220 is energized, the muting circuit is interrupted by the downward movement of the pole 257, as viewed in Fig. 2.

The set being now in condition to receive a station if one of the buttons 218 is pressed inwardly, the grid of the gas tube 107 is grounded and the tube is de-ionized. This grounding occurs through the volume control relay 215', but this relay is not actuated since only a negligible current flows. The de-energization of the relays 109 and 220 causes the motor to be put into operation and it remains in operation as long as the button 218 is pressed. When the button is released, the motor continues to operate until the condensers tune in a station of sufficient signal strength to ionize the tube 107. This ionization is effected by a positive voltage applied to the grid of the tube through the switch 124', which is controlled by a governor or other timing device, such for instance, as that described in connection with the previous embodiment.

I have found it to be advantageous to locate the clutch elements 271 and 272, together with the control relay 109, at an intermediate point of the gear train between the motor pinion 266 and the gear 276 driving the gang of condensers. At the low speed end of the train, the torque transmitted by the clutch is high, and the clutch elements would require a larger amount of energy for quick disengagement. On the other hand, at the high speed end of the train, the torque is small but the energy of rotation of the clutch members which remain connected to the condensers after the clutch is disengaged is high. As a matter of fact, this energy of rotation increases with the square of the speed and tends to prolong the time between the disengagement of the clutch and the stoppage of the condenser. For quickest condenser stoppage with reasonable clutch operating forces, a location of the clutch at an intermediate point of the gear train is highly advantageous. It is also desirable to decrease as far as practical the energy of rotation of all the parts which remain connected to the condenser shaft 277 and rotate therewith after the clutch is disengaged. Those elements, such as the gear 270, which are disconnected from the condenser shaft 277, after disengagement do not contribute to the continued rotation of the condenser; therefore their energy of rotation may be disregarded.

In Figs. 14, 15, and 16, I have shown a modified clutch arrangement operated by the relay 109.

In these figures, the gear 296 corresponds to the gear 274 of the last described embodiment and the gear 297 corresponds to the gear 270. The gear 296, which meshes with the gear 296, corresponds to the gear 273. The hub of the gear 297 carries one or more projections 299 which are adapted to be engaged by an arm 300 rigidly carried on the end 301 of the shaft member 302. The end 301 is round and has a bearing 303 in a plate 304. The plate 304 is rigidly mounted upon and in spaced relation to a plate 305. The plate 305 is provided with a bearing 306 for the enlarged portion 307 of the shaft member 302. Between the enlarged portion 307 and the end portion 301, the member 302 is provided with an intermediate portion 308 which is of non-round exterior shape. It may be square, as shown in Fig. 16, and it extends through a bore 309 of corresponding shape in the gear 298. The gear 298 is located between the two plates 304 and 305, and the member 302 is freely movable within it in longitudinal direction. Between the plate 304 and the arm 300 a conical coil spring 310 is situated which urges the shaft member 302 normally to the right, as shown in Fig. 15, pressing the rounded end 301 against the flat center portion of the hub of the gear 297. It may here be noted that the gear 297, the member 302, and the pole of the relay 109 are in axial alignment. The end of the enlarged portion 307 of the member 302, that is, the end which is normally located adjacent the pole of the relay 109, carries a frusto-conical head 313 of magnetic material. This head flares outwardly from the enlarged portion 307 and terminates in a large flat face, thin at the periphery, located quite close to the pole of the relay 109, as shown in Fig. 15.

When the relay 109 is not energized, the elements just described have the relation shown in Fig. 15. The spring 310 forces the end portion of the shaft member 301 into contact with the hub of the gear 297. A friction washer 311 made from material such as Bakelite surrounds the pole piece of the relay 109, projecting a few thousandths of an inch beyond the face 312 of the pole piece. When the head 313 is attracted by the energization of the relay 109, it bears upon the surface of the washer 311 and does not make contact with the pole face, remaining separated from the face 312 of the pole piece by a small air gap. The washer 311 constitutes an effective braking surface against which the rotation of the head 313 of the shaft member 302 is effectively braked when the relay 109 is energized.

In this embodiment of the invention, part of the gear train of the tuning control is common to the gear train of the volume control, both trains including the motor pinion 266 and the gear 297. The pinion 322, which is integral with the gear 297, meshes with a gear 383 mounted for free rotation on a stub shaft 384. Upon the shaft 384 is mounted a pinion 385 which is adapted to be moved on the shaft towards the gear 383. The gear 383 is provided with a plurality of projections 386 directed towards the side on which the pinion 385 is located. The adjacent end of the pinion 385 carries an arm 387 which is adapted to engage one of the pins 386 when the pinion 385 is moved to the left, as viewed in Fig. 14. This movement of the pinion 385 is effected by a rod 381 which abuts against a disc 388, rigidly mounted in the end of the pinion 385 remote from the gear 383. The rod 381 is mounted for axial movement in a support 389. The rod 381 is moved to the left, as viewed

in Fig. 14, when the volume control relay 332 (Fig. 17) is energized. The relay 215' may also be adapted to operate the rod 381 when energized, if it is desired to employ the volume control clutch shown in Fig. 14 in connection with the embodiment of the invention illustrated in Figs. 11, 12, and 13.

In the embodiment of the invention illustrated in Fig. 17, which like Fig. 1, is adapted to operate from an alternating current supply, an intermediate frequency tube is indicated by the reference numeral 24. This tube is coupled through the transformer 30 to the diode detector and first audio frequency amplifying tube 23, the relation of the tubes being substantially similar to the relation of the corresponding tubes in Fig. 1. A winding 37, which is closely coupled to the tuned secondary of the transformer 30, is connected to the first grid of the double triode 320. The first plate circuit of the tube 320 includes a sharply tuned high Q circuit comprising a winding 321 and tuning condenser 322, by means of which the plate circuit is tuned sharply to the intermediate frequency. The winding 321 is coupled to a winding 323 which is connected to the second grid of the tube 320. The winding 321 is also coupled to a regenerative coil 324, which is connected to the first cathode of the tube 320, and serves to feed back energy from the plate circuit to the grid circuit of the first triode elements of the tube 320. The regenerative coil 324 is connected through a condenser 325 and adjustable rheostat 326 to ground. The rheostat 326 is adjusted to prevent oscillation while providing the desired regenerative feedback. The second set of triode elements of the tube 320 are analogous to the tube 39 of the first described embodiment. Regeneration is employed in this arrangement to increase the Q and therefore the selectivity of the stop-on-carrier tuned circuit. The double triode arrangement is employed to prevent coupling between the regenerative stop-on-carrier circuit from adversely influencing the by-pass characteristics of the transformer 30. A single triode, as shown for instance in Fig. 1, may of course be employed with the control circuits of this embodiment of the invention. The cathode of this tube is connected to an inductance 123 and resistance 125 to ground. The inductance 123, resistance 125, and condensers 124 and 126 have the same relation and function in a similar manner to those of the previous embodiment. The inductance 123 and resistance 125 are connected to the grid of a gas tube 107. The power supply includes an auxiliary transformer 55 and a power transformer 53. The primary of the transformer 55 is controlled by a switch 64. This switch is physically connected to a switch 65 so that these switches open and close together and are mounted on and actuated by the volume control. These and the other elements of the power supply unit are similar to those of Fig. 1 and are indicated by the same reference numerals.

The set may include a remote control unit similar to that of the first described embodiment. This unit may comprise switches 75, 76, and 77. The switches may be connected to a common wire 72, which is adapted to be grounded through a switch 327. The other side of the switch 75 is connected to the other side of the switch 76 through a resistance 73. Said other side of the switch 76 is connected by a conductor 70 to a relay 328 and to a contact 329. The other side of the switch 77 is connected through a conductor

71 to a relay 332 and to a pole 333 of a double pole switch which includes a pole 334 mechanically connected to the pole 333. The exterior portions of the three conductors 70, 71, and 72 may be formed into a cable and be connected to the set by means of a plug 335 which is adapted to be inserted in a receptacle 336. The remote control may be removed from the set by merely withdrawing the plug 335.

It will readily be understood that a plurality of units 74 may be employed, if desired, the corresponding elements being merely connected in parallel, as shown in Fig. 1.

The switch 327 is a single pole switch adapted in one position to connect the conductor 72 to ground. This switch is physically connected to the switch 336' which is adapted, when the switch 327 is open, to connect conductor 337 to contact 338 of the relay 328. One side of the secondary of the transformer 55 is connected to the winding of the relay 332 and to the relay 328. One side of the switch 65 is connected to the pole 339 of relay 340. The other side of the switch 65 is connected to contact 341 of relay 332.

A switch pole 342, controlled manually by a button 343, is normally in engagement with a resilient contact 344. When the button 343 is pressed inwardly, the pole 342 is moved away from the contact 344. When, however, the button 343 is pulled outwardly, that is, downwardly, as viewed in Fig. 17, the contact 344 is brought into engagement with the contact 329. The contact 344 is connected to a pole 345 which is normally in engagement with the contact 338. When the relay 328 is energized, the pole 345 moves away from the contact 338. The pole 342 is connected to a contact 346 which is normally engaged by the manually operable two-way switch pole 347. The switch pole 347 is maintained in neutral position, as shown in Fig. 17, by means of springs 348. The switch pole 347 is grounded. When the switch pole 347 is thrown in one direction, it is brought into engagement with the contact 349, which is connected to the contact 350, associated with the pole 333. When, however, the switch pole 347 is thrown in the other direction, it is brought into engagement with contact 351, which is connected to a contact 352, also associated with the pole 333. The contacts 330 are also connected to contacts 350 and 352. An arm 331, moving with the shaft of the gang of condensers, from which it is insulated, is adapted to engage contacts 330 at each end of the condenser travel, automatically reversing the direction of the condenser travel. The arm 331 is connected through a switch 450 to a contact 451, which is normally engaged by the grounded pole 360. The switch 450 is mechanically connected to the switches 64 and 65 so that the contacts 330 cannot be grounded when the relay 332 is energized or the switches 64 and 65 are open. The secondary of the transformer 55 is connected to both windings 353 and 354 of the reversible motor 36 which actuates the tuning condensers and also the volume control. The windings 353 are connected to a contact 355 on one side of the pole 334. The windings 354 are connected to a contact 356 on the other side of the pole 334. The armature of the relay 332 carries a finger 356' which is adapted to cooperate with a ratchet wheel 357. The ratchet wheel 357 is rigidly connected to a cam wheel 358 which is provided with a series of alternating recesses and projections. The

cam wheel is adapted to cooperate with a cam member 359 carried by the pole 334. Each time the relay 332 is energized, the cam wheel 358 is tuned one step, moving the projection 359 from a hump on the cam wheel into a recess on the cam wheel, or vice versa. Consequently, the poles 333 and 334 are moved alternately from a position in which they engage the contacts 350 and 355, respectively, to another position in which they engage the contacts 352 and 356, respectively, and vice versa. On each energization of the relay 332, the pole 360 engages the contact 341 and may immediately separate therefrom. The armature of the relay 328 is provided with a projection 361 which is adapted to engage a ratchet wheel 362 in the same manner as the projection 356' engages the ratchet wheel 357. The ratchet wheel 362 is rigidly connected to a cam wheel 363 which is similar to the cam wheel 358. This cam wheel cooperates with a projection 364 on a pole 365. The pole 365 is rigidly connected to a pole 366. When the projection 364 is received in a recess in the cam wheel 363, the pole 366 engages a contact 367, which contact is connected to an incandescent lamp 368. The other side of the incandescent lamp and the pole 366 are connected to the filament supply, and it will readily be understood that when the cam wheel 363 is in the position in which it is shown in Fig. 17, the lamp 368 is illuminated. It shines through a window 369 which may include a layer of translucent material 370. This material may, for example, be white Celluloid. On the rear side of the sheet 370 is a layer of colored material 371, which may be red. This layer carries, suitably in black or in letters of a contrasting and preferably opaque color, a suitable indicating legend, such as the word "distant." On the front of the layer 370 is carried another suitable legend, such as the word "local." This legend should be translucent and have the same color as the layer 371, namely red. It will readily be understood that when the lamp 368 is lit, the legend "distant" appears to the observer, the legend "local" being obscured by the general background of the same color. When, however, the lamp 368 is not lit, the rear legend "distant" is not seen, and only the front legend, for example, "local" is seen by the observer.

The gas tube 107 has associated with it resistances 105, 106, 108, and 111, and condenser 112, in the same relation as described in connection with the first described embodiment. The resistance 105 is adapted to be grounded in one position of the cam wheel 363 through contact 372, pole 355, contact 338, pole 345, contact 344, pole 342, contact 346, and pole 347. When the cam wheel 363 occupies its other position, that is, the position shown in Fig. 17, the resistance 108 is grounded through contact 373, pole 365, and other connections, as before. It is to be noted that one or the other of these two resistances is grounded at all times except when the relay 328 is energized, or when the button 343 is pressed, or when the pole 347 is out of engagement with contact 346.

The pole 339 of the relay 340 is rigidly connected to the grounded pole 374. A thermostat 375 keeps the pole 339 and 374 in the positions they occupy when the relay 340 is energized. The thermostat 375 is controlled by a heater winding 376 which is connected to the filament supply and is turned on when the switches 64 and 65 are closed. When the relay 340 is energized, the

pole 339 is moved away from the grounded contact 377 and the pole 374 is moved into contact with the contact 378, which is connected to the automatic volume control delay condenser 379, which operates in the manner hereinbefore described in connection with the corresponding condensers 119 and 259. At the same time, the pole 374 is moved away from the contact 330, making the signals audible which were muted during tuning in the manner hereinbefore described. Assuming that the switch 327 is connected to the conductor 72, that the switch 336' is opened, and that the cable 73 is connected to the set, then if the set is out of operation, the switches 64 and 65 are opened and only the transformer 55 is energized. The set is put into operation by pressing the button 77, whereupon a circuit is completed from ground through the switch 327, conductor 72, switch 77, conductor 71, relay 332, and secondary of the transformer 55 to ground. The movement of the armature of the relay 332 moves the pole 360 into engagement with the contact 341, thus completing a circuit through the motor 36 and through one or the other of the contacts 355 or 356 which is engaged by the pole 334. If the resulting rotation of the motor does not start the set, the button 77 is released and pressed again. This actuation results in changing the pole 334 into engagement with the proper contact to start the set. When the relay 332 is energized, the clutch for the volume control is put into engagement by the rod 381 and consequently the operation of the motor in the proper direction closes the switches 64 and 65 and continues to turn the volume control in the direction to increase volume as long as the button 77 is pressed. The button is released as soon as the switches 64 and 65 are closed. Then, as soon as the filaments of the tubes are heated, the volume may be adjusted to the proper level. If, at any time, the volume level is too high, it can be lowered by merely pressing the button 77 again. If too low, the button 77 is again pushed. This actuation results in the fact that the pole 334 is moved to the right or to the left by the cam wheel 353 on each actuation of the button 77. The closure of the switch 64 results in the energization of the filament supply. Until the filaments heat up, the thermostat 375 holds the pole 339 out of engagement with the contact 377, and the motor cannot be put into operation except by the button 77. When the heater 376 has warmed the thermostat up, the pole 339 moves upwardly into engagement with the contact 377 if the set is not receiving a signal sufficient to maintain the tube 107 ionized. Consequently, the motor is put into operation in a direction depending upon the position of the pole 334 until such a station is tuned in by the gang of condensers. Owing to the nonionized state of the tube 107, the relay 109 is not energized. When a station is received with sufficient signal strength, the tube 107 is ionized and the relays 340 and 109 are energized. The energization of the former opens the motor circuit and the energization of the latter declutches the condenser drive and applies a brake. The tube 107 remains ionized while the station is being received. When the button 75 is pressed, a circuit is completed from ground through the resistance 78, the relay 328, and the secondary of the transformer 55 to ground. The energization of the relay 328 moves the pole 345 away from the contact 338, thus breaking the circuit which connects resistance 105 or 108, de-

pending upon the position of the pole 365, to ground. It will be readily understood that when this ground connection is broken, the voltage of the cathode of the tube 107 attains a high positive value corresponding to a high negative grid bias, the plate circuit is broken, and the tube is de-ionized. The de-ionization of the tube 107 causes the relay 109 to relax the brake and engage the clutch, and causes the relay 340 to complete the motor circuit. The direction of rotation of the motor depends upon the position of the pole 334. If it is desired to reverse this direction, it is merely necessary to close the switch 77 for the shortest possible time. This will have no appreciable effect upon the volume level. It is here to be noted that the energization caused by the button 75 is insufficient to cause actuation of the ratchet wheel 362. If the button 76 is depressed, it has the same effect as the button 75 as has just been described, with the addition that the cam 363 is moved one step and the circuit connecting the plate of the tube 107 to ground is changed from resistance 105 to resistance 108, or vice versa, changing the sensitivity of the stop on carrier tuning system. At the same time, the incandescent lamp 368 is either extinguished or lit, as the case may be.

The energization of the relay 332 displaces the rod 381 which controls the volume control clutch in the manner described in connection with Fig. 14. During normal operation of the device, to change from station to station, it is merely necessary to push momentarily the button 75. When the condenser shaft 134 reaches the end of its travel in either direction, a circuit is completed through the relay 332 by the contact 331, which moves with the condenser shaft 334, engaging one of the contacts 330, thereby producing the same effect as if the button 77 had been pressed momentarily. The result is that a circuit is completed through the relay 332 for a short time, which has the effect of reversing the motor, the motor current being passed through the windings 353 or windings 354, depending upon the position of the pole 334. If it is desired to reverse the movement of the condenser shaft 134 at any time, it is merely necessary to press momentarily the button 77. This changes the location of the pole 334. This enables a user to go back immediately to a station which he has just left. All he has to do is push the button 77 momentarily and then the button 75 momentarily. The rotation of the tuning condenser or other type of variable reactance is controlled by the relays 109 and 340. The volume control clutch actuated by the rod 381 is operated by the relay 332, and may suitably be of the construction illustrated in connection with Fig. 14 or Fig. 18.

The manual controls 343 and 347 on the receiver are adapted for operation of the set without the aid of the remote control unit 74. Thus, if the button 343 is pressed, the cathode circuit of the tube 107 is broken and the tube de-ionized. The result is that the relays 109 and 340 are de-energized so that the motor circuit is completed so as to drive the condensers. When a signal of adequate strength is received, the buttons 343 having been previously released, the tube 107 becomes ionized and the resulting energization of the relays 109 and 340 stops the condensers in tune with the received carrier. When the switch 347 is moved away from its intermediate position into engagement with one of the contacts 349 or 351, the cathode circuit is likewise broken and the motor tends to go into operation in the

direction determined by the pole 334. Thus, if the switch 347 is thrown into engagement with the contact 351, no circuit is completed, since the pole 333 is out of engagement with the contact 352 which is connected to the contact 351. The motor therefore operates in a direction determined by the windings 353, and it is preferred that the manual displacement of the switch 347 in either direction should cause the rotation of the dial in the corresponding direction. If, however, the switch 347 is thrown in the opposite direction, that is, into engagement with the contact 349, a circuit is completed from ground, switch 347, contact 349, contact 350, pole 333, relay 332, and secondary of the transformer 55 to ground. The energization of the relay 332 results in the rotation of the cam wheel 353 one step and the movement of the pole 333 away from the contact 350, thereby breaking the circuit completed by the switch 347 and displacing the pole 334 into engagement with the contact 356. The motor is now energized through the windings 354 and operates in the opposite direction. It will be understood that the motor will continue to operate in the appropriate direction as long as the switch 347 is held in engagement with the contact 349 or 351 and out of engagement with the contact 346. When the switch 347 is released, the motor will be arrested by the tuning in of the next carrier of adequate strength. When it is desired to change the sensitivity of the stop on carrier system, the button 343 is merely pulled outwardly. This results in the completion of a circuit through the relay 328 and a stepwise movement of the cam wheel 363.

The manual controls 347 and 343 are adapted to be used for tuning without the automatic stop on carrier feature. For this purpose, the switch 327 is opened and the switch 336' is closed. The plug 335 may be removed from the receptacle 336, if desired. This is not necessary, however, since the remote control unit 15 is rendered inoperative by the opening of the switch 327. Owing to the closing of the switch 336', the plate of the tube 107 is grounded directly through the switch 336', contact 338, pole 345, contact 244, pole 342, contact 346, and switch 347. Consequently, the tube 107 is ionized at all times except when this circuit is interrupted. The circuit may be interrupted by pressing the button 343 inwardly, whereupon the motor will go into operation to tune the condensers in a direction determined by the pole 334. When the button 343 is released, the motor stops immediately. When the switch 347 is thrown into engagement with the contact 349, the motor operates in one direction, and when it is thrown into engagement with the contact 351, the motor operates in the opposite direction. When the switch 347 is allowed to return to normal position, the motor stops operating. Consequently, by merely manipulating the lever 347 in one direction or in the opposite direction, the dial indicator will be caused to move in corresponding directions to any desired extent. When operating in this way, the set may be finally tuned by hand.

When controlling the set by means of the controls 343 and 347, it is preferred to actuate the volume control of the set by hand.

In the embodiment of the invention illustrated in Figs. 18 and 19, the relation of the motor 36 and the stop-on-carrier relay 109 is substantially similar to that illustrated in Figs. 14 and 15, and corresponding parts are designated by similar reference numerals. In this embodiment of the

invention, the gear 333 is rigidly mounted on a shaft 390 which is rotatably mounted on chassis frame members 391 and 392. This shaft carries a knob 393 whereby the set can be tuned manually, for example, a set such as that described in connection with Fig. 17, or other arrangements adapted to manual tuning.

It will be understood from the previous description that when the relay 109 is energized, the arm 389 is withdrawn from engagement with the pin 290. Consequently, the knob 393 may be turned at will without rotating the armature of the motor 36.

The shaft 390 carries a pulley 394 over which passes a belt 395. This belt passes twice around a drum 396 and around an idler 397. The idler 397 is carried at one end of a lever 398 which is pivoted at 399 to the chassis. The lever 398 is biased by a spring 400 so that it tends to keep the belt 395 at substantially the same degree of tautness at all times.

Upon the shaft 390 on the rear side of the pulley 394, I mount for free rotation a boss 401 of an arm 402. The boss 401 is normally pressed into frictional relation with the pulley 394 by means of a collar 403 and spring 404. The collar 403 is provided on its rear side with a flange 405 which is engaged by a yoke formation on the upper end of a lever 406. The lever 406 is pivotally mounted on a frame member 407 and is normally biased by a spring 408 so as to move the collar 403 away from the boss 401 against the pressure of the spring 404. The spring 408 is stronger than the spring 404 so that the boss 401 is normally free on the shaft 390. A contact member 409 on the lever 406 is adapted to be engaged by the shaft of the motor which carries the pinion 236. The armature of the motor is arranged to have a substantial axial movement towards the left, as viewed in Fig. 19, when it is put into operation. Consequently, when the motor 36 starts, the armature moves to the left and the lever 406 is moved to the left, as viewed in Fig. 19. When this occurs, the spring 404 forces the collar 403 into engagement with the boss 401 so that the arm 402 is driven with the shaft 390 until it reaches an abutment, whereafter the arm 402 is arrested and remains stationary, notwithstanding the continued rotation of the shaft 390.

The arm 402 carries two adjacent rearwardly directed pins 410 which are located normally one on each side of a spring contact 411. When the collar 403 is moved away from the boss 401, the arm 402 is moved by the spring contact 411 into the position in which it is shown in Fig. 18. When, however, the motor is put into operation in one direction or the other, the boss 401 is frictionally held against the pulley 394 so that the arm 402 is carried in one direction or the other by the initial movement of the motor. In its normal position, the contact 411 is located in intermediate relation to two rigid contacts 412, these contacts being spaced from the normal position of the contact 411 to such an extent that the contact member 411 is brought into engagement with one or the other of the contacts 412 after the operation of the motor to a predetermined extent, for example, to an extent corresponding to a movement of the condenser which will change the frequency of the intermediate signal about five to eight kilocycles. This particular number of kilocycles is selected in view of the fact that at the present time the frequencies of broadcast stations are separated

by ten kilocycles. It is only necessary that the motor should operate sufficiently to diminish the signal received from the station which it is desired to tune away from to such an extent that this signal will not again energize the stop-on-carrier relay 109. The two contacts 412 are connected together and to a conductor 413. The contact 411 is connected to a conductor 414. These three contacts may be located in the relation occupied by the switch 124' in Fig. 1, that is, in the cathode circuit of the stop-on-carrier tube 39. The conductors 413 and 414 may also be connected in series with the cathode circuit at the point 124' in Fig. 17. The net effect of the switch constituted by these contacts is similar to but more exact than that obtained by the switch 124', which is controlled by the governor, as has been previously described.

The drum 396 is rigidly mounted on a hub 415, which is rigidly secured to a sleeve 416, for example, by means of a set screw. The sleeve 416 is rotatably mounted on the shaft 134 which extends from the shaft 277 of the gang of condensers. The shaft 134 is for the purpose of carrying the hand or indicator 229 which cooperates with the dial 238. The inner end of the sleeve 416 is formed to provide an inner race 418 for a plurality of balls 419. The outer race for these balls is provided by two annular members 420 which are resiliently held together by means of bolts 421 and springs 422. The annular members 420 may suitably consist of washers, the inner portion of which are displaced into frusto-conical form. The frusto-conical formations of the two annular members are located in divergent relation, as best seen in Fig. 19, so that opposite sides of the balls 419 are engaged by them. The annular members 420 are provided with a circumferential series of notches 423 which are adapted to receive a tooth 424 carried by a lever 425. The lever 425 is pivotally mounted on the frame member 392 and it is biased towards the annular members 420 by means of a spring 426. A cord 427 is connected to the lever 425 and to a drum 428 which is rigidly carried by the shaft 429 of the wave change switch. The arrangement is such that the tooth 424 is maintained out of engagement with the annular members 420 during ordinary broadcast reception, but when the shaft 429 is rotated in the clockwise direction, as viewed in Fig. 18, to adapt the set for the reception of short wave transmission, the spring 426 is permitted to draw the tooth 424 into one of the recesses 423. Consequently, when the receiver is set for the reception of short wave, the outer race of the balls 419 is held stationary. The balls 419 are located in openings 430 of a sleeve 431, which is rigidly secured to the shaft 277 of the gang of condensers. The outer end of the sleeve 431 is reduced and extends into the interior of the sleeve 415, providing a shoulder in register with the inner end of the sleeve 415. Between said shoulder and said inner end, I locate a spring washer or other suitable friction member 432. When the drum 396 is driven, the lever 425 being in the position shown in Fig. 18, the sleeves 415, 416, and 431 rotate as a unit so that the gang of condensers is driven directly. When, however, the annular members 420 are held against rotation by the tooth 424, the rotation of the sleeve 431 directly by the sleeve 415 is prevented. The balls 419 are caused to roll around the outer race by the rotation of the inner race member 418 so that they execute a planetary movement around the axis of the shaft

134. This movement is very substantially slower than the rate of rotation of the drum 396, and consequently the rate of drive of the gang of condensers is reduced to any desired extent so as to adapt the set for accurate tuning on higher frequency bands. It will be understood in this connection that to maintain a high accuracy of tuning, it is desirable to reduce the speed of rotation of the condenser when the set is operated on higher frequency bands.

The operation of this embodiment is as follows:

When the set is receiving a station, the motor 36 is not operating, and consequently, the arm 402 and contact 411 occupy the positions shown in Fig. 18. When the motor is put into operation, as described in connection with the previously described embodiments, and the gas tube 107, becoming de-ionized, the drive of the gang of condensers is put into operation and continues until the tube 107 is again ionized, the relay 109 is energized, and the motor 36 is stopped. When the drive of the condensers starts, the arm 402 moves with the shaft 390. When the motor 36 is started, the axial movement of its armature displaces the lever 406 to the left, as viewed in Fig. 19. The collar 403 is now free to be pressed by the spring 404 against the hub 401 of the arm 402, which is in turn pressed against the pulley 394. Consequently, the arm 402 moves until the contact 411 is brought into engagement with one or other of the contact stops 412, depending upon the direction of rotation of the motor. Until the contact 411 has engaged one or other of the contacts 412, the stop-on-carrier system is rendered inoperative. Consequently, the receiver will tune away from the station being received, notwithstanding that the cathode circuit of the tube 107 is opened for the smallest possible time. When the contact 411 reaches one of the contact stops 412, the arm 402 is no longer able to move with the shaft 390 and consequently its hub 401 slips on the shaft until the next station is received which is strong enough to actuate the stop-on-carrier mechanism. When the motor 36 is thus arrested, the spring 408 moves the lever 406 to the right, as viewed in Fig. 19, and the hub 401 of the arm 402 is released so that the contact 411 is enabled to move to its neutral position shown in Fig. 18. It is to be noted that the movement of the contact 411 away from the contacts 412 does not de-ionize the tube 107. This de-ionization can be effected only by manual operation in the manners hereinbefore indicated, that is, by grounding the grid of the gas tube 107 or breaking its cathode circuit. It will be understood from the previous description that when stations in the ordinary broadcast band are being received, the drum 396 drives the gang of condensers directly. Whenever the stations in the short wave band are being received, the gear reduction system, including the balls 419 is rendered effective to reduce the rate of drive of the gang of condensers.

Fig. 20 is a fragmentary wiring diagram showing certain changes or modifications which may be made in the wiring diagram shown in Fig. 1. Similar parts are designated by the same reference numerals. This embodiment of the invention will be readily understood with reference to Fig. 1 by a mere description of the essential differences which Fig. 20 embodies. The gas tube 107 in this embodiment comprises two control grids, one of which is connected to the cathode

of the tube 39. In the embodiment of Fig. 20, the negative voltage derived from the diode elements of tube 23 is not supplied to the grid of the tube 39 as it was in the wiring diagram of Fig. 1. According to the embodiment of Fig. 20, this negative voltage is connected through a resistance 440, an additional pole 441 of the relay 53, and an additional contact 442 of this relay, to the other grid of the tube 107. The lower end of the winding 37 is grounded.

It will be readily understood that the tube 107 may be deionized, for example, by opening the cathode circuit of that tube. This may be done by opening the contacts 81 and 82 on the relay 69. The contact 82 is grounded and the contact 81 is connected to the pole 101. When the relay 69 is energized, the tuning motor is thus put into operation. The relay 53 is deenergized so that the pole 441 is in engagement with the contact 442. When a station is tuned in, a negative voltage having a double-peaked selectivity curve is applied to one of the grids of the tube 107, being the lower grid, as illustrated in Fig. 20. At the same time, a positive voltage is applied to the other grid, this voltage being derived from the cathode of the tube 39. This voltage has a sharp, single-peaked selectivity curve. As a result of the conjoint action of the separate voltages applied to the two grids of the tube 107, this tube becomes ionized when a station of sufficient strength is tuned in. The immediate energization of the relay 109, aided by the discharge of the condenser 112, effects the instant opening of the clutch. The energization of the relay 53 stops the motor. It may be pointed out that the purpose of the pole 441 and the contact 442 on the relay 53 is to disconnect the grid of the gas tube 107 from the diode elements of the tube 23 so that the positive voltage on the grid of the gas tube 107 will not interfere with the detector action of the diode during the reception of an audible signal. The double grid gas tube 107 in Figs. 20 and 21 may be, for example, the R. C. A. 2050.

The modification of the invention illustrated in Fig. 21 is substantially similar to that shown in Fig. 20, the principal difference being that the tube 39 in this embodiment of the invention is a diode instead of a triode. The operation is substantially the same, the tube 107 being subjected to the conjoint action of the voltages applied to the tube grids, which voltages, when derived from a received signal of sufficient strength, cooperate to stop the tuning element for the reception of the signal to which the set has been tuned. It may be noted, however, that the choke coil 123 employed in the anti-static time filter must be of very much higher inductance than the corresponding choke coil employed in the cathode circuit of the triode, as shown in Fig. 20. This is because of the higher plate impedance and the lower current of the diode, and also due to the fact that there is a degenerative action produced in the triode by the choke coil 123 that aids in discriminating against static, which is, of course, absent when the diode is employed, as in Fig. 21.

While it is desirable to have the tuning condenser or other type of variable reactance, such as a variable inductance, employed for tuning, operate at a considerable speed so as to avoid delay in tuning between two widely separated stations, there are, nevertheless, several reasons for limiting the speed. The character of the effective stopping signal is greatly influenced by the rate at which the station is tuned in. It is desir-

able for reasons of selectivity and exact tuning and the avoidance of a plurality of stoppages on the same signal to have the effective stopping signal extremely sharp. A signal width of the order of three kilocycles has given good results. This selectivity should be secured, as far as practical, by improving the Q of the stop-on-carrier tuned circuit rather than by too greatly cutting down the effective value of the positive stopping signal by too high a value of negative signal to reduce its width. Thus, a stronger stopping signal is obtained from a station of a given signal strength. With such a sharply tuned stop-on-carrier circuit, the duration of the stopping signal becomes very short with high speeds of rotation of the tuning condenser. As the duration of the stopping signal becomes shorter, there is less difference between a stopping signal from a desired station and an impulse of static, and it is therefore harder to discriminate between desired signals and undesired static. Further, if the carrier of a station is weak and the percentage of modulation is high and at a low audio frequency, the amplitude of the carrier may be reduced almost to zero for brief intervals. The stopping signal should be longer in duration than these zero signal intervals to minimize the skipping of stations. Furthermore, the faster the tuning condenser moves, the greater is the energy of rotation of its moving parts and the mechanism driving them. Additional difficulties are then presented by the need for instantaneously operating clutch or brake means to effect stoppage at resonance. It has been found that satisfactory results can be obtained by causing the condenser to traverse the band of broadcast frequencies in about six or seven seconds. Satisfactory operation has also been obtained on the short wave band by causing the condenser to traverse the band from 7 to 22 megacycles in from 30 to 35 seconds. At the above condenser tuning speeds and employing a stop-on-carrier triode 39, an anti-static filter system consisting of inductance 123, having a value of about 10 henries, condenser 124, having a value of about $\frac{1}{16}$ mf., and a resistance 125, having a value of about 30,000 ohms, has been found to give satisfactory results. It is also desirable at these speeds to reduce the energy of rotation of those parts that remain connected to the tuning condenser after the operation of the relay 109, as far as practical. It is also desirable to reduce the mass of the parts moved by the relay 109 as far as is consistent with an efficient magnetic circuit. Further, the parts moved by the relay 109 should be made to operate as easily as possible.

Attention is directed to the fact that the three specific types of gas tube mentioned herein, namely, the 884, the 2051, and the 2050, are not equally well adapted to the different methods of deionizing the tubes herein shown. The 884 is readily deionized by grounding the grid and thereby giving it a high momentary negative bias relative to the cathode. This method of deionizing is shown in Fig. 1 and Fig. 2. The R. C. A. 2050 and 2051 are more readily deionized by opening the cathode circuit, which method of deionizing is shown in Figs. 17, 20, and 21.

Although the invention has been described in connection with the specific details of preferred embodiments thereof, it must be understood that such details are not intended to be limitative of the invention except insofar as set forth in the accompanying claims.

Having thus described my invention, I declare that what I intend to claim is:

1. In a radio receiver having a power actuated tuning element, in combination, an amplifier, voltage supply means deriving a voltage from a received signal amplified by said amplifier, an inductance and a resistance in series with the output of said voltage supply means, a condenser across said resistance, a gas tube having its grid connected between said resistance and said inductance, and means in the plate circuit of said gas tube to control said tuning element.

2. In a radio receiver having a tuning element, amplifying means, an electron tube having a plate, grid and cathode, means coupling said grid to said amplifying means to provide a first control voltage to the grid, means including a rectifier coupled to said amplifying means supplying a second control voltage to said grid, a source of direct current plate voltage connected to the plate of said tube, an impedance in the plate-cathode circuit of said electron tube, means connected to the cathode side of said impedance for controlling said tuning element, and means for biasing said grid so that a substantial change in current flow through said impedance occurs when the first control voltage attains a maximum value exceeding the second as the tuning element is moved to tune in a station.

3. In a radio receiver having a power actuated tuning element, in combination, an amplifier for supplying signals from the amplifier to the grid, a gas tube having a grid, a plate, and a cathode, means coupling said grid to said amplifier, a relay in the plate circuit of said gas tube for arresting said tuning element, a source of plate current connected to said relay, and a condenser connected between the source side of said relay and said cathode producing a surge of current through said relay when a signal is impressed on said grid to ionize said gas tube.

4. In a radio receiver having a power actuated tuning element, in combination, an amplifier, a gas tube having a grid, plate, and cathode, means coupling said grid to said amplifier, means associated with said plate for stopping said tuning element when a positive signal on said grid causes said gas tube to ionize, resistance means connected between said cathode and ground, and a manually operable switch for grounding said grid to deionize said gas tube and start said tuning element.

5. In a radio receiver having a power actuated tuning element, in combination, amplifying means, electron tube means having two grids, one of which is coupled to said amplifying means, rectifying means coupled to said amplifying means supplying a bias to the other grid of said electron tube means, and means responsive to the plate current of said electron tube means to stop said tuning element in response to an amplified signal.

6. In a radio receiver having a power actuated tuning element, amplifying means having a tuned output transformer with a flat top resonance characteristic and a rectifier, an electron tube having a plate, grid and cathode, means connected to the plate-cathode circuit of said tube for controlling the tuning element actuating means, means including a connection from the grid of said tube to said rectifier for supplying a first control voltage to grid, a second electron tube having a plate, grid and cathode, means for supplying a second control voltage to the grid of said first electron tube, said means including a coupling between said transformer and the grid

of said second tube, a coupling between the plate circuit of said second tube and said connection to the grid of said first tube including a sharply tuned circuit in the plate circuit of said second tube, and means coupled to said sharply tuned circuit for effecting regeneration in said tuned circuit to increase its Q.

7. In a radio receiver having a power actuated tuning element, in combination, an amplifier, a gas tube having a grid, a plate, and a cathode, means coupling said grid to said amplifier, two relays connected in series in the plate circuit of said gas tube, a source of plate current connected to said relays, and a condenser connected between a point in the plate circuit between said two relays and said cathode for producing a surge of current through one of said relays when said gas tube is ionized.

8. In a radio receiver having a variable tuning element, in combination, amplifying means, a gas tube having a grid receiving a signal derived from said amplifying means, means in the plate circuit of said gas tube to stop said tuning element in substantial resonance with an amplified signal, resistance means in the cathode circuit of said gas tube, and means comprising a stepping relay and switch means operated thereby from one to another of two positions on successive operations thereof for varying said resistance means between two values to vary the degree of the signal required to ionize said gas tube between said two values.

9. In a radio receiver having a tuning means in combination, an amplifier, an electron tube means coupled to said amplifier, means for deriving two separate voltages from said electron tube means, a gas tube having two control elements, means for impressing one of said voltages on one of said elements, means for impressing the other voltage on the other element to ionize said tube, and means in the plate circuit of said gas tube for arresting said tuning means on ionization.

10. In a radio receiver having a power actuated tuning means in combination, an amplifier, an electron tube coupled to said amplifier, a second electron tube coupled to said amplifier, a gas tube having two control elements, sharply resonant means for supplying a voltage from first said electron tube to one of said elements, means for supplying an opposite voltage from second said electron tube to the other control element, and means in the plate circuit of said gas tube for arresting said tuning element.

11. In a radio receiver having a tuning element, amplifying means, an electron tube having a plate, grid and cathode, means coupling said grid to said amplifying means to provide a first control voltage to the grid, means including a rectifier coupled to said amplifying means supplying a second control voltage to said grid, a source of direct current plate voltage connected to the plate of said tube, an impedance in the plate cathode circuit of said electron tube, a gas tube having a plate, grid and a cathode, said gas tube having low resistance between plate and cathode when ionized and a high resistance when not ionized, a source of direct current plate voltage connected to the plate and cathode of said gas tube, relay means in said plate circuit for arresting said tuning element, a connection from the grid of the gas tube to the cathode side of said impedance, and means for biasing the grid of said electron tube so that a substantial change in current flow through said impedance occurs

when the first control voltage attains a maximum value exceeding the second as the tuning element is moved to tune in a station, whereby said gas tube is ionized and said relay energized to arrest the tuning element.

12. In a radio receiver having an adjustable tuning reactance, automatic means comprising a relay adapted when energized to arrest said reactance to tune in a desired carrier, a circuit including a source of direct current, a limiting resistance, said relay and switch means in series, said switch means being adapted to pass current to said relay to energize the relay, and a condenser shunted across said relay and switch means, whereby said condenser is charged when said switch means interrupts the flow of current through the relay and is discharged through the relay to effect rapid energization of the relay when the switch means passes current.

13. In a radio receiver having an adjustable tuning reactance, power means for adjusting said reactance, automatic means comprising a relay adapted when energized to arrest said reactance to tune in a desired carrier, a circuit including a source of direct current, a limiting resistance, said relay and switch means in series, and a condenser shunted across said relay and switch means, said switch being adapted to pass current through said relay, whereby the relay is energized rapidly by the discharge of the condenser, and the relay is held energized by current from said source limited by the limiting resistance, and said switch being adapted to interrupt the flow of said current, whereby the relay is deenergized.

14. In a radio receiver having a power actuated tuning element, in combination, an amplifier, a gas tube having a grid, a plate, and a cathode, means coupling said grid to said amplifier, a relay and a current limiting resistance connected in series in the plate circuit of said gas tube, a source of plate current connected to said current limiting resistance and said relay, and a condenser having one side connected between a point in the plate circuit between the relay and the limiting resistance and having the other side connected to said cathode for producing a surge of current through said relay when said gas tube is ionized.

15. In a radio receiver having a power actuated tuning element, in combination, an amplifier,

voltage supply means deriving a voltage from a received signal amplified by said amplifier, an inductance and a resistance in series with the output of said voltage supply means, a condenser across said resistance, an electron tube having a control electrode connected between said resistance and said inductance, and means in the plate circuit of said tube to control said tuning element.

16. In a radio receiver having a power actuated tuning element, in combination, an amplifier, a gas tube having a control electrode, plate, and cathode, a source of direct current plate supply voltage for said tube, means coupling said control electrode to said amplifier, means associated with said plate for stopping said tuning element when a signal derived from the amplifier and applied to said control electrode causes said gas tube to ionize, resistance means connected between said cathode and the plate supply voltage, and means including a manually operable switch for connecting said control electrode to a point between said resistance means and said plate supply voltage for deionizing said gas tube and starting said tuning element.

17. In a radio receiver having tuning means, in combination, an amplifier, electron tube means coupled to said amplifier, means for deriving two separate control voltages from said electron tube means, an electron tube having two control elements, means for impressing one of said voltages on one of said elements and the other voltage on the other element to control the plate current of said tube, and means controlled in response to the plate current of said tube for arresting said tuning means.

18. In a radio receiver having an adjustable tuning reactance, the combination including, automatic means comprising a relay adapted when energized to arrest said reactance to tune in a desired carrier, a circuit including a source of direct current, a current limiting resistance, and a gas tube in series with said relay, and a condenser shunted across said relay and tube, whereby said condenser is charged when said gas tube is deionized and interrupts the flow of current through the relay and is discharged through the relay to effect rapid energization of the relay when the gas tube is ionized.

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