July 18, 1939. J. M. RIDDLE, JR 2,166,693

SELECTIVITY CONTROL SYSTEM

Filed June 30, 1937

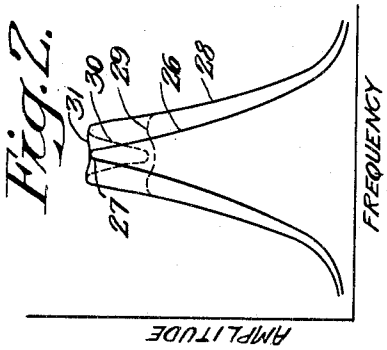


Fig. 2.

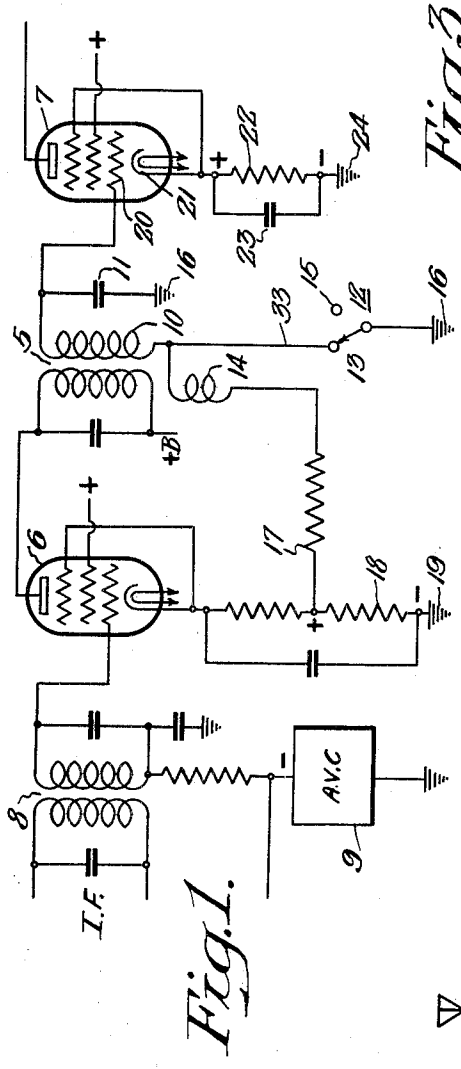


Fig. 1.

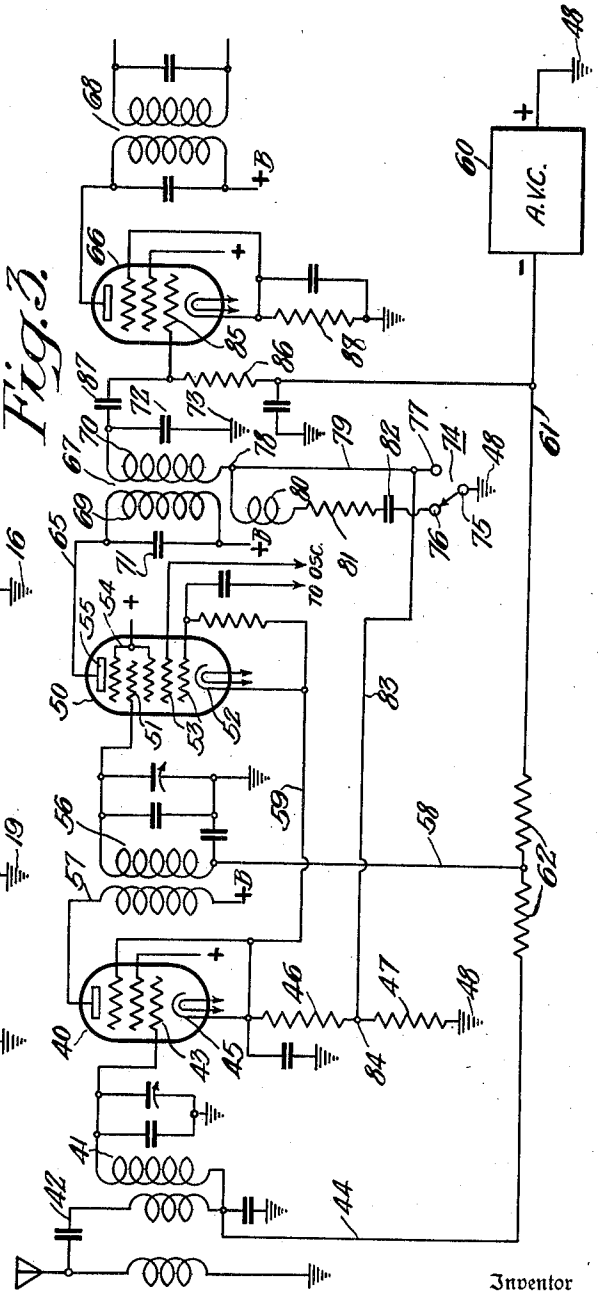


Fig. 3.

Inventor

James M. Riddle Jr.

By

Attorney

Patented July 18, 1939 2,166,693

UNITED STATES PATENT OFFICE

2,166,693

SELECTIVITY CONTROL SYSTEM

James M. Riddle, Jr., West Collingswood, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Application June 30, 1937, Serial No. 151,217

6 Claims. (Cl. 250—20)

The present invention relates to selectivity control systems for radio receivers requiring a high degree of sensitivity, such as automobile receivers, for example, and has for its object to provide improved and simplified means for changing the selectivity and concurrently adjusting the gain to maintain the volume level substantially constant, or to change the volume level as required in any case, conjointly with selectivity and in predetermined relation thereto.

Control circuits for automobile receivers are preferably simplified, whereby a large number of circuit components and circuit changes are eliminated. Accordingly, it is a further object of the present invention to provide a simplified selectivity control system for a radio receiver adapted for use in vehicles, wherein the selectivity and gain may be adjusted concurrently by a single circuit switching operation.

In accordance with the invention, selective switching of an additional coupling coil in an intermediate frequency transformer into and out of circuit for selectivity control, is accompanied by a concurrent change in the gain of the amplifying system. The selectivity and gain are changed concurrently in predetermined relation to each other by a single means. In a specific embodiment of the invention, the loss in gain occurring in changing the coupling between intermediate frequency amplifier circuits is prevented or compensated.

The invention will, however, be better understood from the following description, when considered in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

In the drawing,

Figure 1 is a schematic circuit diagram of a portion of an intermediate frequency amplifier for a radio receiving system, provided with a selectivity control system embodying the invention,

Figure 2 shows curves illustrating a method of operation of the circuit of Fig. 1, and

Figure 3 is a schematic circuit diagram of an amplifier for a radio receiving system provided with a further embodiment of the invention.

Referring to Fig. 1, a selectivity control circuit is applied to an intermediate frequency amplifier coupling transformer 5, which is utilized to couple two intermediate frequency amplifier tubes 6 and 7. As superheterodyne receivers are well known, the remainder of the receiving system is not illustrated except for an intermediate frequency coupling transformer 8 which couples the tube 6 to the preceding portions of the receiving system, and a circuit element in block form indicated at 9 representing the automatic volume control elements of the receiving system as applied to the tube 6 and the preceding tubes.

As is well understood, the intermediate frequency signals are amplified by the tubes 6 and 7, being applied thereto through the tuned circuits of the coupling transformers 8 and 5, respectively, and the intermediate frequency output from the tube 7 is applied to any suitable circuit, such as a following detector or amplifier circuit.

In conjunction with the transformer 5, which, as hereinbefore referred to, is arranged to provide selectivity control, the tuned secondary circuit includes a secondary winding 10 and a shunt tuning capacitor 11. The low potential end of the secondary 10 is selectively connectable directly to the tuning capacitor 11 through a switch 12 having a contact 13 for this purpose, or may be connected indirectly to the tuning capacitor 11 through a coupling coil 14 when the switch is moved to a contact 15 to open circuit the direct connection with the capacitor 11. In the present example, the capacitor 11 and the switch are connected to chassis ground, as indicated at 16, as the common circuit return connection for the receiving system.

When the switch is moved to the contact 15, the circuit through the coupling coil 14 is arranged to include a series resistor 17 and a fixed potential source 18, the latter being connected to ground 19. The fixed potential source 18 is preferably a portion of the self-bias resistor for the preceding amplifier tube 6 although it may be any suitable source of constant potential having a relatively low resistance to ground and having a polarity such that upon being included in circuit with the coil 14 and the tube 7, the gain of the tube 7 is increased by an amount corresponding to the decrease in gain effected by the insertion of the coil 14 in the secondary circuit to which the tube 7 is connected.

The amplifier tube 7 may be of any suitable type, preferably of the high mu pentode type, such as an RCA 6K7, with a control grid indicated at 20 connected with the secondary coil 10 to receive signals therefrom, and biasing potential therethrough, selectively from the direct chassis ground connection provided by the switch contact 13 or the indirect connection provided through the coil 14. The cathode of the tube 7, indicated at 21, is provided with a self-bias resistor 22 and a suitable intermediate frequency

by-pass capacitor 23. The resistor 22 is connected to the chassis or common circuit return 24, wherefrom a predetermined biasing potential is applied to the control grid 20.

When the switch 12 is closed to the contact 13, the coil 14 is rendered ineffective to provide additional coupling with the primary, and at the same time the biasing potential provided by the source 22 is applied to the grid 20 to provide a predetermined high gain through the amplifier stage comprising the transformer 5 and the tube 7, and a high degree of selectivity, as shown by the curve 26 in Fig. 2, to which attention is now directed along with Fig. 1. It will be seen that the frequency response for maximum gain is relatively sharp at the peak 27, the response characteristic being adjusted for any desired degree of selectivity by adjusting the coupling of the transformer windings and other constants of the circuit.

For receiving strong local signals with increased fidelity, the coil 14 is effectively inserted in the secondary circuit of the coupling transformer by merely opening the ground connection which is provided by operating the switch to open the connection with the contact 13 and in the present example, moving the switch to the open circuit contact 15. Extension of this circuit for remote control purposes involves merely the extension and shielding of the lead indicated at 33 to the switch and ground.

While the operation of the switch to the contact 15 provides increased coupling, it may cause the gain of the system to be lowered slightly, as indicated by the curve 28 and a flat top portion thereof shown in dotted lines at 29. The reduction in gain is compensated by the same circuit switching operation and means, for the reason that in addition to the coupling provided by the coil 14, the biasing potential provided by the source 18 is in series between the coil 14 and the self-bias resistor 22 through the ground connections 19 and 24, and causes a reduction in the biasing potential effective on the grid. This is because the potential source 18 is in opposition to the self bias source 22 by an amount sufficient to reduce the negative bias to restore the gain to the previous level, as indicated by the flat top 31 of the curve 28.

The resistance in series at 17, and as further augmented by the resistor 18, provides effective means for preventing a double peak, indicated at 30, from appearing in the flat top 31, sufficient resistance being introduced in circuit to overcome the effect of a certain amount of overcoupling which is provided between the coil 14 and the primary winding of the transformer 5. which normally tends to produce the double peaked response.

The signal amplitude produced in either case, as indicated by the curves 26 and 28, may be made the same by proper adjustment of the biasing potential provided by the source 18, this being in the present example, sufficient to restore the level from that indicated at 29 to that indicated at 31.

The means provided for this purpose includes merely a selector switch having contacts closed to connect the low potential end of the secondary of the coupling transformer directly with the secondary tuning capacitor. Opening the switch contacts then renders effective the additional coupling coils between primary and secondary, the series damping resistor and the biasing means, to decrease the selectivity, to prevent double peaked response, and to restore the gain to that provided for the previous selective response connection, all being effected by simply opening the switch contacts. Selectivity and gain control is thus provided by connecting a single lead to ground through a simple two-point switch, whereby it is readily adapted for automobile receivers and the like, permitting a dashboard control of selectivity, if desired, by merely shielding the lead, indicated at 33, when extended. Usually, however, this lead will be included within the receiver, as will also the switch 12.

It will be noted that the resistor 18 forms part of the self-bias resistor for a preceding amplifier tube 6. The series circuit connected in parallel with the resistor 18 may include sufficient resistance, for example at 17, to prevent any material change in gain in the preceding tube, or it may have sufficiently low resistance to provide a predetermined change in gain and sensitivity, as may be desired.

For example, the concurrent change of selectivity and gain through a single selector switch and circuit may be applied to a plurality of amplifying stages, wherein the gain of a plurality of tubes is dependent upon the change in biasing potential effected by control of a single biasing resistor section in the cathode return lead of a plurality of the controlled tubes, without increasing the number of contacts provided in the switch from that shown at 12.

Furthermore, the gain or sensitivity may be adjusted conjointly with the selectivity to provide increased sensitivity when the selectivity is maximum, and a decreased sensitivity when the selectivity is minimum and the fidelity is at a maximum for receiving strong local signals, and also the tuning of the selectivity control circuit may be adjusted without increasing the number of switch contacts, as will be seen from a consideration of the circuit shown in Fig. 3, to which attention is now directed.

In the receiving system shown, a radio frequency amplifier tube 40 is provided with a tuned input circuit 41, which is coupled to an antenna by a signal input circuit 42. The tube 40 is provided with a signal input or control grid 43, connected through the input circuit to an automatic volume control lead 44, and the cathode, indicated at 45, is connected through a cathode or self-bias resistor comprising two sections 46 and 47, in series between the cathode and the common circuit return element or chassis, indicated at 48.

The first detector or mixer tube is indicated at 50, and comprises a signal input grid 51, a cathode 52, oscillator elements 53, a screen 54 for the control grid 51, and an output anode 55. The control grid is coupled through a tuned input circuit 56, with the output circuit 57 of the preceding radio frequency amplifier tube 40, and through the input circuit 56 and a lead 58, is connected to the automatic volume control lead 44. The cathode 52 is connected through a lead 59 with the cathode 45 of the preceding tube, whereby the cathode resistors 46 and 47 are common to both tubes for applying bias to the grids.

Additional bias is provided by automatic volume control means 60, connected between the chassis 48 and an extension 61 and an automatic volume control lead 44. In the present example, the leads 44 and 58 provide branch circuits through series filter resistors 62 from the lead 61.

Intermediate frequency signals resulting from mixing in the tube 50 are derived from the output circuit 65 connected with the output anode 55, and the output circuit is coupled to an intermediate frequency amplifier of which the first tube is indicated at 66, through a suitable coupling transformer 67. Output coupling for the tube 66 is indicated by the interstage transformer 68.

Any of the intermediate frequency amplifier transformers may be utilized to provide selectivity control, and in the present example the transformer 67 is selected for this purpose, being at the input of the intermediate frequency amplifier. The transformer comprises a primary winding 69, a secondary winding 70, and shunt tuning capacitors 71 and 72 for the primary and secondary windings respectively, the latter being connected to ground or chassis as indicated at 73.

As in the preceding embodiment of the invention, the tuned secondary winding 70 is selectively connectable to chassis or ground 43 through a switch 74 having a movable contact 75 and two fixed contacts 76 and 77. The low potential terminal 78 of the secondary winding 70 is connected directly to the contact 77 through a lead 79, and indirectly to the contact 76 through a coupling winding 80. The latter is inductively coupled to the primary winding 69 and is in circuit with series resistor 81 and series capacitor 82, as shown. The capacitor is used as a stopping capacitor for preventing the flow of direct currents, and is of such a value that when inserted in circuit with the secondary, by moving the switch to the position shown, it corrects the tuning of the secondary circuit slightly, to restore it to resonance, as provided when the switch is at the contact 77 to exclude the series circuit above referred to.

The contact 77 is also connected, through a bias supply lead 83, with a tap point 84 located on the self-bias resistor 46—47, and in the present example is connected between the resistor sections.

The control grid of the intermediate frequency amplifier tube is indicated at 85, and is connected through a grid resistor 86 to the automatic volume control lead 61. It is also coupled to the secondary circuit of the transformer 67, through a coupling capacitor 87, whereby the bias potential on the intermediate frequency amplifier is controllable only by the automatic volume control means, and the initial bias is provided by a suitable self-bias resistor 88 in the cathode lead of the tube 66.

The operation of the system described is such that the two-point switch 74 is effective to control both the selectivity and the sensitivity of the system conjointly, and in addition to correct for slight changes in tuning of the secondary circuit of the selectivity control transformer 67.

When the switch in the position shown, whereby contact is made through the switch contacts 75 and 76, the coupling coil 80, the series resistor 81, and the series capacitor 82 are in circuit with the secondary tuned circuit comprising the secondary 70 and the tuning capacitor 72. Because of the additional coupling provided between the coil 80 and the primary winding 69, the response of the receiving system is broadened, that is, the selectivity is decreased. The series resistor 81 prevents a double peak in the broadened response characteristic, as hereinbefore explained in connection with Fig. 2, and the capacitor 82 permits a relatively large coupling inductance 80 to be inserted by the switching operation, without changing the mean frequency of the band passed by the transformer 67 when the selectivity is broadened. The additional coupling thus includes damping means for the secondary circuit.

In this position of the switch, the full biasing potential available across the self-bias resistor 46—47 is applied to the control grids 43 and 51 of the several tubes, to provide a predetermined lower gain or sensitivity suitable for the reception of relatively strong signals with improved fidelity.

In an automobile receiver, this condition of operation is desirable when operating in the vicinity of strong local stations having good fidelity, or when increased sensitivity would be undesirable in the presence of static and other stray signal noises. Sensitivity is not reduced to a relatively low level, but may be considered as the normal sensitivity from which the sensitivity may be increased for extreme distance reception.

As is well understood, an automobile radio receiver must have a relatively high degree of sensitivity under all conditions of operation, because of the nature of the small signal pick-up system permissible on a moving vehicle. Therefore, when distant reception is desired, under favorable conditions, the selectivity may be increased to normal or relatively sharp and the sensitivity may be raised above normal by moving the switch contact 75 to the contact 77. This simple switching operation places the capacitor 72 directly in shunt with the secondary 70, to the exclusion of additional coupling and effectively short-circuits a portion of the self-bias means comprising the section 47. This reduces the biasing potential applied to the control grids of the several amplifier tubes, such as the tubes 40 and 50, thereby raising the sensitivity and the gain of the system above a predetermined normal value. In either mode of operation, the automatic volume control means 60 operates in the usual manner to control the output of the receiver when the signal strength exceeds a predetermined level.

From the foregoing description, it will be seen that in accordance with the invention, the sensitivity and selectivity of a radio receiving system for automotive vehicles and the like may be provided by a single control circuit including a simple switch having a minimum number of switching contacts, and that the control circuit is particularly adapted for remote control extensions for dash-board operation and the like.

Furthermore, it will be seen that, without additional contacts in the switching control means, corrections may be obtained for tuning of the selectivity control circuit when a high degree of coupling is desired, and that the coupling may effectually be controlled to prevent a double peaked response characteristic without additional contacts in the control switch. Not only is the control of sensitivity and selectivity confined to a single element of the receiving system, such as the amplifying means, but it may be confined to a single circuit associated with one amplifying stage and the input coupling means therefor. By suitable choice of the biasing potential controllable conjointly with selectivity by the single switch means, the gain or sensitivity of the system may be maintained constant, or may be increased or decreased, as desired, with change in selectivity.

I claim as my invention:

1. In an intermediate frequency amplifier, the

combination with an intermediate frequency amplifier tube, of means for applying signals thereto including a coupling transformer having a tuned secondary winding responsive to a mean intermediate frequency, means for applying a biasing potential to said tube through said secondary winding including a circuit having a switch therein, said switch being closed to complete said circuit and means for controlling the selectivity and sensitivity of the amplifier stage including said tube, said last-named means comprising an additional coupling winding for said secondary connected to said first-named circuit adjacent to said secondary winding, a series damping resistor and a direct current potential drop producing circuit element, said elements being connected in series across said switch, whereby, when said switch is opened, said elements are included in the secondary circuit.

2. In a superheterodyne receiver, the combination with an intermediate frequency amplifier including a plurality of amplifier tubes, of means for applying a biasing potential to certain of said tubes to adjust the gain thereof, a switch having contacts for adjusting said gain in circuit with said first-named means, a coupling circuit for another of said tubes tuned to a predetermined mean frequency, means for controlling the selectivity of said circuit without changing the mean frequency response thereof including a serially connected coupling winding, a resistor for removing a double peak response and a series capacitor for imparting to said coupling winding a high inductance characteristic, and a contact in said switch for controlling said last-named means.

3. In an intermediate frequency amplifier, the combination of an interstage coupling transformer having a tuned primary circuit, a tuned secondary circuit, and an additional coupling winding for said secondary circuit connected therewith at the low potential end thereof, a series resistor in circuit with said coupling winding, means providing a biasing potential for said amplifier in circuit with said coupling winding and a selectivity and sensitivity control switch in circuit with said last-named means and coupling means having contacts operable to effectively exclude said coupling winding, resistor and potential source from the secondary tuned circuit.

4. In a radio receiving system, the combination with a signal amplifier, of selectivity and sensitivity control means comprising a tuned signal input circuit, an amplifier tube having a control grid connected with said circuit, a single circuit connected with said first named circuit providing increased signal input coupling and decreased selectivity for said first named circuit, said single circuit including a series double-peak response controlling resistor and means providing additional biasing potential for said grid, and a single selectivity and sensitivity control switch having contacts for short circuiting said last named circuit.

5. In a radio receiver for automotive vehicles, circuit means for conjointly controlling the selectivity and sensitivity thereof including a circuit having a coupling winding therein, a series resistor and a bias potential supply element, a switch for short-circuiting said circuit, an amplifier tube, a tuned input circuit therefor having a coupling winding and a tuning capacitor connected at the low potential side thereof through said first-named circuit.

6. In a radio receiving system including a plurality of signal amplifier tubes, the combination of means providing a potential for adjusting the gain of at least one of said tubes, means for adjusting the coupling between certain of said tubes to control the selectivity characteristic of said system, said last named means including a coupling winding and a single control circuit through said winding and said first named potential means, and a single switch means in said control circuit for conjointly controlling connections with said winding and potential means, thereby conjointly to control the adjustment of gain and selectivity by operation of said switch means in said circuit.

JAMES M. RIDDLE, JR.