April 2, 1946. J. R. FORD 2,397,850

AMPLIFIER GAIN CONTROL

Filed Aug. 22, 1942

FIG. 1.

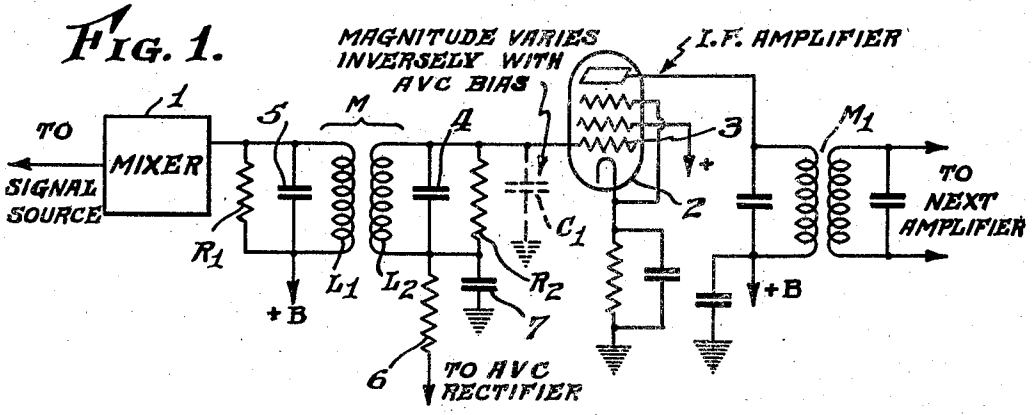


FIG. 2.

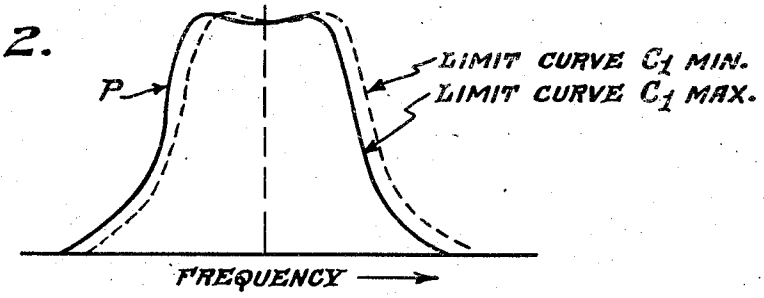


FIG. 3.

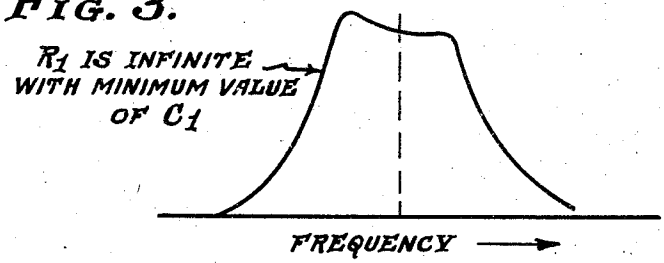
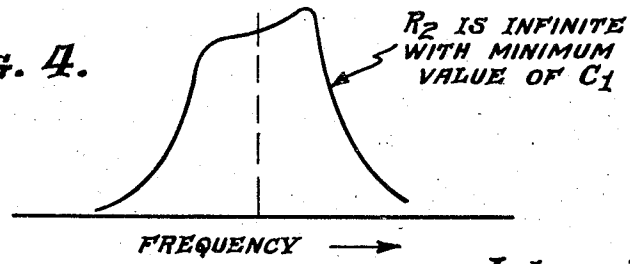


FIG. 4.



Inventor
John R. Ford

By H. S. Sawyer

Attorney

Patented Apr. 2, 1946 2,397,850

UNITED STATES PATENT OFFICE

2,397,850

AMPLIFIER GAIN CONTROL

John R. Ford, Narberth, Pa., assignor to Radio Corporation of America, a corporation of Delaware

Application August 22, 1942, Serial No. 455,733

2 Claims. (Cl. 179—171)

My present invention relates to amplifier gain control circuits, and more particularly to tuned radio frequency amplifiers provided with automatic gain control.

One of the main objects of my present invention is to avoid any change in the shape of the frequency response curve of a radio frequency amplifier due to change in input, or grid, capacity as the gain of the amplifier is varied.

Another important object of this invention is to provide a radio frequency amplifier provided with a band pass input circuit and means for varying the gain of the amplifier; there being included in the band pass input circuit sufficient loading to prevent a change in the shape of the band pass response curve of the input circuit as the gain of the amplifier is varied.

Another object of the invention is to provide an amplifier of the pentode type provided with a pair of coupled tuned input circuits, the coupling between the tuned circuits being chosen to provide a substantially flat top band pass curve, and the tuned circuits being individually loaded to a sufficient extent to prevent a substantial change in the response curve shape as the input capacity of the pentode tube is varied in response to gain control of the tube.

Still other objects of the invention are to improve generally the efficiency and fidelity of intermediate frequency amplifiers of the band pass type which are subject to gain control action, and more especially to provide such amplifiers in an economically manufacturable manner.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims; the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description taken in connection with the drawing in which I have indicated diagrammatically a circuit organization whereby my invention may be carried into effect.

In the drawing:

Fig. 1 shows an intermediate frequency (I. F.) amplifier circuit embodying the invention,

Fig. 2 graphically shows the effect of the present invention,

Fig. 3 illustrates one change in the band pass response curve in the absence of the invention,

Fig. 4 illustrates a different type of undesirable change in the band pass response curve in the absence of the invention.

Referring now to Fig. 1, and assuming for the purposes of illustration that the invention is embodied in a superheterodyne receiver of the broadcast band covering a range of 550 to 1700 kilocycles (kc.), reference is made to numeral 1 which denotes the usual mixer, or converter, stage of the receiver. Those skilled in the art are fully acquainted with the circuit details of a mixer stage, and are also fully acquainted with the manner of connecting the input terminals thereof to one or more preceding tunable radio frequency amplifiers. The latter usually have a signal collecting device which feeds the first of the amplifiers. It is to be clearly understood that the invention is not limited to a receiver of the superheterodyne type, nor to the particular specified operating range. For example, the invention may be used in the megacycle range if desired. The output circuit of the mixer develops the intermediate frequency (I. F.) energy, and let it be assumed that the operating I. F. value is 465 kc. Here, again, any other value of I. F. may be employed.

The numeral 2 designates a pentode amplifier tube, although any other type of tube may be used which functions well as an I. F. amplifier. The control grid 3 thereof is connected to the high potential side of the resonant input circuit which comprises coil L_2 shunted by condenser 4. The input circuit L_2—4 is tuned to the operating I. F. value. Coil L_2 is magnetically coupled, as indicated at M, to the primary coil L_1. The latter is shunted by condenser 5. The circuit L_1—5 is tuned to the operating I. F. value. The primary resonant circuit of the I. F. transformer is arranged in the output, or plate, circuit of the mixer tube. Hence, the low potential end of coil L_1 is connected to the plus B terminal of the direct current supply source. A resistor R_1 is connected in shunt with the primary circuit.

The low potential end of coil L_2 is connected through a filter resistor 6 to a point on the load impedance of an AVC (automatic volume control) rectifier such that with increase of carrier intensity the aforesaid point becomes increasingly negative. Those skilled in the art are fully aware of the manner of constructing an AVC circuit, and, therefore, it is not necessary to describe in detail the AVC circuit. It is pointed out that there will be applied to the control grid 3 of amplifier tube 2 a variable negative bias which functions to control the gain of the amplifier tube. In the specific illustration disclosed in this application, the variable negative bias is that produced by the usual carrier rectifier of the diode type, and a point of increasing negative potential with increased carrier amplitude is connected to the

lower end of coil L_2 through the carrier filter resistor 6. Gain may also be controlled by varying the voltage of another electrode, as for example the screen grid.

The secondary circuit L_2—4 is shunted by resistor R_2. The low potential end of the secondary circuit may be bypassed to ground by condenser 7 for I. F. currents. In the plate circuit of amplifier 2 there is arranged an I. F. transformer M_1 whose primary and secondary circuits are individually tuned to the operating I. F. value. The remaining parts of the circuit shown are purely conventional, and need not be described in further detail. It is sufficient to point out, however, that the secondary circuit of transformer M_1 may be coupled to the input electrodes of a following I. F. amplifier 2. The following amplifier may be succeeded by a demodulator which is followed in turn by one or more stages of audio frequency amplification terminated by a reproducer.

I have indicated in Fig. 2 a full line curve P which shows the band pass response curve of the I. F. resonant network between the mixer stage and the input electrodes of I. F. amplifier tube 2. This substantially flat-top, band pass response curve is secured by proper choice of the coupling M, and the proper choice of the values of the load resistors R_1 and R_2. If the coupling M is adjusted to pass a given band of frequencies, the pass band may be made substantially flat topped either by adjusting R_1 to a suitable value with R_2 infinite, or by adjusting R_2 to a suitable value with R_1 infinite. In either case the band pass response curve will be substantially represented by the full line curve P in Fig. 2.

This response curve shape is, however, not maintained when the gain of amplifier tube 2 is varied. As the bias voltage applied to the control grid 3 is increased in a negative sense on the control grid of amplifier tube 2, its grid input capacity decreases in magnitude. I have represented the input grid capacity in dotted lines as C_1. This inherent grid to cathode capacity shunts the secondary circuit L_2—4. It is pointed out that the inherent grid to cathode capacity C_1 will have a minimum value for maximum AVC bias magnitude, while the capacity C_1 will have maximum value with minimum AVC bias magnitude. In other words, the magnitude of the inherent capacity C_1 varies inversely with the magnitude of AVC bias. Merely by way of example, it is pointed out that the capacity C_1 may vary as much as 3 micromicrofarads in the case of an I. F. amplifier tube. The capacity effect C_1 is known as the "Miller" effect, and is due to feedback through the plate to grid capacity of tube 2. This feedback is a function of tube gain.

The effect of the input capacity C_1 on the shape of the band pass response curve, as the gain of amplifier tube 2 is varied, is illustrated in Figs. 3 and 4. Taking the case of R_1 having infinite value, while R_2 is adjusted to a value such as to give a desired flat top band pass curve, the curve will appear as shown in Fig. 3 if the AVC bias is increased thereby decreasing the magnitude of grid capacity C_1. It will be noted that the upper left portion of the curve is raised while the opposite right hand portion is lowered. This results in distortion of the modulation side band frequencies. On the other hand if the resistor R_2 is infinite, and R_1 is chosen so as to provide the desired band pass curve, an increase in AVC bias will cause the band pass curve to appear as shown in Fig. 4.

According to my present invention the effects represented in either of Fig. 3 or 4 are prevented. The band pass shape of the curve is maintained, as indicated by the dotted line curve in Fig. 2, for all values of the capacity C_1. It will be noted, however, that frequency displacement of the mid-band frequency value occurs. However, this frequency displacement is so small as to be inappreciable. When receiving modulated carrier energy in the broadcast band, the band pass circuit generally has a width of 10 kc. With such a frequency band value, a slight shift in mid-band frequency is not observed in the reproduction of the modulation frequencies. What is more essential is that the shape of the band pass curve be maintained.

In order to maintain the band pass response curve for all values of C_1, it is merely necessary critically to load the winding L_2 as described above. It is now possible to find a resistance load for the opposite coil such that the frequency curve will remain flat while shifting upward in frequency. For example, if loading of coil L_1 is so chosen that R_1 is infinite, then the magnitude of R_2 will be such as to prevent the change in curve shape which is shown in Fig. 3. What will occur will be a slight shift in mid-band frequency while the response curve itself has its shape maintained.

To enable one skilled in the art to practice the invention the following specific description is given. First design an I. F. transformer to be loaded on one coil, and having the proper coefficient of coupling to give the desired band width. Determine the value of R_1 necessary to give a flat top response with no loading on the grid coil. Then determine R_2 necessary to give a flat top response with no loading on the plate coil. With R_2 connected across the grid coil a resistor can be found greater in value than R_1 which, when connected across the plate coil, will permit the gain to be changed without altering the shape of the response curve. The response curve will now be slightly more rounded than before. A slight increase in the value of R_2 will restore the original curve.

Suppose the tube 2 is a high mutual conductance pentode operating in an I. F. stage at 30 megacycles, and that the band width is 2 megacycles. Capacitors 4 and 5 are 68 and 10 mmf., (micromicrofarads) respectively. The following relations between R_1 and R_2 result:

R_1	R_2	Result when grid bias is changed
Infinite	470 ohms	Gain falls at high end of pass band.
2200 ohms	Infinite	Gain falls at low end of pass band.
6800 ohms	560 ohms	Gain remains flat over pass band which shifts upward about 100 kc.

While I have indicated and described a system for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is by no means limited to the particular organization shown and described, but that many modifications may be made without departing from the scope of my invention, as set forth in the appended claims.

What I claim is:

1. In combination with a high frequency amplifier tube provided with input electrodes and output electrodes, a band pass input network connected to said input electrodes, said network comprising a pair of resonant circuits each tuned to a frequency of the order of 30 megacycles.

means for coupling said resonant circuits to provide a response curve for the amplifier which has a substantially flat top over a band width of the order of 2 megacycles, means for varying the gain of said amplifier tube thereby introducing a variable magnitude of input electrode capacity across the resonant circuit directly connected to said input electrodes, a resistance of the order of 6800 ohms connected across one of said resonant circuits, a second resistance of the order of 560 ohms connected across the second of the resonant circuits, said two resistances functioning to permit the aforesaid band pass response curve maintain its shape over a midband frequency shift up to 100 kilocycles regardless of the magnitude of said input electrode capacity.

2. A method of constructing a band pass amplifier of the type comprising an amplifier tube having an input network consisting of a pair of resonant circuits each tuned to a common desired frequency; the method including the steps of reactively coupling said circuits in cascade to provide a band pass response curve of a desired width for the amplifier, first loading the first resonant circuit with resistance sufficient to provide said response curve with a flat top while maintaining the second resonant circuit free of loading, removing the loading of the first circuit during the step of loading the second circuit with sufficient resistance to secure said flat top response curve, and loading again said first resonant circuit while, maintaining said second resistive loading, to a resistance value sufficiently in excess of said first loading resistance value to maintain said flat top response curve over a relatively substantial range of variation of the gain of said amplifier tube.

JOHN R. FORD.