

Jan. 2, 1940:

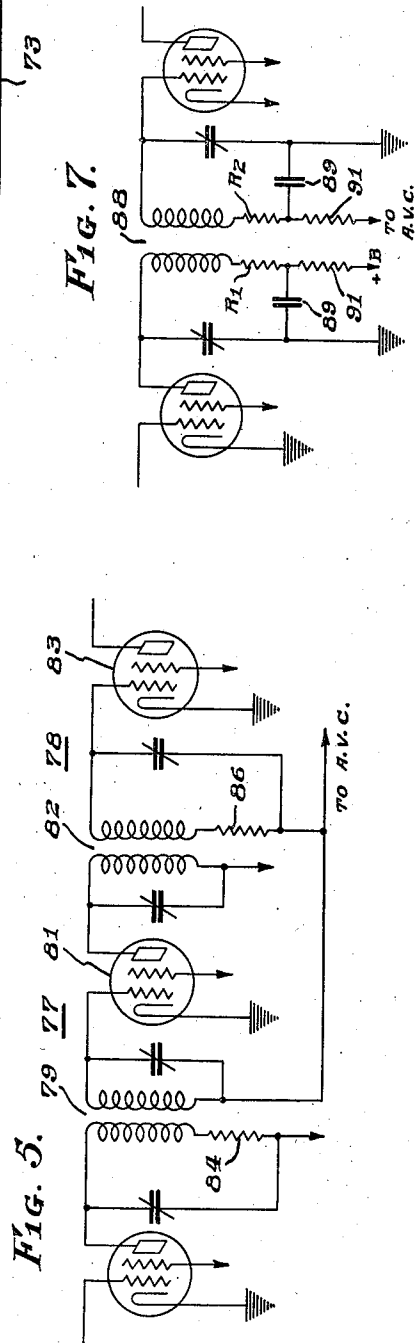
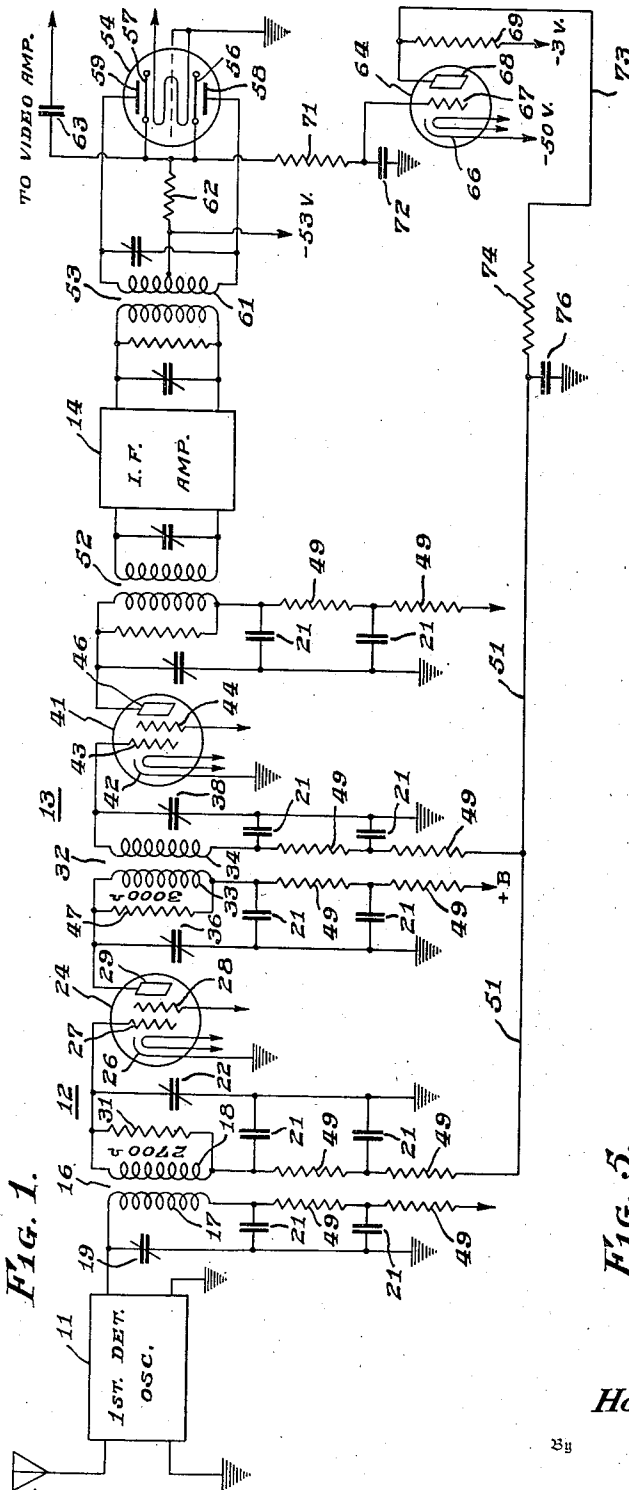
H. C. ALLEN

2,185,879

HIGH FREQUENCY AMPLIFIER

Filed Aug. 29, 1936

2 Sheets-Sheet 1



Inventor
Horace Clifford Allen

J. Huff

Attorney

Jan. 2, 1940.

H. C. ALLEN

2,185,879

HIGH FREQUENCY AMPLIFIER

Filed Aug. 29, 1936

2 Sheets-Sheet 2

Fig. 2.

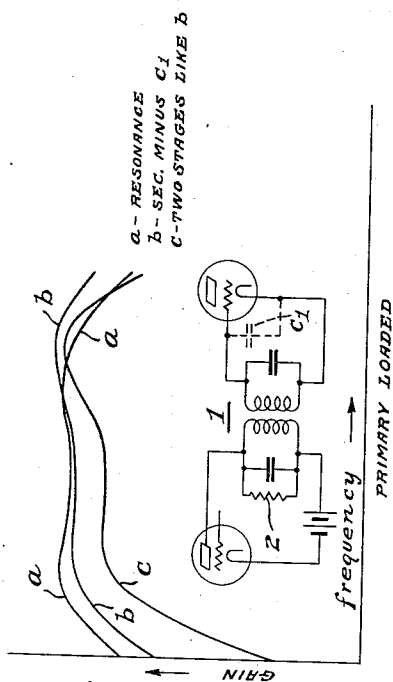


Fig. 3.

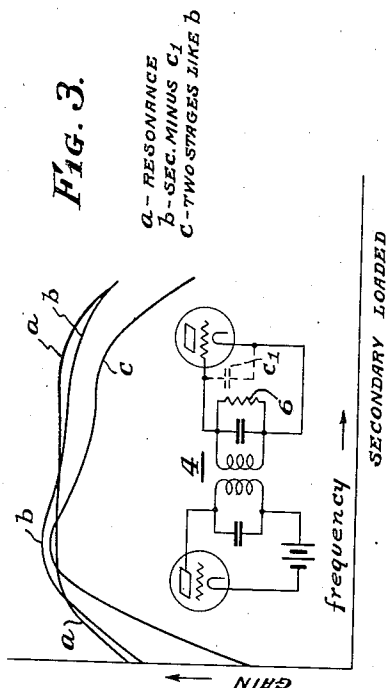


Fig. 4.

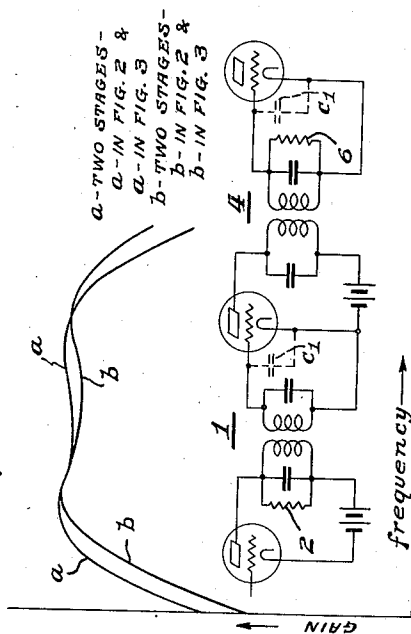
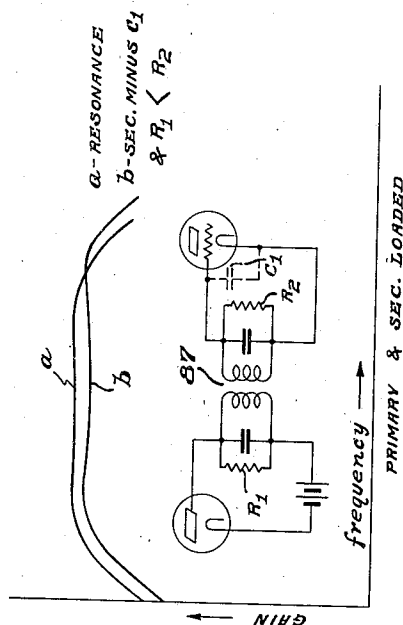


Fig. 6.



Inventor
Horace Clifford Allen

39

J. Huff

Attorney

UNITED STATES PATENT OFFICE

2,185,879

HIGH FREQUENCY AMPLIFIER

Horace Clifford Allen, Marlton, N. J., assignor to
Radio Corporation of America, a corporation
of Delaware

Application August 29, 1936, Serial No. 98,453

8 Claims. (Cl. 179—171)

My invention relates to high frequency amplifiers and particularly to amplifiers in radio or television receivers having automatic volume control.

In superheterodyne receivers for the reception of short waves such as those preferred in television transmission, the intermediate frequency amplifier must be tuned to such a high frequency that the tuning capacities are comparable to the tube input capacities. For the most satisfactory operation such receivers require automatic volume or gain control, the gain of the I. F. amplifier being varied in accordance with variations in the strength of incoming signals as by varying the negative bias on the control grids of the amplifier tubes.

It is well known that the input capacity of a vacuum tube depends, not only upon the physical dimensions of the tube parts, but also upon the amount of voltage applied to the tube electrodes. For example, a change in negative bias applied to the control grid changes the input capacity. This change in capacity with change in electrode voltage is caused by the space charge effect, the cloud of electrons surrounding the cathode acting as a "virtual cathode" and varying in size with changes in tube bias or the like.

It will be apparent that the operation of an A. V. C. circuit in the above-mentioned type of receiver will tend to detune the I. F. amplifier.

It is an object of my invention to provide an improved television or short wave radio receiver of the type having either manual or automatic volume or gain control.

More specifically, it is an object of my invention to provide an improved high frequency amplifier so designed that its gain may be varied without adversely affecting its selectivity characteristic to any substantial extent.

A further object of my invention is to provide an improved I. F. amplifier in a short wave receiver.

It is the usual practice to tune an I. F. transformer in a superheterodyne receiver by connecting condensers across both the primary and the secondary to tune them to approximately the same frequency and coupling the primary and secondary closely enough to produce a double peaked curve in the absence of loading resistance in the circuit. In order to obtain a broad flat response curve, either the primary, the secondary, or both are loaded by one or more resistors. I have discovered that by properly loading either a single amplifier stage or successive amplifier stages the selectivity characteristic

of the amplifier is not greatly changed by changes in bias produced by the A. V. C. circuit.

Other objects, features and advantages of my invention will appear from the following description when taken in connection with the accompanying drawings in which

Figure 1 is a circuit diagram of one embodiment of my invention,

Figures 2, 3 and 4 are curves and circuit diagrams which are referred to in explaining my invention,

Figure 5 is a circuit diagram showing another embodiment of my invention,

Figure 6 is a pair of curves and a circuit diagram which are referred to in explaining another embodiment of my invention, and

Figure 7 is a circuit diagram of still another embodiment of my invention.

My invention will best be understood by referring first to Figures 2, 3 and 4. In Figure 2 the curve *a* is a selectivity curve for the tuned intermediate frequency transformer indicated at 1. This transformer has its primary loaded by means of a shunting resistor 2 whereby the selectivity curve is made flat-topped. The curve *a* represents the selectivity characteristic of the I. F. transformer when the Capacity C_1 is included in shunt to the transformer secondary. The capacity C_1 is present in all amplifiers because of the input capacity of the amplifier tube. If the capacity C_1 is removed, as by making the control grid of the amplifier tube more negative for the purpose of reducing the gain of the amplifier and thereby reducing the input capacity, the selectivity curve of the I. F. transformer is as shown by the curve *b*. If two such stages are connected in cascade, their overall selectivity characteristic is as shown by the curve *c*. Obviously such a selectivity characteristic is undesirable as it accentuates the high frequencies.

Referring to Figure 3, the curve *a* is the selectivity curve for an I. F. transformer 4 having its secondary loading by a resistor 6 and having capacity C_1 in shunt to the secondary. If the capacity C_1 is removed, as by making the control grid more negative to reduce the gain of the amplifier, the selectivity of the I. F. transformer is then represented by the curve *b*. If two such amplifier stages are connected in cascade, their overall selectivity characteristic is as represented by the curve *c*. Obviously this overall selectivity curve is just as undesirable as the selectivity curve *c* in Figure 2 since it accentuates the low frequencies.

In accordance with one embodiment of my invention I take advantage of the characteristics of the amplifier stages shown in Figures 2 and 3 by connecting them in cascade as indicated by the circuit diagram in Figure 4. Since the first I. F. transformer 1 has its primary loaded while the second I. F. transformer 4 has its secondary loaded, the overall selectivity characteristic for the two amplifier stages, when the capacities C_1 are in shunt to the transformer secondaries, is indicated by the curve *a* (Fig. 4). If the capacities C_1 are removed, as by making the control grids of the tubes more negative for the purpose of decreasing the gain of the amplifier, the overall selectivity characteristic is changed to that indicated by the curve *b* (Fig. 4). It will be noted that the curve *b* is flat-topped and that the only effect of decreasing the gain of the amplifier has been to shift the selectivity curve a slight amount towards the high frequency end of the frequency spectrum.

Referring now to Figure 1, my invention is shown applied to a television receiver of the super-heterodyne type comprising a first detector and an oscillator indicated at 11. An incoming signal is converted by the first detector and oscillator to an intermediate frequency signal which is supplied through two gain controlled I. F. amplifier stages 12 and 13 to a plurality of I. F. amplifier stages indicated at 14, the amplifier stages 14 not having any gain control.

The first I. F. amplifier stage 12 comprises an I. F. transformer 15 having a primary 17 and a secondary 18, the primary being tuned by means of a tuning condenser 19 connected thereacross through a filter condenser 21. The secondary is tuned by means of a tuning condenser 22 connected across the secondary through a second filter condenser 21. The secondary 18 is coupled across the input electrodes of an amplifier tube 24 which preferably is of the screen grid type having an indirectly heated cathode 26, a control grid 27, a screen grid 28, and a plate 29.

In the first amplifier stage 12 the I. F. transformer 15 is loaded by means of a resistor 31 connected in shunt to the secondary.

The second I. F. amplifier stage 13 comprises an I. F. transformer 32 having a primary 33 and a secondary 34. The primary 33 is tuned by means of a tuning condenser 35 connected across the primary through another filter condenser 21. The secondary 34 is tuned by means of a tuning condenser 33 connected across the secondary through another of the filter condensers 21. The secondary 34 is coupled to the input electrodes of an amplifier tube 41 which preferably is of the screen grid type having an indirectly heated cathode 42, a control grid 43, a screen grid 44, and a plate 46.

The second I. F. transformer 32 is loaded by means of a resistor 47 connected in shunt to the primary 33.

In order to prevent interaction between amplifier stages double filtering is provided in both the plate grid circuits of the amplifier tubes. The double filters comprise the filter condensers 21 and filter resistors 49.

The control grid 27 of the amplifier tube 24 is connected through the transformer secondary 18 and two filter resistors 49 to a conductor 51 which leads to the automatic volume control device. Likewise the control grid 43 of the amplifier tube 41 is connected through the secondary 34 of the transformer 32 and through two filter resistors 49 to the conductor 51.

The output of the second I. F. amplifier tube 41

is supplied through a tuned I. F. transformer 52 to the other I. F. amplifier stages indicated at 14. The final output of the I. F. amplifier is supplied through a tuned I. F. transformer 53 to a push-pull detector 54. It may be noted that the I. F. transformers 52 and 53 may be loaded in any suitable manner in order to provide a flat-topped selectivity curve since no automatic volume control voltage is applied to the amplifier stages following stage 13 and therefore no difficulty is experienced with detuning of the transformers.

The detector tube 54 includes a pair of indirectly heated cathodes 56 and 57 and a pair of plates 58 and 59. The plates 58 and 59 are connected to opposite ends of the secondary 61 of transformer 53 while the cathodes 56 and 57 are connected through a resistor 62 to the midpoint of the secondary 61. The picture signal is taken off the cathode end of resistor 62 and supplied to the picture amplifier (not shown) through a coupling condenser 63.

The particular automatic volume control circuit which has been shown by way of example includes an amplifier tube 64 having an indirectly heated cathode 66, a control grid 67 and a plate 68. The cathode 66 is connected to a source of potential of -50 volts while the plate 68 is connected through a plate resistor 69 to a source of potential of -3 volts whereby the plate is maintained 47 volts positive with respect to cathode. The secondary end of the detector output resistor 62 is connected to a -53 volt source of potential. The cathode end of the resistor 62 is connected through a filter resistor 71 to the control grid 67 of the A. V. C. tube, a filter condenser 72 being provided between the cathode end of the filter resistor 71 and ground. It will be apparent that if there is no current flowing through the detector output resistor 62 the control grid 67 of the A. V. C. tube is 3 volts negative with respect to its cathode 66.

It should be understood that specific voltages have been given merely to aid in the explanation of the invention and that various other voltages may be employed if preferred. Voltages preferably are obtained from a voltage divider not shown.

The gain control voltage is supplied from the A. V. C. tube 64 to the control grids of the I. F. amplifier tubes 24 and 41 through a conductor 73, a filter resistor 74, and the conductor 51. A suitable filter condenser 75 is connected between the grid end of the filter resistor 74 and ground.

The A. V. C. circuit operates as follows: When there is no incoming signal there is no current flowing through the detector output resistor 62, and the control grid 67 of the A. V. C. tube 64 is 3 volts negative with respect to the cathode 66. At this time there is a minimum flow of current through the plate resistor 69, and the plate end of the resistor 69 is the least negative whereby the control grids of the I. F. amplifier tubes 24 and 41 are biased for maximum gain. When the receiver is tuned to an incoming signal, or if the strength of an incoming signal increases, there is an increase in the direct current component flowing through the detector output resistor 62 whereby the grid of the A. V. C. tube 64 becomes less negative and the plate end of the resistor 69 becomes more negative. Thus a more negative bias is applied to the control grids of the I. F. amplifier tubes 24 and 41 to decrease their gain. As previously explained, this results in a decrease in the input capacity of the tubes 24 and 41 whereby the I. F. transformers 16 and 32 must be properly

loaded in order to avoid an undesirable over-all selectivity characteristic. Since in the two amplifier stages 12 and 13 one stage has the transformer secondary loaded while the other stage has the transformer primary loaded, the effect of the reduction in gain is merely to shift the selectivity curve from the position shown in curve *a* in Figure 4 to the position shown by the curve *b* in the same figure.

As shown in Figure 5 the I. F. transformers may be loaded by connecting resistance in series with either the transformer primary or secondary and its tuning capacity. In this figure there are shown two I. F. amplifier stages 77 and 78, the first stage comprising an I. F. transformer 79 and an amplifier tube 81, and the second stage comprising an I. F. transformer 82 and an amplifier tube 83. In the first amplifier stage 77 the transformer primary is loaded by means of a series resistor 84 while in the second amplifier stage the secondary is loaded by means of a series resistor 86. The results obtained by loading successive amplifier stages in this manner is substantially the same as that obtained by loading amplifier stages as illustrated in Figure 1.

It will be understood that in Figs. 1 and 5 it is immaterial whether the primary loaded and secondary loaded stages are cascaded in the order illustrated or in the reverse order.

In a preferred adjustment of the circuit shown in Fig. 1 the selectivity curves of stages 12 and 13 are made flat-topped for a condition when the amplifier gain lies about half way between minimum and maximum gain, say when the control grid bias is -8 volts. With this adjustment the selectivity curve for the primary loaded stage is peaked at the low frequency side and shifted toward the low frequency end of the frequency spectrum when the amplifier gain is increased as by making the control grids 3 volts negative. At the same time the selectivity curve for the secondary loaded stage becomes peaked at the high frequency side and is shifted towards the low frequency end of the frequency spectrum. A decrease in amplifier gain, such as a decrease caused by making the control grids 20 volts negative, produce a peaking and shifting of the selectivity curves as illustrated in Figs. 2 and 3.

Also, good results may be obtained by making the selectivity curves of stages 12 and 13 flat-topped at either the condition of maximum gain or at the condition of minimum gain.

While the preferred way of varying the gain of the amplifier is by varying the bias on the control grids, the gain may be varied by varying the positive voltage applied either to the screen grids or to the plates of the tubes. Or, if desired, an extra grid may be provided in the amplifier tubes for gain control purposes, the voltage applied to this extra grid being changed to vary the gain. Regardless of the method of gain control employed, the input capacity of the tubes is varied and my invention should be employed for obtaining a good overall selectivity characteristic.

Another embodiment of my invention is indicated by the diagram in Figure 6. The selectivity curve of an amplifier stage having both the transformer primary and the transformer secondary loaded will remain flat-topped even though there is a change in tube input capacity C_1 providing there is the proper ratio of primary loading to secondary loading.

In Figure 6 the curve *a* is a selectivity curve for the I. F. transformer 87 when the input ca-

capacity C_1 is in shunt to the transformer secondary. The curve *b* (Fig. 6) is the selectivity curve for the transformer 87 after the capacity C_1 has been removed, as by making the control grid of the amplifier tube more negative. In order to keep the curve *b* flat-topped, the loading resistance R_1 across the transformer primary should have about one-half the resistance of the loading resistor R_2 across the transformer secondary. In this case the primary has twice the loading of the secondary. In general, the ratio of the primary loading to the secondary loading should be less than 3 to 1 and greater than 1 to 1.

Referring to Figure 7, there is illustrated an I. F. amplifier stage including an I. F. transformer 88 in which both the primary and the secondary are loaded, the primary being loaded more than the secondary as in the amplifier stage shown in Figure 6. In Figure 7 the loading is obtained by connecting loading resistors R_1 and R_2 in series in the tuned primary and tuned secondary circuits, respectively. The resistor R_1 has about twice the resistance of the resistor R_2 . It will be understood that the loading resistance may be included in the secondary and primary coils themselves by winding the coils of wire having the proper resistance. The condensers 89 and resistors 91 are filter elements corresponding to elements 21 and 49 in Fig. 1.

In an amplifier stage where the primary and secondary of the transformer are unequally loaded in order to provide a flat-topped selectivity curve, the secondary may be loaded more heavily than the primary if preferred. In that case the selectivity curve corresponding to the curve *b* in Figure 6 will be of the same shape as the curve *b* but it will be shifted towards the low frequency end of the frequency spectrum instead of towards the high frequency end.

If the amplifier design shown in Figs. 6 and 7 is employed, the I. F. amplifier generally should include at least two such amplifier stages since, as a rule, at least two stages should have gain control.

The ideas embodied in the circuits shown in Figs. 1 and 6 may be combined in a single circuit. For example, one gain controlled amplifier stage may have its transformer loaded as shown in Fig. 6 (or Fig. 7) where the primary has the greater loading while the other gain controlled amplifier stage may have its transformer loaded as shown in Fig. 6 except that the secondary has the greater loading.

It may be noted that the embodiments of my invention illustrated in Figs. 1 and 5 are the preferred ones since it is possible to obtain more gain from an amplifier stage when only the primary or the secondary of a transformer is loaded than when both primary and secondary are loaded.

It is not thought necessary to give specific values for the I. F. transformer elements although the loading resistance values for one particular receiver are indicated in Fig. 1 by way of example. This receiver is designed to amplify picture signals having an intermediate carrier frequency of 11 megacycles, this carrier being located at one side of the I. F. amplifier pass range for single side band reception. The frequency band width of the I. F. amplifier is 1500 kilocycles.

From the foregoing description it will be apparent that various other modifications may be made in my invention without departing from the spirit and scope thereof and I desire, therefore, that only such limitations shall be imposed

thereon as are necessitated by the prior art and as set forth in the appended claims.

I claim as my invention:

1. In combination, a plurality of amplifier stages connected in cascade, each of said stages comprising an electric discharge tube having input electrodes and comprising a transformer, said transformer having a primary and a secondary, said secondary being coupled across said input electrode, said primary and said secondary each being tuned and coupled to produce a band pass selectivity characteristic, means for resistively loading the transformer in one of said stages with the primary loaded more than the secondary, means for resistively loading the transformer in another of said stages with the secondary loaded more than the primary, and means for varying the gain of the tubes in said stages, the values of said resistive loadings being such that the overall selectivity characteristic of said amplifier stages remains substantially flat-topped during changes in the gain of said tubes.

2. In combination, a plurality of amplifier stages connected in cascade, each of said stages comprising an electric discharge tube having input electrodes and comprising a transformer, said transformer having a primary and a secondary, said secondary being coupled across said input electrode, said primary and said secondary each being tuned and coupled to produce a band pass selectivity characteristic, means for resistively loading the transformer primary only in one of said stages, means for resistively loading the transformer secondary only in another of said stages, and means for applying to the input electrodes of the tubes in said stages a biasing voltage which varies in accordance with the gain desired in said amplifier, the values of said resistive loadings being such that the overall selectivity characteristic of said amplifier stages remain substantially flat-topped during changes in said biasing voltage.

3. In a superheterodyne receiver, and I. F. amplifier comprising an amplifier stage which includes an electric discharge tube having a plurality of electrodes including a control electrode and a broadly tuned I. F. transformer a secondary connected to said control grid and having a primary, a second amplifier stage connected in cascade with said first stage and including an electric discharge tube having a plurality of electrodes including a control electrode and a broadly tuned I. F. transformer having a secondary connected to said last-named control electrode and having a primary, means for loading the transformer in one of said stages with the primary loaded more than the secondary, means for loading the transformer in the other of said stages with the secondary loaded more than the primary, and means for varying the voltage applied to at least one electrode in each of said tubes for varying the gain of said stages, the values of said loadings being such that the overall selectivity characteristic of said amplifier stages remains substantially flat-topped during changes in said last-mentioned voltage.

4. In a superheterodyne receiver, an I. F. amplifier comprising an amplifier stage which includes an electric discharge tube having a plurality of electrodes including a control electrode and a broadly tuned I. F. transformer having a secondary connected to said control grid and having a primary, a second amplifier stage connected in cascade with said first stage and including an electric discharge tube having a plurality of elec-

trodes including a control electrode and a broadly tuned I. F. transformer having a secondary connected to said last-named control electrode and having a primary, means for resistively loading the transformer primary only in one of said stages, means for resistively loading the transformer secondary only in the other of said stages, and means for applying a biasing voltage to said control electrodes which varies in accordance with the strength of an incoming signal, the values of said resistive loadings being such that the overall selectivity characteristic of said amplifier stages remains substantially flat-topped during changes in said biasing voltage.

5. In combination, a plurality of amplifier stages connected in cascade, each stage comprising a transformer having a tuned primary and a tuned secondary which are so coupled as to provide a broad selectivity characteristic and an electric discharge tube having input electrodes coupled to said secondary, means for loading the transformer in one of said stages with the primary loaded more than the secondary, means for loading the transformer in another of said stages with the secondary loaded more than the primary, and means for varying the gain of said electric discharge tubes, the values of said loadings being such that the overall selectivity characteristic of said stages remains substantially flat-topped during changes in the gain of said electric discharge tubes.

6. In combination, a plurality of amplifier stages connected in cascade, each stage comprising a transformer having a tuned primary and a tuned secondary which are so coupled as to provide a broad selectivity characteristic and an electric discharge tube having input electrodes coupled to said secondary, means for resistively loading the transformer primary only in one of said stages, means for resistively loading the transformer secondary only in another of said stages, and means for varying the direct current potential between the input electrodes in said stages whereby the gain of said amplifier stages may be controlled, the values of said resistive loadings being such that the overall selectivity characteristic of said amplifier stages remains substantially flat-topped during changes in said direct current potential for varying the gain of said stages.

7. In combination, a plurality of amplifier stages connected in cascade, each stage comprising a transformer having a tuned primary and a tuned secondary which are so coupled as to provide a broad selectivity characteristic, and an electric discharge tube having a plurality of electrodes including input electrodes, said input electrodes being connected to said secondary, means for varying the direct current potential applied to at least one electrode of each tube in said stages whereby the gain of said stages may be controlled, means for so resistively loading the transformer in one of said stages with the primary loaded more than the secondary that said one stage has a substantially flat-topped selectivity characteristic for a certain value of direct current potential applied to said one electrode in said one stage and whereby the high frequency response in said one stage is accentuated when said direct current potential is changed to reduce the gain in said one stage, and means for so resistively loading the transformer in another of said stages with the secondary loaded more than the primary that the selectivity characteristic of said one stage is substantially flat-topped for a

certain value of direct current potential applied to said one electrode in said other stage and whereby the low frequency response in said other stage is accentuated in response to a change in said direct current potential such that the gain of said other stage is reduced, the values of said resistive loadings being such that the overall selectivity characteristic of said amplifier stages remains substantially flat-topped during changes in said direct current potential for varying the gain of said stages.

8. In combination, a plurality of amplifier stages connected in cascade, each stage comprising a transformer having a tuned primary and a tuned secondary which are so coupled as to provide a broad selectivity characteristic and an electric discharge tube having input electrodes coupled to said secondary, means for varying the direct current potential between the input electrodes in said stages whereby the gain of said amplifier stages may be controlled, means for so resistively loading the transformer primary in one of said stages that said one stage has a sub-

stantially flat-topped selectivity characteristic for a certain value of direct current potential applied between the input electrodes in said one stage and whereby the high frequency response in said one stage is accentuated when said direct current potential is changed to reduce the gain in said one stage, and means for so resistively loading the transformer secondary in another of said stages that the selectivity characteristic of said one stage is substantially flat-topped for a certain value of direct current potential applied between the input electrodes in said other stage and whereby the low frequency response in said other stage is accentuated in response to a change in said direct current potential such that the gain of said other stage is reduced, the values of said resistive loadings being such that the overall selectivity characteristic of said amplifier stages remains substantially flat-topped during changes in said direct current potential for varying the gain of said stages.

HORACE CLIFFORD ALLEN.