

May 11, 1937.

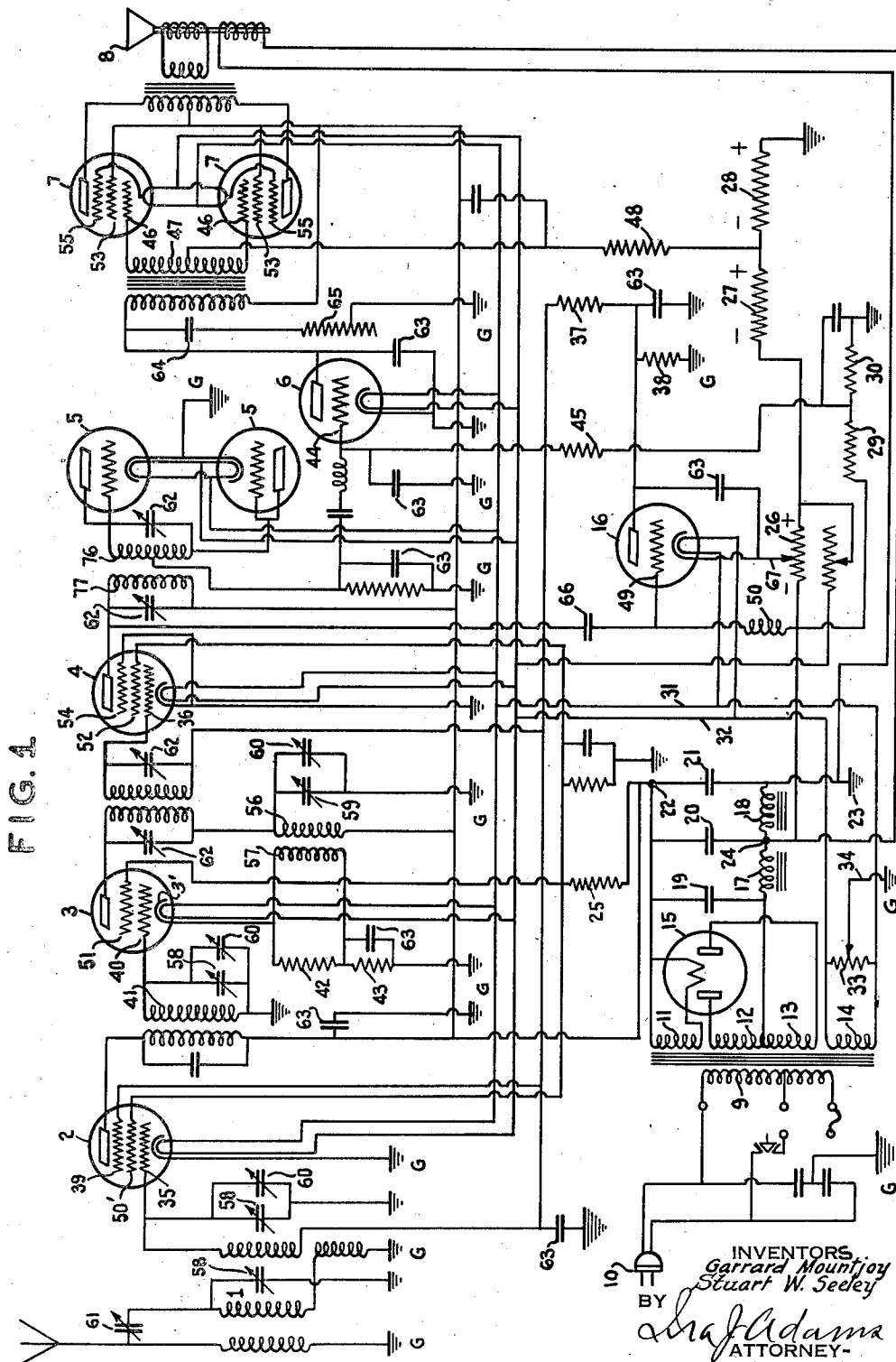
G. MOUNTJOY ET AL

2,079,657

AUTOMATIC VOLUME CONTROL

Filed June 21, 1933

2 Sheets-Sheet 1



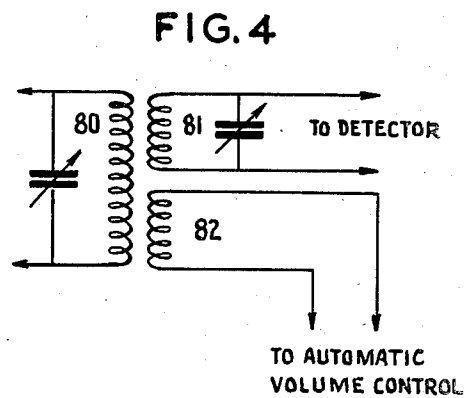
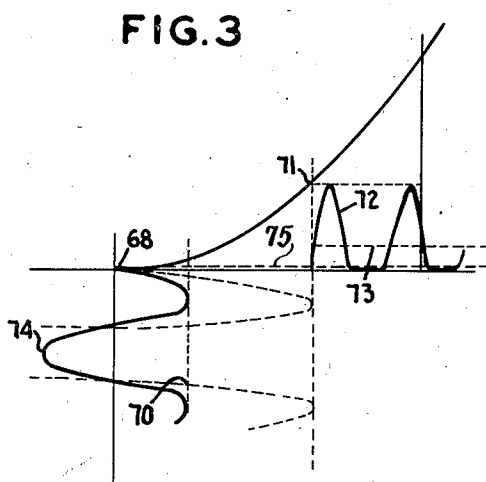
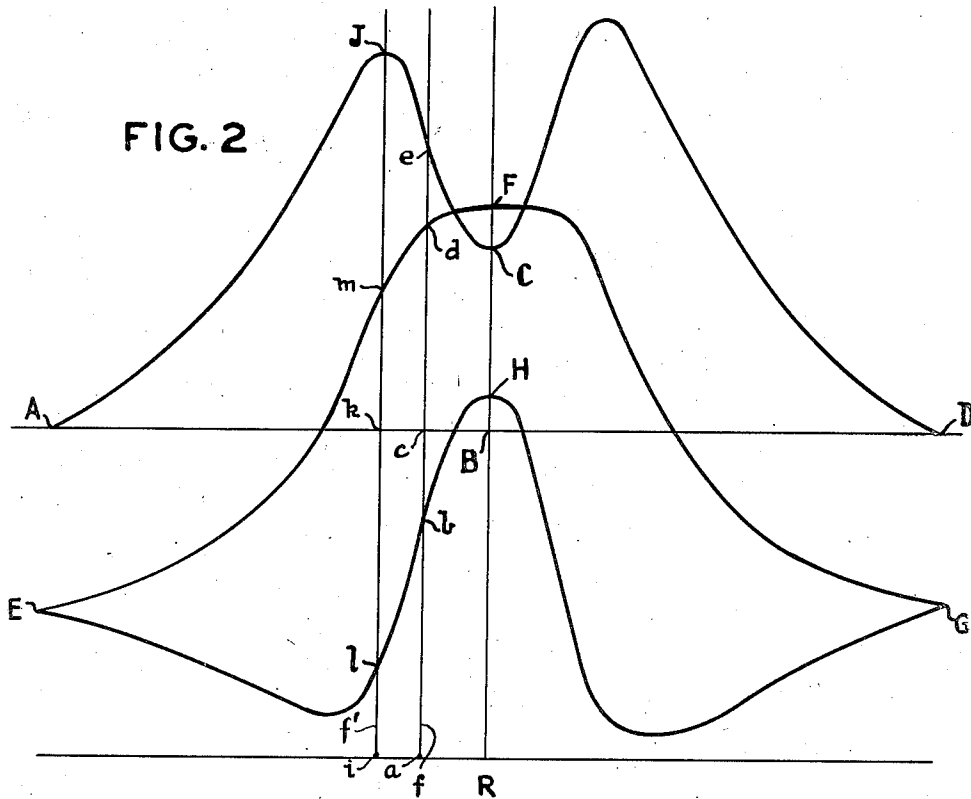
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2 Sheets-Sheet 2



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AUTOMATIC VOLUME CONTROL

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12 Claims. (Cl. 250—20)

This invention relates to automatic volume control systems. It is applicable to any vacuum tube system where the output is to be maintained a desired value or otherwise controlled, but it is shown in connection with a radio receiving set.

The object of the invention is to eliminate side band noises particularly noticeable in receiving sets when searching for particular stations.

More particularly, the object is to eliminate side band noises in sets having an automatic volume control tube known as A. V. C. tube.

Other objects will appear in the following specification, reference being had to the drawings in which:

Fig. 1 is a schematic diagram of the circuit of a superheterodyne receiving set employing the invention.

Fig. 2 represents voltage-frequency curves of a transformer across the primary of which are tapped the A. V. C. tube and final detector respectively.

Fig. 3 shows the grid voltage-plate current curve, the time-plate current curve and the time-grid voltage curve of the automatic volume control tube.

Fig. 4 is a modification.

In the drawings the receiving set consists of a link circuit 1, a R. F. amplifier tube 2, an oscillator detector tube 3, an intermediate frequency amplifier tube 4, a second push pull detector 5, an audio amplifier tube 6, push pull amplifier tubes 7 and a loud speaker 8. Vacuum tubes 2, 4 and 7 are of the pentode type. Vacuum tube 3 is of the screen grid type while detectors 5 are of the Fleming type. All of the tubes referred to are of the indirectly heated cathode type except tubes 7 which are directly heated.

The primary 9 of the power supply is adapted to be connected to the alternating current mains through plug 10. This primary is coupled to secondaries 11, 12, 13 and 14. Secondary 11 furnishes the filament current for rectifier tube 15. Coils 12 and 13 are connected to the plates of rectifiers 15, thus enabling the full wave to be utilized. Secondary 14 is used to supply the heater and filament current of the tubes 2, 3, 4, 5, 6, 7, already referred to and also the filament current of the A. V. C. tube 16 to be referred to later. The power supply has chokes 17, 18 and condensers 19, 20, and 21 for filtering out the ripples of the rectified current. Choke 18 as will be seen is the field coil of the loud speaker 8. The power supply has the terminals 22, 23,

24, for the various circuits. Resistance 25 connected to terminal 22 provides for still another supply voltage. Resistances 26, 27 and 28 on the one hand, and resistances 29 and 30 on the other, are connected in shunt to choke 18, and also furnish additional supply voltages due to there being resistance in the choke.

The filamentary heaters and cathodes of tubes 2, 3, 4, 5, 6, 7 and 16 are all connected in parallel to the low voltage buses 31, 32. The center of these buses is grounded through resistance 33 and the tap 34.

The plates or anodes of tubes 2, 3, 4, 6, and 7 are all connected through their transformer coils to the supply terminal 22. The indirectly heated, or unipotential cathodes of tubes 2, 3, 4, 5, and 6 are grounded as shown by reference character G on the drawings. The directly heated cathodes of tubes 7 are grounded through center tap 34 in the power supply. The plate-cathode circuits are therefore tapped across terminals 22, 23 of the power supply.

The control electrodes 35 and 36 of tubes 2 and 4 and the suppressor grid 39 are connected through resistance 37 to the negative end of resistance 38, the positive end of resistance 38 being grounded and thus connected to supply terminal 23 which is also connected to the positive end of resistance 28.

The control electrode 40 is grounded through its transformer coil 41 and thus takes a negative potential in respect to its cathode 3' by the drop in resistance 42, 43, caused by the electron current of that tube. The control electrode 44 is connected through resistance 45 to the negative end of resistance 30, the positive end being grounded and thus connected to the cathode of the tube 6. The control electrodes 46 of tubes 7 are connected through the center tap of coil 47 and resistance 48 to the negative end of resistance 28. The positive end of this resistance is grounded and thus connected to the filamentary cathodes of the tubes 7. The control electrode 49 of A. V. C. tube 16 is connected through coil 50 to the negative end of resistance 26. An intermediate positive tap of the resistance 26 is connected to the cathode of the tube 16. All these connections produce the desired bias on the control electrodes.

The screen electrodes 50', 51, 52 of tubes 2, 3 and 4 are connected through resistance 25 to the high positive terminal 22 of the supply system and the screen electrodes 53 are connected directly to this terminal 22. These connections give the proper positive voltage on the screens.

The suppressor electrodes 54, 55, are connected directly to the cathodes of their respective tubes.

The anode circuit of the detector-oscillator 3 is coupled to the control electrode circuit through transformer coils 56, 57, which places a radio frequency feed-back voltage across the resistance 42 in the grid-filament circuit.

In the various circuits the condensers 58 tune the circuits to the desired signal while condenser 59 tunes the oscillator circuit to such frequency as to produce the desired super audible beat or intermediate frequency. Reference character 60 indicates in various places in the drawings trimming condensers for factory or service adjustments of capacity to enable the condensers 58 and 59 to be uni-controlled from one knob or drum. Condenser 61 is the antenna equalizing and coupling capacity and condensers 62 tune their circuits to the intermediate frequency. When once adjusted these condensers 60, 61 and 62 normally require no further adjustments. Condensers 63 are radio or intermediate frequency bypass condensers and condensers 64 and adjustable resistance 65 constitute an audio frequency volume control shunt. Condenser 66 is a coupling condenser to place intermediate frequency on the control electrode 49 of the A. V. C. tube.

The general operation of the receiving set is as follows:

The volume control tap 67 will be set to give such negative bias 68 (Fig. 3) to the A. V. C. tube 16 as to produce the desired room volume for station signals of the lowest intensity capable of being received at the desired volume. At such setting the A. V. C. tube draws very little plate current, as shown by line 75 of Fig. 3. The radio frequency amplifier tube 2 and the intermediate frequency tube 4 therefore receive very little negative bias on their control electrodes from resistance 38, and have maximum sensitivity. Now, suppose a much stronger station is tuned in. The signal on reaching the output of tube 4 tends to produce a much higher voltage. This tends to place a higher voltage on the control electrode 49 of the A. V. C. tube which reduces the negative bias therein on its positive swing. Curve 70 (Fig. 3) shows the initial voltage applied to the grid of the A. V. C. tube. The positive swing brings the peak of the plate current in this tube up to point 71 of the curve. The curve 72 gives the plate current curve of the A. V. C. tube. The line 73 indicates the average of such plate current which produces a considerable drop in resistance 38. This produces a strong negative bias on the tubes 2 and 4 which reduces the amplification. This reduces the voltage in the output of the vacuum tube 4 and finally a point of balance is obtained where the curve 74 indicates the impressed voltage on the A. V. C. grid 49, and the line 75, the average plate current flowing through the resistance 46. This balance of course would be obtained practically instantaneously due to the high frequency of the oscillations involved but the detailed explanation is given to aid in the understanding of the action.

In the usual systems of the prior art, the control voltage for the A. V. C. tube would be obtained from the secondary 76 so that the detector and A. V. C. tube receive impulses from identically selective channels. This has resulted in side band noises as the operator tuned slightly off the carrier wave or as the signal wave was being approached. This was due to the fact that as the circuit was tuned slightly off the carrier, the carrier voltage dropped off also and this

reduced the biasing voltage 75 (Fig. 3). Tubes 2 and 4 therefore had increased sensitivity due to their having lower negative bias. The side band frequency consequently had high amplification and the side band noise or hiss came in with increased volume.

In other prior art systems the control voltage for the A. V. C. tube is obtained from the untuned primary of the transformer feeding the detector. When the coupling is reasonably close the primary voltage curve maximizes at the resonance point and falls off rather sharply at each side of resonance. Consequently the side-band noises have increased volume as the circuit is adjusted to either side of the tuning point. When the coupling is loose in such type of system, the voltage curve of the primary takes in general the shape of the voltage curve of the tuned secondary but it maximizes slightly off of the resonant frequency of the low frequency side. This means that the voltage on the high frequency side of the resonance point decreases all the more for a given frequency change. Hence, if there be a tendency in such system to slightly limit the volume of the low side band noise there would be a greater tendency to increase the volume of the high frequency side-band noise.

We have overcome this difficulty by tuning both the primary 77 and the secondary 76 and adjusting the coupling between them until a double hump voltage-frequency curve A, C, D, is obtained for the primary 77 and a single hump curve E, F, G, is obtained for the secondary. These curves are the characteristic voltage frequency curves obtained by applying a constant radio frequency voltage to a selective circuit previous to the primary 77 with varying frequencies, for example, to the grid of tube 4 without any automatic volume control. These curves are not the actual characteristic voltage curves of the transformer in use as such characteristics are altered by the A. V. C. tube. Such curves, however, show the true proportion between the secondary and primary voltages at any frequency with the A. V. C. tube functioning as will be subsequently explained.

When the set is in use the A. V. C. tube, connected as shown, will keep the voltage impressed on primary 77 substantially constant. The curve of the primary voltage will be given by a curve such as A, B, D which is approximately a straight line. The curve of the voltage in the secondary 76 will no longer be given by curve E, F, G, but by the new curve E, H, G, but for any frequency f the voltage ordinates bear the ratio

$$\frac{ab}{ac} = \frac{ad}{ae}$$

Now, with the voltage frequency characteristics as outlined above, let it be assumed that the selective controls are set for the resonance frequency R. The modulated carrier wave will produce a bias for the amplifier tubes under influence of the initial voltage RC until it is reduced to RB, which reduction for all practical purposes takes place instantaneously. Any tendency for the primary voltage to increase above the point B is of course resisted by the ensuing increased effect of the A. V. C. tube. Now, if the selective controls are moved off the resonance point to the region f' of the side band frequency the carrier voltage tends to rise from C to J. The A. V. C. tube of course

maintains the primary voltage at k but the secondary voltage drops to l where

$$\frac{il}{ik} = \frac{im}{ij}$$

The side band noise is thus reduced. If the selective controls had been moved to the region of the upper side band frequency the upper hump would have caused the reduction of the upper side band noise in the same way.

In Fig. 4 I have illustrated a modification in which a tuned transformer circuit 80 feeds into two secondaries 81 and 82. The secondary 81 is tuned or otherwise made more selective while the secondary 82 is made less selective by absence of, or broadness in, tuning by damping or otherwise. The secondaries 81 and 82 are connected directly or indirectly to the detector and A. V. C. tube respectively. The operation in this arrangement would be similar to that already described.

Our improvement obviously is capable of use in other than superheterodyne receiving sets and while I prefer to utilize the double hump voltage characteristic of one of the transformers in the set, good results may be obtained by connecting the A. V. C. tube to a less selective circuit than the circuit to which the detector is connected, even though no double hump voltage characteristics are present.

Instead of using the arrangement shown one can get similar results by having more or less independent channels for the A. V. C. control voltage and the detector voltage with the A. V. C. channel made less selective by damping or other means.

Of course the advantages of our system may be obtained where there are no tuned radio frequency stages ahead of the oscillator. In such a system the side-band noises are minimized the same way as the oscillator is varied above or below the desired value in the tuning process. Likewise the advantages of the invention may be obtained in straight tuned radio frequency receivers.

The invention is not limited to biasing systems of the A. V. C. tube type as other systems may likewise be used. Various modifications may be devised without departing from the spirit of the invention.

Having described our invention, what we claim is:

1. In receiving sets, a vacuum tube amplifier, a circuit having means to render it selective to any one of a plurality of modulated frequencies, means to produce a negative bias on the control electrode of said tube that varies directly with the intensity of the carrier frequency of the signal being received, and means to cause the second mentioned means to increase the bias as the first mentioned means is rendered selective for either side band frequency of said signal.

2. In receiving sets, a detector, a tuned loop connected to said detector, a second tuned loop coupled to the first mentioned tuned loop with a coefficient of coupling for producing a broader voltage-frequency curve in the second loop than in the first loop, an amplifier tube arranged in cascade with said loops and means to produce a negative bias on the control electrode of said tube that varies with the voltage in the second tuned loop.

3. In receiving sets, a detector, a tuned loop connected to the detector, a second tuned loop coupled to the first mentioned tuned loop with a coefficient of coupling for producing a broader voltage-frequency curve in the second loop than in

the first loop, an amplifier tube arranged in cascade with said loops, a vacuum tube having its control electrode normally biased substantially to the cut-off point and connected to receive alternating electromotive forces from the second tuned loop to produce a less negative potential on said electrode during each positive half cycle, a resistance in the anode circuit of the second vacuum tube and connections between the resistance and the control electrode of the first tube to place a negative bias thereon from the drop in said resistance.

4. In receiving sets, a signal source, a tuned loop, a vacuum tube having its input and output circuits coupled respectively to said signal source and said tuned loop, a second tuned loop coupled to the first tuned loop sufficiently close to produce a double hump intensity-frequency curve, a signal indicator coupled to the second tuned loop, a second vacuum tube, a source of negative bias and a resistance included respectively in its input and output circuits, the input circuit of the second vacuum tube being coupled to the first tuned loop and the input of the first vacuum tube being coupled to said resistance to receive a negative bias therefrom.

5. In receiving sets, an amplifier tube, two circuits connected to said amplifier tube including frequency selective means, said circuits also having means to increase the voltage in one circuit at a relatively greater rate than that of the other circuit as the frequency varies away from the desired carrier frequency in either direction, a detector connected to the last mentioned circuit, and means to produce a bias on the control electrode of said amplifier tube that varies with the voltage of the other of said circuits.

6. In receiving sets, a vacuum tube amplifier, a circuit connected to said amplifier containing frequency selecting means and two coils, said coils having voltage frequency-characteristics such that as the frequency varies from the carrier frequency in either direction, the relative voltage change of one coil is greater than the relative voltage change of the other coil, a detector connected to the coil having the last mentioned change and means to apply a bias to said amplifier that varies with the voltage in the other coil.

7. In receiving sets, a vacuum tube amplifier, a circuit connected to said amplifier containing frequency selecting means and primary and secondary transformer coils, said coils having respectively rising and falling voltage characteristics as the frequency varies from the carrier frequency in either direction, a detector connected to the coil with the falling characteristic and a volume control tube connected to the other coil and adapted to apply a bias to said amplifier tube that varies with the voltage of said other coil.

8. In combination, with a radio receiver comprising a radio frequency amplifier, a detector and a reproducer, a gain control tube coupled with the detector and the amplifier to maintain the signal carrier strength at the detector in spite of variations in the signal carrier level impressed on the amplifier, and means for over-coupling the gain control tube to the detector so that the coupling has a double peaked resonance curve characteristic.

9. A radio receiver of the type including at least one tunable high frequency amplifier, a following detector having a resonant input network, a reproducer connected to the detector output,

- a rectifier having a resonant input network coupled to said detector input network, and an output electrode of the rectifier being connected to a gain control electrode of said amplifier for automatically regulating the gain of the amplifier so that the signal intensity level to the said detector is substantially constant, said receiver being characterized by the fact that the value of the coefficient of coupling of said coupled network is such that the resonance curve of the rectifier input network has a pair of spaced peaks whereby the reproducer volume is a maximum solely when said amplifier is tuned to a signal carrier frequency.
10. In receivers for modulated carrier waves, an amplifier tube, a circuit connected to said amplifier tube, and means for varying the mutual conductance of said amplifier tube inversely with the strength of the carrier wave while in resonance relation with said circuit and for decreasing the mutual conductance as the carrier wave departs from resonance relation therewith in either direction.

11. In receivers for modulated carrier waves,

an adjustable heterodyne oscillator adapted to beat with a signal frequency to produce a desired intermediate frequency, a vacuum tube amplifier connected thereto, a circuit tuned to the desired intermediate frequency and connected to the amplifier tube, means for varying the mutual conductance of said amplifier tube inversely with the strength of the desired intermediate frequency and for decreasing the mutual conductance as the intermediate frequency varies from the desired value in either direction therefrom.

12. In receiving sets, a detector, a tuned loop connected to said detector, a second tuned loop coupled to the first mentioned tuned loop with a coefficient of coupling for producing a broader voltage frequency curve in one loop than in the other, an amplifier tube arranged in cascade with said loops, and means to produce a negative bias on the control electrode of said tube that varies with the voltage of the loop having the broader voltage frequency curve.

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