

March 22, 1938.

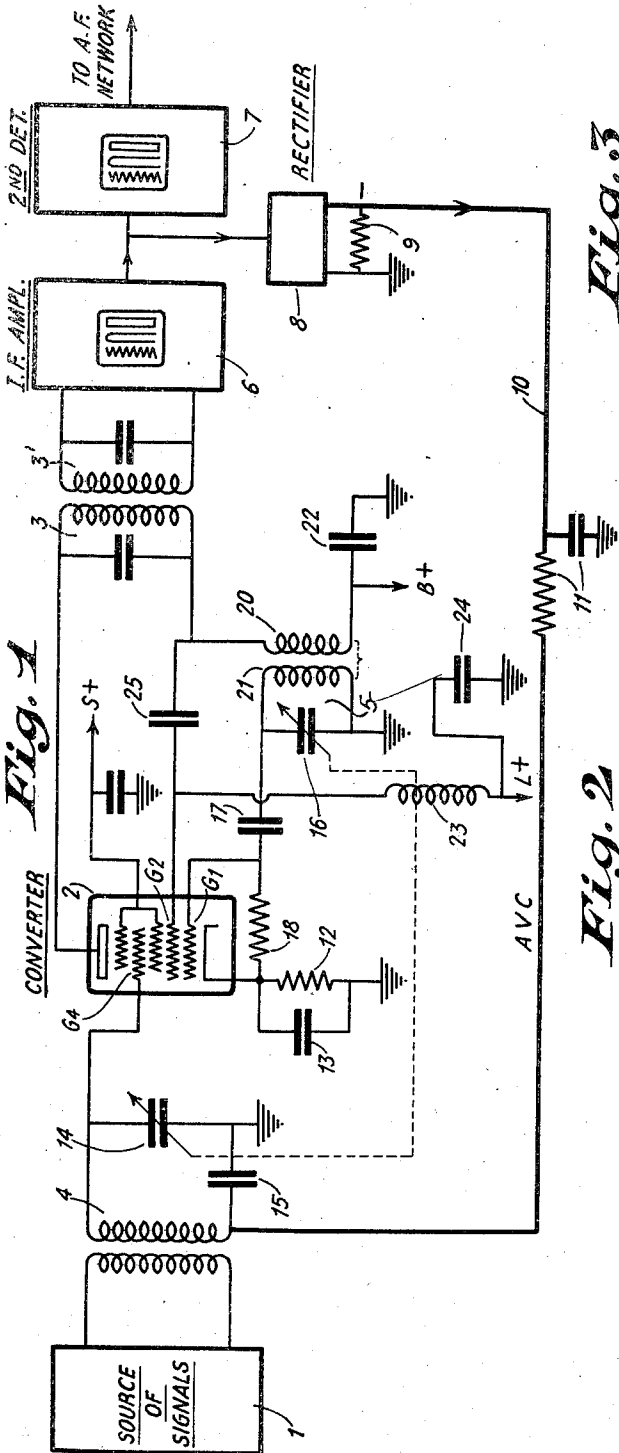
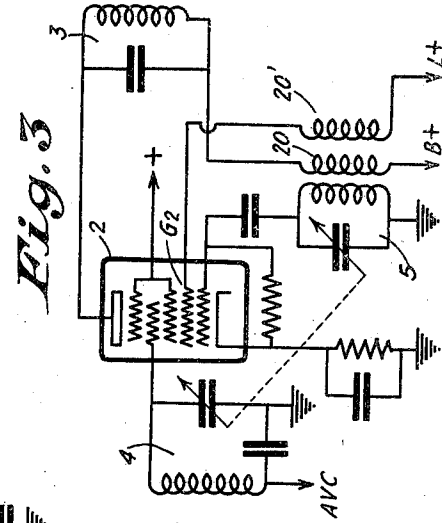
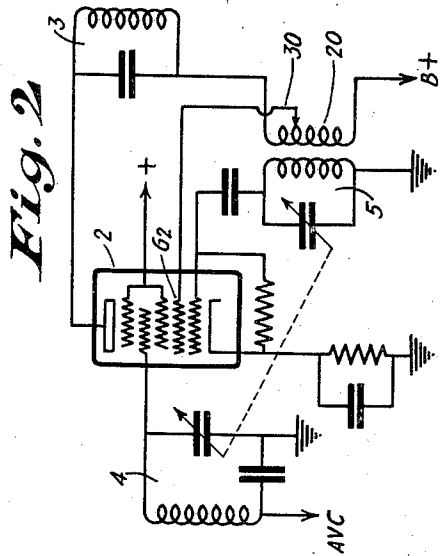
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2,111,765

AUTOMATIC VOLUME CONTROL

Filed May 14, 1935

2 Sheets-Sheet 1



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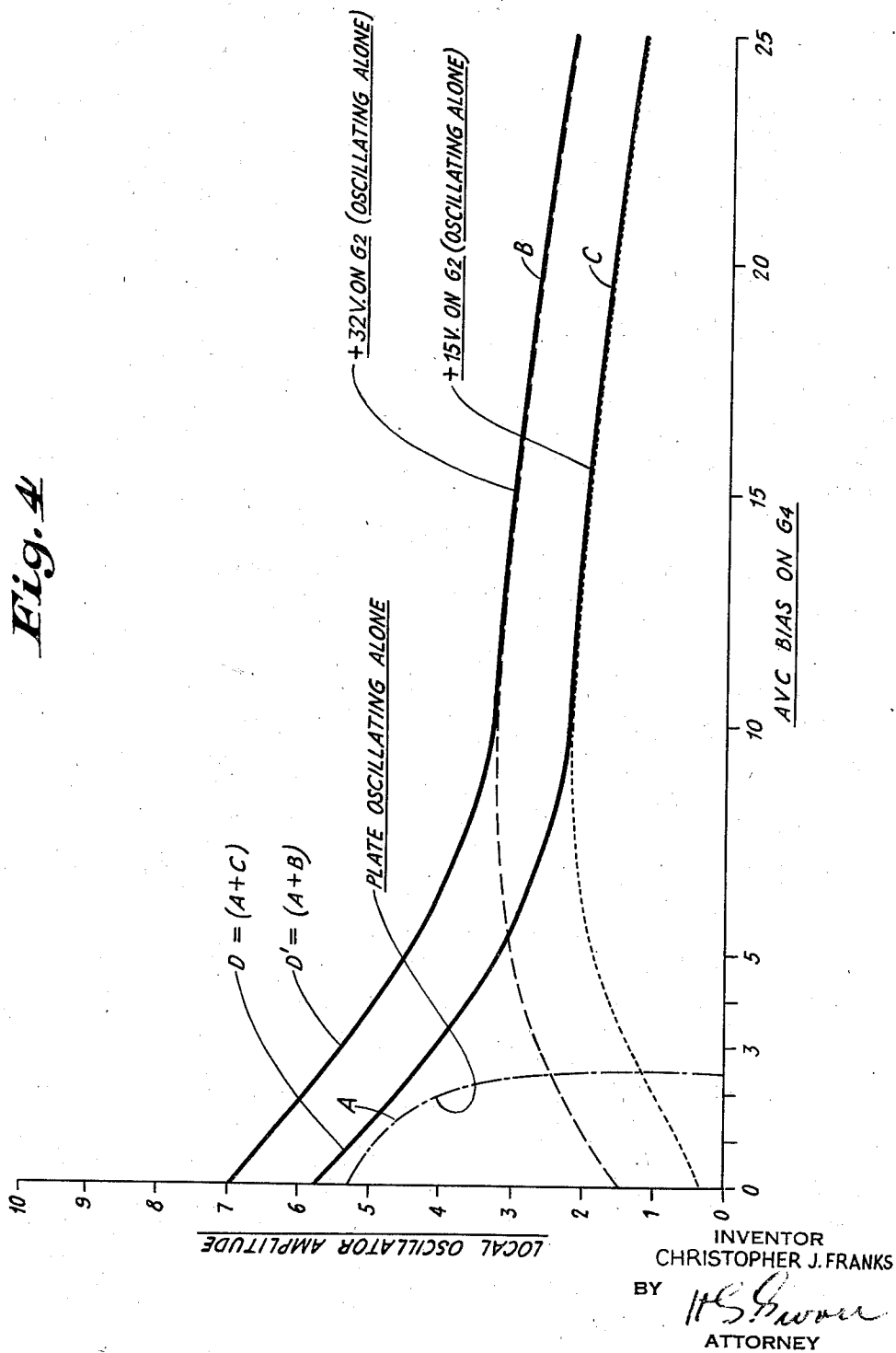
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Fig. 4



UNITED STATES PATENT OFFICE

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AUTOMATIC VOLUME CONTROL

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8 Claims. (Cl. 250—20)

My present invention relates to superheterodyne receivers, and more particularly to novel and improved methods of, and devices for, automatically regulating the volume of superheterodyne receivers.

It has heretofore been proposed to provide automatic volume control arrangements for superheterodyne receivers. In such volume control arrangements the gain of the converter network has been varied, as well as the gain of the various super-audible frequency amplifiers, in response to received signal carrier amplitude variations. For example, and as shown in my Patent No. 2,078,072, dated April 20, 1937, it has been proposed to vary the gain of a pentagrid converter tube of a superheterodyne receiver by varying the signal grid bias of the converter tube, this being accomplished in addition to the variation of signal grid bias of the radio frequency and intermediate frequency amplifier stages.

However there are many situations wherein it is desired to have a more rapid automatic gain control action on the pentagrid converter tube of a superheterodyne receiver. By increasing the rapidity of the automatic volume control action on the converter tube it may be possible, for example, to dispense with automatic bias control of the super-audible frequency amplifier stages. One of the problems to be overcome in providing a more rapid automatic gain control of the converter network of a superheterodyne receiver involves the need for maintaining substantial local oscillator voltage in the converter network throughout the automatic gain control action.

Accordingly it may be stated that it is one of the primary objects of my present invention to provide in a superheterodyne receiver employing a pentagrid converter network, an automatic volume control arrangement which functions simultaneously to vary the converter tube gain and the local oscillator voltage amplitude in response to signal carrier amplitude variations.

Another important object of the invention is to provide in conjunction with a pentagrid converter network of a superheterodyne receiver, an automatic gain control arrangement which operates to vary the gain of the converter tube by varying the negative grid bias on the signal grid of the converter, and simultaneously varies the local oscillator voltage amplitude in a sense such that the oscillator voltage amplitude decreases appreciably with signal amplitude increase thereby providing a more rapid automatic regulation of the converter network.

Another object of the invention is to provide

an improved and rapid automatic volume control method for a superheterodyne receiver employing a pentagrid converter network, the converter being particularly characterized by its inclusion of a double feed back arrangement from the oscillator anode electrode and plate of the converter tube, and the automatic volume control arrangement functioning to increase the negative bias on the signal grid of the converter tube and thereby substantially render inoperative the feed back from the plate of the converter tube as the received signal carrier amplitude increases.

Still other objects of the present invention are to improve generally the efficiency of superheterodyne receivers employing pentagrid converters and utilizing automatic volume control, and more especially to provide such receivers which are not only reliable and efficient in operation, but economically manufactured and assembled.

The novel features which I believe to be characteristic of my invention are set forth in 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 drawings in which I have indicated diagrammatically several circuit organizations whereby my invention may be carried into effect.

In the drawings:—

Fig. 1 diagrammatically shows a superheterodyne receiver embodying the present invention,

Fig. 2 shows a converter network of Fig. 1 embodying a modified form of the invention,

Fig. 3 shows a further modification of the converter network,

Fig. 4 graphically illustrates the operation of the present invention.

Referring now to the accompanying drawings, wherein like reference characters in the different figures designate similar circuit elements, there is shown in Fig. 1 the networks of a superheterodyne receiver of conventional and well known construction. The receiver embodies a source of signals f , and this may comprise the usual signal collector which may be a grounded antenna circuit; a loop antenna; an automobile signal pick-up device and even a radio frequency distribution line such as used in hotels or apartment houses at the present time. The source f may, also, be considered as including one or more, stages of tunable radio frequency amplification, and the number of stages to be employed will depend upon the signal amplitude desired at the input circuit of the pentagrid converter tube.

The signal source 1 is followed by a pentagrid converter tube 2 which is of the well known 6A7 type. Since the electrode structure of such a tube is well known at the present time, and its circuits, and their functions, are also very well known, it is sufficient to point out that the converter functions to convert the signal input energy to a desired intermediate frequency which is produced in the intermediate frequency output circuit 3 of the converter tube.

The signal energy is impressed upon the tunable signal input circuit 4 of converter tube 2, and the tunable local oscillator network 5 functions to tune the local oscillator network to that frequency which will differ from the frequency of input circuit 4 by the frequency of the network 3. The converter tube is followed by an intermediate frequency amplifier network 6; the latter may comprise one, or more, stages of intermediate frequency amplification. The network 3-3' is resonant to the operating intermediate frequency, and this frequency may be chosen from a range of 75 to 450 kc. The amplified output of the intermediate frequency amplifier network 6 is then impressed upon a second detector 7, and the latter may be of any desired type. The demodulated output of the second detector 7 is impressed upon an audio network, and the latter may comprise one, or more, stages of audio frequency amplification, followed by a reproducer.

In order to overcome the effects of variations of received signal strength there is employed an automatic volume control arrangement, and this latter arrangement functions to maintain the signal carrier amplitude at the input of the demodulator 7 substantially constant over a wide range of signal carrier amplitude variation at the signal collector of the receiver. The automatic volume control arrangement (hereinafter designated as AVC) may comprise a rectifier 8 of any desired and well known type, and the function of the rectifier is to produce a varying direct current voltage across the output load resistor 9. The varying direct current voltage is impressed as a gain control bias upon the signal grid of the converter tube 2, and this is accomplished through the lead 10 which includes the filter network 11.

The function of the network 11 is to suppress pulsating components of the rectified signal energy, and prevent them from being impressed on the signal grid of the converter tube 2. Of course, there may be additional variable bias leads from lead 10 to the intermediate frequency amplifier grid circuits, and also to the grid circuits of the radio frequency amplifier. However, such additional leads are not shown since such control circuits are well known to those skilled in the art. While the demodulator 7 and rectifier 8 are shown as conventional in nature, it will be understood that any desired type of specific circuits may be used for accomplishing their functions. For example, the multi-function tubes disclosed in my aforesaid copending application may be utilized for these demodulation and rectification functions. In general, it is to be understood that any of the automatic volume control circuits shown in my aforesaid copending application may be utilized in conjunction with the tunable converter tube 2 disclosed herein.

The pentagrid converter tube 2 includes the usual cathode and plate, and the intermediate five grids. The grid G_1 functions as the local oscillator grid, while the grid G_2 functions as the

oscillator anode. Grid G_4 has the signal energy impressed thereon, and the signal grid is disposed between a pair of screen grids which are connected to a point of positive direct current potential, the screening grids functioning as electrostatic screens because they are at ground alternating current potential. The cathode of converter tube 2 is connected to ground through the usual signal grid bias resistor 12, the latter being suitably bypassed by condenser 13. The variable tuning condenser 14 in the signal input circuit 4 has the grounded side thereof connected to the low alternating potential side of the signal input coil through a blocking condenser 15.

The variable tuning condenser 16 of the local oscillator network 5 has one side thereof grounded, while its high potential side is connected to the oscillator grid G_1 through a condenser 17. The grid side of condenser 17 is connected through the resistor 18 to the cathode. The resistor 18 and condenser 17 function as a leaky grid condenser network for the local oscillator section of the converter network. The dotted line representation used in conjunction with condensers 14 and 16 designates that these two condensers have their rotors mechanically uncontrolled, and it is to be understood that the local oscillator circuit 5 also is provided with proper padding condensers to keep the local oscillator network 5 properly "tracked" with the tuning of the signal input circuit 4.

Whereas in prior pentagrid converter arrangements it has been the practice to provide feedback from the oscillator anode G_2 to the oscillator grid G_1 in order to create the local oscillations, in the present converter network the plate of the converter tube 2 is also utilized to provide feedback. This double feedback arrangement is provided in order to have a strong local oscillator voltage amplitude when weak signals are received, and a substantially weak oscillator voltage amplitude when relatively strong signals are received. This is accomplished by connecting the plate of converter tube 2 to an appropriate source of positive potential B through a path which includes the coil of the intermediate frequency output network 3 and the oscillator feedback coil 20.

The coil 20 is magnetically coupled to the coil 21 of the local oscillator network 5. The condenser 22 connects the B side of feedback coil 20 to ground for proper bypassing action. The oscillator anode G_2 is connected to a source of positive potential L, which potential has a magnitude substantially less than that of source B, through a path which includes the radio frequency choke 23, the low potential side of coil 23 being connected to ground through a proper bypassing condenser 24. The plate side of feedback coil 20 is connected to the grid side of choke 23 through a blocking condenser 25, and the latter is given a magnitude of about 250 micro-microfarads.

It will, therefore, be seen that the grid G_2 feeds back radio frequency energy to the oscillator grid G_1 through a path including condenser 25, the feedback coil 20 and the oscillator circuit 5. The plate of converter tube 2, also, feeds back radio frequency energy to the oscillator grid G_1 through a path including feedback coil 20 and oscillator circuit 5. By means of this arrangement the grid G_2 does not furnish the entire oscillating anode conductance. The plate of the converter tube furnishes some of this oscillating anode conductance, and the latter is controlled

substantially to cut-off by the increasing negative bias on the signal grid G_4 . Ultimately, and after the point of cut-off of the plate feedback through coil 20, there will only be left the feedback action due to the grid G_2 , and this feedback action is designed to be sufficient to keep the oscillator voltage of sufficiently high and adequate amplitude no matter what value of AVC bias is applied to G_4 .

The arrangement shown in Fig. 1 is the preferred embodiment of the invention, whereas Figs. 2 and 3 show alternative embodiments which from practical considerations are not as preferable as the arrangement shown in Fig. 1. In Fig. 2, for example, the oscillator anode G_2 is connected by a lead 30 to a point on the feedback coil 20, this point being at a lower radio frequency potential than the point of coil 20 to which the plate of tube 2 is connected. In other words, in Fig. 2 there is shown an alternative embodiment for securing the result secured with the arrangement shown in Fig. 1 by tapping the grid G_2 down upon the feedback coil 20.

It will be observed that the arrangement in Fig. 1 differs from that shown in Fig. 2 in that while the grid G_2 is connected to the same point of feedback coil 20 as the plate of tube 2 in so far as radio frequency potentials are concerned, yet it is provided with direct current voltage through a parallel path and through the choke 23. The energizing direct current voltage L applied to grid G_2 in Fig. 1 is substantially lower than that applied by source B to the plate so that the initial feedback due to the grid G_2 is much less than that from the plate. In Fig. 2 this diminished initial feedback by the grid G_2 is secured by tapping down the grid upon the feedback coil 20, and supplying the plate and grid G_2 from a common source of voltage B .

The alternative embodiment in Fig. 3 resembles that shown in Fig. 1 in that the voltage L is applied to the coil G_2 , but an auxiliary feedback coil 20' is utilized. The auxiliary feedback coil 20', connected in the lead to the grid G_2 , is wound on the plate feedback coil 20. The coils 20 and 20' are poled so that the voltages which they induce into circuit 5 are in phase. They are wound in the same direction, and like ends are grounded. This modification, of course, differs from that shown in Fig. 2 in that the energizing direct current voltage of the grid G_2 is much lower than that used for the plate of the converter tube. As stated heretofore, the arrangement shown in Fig. 1 is preferable to those shown in Figs. 2 and 3. From practical considerations, it will be observed that in the arrangement of Fig. 1 there is avoided the necessity of cutting down the plate turns on the oscillator feedback coil, and there is, furthermore, avoided the need for an auxiliary feedback coil. However, it is to be clearly understood that the operation and functioning of the circuits are substantially the same, the circuit arrangement in Fig. 1 being more efficient insofar as the rapidity of volume control action is concerned.

Considering now the operation of the invention, and with particular reference to the circuit arrangement of Fig. 1, it is pointed out that when relatively weak signals are received the AVC bias on the signal grid G_4 is substantially zero, and the converter tube operates at its maximum gain. Both feedback paths are then functioning at their maximum efficiency. As pointed out heretofore the energizing voltage L on the

grid G_2 is such that the initial feedback from this grid is much less than that from the plate of the converter tube. In Fig. 4 there is graphically shown these relationships. Curve A denotes the variation of oscillation voltage amplitude with increasing negative bias on grid G_4 with feedback from the plate of converter tube 2 alone. The curve B shows the same relationship for the grid G_2 furnishing feedback alone and with substantially +32 volts on the grid G_2 .

By way of contrast the curve C shows the same relationship for the grid G_2 feeding back by itself with +15 volts on this grid. The curves D and D' show the resultant oscillator amplitude variation curves. In other words these curves show the change in oscillator amplitude, considering the effects of the plate feedback and the grid G_2 feedback. It will be observed from the curves of Fig. 4 that with zero AVC bias on grid G_4 there is a maximum resultant oscillator voltage amplitude produced in the converter tube 2, and that the component of oscillator voltage due to the grid G_2 is substantially less than that due to the plate acting by itself. The curve D shows the resultant oscillator curve due to curves A and C; curve D' shows the resultant of the curves A and B.

As the signal carrier amplitude increases, the negative bias on signal grid G_4 increases; and eventually cuts off the feedback from the plate of the converter tube. Considering Fig. 4 again, it will be seen from curves D and D' that when the signals have reached the point where substantial AVC bias is produced the effective oscillator voltage amplitude has been substantially reduced to the point where curves B and C correspond with the resultant oscillator voltage amplitude.

Thus there is a substantial decrease of the effective oscillator amplitude from zero AVC bias to large values of such bias. As a result of the present invention there is not only secured a reduction in gain of the converter tube due to the increasing bias of signal grid G_4 , but the local oscillator voltage amplitude is substantially decreased, and both these effects combine to secure a very rapid automatic volume control action. It is to be particularly noted that the decrease of the effective oscillator voltage amplitude, even at large AVC bias values, is not sufficient to interfere with the converter action of tube 2. The grid G_2 , as shown by curves B and C in Fig. 4, feeds back sufficient radio frequency energy to produce a satisfactory and adequate oscillator voltage amplitude.

By way of example, and in no sense limiting, it is pointed out that in general the magnitude of the B voltage is about three times as great as the voltage L . Thus, where L is about 32 volts, the value of B is some 100 volts. If 250 volts were used on the plate, as is normal for 6A7 operation, then the value of L should be in the range of 75 to 150 volts.

While I have indicated and described several systems 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 organizations 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 a converter network using a pentagrid tube provided with oscillator and mixer electrodes, the method of automatically controlling

the output of the converter which includes feeding back radio frequency energy from the oscillator anode, additionally feeding back energy from the mixer plate of the converter tube to an extent substantially greater than the oscillator feedback, and increasing the negative bias on the signal grid of the converter tube as received signal carrier amplitude increases whereby the feedback from the aforesaid plate is substantially eliminated at a predetermined value of negative bias on the signal grid.

2. In a converter network using a pentagrid tube provided with oscillator and mixer electrodes, the method of automatically controlling the output of the converter which includes feeding back radio frequency energy from the oscillator anode, additionally feeding back energy from the mixer plate of the converter tube, increasing the negative bias on the signal grid of the converter tube as received signal carrier amplitude increases whereby the feedback from the aforesaid plate is substantially eliminated at a predetermined value of negative bias on the signal grid, and maintaining the initial feedback from the oscillator anode much less than that from the plate.

3. In a detector-oscillator system using a tube having oscillator electrodes and detector electrodes, the method of automatically regulating the gain of the tube in response to received signal variations consisting in feeding back radio frequency energy from the detector output electrode to the oscillator grid electrode, proportioning the last feedback and the oscillator normal feedback so that the last feedback initially predominates, and substantially eliminating the last feedback when signals above a desired amplitude are received.

4. In a detector-oscillator system using a tube having oscillator electrodes and detector electrodes, the method of automatically regulating the gain of the tube in response to received signal variations consisting in feeding back radio frequency energy from the detector output electrode to the oscillator grid electrode, proportioning the last feedback and the oscillator normal feedback so that the last feedback initially predominates, substantially eliminating the last feedback when signals above a desired amplitude are received, and maintaining the normal oscillator feedback of adequate amplitude regardless of the amplitude of received signals.

5. A converter network including a pentagrid tube provided with oscillator and mixer electrode sections, means for providing a double feedback from the oscillator anode electrode and the mixer output electrode, the mixer output electrode feedback initially exceeding the oscillator anode feedback to a substantial extent, and automatic gain control means for increasing the negative bias on the tube signal grid, as signals increase, to thereby eliminate the mixer feedback.

6. In combination, a tube having at least a cathode, an oscillator grid, an oscillator anode

electrode, a signal grid and an output electrode, a signal input circuit connected between the cathode and signal grid, a network including a resonant circuit tuned to a predetermined local oscillation frequency, coupling the oscillator anode and grid, a beat frequency circuit connected to said output electrode, means reactively coupling the output electrode and the oscillator grid to provide an energy feedback and thereby produce oscillations of said local frequency which are of an amplitude substantially exceeding the amplitude of oscillations produced by said first coupling, said signal grid being disposed between the oscillator anode and output electrode, and means for varying the direct current potential relations between the signal grid and cathode thereby to regulate the magnitude of energy feedback through said reactive coupling means.

7. In combination, a tube having at least a cathode, an oscillator grid, an oscillator anode electrode, a signal grid and an output electrode, a signal input circuit connected between the cathode and signal grid, a network including a resonant circuit tuned to a predetermined local oscillation frequency, coupling the oscillator anode and grid, a beat frequency circuit connected to said output electrode, means reactively coupling the output electrode and the oscillator grid to provide an energy feedback of at least the same magnitude as that through said first coupling, said signal grid being disposed between the oscillator anode and output electrode, and means for varying the direct current potential relations between the signal grid and cathode thereby to control the energy feedback through said reactive coupling means, said output electrode being maintained at a substantially greater positive direct current potential than said oscillator anode whereby the feedback from said oscillator anode is a minimum when said potential difference is a minimum.

8. In combination, a tube having at least a cathode, an oscillator grid, an oscillator anode electrode, a signal grid and an output electrode, a signal input circuit connected between the cathode and signal grid, a network including a resonant circuit tuned to a predetermined local oscillation frequency, coupling the oscillator anode and grid, a beat frequency circuit connected to said output electrode, means reactively coupling the output electrode and the oscillator grid to produce a feedback of energy which substantially exceeds the energy feedback due to said first coupling, said signal grid being disposed between the oscillator anode and output electrode, and means for varying the direct current potential relations between the signal grid and cathode thereby to control the energy feedback through said reactive coupling means, said last varying means comprising a beat frequency energy rectifier, and connections for impressing between the cathode and signal grid the direct current output of the rectifier.