

March 5, 1940.

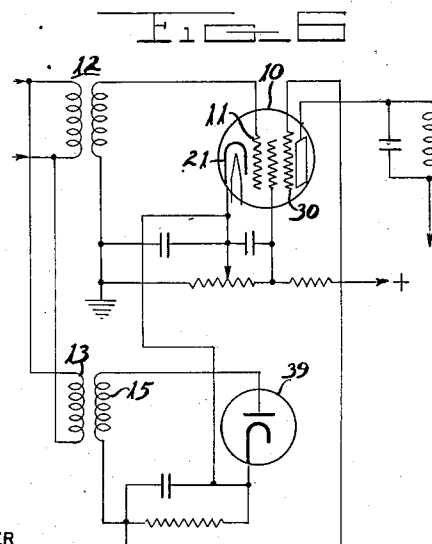
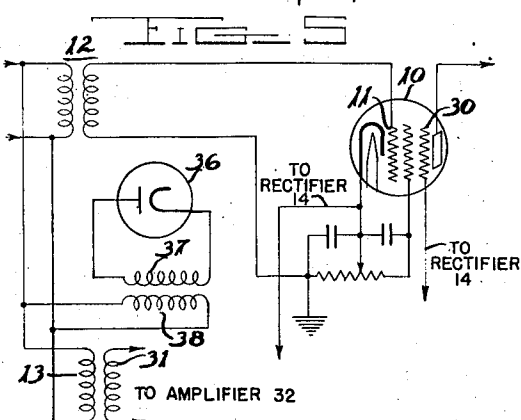
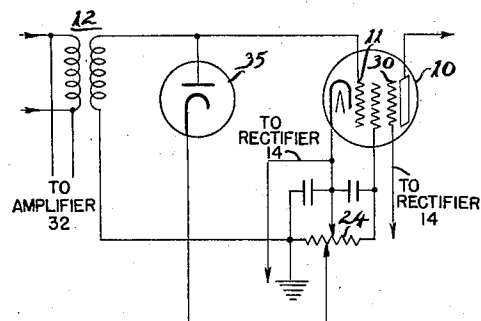
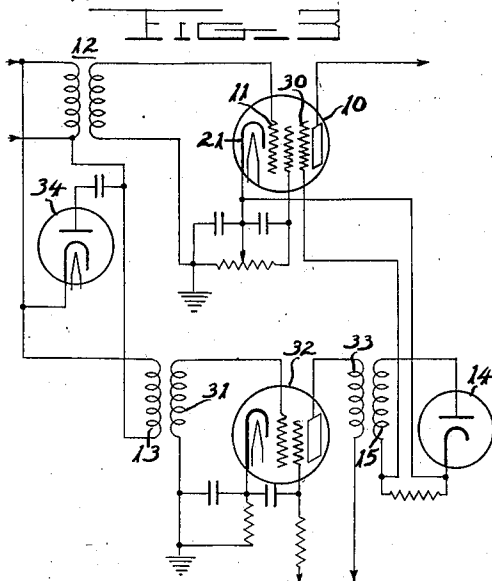
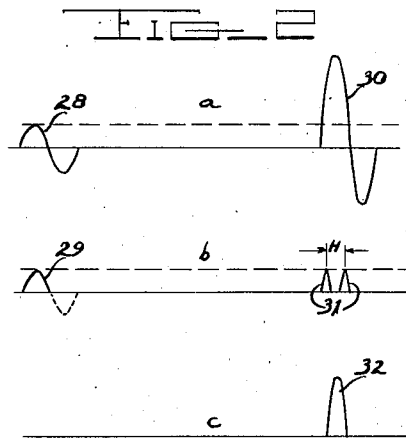
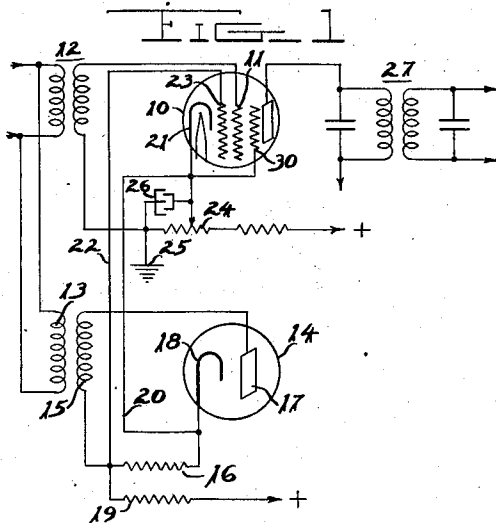
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2,192,189

STATIC LIMITATION IN RADIO RECEIVERS

Filed March 12, 1938

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig 7

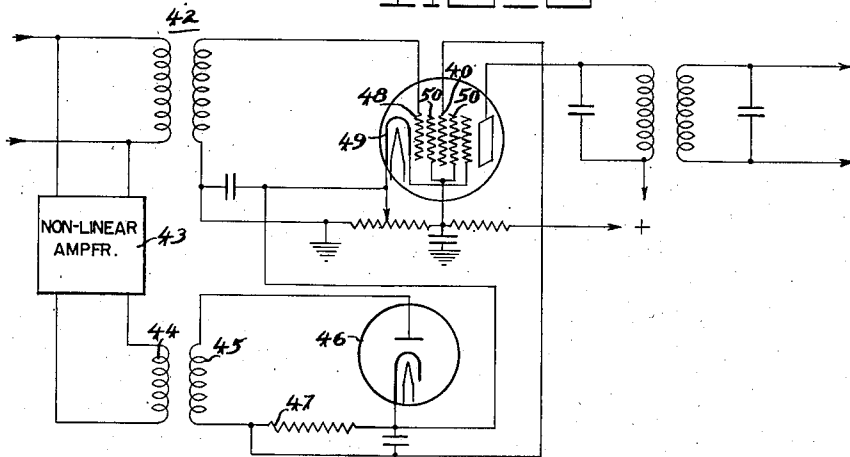
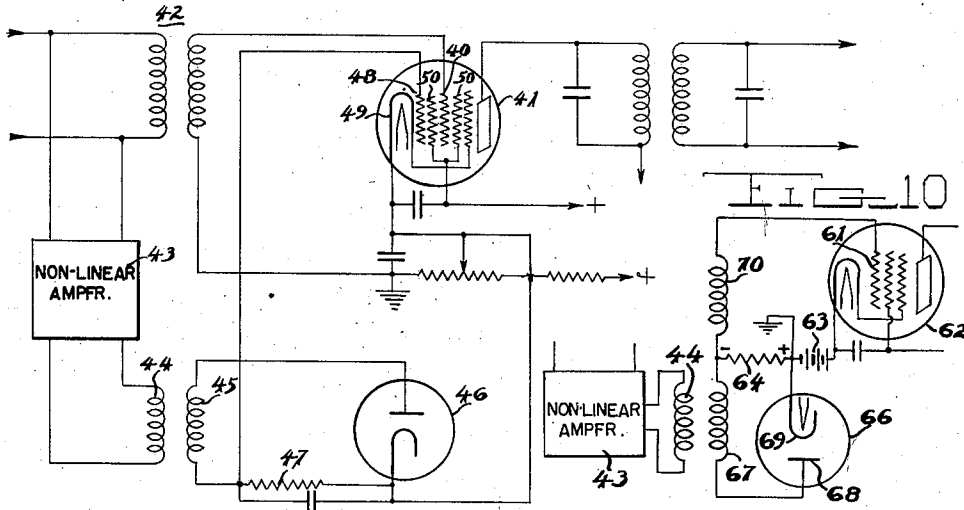
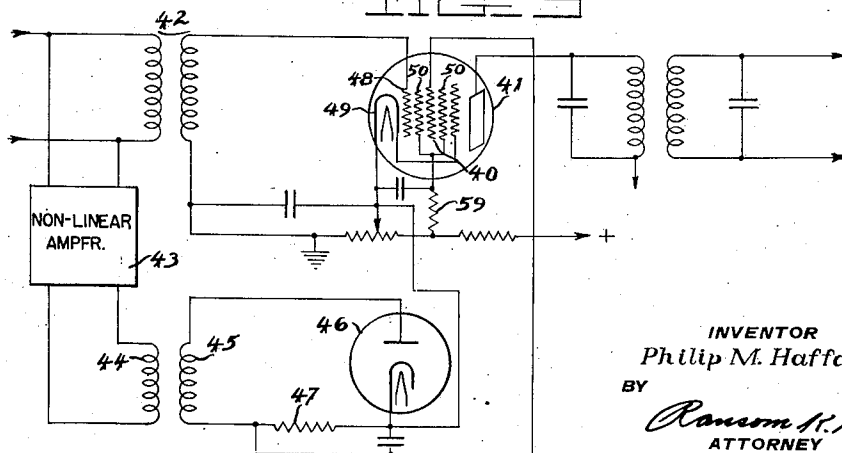


FIG. 9



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STATIC LIMITATION IN RADIO RECEIVERS

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Application March 12, 1938, Serial No. 195,542

15 Claims. (Cl. 250—20)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

This invention relates to means for suppressing the effect of static components in energy received by a radio receiver, to prevent rapid changes in plate current, due to the static, in a code receiver during "no signal" intervals.

Among the several objects of this invention are:

To provide means for converting energy surges of excessive amplitude to a frequency sufficiently removed from the signal frequency to permit frequency discrimination between the disturbing surges and the signal;

To provide means normally inactive to permit a signal to pass through a radio receiver tube but is rendered active by excessive surges of energy to effect plate current cut-off during periods of excessive amplitude;

To provide means for changing excessive amplitudes into harmonics that will be eliminated by subsequent tuned stages;

To improve the operation of code receivers by diminishing the effects of excessive amplitude energy thereon.

In the drawings:

Fig. 1 depicts a system for changing the bias on the cathode and on a normally inactive grid in a vacuum tube to reduce the plate current when excessive surges are received;

Fig. 2a shows a normal signal wave and a wave of excessive amplitude, 2b illustrates the form of the output wave of normal amplitude and the form of the output for excessive amplitudes, and 2c shows the voltage wave across the rectifier due to the excessive amplitude;

Figs. 3, 4, and 5 show various arrangements of means acting as a variable impedance across the input of a vacuum tube network and means for applying control potential to the suppressor grid;

Fig. 6 also shows means for changing the potential on the suppressor grid to control the output of the tube;

Fig. 7 shows a different type of tube used similarly to Fig. 6;

Figs. 8 and 9 disclose other networks for the same purpose utilizing the same type of tube as in Fig. 7;

Fig. 10 shows a modification in which the control voltage is applied to the signal grid.

I have found that with many static suppressing systems where a signal is superimposed upon a constant plate current the effect of static will, in many cases, cause actual plate current cut-off, or at least such a rapid change in plate current that the effect of such changes in the following tuned circuits is nearly, if not quite, as bad as

the static itself, when the system is adapted to code reception.

The ideal system, of course, would be one in which the output of the suppressing stage will not carry anything other than the desired signal, that is, during periods when there is no code character present, no plate current will be flowing.

Although such a system has been sought and various balancing circuits tried out, no successful means has been produced effectively to segregate static from a desired code signal, although partial success seems to be obtained by various limiting systems that cut off the peaks of abnormally high amplitudes. In any event such a system cannot hold the inter-character static to below the level of the signal amplitude.

The present system is radically different from any other of which I know, both in theory and in actual operation, is simple and adds little to the complications of operating the receiver, yet any instantaneous surges of static of high amplitude as compared to the average readable code signal are reduced to a minimum even during periods of "no signal" such as inter-character spaces.

Under ideal receiving conditions for code messages, there must be in the antenna system no strong parasitic disturbances present at the frequency of the desired signal, or within less than, say, 200 cycles of the desired signal frequency. If no interfering station is in operation within the above limits good aural reception is afforded on receivers of modern design. However, such a condition is seldom found in actual practice as parasitic and atmospheric disturbances are nearly always in evidence when the sensitivity of a receiver is set to a high level. Such parasitic disturbances now assume extreme proportions in amplitude and are as a rule many times stronger than the desired signal, though perhaps of short duration.

Now, if we convert a large percentage of these higher amplitude surges to some frequency considerably removed from that of the desired signal, it would make possible further discrimination between the heavy static surges and the signal wave on the basis of difference of frequency. This is the underlying principle involved in the present invention and is distinct and remote from those systems for static suppression in radio telephone reception wherein plate current is present and flowing during "no signal" intervals, and is cut to zero during periods of excessive input potentials.

To accomplish the end of no plate current change at the desired periods of "no signal", I operate the tube just at or slightly beyond the point of plate current cut-off, commonly known as Class B, Class BC or Class C operation. Thus, when no signal is present there is no plate current flowing because the signal grid is biased to just below plate current cut-off, and when the signal does come in this grid is caused to swing into the working range and thus allows the plate current to flow during periods of normal signal strength and amplitude on the positive half of the cycle only, somewhat similar to Class C operation. However, when parasitic and atmospheric surges of extreme amplitudes are introduced into the receiver, a rectifier and its associated circuit cause another grid situated in the electron path between cathode and anode but normally inactive, to cause plate current cut-off during such periods of excessive amplitudes even though the signal grid would allow electrons to pass while the desired signal is "on". This naturally causes a hole in the wave but this action is occurring on the individual radio frequency wave and leaves two small waves, of shorter base line than the fundamental, that represent harmonics which may, in some instances, be several orders above the fundamental frequency. These harmonics are effectually blocked out by succeeding stages of tuned circuits and thus will become far less effective in shocking the following stages into excitation than is the case with an ordinary limiting system, because of the wave shape presented to the following transformers and the characteristic inherent in any circuit containing an inductive factor, to a wave of flat top form when, although some harmonic components will be present, they will not be generated as efficiently as when the wave presented to the primary is of the form produced by the present system, hereinafter discussed in detail.

Referring now to Fig. 1, the radio frequency tube 10 receives input potential on grid 11 from coupling transformer 12 across the primary of which a coupling inductance 13 is connected to supply radio frequency energy to rectifier tube 14 which has a coupling inductance 15 and a resistor 16 in series with its anode 17 and cathode 18. The cathode 18 has impressed upon it a suitable small positive potential through resistor 19 to prevent rectifying action so long as the amplitude of the energy impressed upon inductance 15 is of less than a predetermined value. Inductance 13 acts as a variable impedance across the primary coil of transformer 12 when rectifier tube 14 is passing current and so exercises a limiting action upon the input to grid 11. The high potential side of resistor 16 is connected by wire 20 to cathode 21 of tube 10, while the low potential side of resistor 16 is connected by wire 22 to grid 23, which grid is normally inactive and exerts no effect upon the electron stream. A positive potential is applied to cathode 21 through a portion of variable resistor 24 whereof the low voltage side is grounded at 25, whereby tube 10 is biased somewhat below cut-off at "no signal". Capacitance 26 is connected from the cathode lead to ground in shunt with that portion of resistor 24 that is effective in biasing grid 11, and is of large capacity to insure a fairly constant bias on the grid.

Energy of normal signal amplitudes, as at 28 in Fig. 2a, is transferred through tube 10 to the following stage through a tuned output network 27, the output wave being as shown at 29 in Fig.

2b, due to the bias on tube 10 which results in substantially Class C operation. When an excessive surge, as at 30 in Fig. 2, is received the rectifier 14 passes current, resulting in a decrease of the impedance of inductance 13 due to the fact that the bias on rectifier 14 is overcome and the rectifier is caused to pass current, thus reducing the input to tube 10. The IR drop across resistor 16 due to the rectifier current impresses increased positive potential on cathode 21 and negative potential on grid 23, thus diminishing still more the current through tube 10, and if amplitude of the surge is sufficiently great, as at 30 in Fig. 2a, the tube 10 is swung to cut-off during the period of excessive amplitude, represented by the hole H between waves 41 in Fig. 2b, which waves 31 have a shorter base than the half wave at 30 and consequently represent higher harmonics which may differ by several orders from the fundamental frequency and hence are rejected by the subsequent tuned networks.

The relation of the voltage across the rectifier load to surge 30 is depicted at 32 in Fig. 2c. When the excessive amplitude is not too much greater the top of the wave will be flattened but no hole will be produced, and the harmonics represented by the flat top will be taken out in the following stages. Since no waves of amplitude much in excess of the normal signal amplitude pass tube 10, the other stage will not be shocked into excitation during "no signal" intervals and if the amplitude is sufficiently great the wave will be thrown off as higher harmonics and not reach the latter stages.

Fig. 3 is in general similar to Fig. 1 but in this case the normally inactive grid is the suppressor grid 30. Here the inductance 13 is coupled to input inductance 31 of an amplifier tube 32 so biased as to amplify disproportionately the higher amplitudes in the input energy as disclosed in my copending application Serial No. 87,404, filed June 26, 1936. Output primary coil 33 is coupled to input secondary 15 of rectifier 14 that is connected to cathode 21 and normally inactive suppressor grid 30 of tube 10 to function as above described. An additional limiting action is secured by the connection of a rectifier 34 in parallel with the primary coil of input transformer 12, whereby excessive amplitudes are by-passed and do not so strongly affect the operation of tube 10.

In Fig. 4 the arrangement is the same as in Fig. 3 except for the connection of the rectifier 35, which is connected in parallel with the secondary coil of transformer 12 with the cathode lead being disposed to include a portion of biasing resistor 24 in the rectifier circuit, whereby the rectified current flowing through tube 35 impresses additional IR drop upon control grid 11 while at the same time the cathode of the by-pass rectifier 35 is given the desired positive bias to prevent rectification at normal signal amplitudes.

In Fig. 5 the by-pass rectifier 36 is coupled by a coil 37 to inductance 38 that is in parallel with the primary of input transformer 12. It is obvious that when rectifier 36 draws current the impedance of the input circuit is much reduced and high amplitude energy is by-passed and thus the input to tube 10 is reduced.

It is to be noted that in the arrangement shown in Fig. 1 the normally inactive grid is between the cathode 21 and the control grid 11, whereas in Figs. 3, 4 and 5 the control grid 11 is between the cathode 21 and the normally inactive grid 30, 75

and it is therefore preferable that some amplification of the radio frequency energy take place before rectification in tube 14, owing to the greater distance of the normally inactive grid from the cathode.

In Fig. 6 the control potential derived from the rectified current flowing through the rectifier tube 39 is applied between the cathode 21 and suppressor grid 30 of the tube 10. Otherwise, this network is very similar to that of Fig. 1.

Fig. 7 discloses the network arrangements for applying the present invention to a tube of the type known as 6L7. The control grid 40 of tube 41 is connected to the secondary of input transformer 42 across the primary of which is connected a non-linear amplifier 43 to amplify disproportionately high amplitude waves; the output of amplifier 43 being coupled by inductance 44 to inductance 45 in the anode-cathode circuit of rectifier 46. The IR drop across resistor 47 in the rectifier circuit is applied to normally inactive grid 48 and cathode 49 of tube 41 to exercise control over the current through tube 41 in the manner above described. Tube 41 is biased to "cut-off" or slightly below at "no signal" and operates substantially as a Class C or BC amplifier.

The embodiment of my invention disclosed in Fig. 8 differs from that in Fig. 7 in that the grid 48 is here the control grid and the grid 40 is the normally inactive grid to which control voltage is applied.

Fig. 9 is like Fig. 8 with the addition of a resistor 59 in series with accelerating grids 50 that are positively biased and hence normally accelerate the electrons in the electron stream but when the electron stream increases above a predetermined value the current flowing from cathode 49 to grids 50 produces a potential drop across resistor 59 and reduces the potential on grids 50 and thus applies an additional limiting action to the electron stream to cut down the output current.

It is to be noted that the preliminary limiting action impressed upon the input changes the wave form of the input energy so that the action of the normally inactive grid, when rendered active by excessive amplitudes of received energy, is much more effective in throwing the high amplitude waves to higher harmonics that may be taken out by the subsequent tuned stages.

Fig. 10 illustrates an application of the principle of this invention wherein the static controlling action is exercised through the signal grid 61 of tube 62. Tube 62 is given a Class C bias by battery 63 and a resistance 64 is in series with cathode 65 and grid 61, the signs + and - adjacent the terminals of resistance 64 indicating the sense of the potential drop therein due to current from rectifier tube 66. Coil 44 receives the output of non-linear amplifier 43 and is coupled to coil 67 in series with anode 68 and cathode 69 of rectifier tube 66, the coil 67 being so poled with respect to input coil 70 of tube 62 that anode 68 is made positive, when the rectifier 66 functions, at the same time grid 61 of tube 62 is swung positive. Reception of an excessive amplitude surge that would swing grid 61 strongly positive causes rectifier 66 to pass current and the IR drop resulting from passage of this current through resistor 64 impresses upon grid 61 sufficient negative potential to neutralize the excessive positive potential.

It will be understood by those skilled in this art that for operation at some frequencies the by-pass

condenser in parallel with the resistance in the rectifier circuit may be omitted if the time lag introduced thereby is undesirable.

In some instances it is preferable to leave the rectifier 14 unbiased when signals are weak and it is desired that the normally inactive grid should come into operation early.

The invention herein described and claimed may be used and/or manufactured by or for the Government of the United States of America, for governmental purposes without the payment of any royalties thereon or therefor.

I claim:

1. In combination, a radio energy transfer device having a primary inductance and a secondary inductance; a vacuum tube having an anode, a cathode, a control grid, and a normally inactive grid; means connecting said control grid and said cathode to opposite sides of said secondary inductance, means for biasing said tube at least to cut-off including a variable resistance whereof a portion is included between said cathode and said secondary inductance, a large capacity condenser connected in shunt with said portion of said resistance, a first inductance connected across said primary inductance, a second inductance coupled with said first inductance, a rectifier tube having an anode and a cathode, means including a second resistance connecting the cathode of said rectifier to one side of said second inductance, means connecting the anode of said rectifier to the other side of said second inductance, means connecting the high potential side of said second resistance to the cathode of said vacuum tube, means connecting the low potential side of said resistance to said normally inactive grid, means including a third resistance to apply positive potential at said low potential side of said second resistance, a ground connection to the low potential side of said variable resistance and a tuned output circuit connected to the anode of said vacuum tube.

2. A vacuum tube network, comprising a vacuum tube having a plurality of electrode elements including a cathode and a normally inactive grid, radio frequency input means connected to said cathode and to another of said electrode elements, a rectifier tube having an anode and a cathode, means including a resistance connecting said anode and cathode of the rectifier, means to maintain on said vacuum tube a substantially constant bias at least to cut-off, means connected across said input means to transfer radio frequency energy to said rectifier, means to bias said rectifier to prevent operation thereof when the said radio frequency energy is of less than a predetermined amplitude but to permit said rectifier to operate when said predetermined amplitude is exceeded, means connecting the high voltage side of said resistance in the rectifier circuit to the cathode of said vacuum tube and means connecting the low voltage side of said resistance to said normally inactive grid.

3. A vacuum tube network, comprising a vacuum tube having a plurality of electrode elements including a cathode and a normally inactive grid, said tube being biased to cut-off at no signal, radio frequency input means connected to said cathode and to another of said electrode elements, means to shunt energy immediately ahead of said input, means to utilize said shunted energy to produce a potential difference when the amplitude of said energy exceeds a predetermined magnitude, means to apply the high potential

value of said potential difference to the cathode of said vacuum tube, and means to apply the low potential value of said potential difference to said normally inactive grid.

4. A vacuum tube network, comprising a vacuum tube having a plurality of electrode elements including a cathode and a normally inactive grid, said tube being biased to cut-off at no signal, radio frequency input means connected to said cathode and to another of said electrode elements, means to divert a portion of the energy from said input means, means coupled to said diverting means to effect disproportionate amplification of high amplitude components of said diverted energy, rectifying means controlled by the said disproportionately amplified components including an element across which a potential difference is set up by the rectified current, and means to apply to said cathode the potential at the high potential terminal of said element and to said normally inactive grid the potential at the low potential terminal of said element.

5. A vacuum tube network, comprising a vacuum tube having a plurality of electrode elements including a cathode and a normally inactive grid, radio frequency input means connected to said cathode and to another of said electrode elements, means to divert a portion of the energy from said input means, means coupled to said diverting means to effect disproportionate amplification of high amplitude components of said diverted energy, rectifying means controlled by the said disproportionately amplified components including an element across which a potential difference is set up by the rectified current, means to apply to said cathode the potential at the high potential terminal of said element and to said normally inactive grid the potential at the low potential terminal of said element, and means connected across said diverting means and responsive to said high amplitude components to act as a low impedance shunt during the incidence of such high amplitude components.

6. A vacuum tube network, comprising a vacuum tube having a plurality of electrode elements including a cathode, a control grid and a normally inactive grid, radio frequency input means connected to said cathode and said control grid, means to divert a portion of the energy from said input means, means coupled to said diverting means to effect disproportionate amplification of high amplitude components of said diverted energy, rectifying means controlled by the said disproportionately amplified components including an element across which a potential difference is set up by the rectified current, means to apply to said cathode the potential at the high potential terminal of said element and to said normally inactive grid the potential at the low potential terminal of said element, rectifying means in shunt across said cathode and said control grid responsive to excess amplitudes of input energy to by-pass a portion of said excess amplitude energy, and impedance means in the circuit of said rectifying means and between said cathode and said control grid whereby the current through said rectifier impresses additional negative bias on said control grid.

7. In a method of operating a vacuum tube network comprising a vacuum tube having electrode elements including a cathode and a normally inactive grid and input means coupled to said tube, the steps of biasing said tube to cut-off, shunting a portion of the received energy immediately ahead of said input, applying said

shunted energy to cause rectified current to flow when the amplitude of the received energy exceeds a predetermined magnitude, said shunted energy being subtracted from the input to the tube, utilizing said rectified current to produce a potential difference, and applying said potential difference to make said cathode more positive and said normally inactive grid negative.

8. In a method of operating a vacuum tube network comprising a vacuum tube having electrode elements including a cathode and a normally inactive grid and input means coupled to said tube, the steps of biasing said tube to cut-off, shunting a portion of the received energy immediately ahead of said input, disproportionately amplifying high amplitude components of said shunted energy, applying said amplified shunted energy to cause rectified current to flow when the amplitude of the received energy exceeds a predetermined magnitude, said shunted energy being subtracted from the input to the tube, utilizing said rectified current to produce a potential difference, and applying said potential difference to make said cathode more positive and said normally inactive grid negative.

9. In a method of operating a vacuum tube network comprising a vacuum tube having electrode elements including a cathode and a normally inactive grid and input means coupled to said tube, the steps of biasing said tube to cut-off, impressing upon the input energy into said tube a limiting action whereby to produce harmonics and flatten the top of the energy wave, drawing energy from the same source as said input energy and deriving rectified current from the energy thus drawn, and applying said rectified current to interrupt the current through said tube during the incidence of energy of amplitudes above a predetermined maximum, thereby breaking up each wave of such excess amplitude into two waves of a higher harmonic and of amplitude not in excess of said predetermined maximum amplitude.

10. In a method of operating a radio receiver to prevent flow of plate current during no signal intervals and shocking of the last stages into excitation, said receiver comprising a stage including input means and a vacuum tube having a cathode and a normally inactive grid, the steps of biasing said tube to cut-off, diverting energy from the signal channel of said receiver immediately ahead of said input means and disproportionately amplifying high amplitude components of said diverted energy, rectifying said disproportionately amplified energy and applying said rectified energy to produce a potential difference, applying said potential difference to said cathode and said normally inactive grid to break up waves having an amplitude in excess of a predetermined magnitude into two waves of a higher harmonic and of amplitude not in excess of said predetermined magnitude, and blocking out said higher harmonic waves in a subsequent tuned stage.

11. In a method of operating a vacuum tube network comprising a vacuum tube having a plurality of electrodes including a cathode and more than one grid, the steps of biasing said tube to cut-off, maintaining one of said grids normally inactive, utilizing excess amplitude of waves of received energy to apply a limiting action to the transfer of energy through said tube during the incidence of such waves of excess amplitude, and further utilizing such excess amplitude energy to make said cathode more positive and render said normally inactive grid negative, whereby each

said wave of excess amplitude is broken up into two waves of a higher harmonic and of amplitude not to exceed normal signal amplitude.

12. A method of operating a vacuum tube network that includes a vacuum tube having a grid and a cathode connected in an input circuit that includes a resistor, comprising the steps of biasing said tube at least to cut-off, collecting radio energy, applying a portion thereof to said network as input, non-linearly amplifying another portion of said energy when the amplitude thereof is in excess of a predetermined value, rectifying said non-linearly amplified energy, and passing said rectified energy through said resistor whereby to reduce the potential on said grid when said grid tends to swing excessively positive due to said excess amplitude.

13. A method of operating a vacuum tube network that includes a vacuum tube and an input circuit therefor, comprising the steps of biasing said tube at least to cut-off at no signal, collecting radio energy, feeding at least a portion of said energy to said circuit, diverting ahead of said circuit a portion of said energy when the amplitude thereof is in excess of a predetermined value, non-linearly amplifying said diverted portion, rectifying said non-linearly amplified portion,

and utilizing said rectified energy to produce a potential drop in said circuit opposed to the energy fed into said circuit.

14. A method of operating a vacuum tube network that includes a vacuum tube and an input circuit therefor, comprising the steps of biasing said tube at least to cut-off at no signal, collecting radio energy, feeding at least a portion of said energy to said circuit, rectifying another portion of said energy when the amplitude thereof is in excess of a predetermined value, and utilizing said rectified energy to produce a potential drop in said circuit opposed to the energy fed into said circuit.

15. In a radio receiver, a vacuum tube having input electrodes, circuit means connecting said electrodes including a resistor and means to impress on said tube a bias at least to cut-off at no signal, a rectifier tube including electrodes connected across said resistor, and means responsive to excessive amplitudes of received energy to supply to said rectifier energy so poled that current from said rectifier produces in said resistor a potential drop opposed to the input potential on said electrodes.

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