

Feb. 4, 1941.

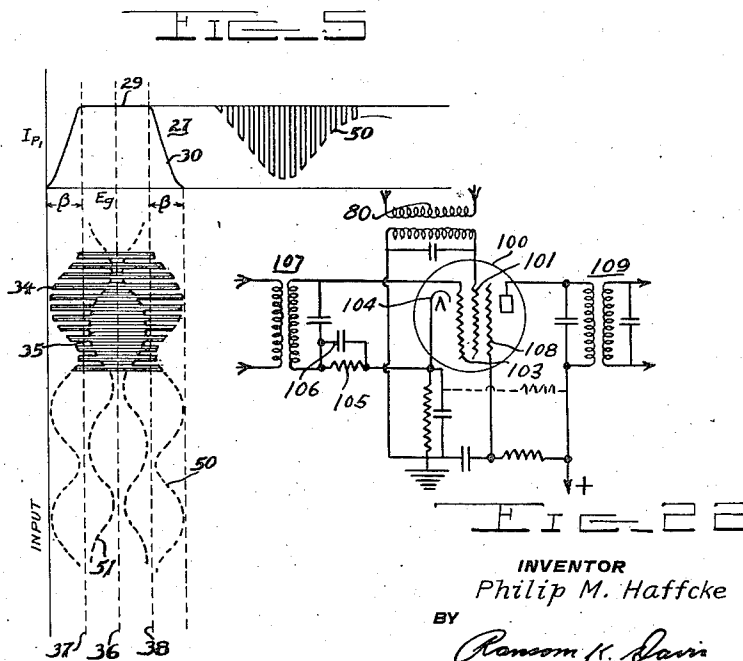
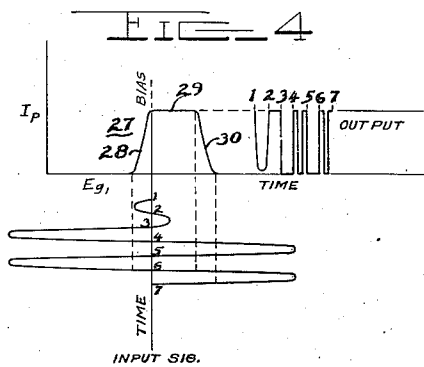
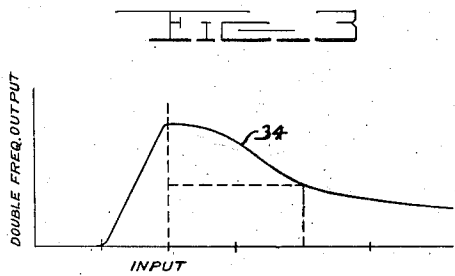
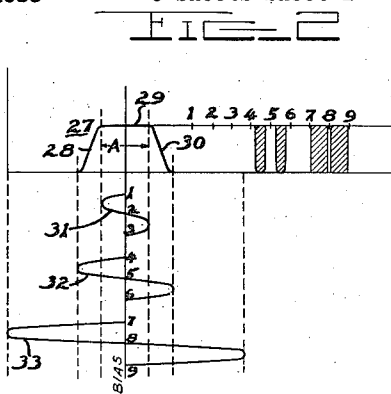
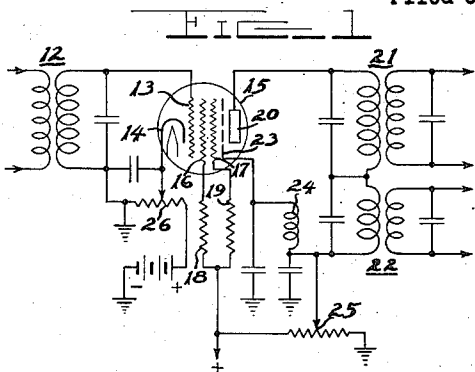
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2,230,243

SIGNAL SELECTION BY AMPLITUDE DISCRIMINATION

Filed June 28, 1938

3 Sheets-Sheet 1



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SIGNAL SELECTION BY AMPLITUDE DISCRIMINATION

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3 Sheets-Sheet 2

FIG. 6

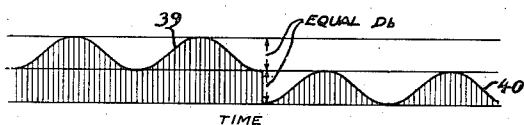


FIG. 7

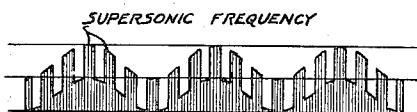


FIG. 8

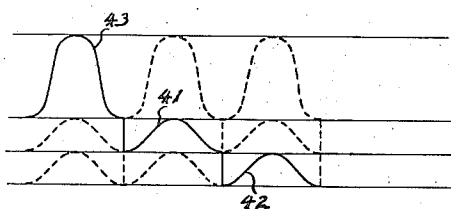


FIG. 9

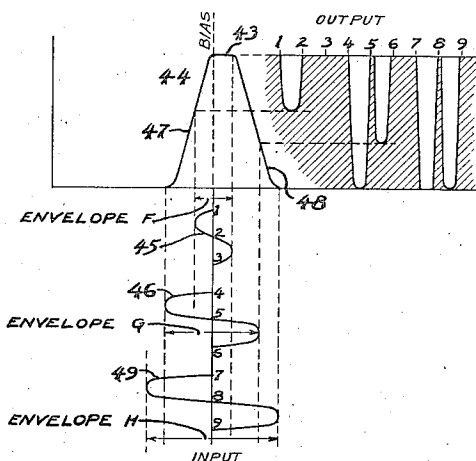


FIG. 10

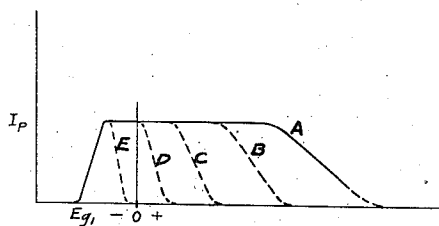
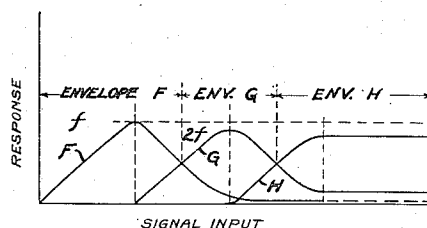


FIG. 11



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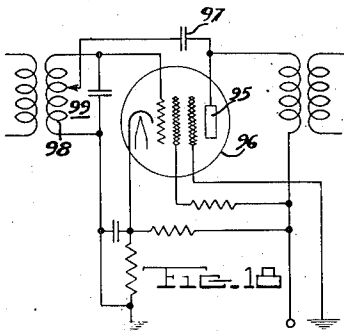
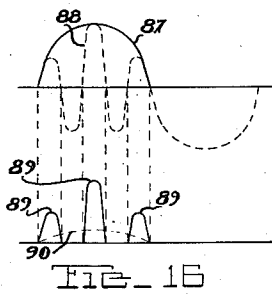
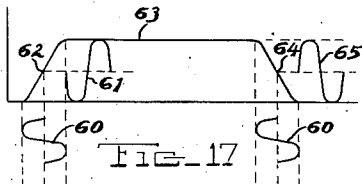
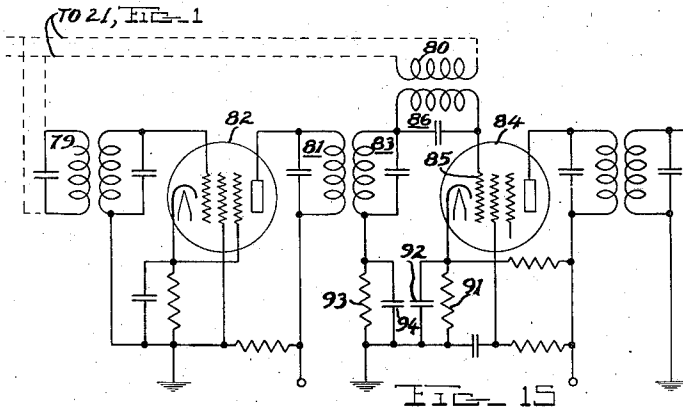
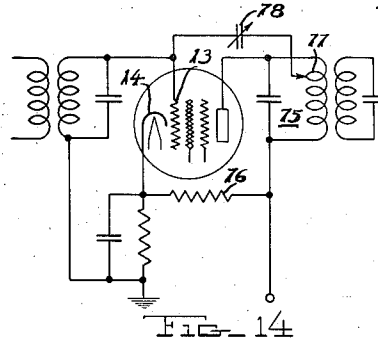
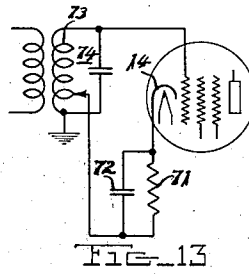
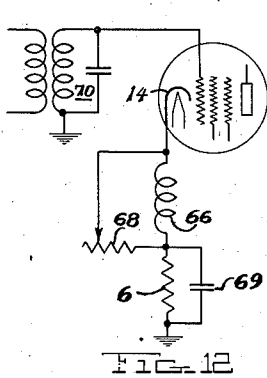
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SIGNAL SELECTION BY AMPLITUDE DISCRIMINATION

Filed June 28, 1938

3 Sheets-Sheet 3



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2,230,243

SIGNAL SELECTION BY AMPLITUDE
DISCRIMINATION

Philip M. Haffcke, Washington, D. C.

Application June 28, 1938, Serial No. 216,275

15 Claims. (Cl. 250-6)

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

This invention relates broadly to radio communication wherein the desired signal is separated by amplitude discrimination from other energy received simultaneously therewith, such as low level noise and high amplitude static disturbance, whether on the same frequency or another frequency not sufficiently different from the signal frequency to be tuned out by frequency discrimination. More specifically, this invention relates to means for, and a method of, radio communication wherein a vacuum tube network is so operated that the grid voltage-plate current characteristic curve has a limb rising from cut-off to a saturation value which may be maintained over a desired voltage range and upon further increase in voltage has a limb descending again to cut-off but with a slope opposite the slope of the first mentioned limb.

Among the numerous objects of this invention are:

To separate a desired signal from accompanying non-signal energy at twice the fundamental signal frequency, by amplitude differentiation;

To cause those portions of waves below chosen amplitude limits to be ineffective to change the output of the vacuum tube and those of greater than a chosen upper amplitude limit to be ineffective by cut-off of plate current, while those portions of the last mentioned waves that lie within the said limits are thrown into higher harmonics;

To provide for secrecy by blanketing message signals, sent at a chosen amplitude, with signals at the same or other frequencies having different amplitudes and which cannot be separated from the message by an ordinary receiver;

To separate a message signal when sent on an envelope defined by breaking up an envelope of different amplitude into supersonic groups;

To provide for receiving a message intelligibly when blanketed by interference of a different amplitude.

In the drawings:

Fig. 1 shows schematically a vacuum tube network adapted to practice the present invention;

Fig. 2 depicts an E_g-I_p curve characteristic of the network of Fig. 1, and certain outputs derivable therefrom;

Fig. 3 is a curve showing the variation of double frequency output in relation to input.

Fig. 4 illustrates changes in the output when the fixed grid biasing potential is shifted to a position different from that in Fig. 2;

Fig. 5 shows two different signal envelopes on

the same carrier, separable by the present invention;

Fig. 6 is generally similar to Fig. 5 but here each of the two envelopes of equal amplitude is produced by, say, a 1000 cycle tone, of equal volume with the minimum of one envelope substantially coinciding with the maximum of the other;

Fig. 7 illustrates the production of an effect similar, for practical purposes, to that in Fig. 6, by breaking up one envelope into supersonic groups;

In Fig. 8 the second envelope, which carries the message is blanketed by a first envelope of less power and a third envelope of much greater power;

Fig. 9 shows the effect of adjusting the circuit's constants to obtain a more sharply pointed E_g-I_p curve and operating with the grid bias at one limit of the saturation current portion of the curve;

Fig. 10 presents a group of E_g-I_p curves resulting from altering the circuit values;

Fig. 11 shows graphically the response under the conditions of operation illustrated in Fig. 9;

Figs. 12 to 14 and 18 depict arrangements that efficiently reduce the effects of undesirable intratube coupling when operated in conformity with the present invention;

Fig. 15 shows means for reducing the average power output by "chopping" a fundamental frequency wave with a harmonic thereof;

Fig. 16 illustrates the relation of the fundamental frequency and the harmonic by which the fundamental is "chopped" by the system of Fig. 15;

Fig. 17 discloses an E_g-I_p characteristic curve and the relation of the input and output voltages about certain points thereon;

Figs. 19 to 21 show various forms of E_g-I_p curves upon which thermionic tubes may be operated for specific purposes.

Fig. 22 shows means for reducing the average power output by chopping.

The present invention is based upon discoveries made while studying the action of tubes and networks such as are disclosed in my Patent 2,106,172. It is shown in this patent that if one or more grids, preferably adjacent the anode of the tube, be given a positive bias and connected through suitable resistances to the cathode they will intercept electrons from the electron stream and during excessive flow of electrons resulting from heavy surges of received energy the flow of current through the above mentioned resistances

will reduce the potential on the grids and cut down the stream of electrons to the anode, even to the point of causing cessation of anode current flow when the circuit values are properly adjusted.

Fig. 1 shows schematically a vacuum tube network adapted to practice the present invention, wherein the input transformer 12 is connected to grid 13 and cathode 14 of tube 15. The interceptor grids 16 and 17 are connected in series with resistances 18 and 19 respectively and also to a source of positive potential. The output circuit between anode 20 and cathode 14 includes a tuned output transformer 21 to pass a chosen fundamental frequency and also a like transformer 22 tuned to pass double the fundamental frequency. Screen grid 23 is connected through a filter choke 24 to a voltage divider 25 that also serves as the supply to anode 20.

Fig. 2 presents an E_p-I_p curve 27 that is characteristic of the tube 15 when operated with the proper circuit values, this curve consisting of a limb 28 rising from cut-off to a straight flat top portion 29 representing saturation current and an oppositely sloping limb 30 descending to cut-off. If the voltage divider 25 be so adjusted as to impress upon signal grid 13 a biasing potential represented by the line designated "bias" in Fig. 2, that is, having a value represented by substantially the midpoint of portion 29 of curve 27, the results next to be described will be attained.

An input voltage wave of amplitude not exceeding one-half the length of portion 29 is indicated at 31 and it will be noted that since it lies within the voltage limits corresponding to saturation current it will have no effect on the output current as is seen by comparing the areas represented by 1-2-3 in the output, corresponding to the points 1-2-3 on voltage wave 31. The curve 32 represents an input voltage wave having an amplitude lying between the cut-off terminal of limbs 28 and 30 of curve 27. It will be noted that those portions of the voltage wave 32 lying within the space designated A, that is, between the limits of the portion 29, have no effect upon the output but the portions of the wave lying between the termini of limbs 28 and 30 do affect the output, as indicated by the spaces 4-5-6 in the output corresponding to the points 4-5-6 on curve 32. However, it will be seen that the effective portions of wave 32 both result in a decrease of the plate current, due to the fact that the voltage swing moves from the saturation zone A down along the respective limbs to cut-off and upward again from cut-off to the portion 29 and hence this effective change in plate current will have twice the frequency of the fundamental or input voltage wave. Curve 33 represents a wave having an amplitude in excess of the values represented by the cut-off points of curve 27. Again, those portions of the wave lying in the zone A have no effect upon the plate current and those portions thereof lying beyond the cut-off values likewise are ineffective to change the plate current, while those portions lying between the termini of limbs 28 and 30 of curve 27 are practically rectangular and therefore represent higher harmonics, in some instances many orders higher than the fundamental frequency of the input voltage, the form of the output wave due to voltage 33 being shown in the output as 7-8-9.

In Fig. 3 the curve 34 shows the variation of double frequency output 4-5-6 in Fig. 2 in re-

lation to the input. It will be noted that the double frequency output rises rapidly for certain changes in the input then declines gently for a space and then curves downwardly on a line that is substantially asymptotic.

The curves 31, 32 and 33 in Fig. 2 represent, respectively, low amplitude noise, the desired signal amplitude, and high amplitude interference that may be either natural or might be deliberately produced spark interference sent out by an enemy attempting to blanket radio communication. The higher harmonic content of the output represented by 7-8-9 will be readily filtered out and eliminated by stages subsequent to the tube 15.

Fig. 4 illustrates the mode of operation to separate high amplitude interference from signal amplitudes. Here the bias of the signal grid 13 is adjusted to a value represented by substantially the junction of portion 29 of curve 27 with the limb 28 thereof. In the light of the discussion of Fig. 2, it will be readily perceived that the portion 1-2 of the input wave lies between the termini of limb 28 and is therefore effective in changing the output, whereas the portion 2-3 lies between the limits of the portion 29 and does not affect the output hence the signal will appear in the output at its fundamental frequency. However, the portion 3-4 of the wave, wherein the amplitude is excessive, will affect the output only as to so much of the wave as lies between the termini of limb 28 and will give a substantially rectangular output 3-4 representing higher harmonics. The portion 4-5 of the wave will likewise appear in the output as higher harmonics due to so much of the wave as lies between the termini of limb 30, but the form thereof is seen to be much narrowed as compared to 3-4.

Fig. 5 represents an application of the present invention wherein a continuous wave is modulated to carry two envelopes 50 and 51 of different amplitude by shifting from one amplitude to the other at supersonic frequency. The carrier having a frequency represented graphically by the transverse lines in Fig. 5 may have a frequency of 50 to 100 times the supersonic frequency of shifting from one amplitude to the other, which supersonic frequency may be from 20 to 30 kilocycles per second. The portions of greater amplitude represented by lined elements 34 define an envelope 50 of greater amplitude lying within the cut-off limits of curve 27 while the envelope 51 of lesser magnitude defined by portion 35 lies within the limits of the portion 29 of curve 27. It is apparent, from previous discussion, that if the signal grid of the tube be biased to a value represented by dashed line 36 the envelope 50 will appear in the output at double the fundamental frequency represented by this envelope and may be made the signal bearing envelope. However, if the control grid of the tube be biased at points represented by either dashed line 37 or dashed line 38 the envelope 50 will not appear in the output except possibly as higher harmonics while the envelope 51 will be in the output at its fundamental frequency. It is apparent that an ordinary receiver cannot discriminate between these two envelopes and hence a signal carried by either one could not be interpreted but the separation of the signal bearing envelope may be readily achieved by the present invention.

Fig. 6 illustrates a different method of utilizing this invention wherein a continuous wave is modulated by, say, a 1000 cycle tone, to carry two en-

velopes 39 and 40 of equal strength or db. where-
in the minimum of the ope substantially coin-
cides with the maximum of the other. It is be-
lieved to be obvious how either of these envelopes
5 may be separated from the other at the receiver
when the methods disclosed herein are followed.

Fig. 7 is an application of the method of trans-
mission set forth in connection with Fig. 5 to the
superposition of one envelope on the other as
illustrated in Fig. 6, that is, the two envelopes
10 are defined by shifting from one to the other
at supersonic frequencies.

In Fig. 8 I show how a signal envelope 41
may be blanketed by an envelope 42 of less or
of substantially the same amplitude as in Fig. 6
and further blanketed by an envelope 43 of much
greater strength, and yet the signal envelope 41
may be readily segregated without cross talk
by the method disclosed in connection with Fig. 2.

It will be apparent to those skilled in this
art that the extent of the saturation portion 29
of curve 27 may be changed either to increase
or decrease the range represented thereby. That
is, adjusting the potential divider 26 away from
the ground connection raises the potential on
cathode 14 and hence it requires a greater grid
potential to cause the tube to pass current and
likewise adjusting the potential divider 25 to-
ward ground has the same effect. Increasing
30 the values of resistors 18 and 19 augments the
negative potential developed on these grids by
interception of electrons and hence narrows the
range over which the output current remains
constant.

Fig. 9 depicts the operation of my invention
when adjustments of the circuit values are made
to decrease the grid voltage range over which
the output remains constant. It will be appar-
ent that when the fixed grid bias has a value
40 represented by the low voltage limit of portion
43 of curve 44 a wave having its extreme values
represented by the range designated envelope F,
represented by the curve 45 will appear in the
output at the fundamental frequency as indi-
cated by 1-2 in Fig. 9 and that a voltage wave
45 having a range represented by envelope G will
appear in the output at twice the fundamental
frequency but the portion 4-5 will have greater
amplitude than one portion 5-6, owing to the
fact that the portion 4-5 represents a voltage
50 change between the values defined by the ter-
mini of limb 47 of curve 44 whereas the portion
5-6 is due to a voltage change that is less than
the range between the terminal of limb 48 of
curve 44. A wave 49 having a voltage range des-
ignated by envelope H will appear in part in
harmonics as in 7-8 and in part as a large
amplitude component 8-9.

Fig. 11 shows graphically the response to the
several input voltages as the signal input in-
creases. The space designated envelope F is that
portion that appears in the output at the fun-
damental frequency; that designated envelope G
is at twice the fundamental frequency and
65 that designated envelope H is in the region of
the higher harmonics. The curves F, G and H
illustrate the change in response to each of the
particular waves as the input changes and cor-
respond respectively to the waves represented by
70 curves 45, 46 and 49 in Fig. 9.

Fig. 10 shows how the form of the E_g-I_p
curve may be varied by altering the values of
resistors 18 and 19 and changing the adjustment
of voltage dividers 25 and 26. It is to be under-
stood that only the general contours of these

curves are shown and not the relative values;
for instance, curve E may be in microamperes,
being produced by applying cathode potential to
shield grid 23 and anode 20 while curve A may
be in milliamperes when a strong positive poten-
5 tial is applied to the shield grid 23 and anode 20.

It should be noted that interceptor grids 16
and 17 should be so proportioned that they have
a high absorption factor for electrons approach-
ing them and that the load in series with each
10 should be of relatively high impedance as com-
pared with the internal impedance between such
grid and the cathode 14.

When the network of Fig. 1 is operated to
produce an E_g-I_p curve like that shown in 15
Fig. 21 with the input grid biased to operate
about the point on the descending limb thereof
defined by the dotted line in that figure, the
output will be 180 degrees out of phase with the
output that would be produced if the input grid
20 were biased at the corresponding point on the
ascending limb of the curve. This is clearly
shown in Fig. 17 where the input wave 60 re-
sults in the output wave 61 when the input grid
is biased about substantially the midpoint 62 25
of the ascending limb of characteristic curve 63.
The same input wave 60, when the input grid is
biased about the midpoint 64 of the descending
limb of curve 63 will give an output wave 65
30 that is easily seen to be 180 degrees out of phase
with wave 61. These conditions make possible
the attaining of a number of desirable results
such as counter-modulation and neutralization.
It is obvious that with the relations existing be-
tween waves 60 and 65 regeneration will be well
35 nigh impossible through the internal capacities
of the tube and will eliminate the necessity for
shielding and counter-regeneration. Counter-
phasing and neutralization are eliminated in
radio frequency circuits and if the frequency,
40 the mu of the tube and internal capacity of the
tube are of proper values there will be no dis-
tortion nor will instability result from the use
of the tube with inductive networks in the input
and output circuits. In this way the capacities
45 within the tube will cause degeneration rather
than regeneration as is the usual case.

If the tube be operated on an E_g-I_p curve
like that of Fig. 19 and the input grid be biased
at the point thereon defined by the dotted line,
50 input signals of low amplitudes will work on the
rising slope and be taken off at the fundamen-
tal frequency but signals of sufficient strength
to pass the apex and go over to the descending
slope will cause double frequency components in
55 the output that will abstract from the incoming
high peaks most of their power and the funda-
mental frequency taken off will be reduced av-
erage power. Also, if the background noise is
low so as to operate only on the rising limb, the
60 signal may be taken off the output at double
frequency, provided it is held within the values
represented by the lower extremities of the two
limbs of the curve, while high amplitude surges
pass off the response curve at both ends along
65 the zero line and do not appear in the output net-
works that are tuned at fundamental and double
frequency. Likewise, the third and higher har-
monics will be tuned out. The harmonics, where
the desired output signal is at fundamental fre-
70 quency, may be used to quench a succeeding
stage during periods of excess surges, or they
may be used to quench an oscillator used for
heterodyning, or to cause an automatic volume
control to build up the sensitivity of succeeding
75

radio frequency and audio frequency stages to compensate for momentary loss of signal strength during periods of static impulses when certain systems of noise reduction are used and the signal is not entirely lost aurally, so that to a listener there will be no apparent loss in signal strength.

If operation be on a characteristic curve such as that in Fig. 20, with the input grid biased about substantially the midpoint thereof, as indicated by the dotted line, the input signal will be converted to double frequency in the output circuits and any high input sufficient to swing to the horizontal zero line on either side will be lost in the subsequent tuned filter circuits. This has advantages over the conventional push-push doubling circuits in that a single input circuit is required and the noise silencing properties, especially in the case of the shot gun variety of static, are superior. In radio frequency circuits a crystal or LC type of filter will lose or eliminate any harmonics to which the filter will not respond.

Fig. 12 discloses a vacuum tube network adapted to utilize the output that is 180 degrees out of phase, as discussed in connection with Fig. 17, to counteract the degenerating action of the internal tube capacities. It will be noted that this very simple arrangement comprises an inductance 66 and a resistance 67 in series between the cathode 14 and the ground, with a variable resistance 68 and a capacitance 69 in parallel with the inductance and the fixed resistance, respectively, the tuned input circuit 70 being grounded.

Fig. 13 illustrates a hookup in general similar to a regenerative network in that the cathode 14 is connected, through resistance 71 and capacitance 72 in parallel to a tap on the inductance 73 in tuned input 74 but, owing to the 180 degrees out of phase relation, there will be neutralizing rather than regenerating action.

Fig. 14 shows another network for utilizing the 180 degrees out of phase output for neutralizing purposes. Here the output circuit 75 is connected to cathode 14 through a resistance 76 and a point on inductance 77 of output circuit 75 is connected to a signal grid 13 through a variable capacitance 78.

Fig. 15 illustrates means for utilizing the fundamental frequency output from circuit 21, Fig. 1, to reduce the average power of the output from a subsequent stage. As indicated by the dotted lines and the legend in Fig. 15 the tuned input circuit 79 and transformer primary 80 are fed from output circuit 21 in Fig. 1. The output circuit 81 of tube 82 is tuned to an harmonic frequency, say the third, and is coupled to the tuned input circuit 83 of tube 84. However, in series between the input circuit 83 and grid 85 of tube 84 there is connected a circuit 86 tuned to the fundamental frequency. It is thus apparent that the input to tube 84 will be the fundamental superimposed on the chosen harmonic. These relations are shown in Fig. 16 where the curve 87 represents the fundamental and the dotted curve 88 represents the harmonic. It will be observed that the envelope is of the same form as the fundamental but the resultant is as shown by the smaller waves 89 which, while preserving the form of the fundamental envelope carry a very much reduced average power as shown by the dotted line 90. Although the amplitude of the individual waves at harmonic frequency may be present they will cause but little, if any, excitation in high L circuits into which the plate cur-

rent may feed. The actual applied bias on the input circuit 85 of tube 84 will be the constant bias supplied by resistance 91 and capacitance 92 plus the momentarily added bias when the current rectifies the signal at harmonic frequency. Resistance 93 and capacitance 94 act to store the energy and may have a time constant equal to the period of the fundamental frequency, to allow the charge of rectified voltage across capacitance 94 to leak off readily after plate current cutoff is reached.

Fig. 18 discloses another type of circuit that has a neutralizing effect when operating with the output 180 degrees out of phase as above described. Here the anode 95 of tube 96 is connected back through capacitance 97 to a point on conductance 98 of tuned input circuit 99. Persons skilled in this art will readily perceive other means of usefully applying the phase relation produced according to the principles of the present invention.

Fig. 22 discloses another circuit adapted to apply the principle of the present invention. Here the transformer primary 80 is fed from 21 in Fig. 1, as in Fig. 12, and feeds the fundamental carrier frequency into tube 100 by way of grid 101 and cathode 104, grid 101 being biased for Class A, B, or C operation, and thus this channel becomes the signal input for the cathode to plate circuit. The circuit comprising grid 103, cathode 104 and resistor 105 and capacitor 106 in parallel rectifies the signal put into it through transformer 107, biasing grid 103 proportionately to the maximum amplitudes of the signals received, due to the voltage drop across resistor 105 and the energy thus stored up in capacitor 106. The time constant of resistor 105 and capacitor 106 is preferably longer than the period of one wave. The transfer of energy through tube 100 will be controlled by the bias on grid 103, and during periods of excessive amplitude the output of the tube may be reduced substantially to zero, particularly if good shielding is effected by the R. F. grounded screen grid 108, crossfeed between the circuits of the receiver being prevented. The audio frequency component injected by the action of the rectifying circuit will be kept out of the output by radio frequency output transformer 109.

When being used in a broadcast receiver for reception of voice, etc., the time constant of 105, 106 may be longer than when used for code or continuous wave reception, where the time of a "dot" may be short and there is a possibility of losing a telegraphic character unless the time constant is sufficiently small. For such purposes, the time constant may be reduced to the period of two to ten waves of the fundamental frequency presented at primary 80, and the network of Fig. 22 then becomes suitable for code or continuous wave uses.

It is obvious that the energy inputs at 80 and 107 may be reversed without departing from the principle of operation. So long as the two input grids control the flow of electrons from the cathode to the plate, and one of these grids is constantly rectifying the signal applied thereto, at fundamental frequency or otherwise, while the other grid acts as carrier control only for the electron stream, the results will be the same.

If the time constant of 105, 106 is made less than the period of the fundamental frequency fed in at 80 and approximately the period of the harmonic fed in at 107, the results depicted in Fig. 16 will be effectively secured. In practice,

the capacity may be provided by the wiring and the resistance may be of any standard type in series in the input circuit fed through 107. It is desirable that resistor 105 have such value that little current may flow during the positive half of the cycle, yet the negative charge during the negative half of the cycle in 107 may cause approximate cutoff when such negative pulses are excessive.

When used in the audio frequency section of a receiver, the input at 80 is audio frequency and the output of the stage is also audio, while the input through 107 may be radio or intermediate frequency. Then the individual audio frequency waves will be chopped by the radio frequency input and undesirable high amplitude surges will be reduced before they enter the reproducing device, such as a loud speaker. The input through 107 may be derived from an amplitude selective device, so that the rectifying circuit supplied thereby will function only when excess amplitudes are received. From the foregoing, it is apparent that the harmonic output from circuit 22, Fig. 1, may be used to control the volume of any stage.

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. A method of operating a vacuum tube in a network wherein the circuit values are such that the E_g-I_p curve of the tube has a limb sloping upwardly from cutoff, a substantially straight flat-top portion, and an oppositely sloping limb descending to cut-off, comprising the steps of biasing said tube to operate about a value represented by substantially the midpoint of said portion whereby input voltage swings of amplitude not greater than one-half the length of said portion will not affect the output of the tube, taking off at double the original frequency the output of the tube resulting from input voltage values lying between the termini of said limbs, and eliminating from the said output the higher harmonic energy resulting from input voltages lying between the termini of said limbs when the extreme values of such voltages lie beyond the said cut-off points.

2. A method of operating a vacuum tube in a network wherein the circuit values are such that the E_g-I_p curve of the tube has a limb sloping upwardly from cut-off, a substantially straight flat-top portion, and an oppositely sloping limb descending to cut-off, comprising the steps of biasing said tube to operate about a value represented by substantially the low voltage limit of said portion whereby input voltage swings of amplitude not greater than the length of said portion are represented in the output of the tube at the frequency of the incoming signal, and eliminating from the said output the higher harmonic energy due to voltage swings whereof the extreme values lie beyond said cut-off points.

3. A method of operating a vacuum tube in a network wherein the circuit values are such that the E_g-I_p curve of the tube has a limb sloping upwardly from cut-off, a substantially straight flat-top portion, and an oppositely sloping limb descending to cut-off, comprising the steps of biasing said tube to operate about a value represented by substantially a limit of said portion whereby input voltage swings of amplitude not greater than the length of said portion are represented in the output of the tube at the frequency of the incoming signal, and eliminating from the said output the higher harmonic energy due to voltage swings whereof the extreme values lie beyond said cut-off points.

4. The method of separating medium amplitude radio signals from low amplitude noise and excessive amplitude disturbances accompanying said signals, in a network including a tube operating on an E_g-I_p curve having a limb sloping upwardly from cut-off, a substantially straight flat-top portion and an oppositely sloping limb descending to cut-off, which comprises operating about a grid bias having a value represented by substantially the midpoint of said portion, adjusting the values in said network so that the extremes of the low amplitude noise swings do not extend beyond the limits of said portion and the extreme values of the signal voltage swings lie within said cut-off points, taking said signal from the output at twice the received frequency, and eliminating from said output the higher harmonics produced in said output by those portions of excessive amplitude swings lying between the termini of said limbs.

5. A method of separating radio signals from excessive amplitude disturbances accompanying said signals, in a network including a tube operating on an E_g-I_p curve having a limb sloping upwardly from cut-off, a substantially straight flat-top portion and an oppositely sloping limb descending to cut-off, which comprises operating about a grid bias having a value represented by substantially the low voltage limit of said portion, adjusting the values in said network so that the extreme values of the swings of the signal voltage do not extend beyond the other limit of said portion and the extremes of voltage swing due to said disturbances lie beyond said cut-off points, separating said signal from said output and eliminating the higher harmonics in said output due to those portions of said excessive amplitudes lying between the termini of said limbs.

6. A method of separating radio signals from excessive amplitude disturbances accompanying said signals, in a network including a tube operating on an E_g-I_p curve having a limb sloping upwardly from cut-off, a substantially straight flat-top portion and an oppositely sloping limb descending to cut-off, which comprises operating about a grid bias having a value represented by a limit of said portion, adjusting the values in said network so that the extreme values of the swings of the signal voltage do not extend beyond the other limit of said portion and the extremes of voltage swing due to said disturbances lie beyond said cut-off points, separating said signal from said output and eliminating the higher harmonics in said output due to those portions of said excessive amplitudes lying between the termini of said limbs.

7. A method of amplitude selection of radio signals, comprising the steps of biasing a vacuum tube to pass saturation current at "no signal," applying to the input of said tube energy modulated at a plurality of amplitudes, intercepting electrons from the electron stream in said tube and utilizing the current derived thereby to depress the potential in the zone of collection of said electrons to reduce the output current over a predetermined portion of the input voltage swing, whereby those portions of excess amplitude swings that appear in the output are thrown into higher harmonics, separating out the por-

8. A method of separating radio signals from excessive amplitude disturbances accompanying said signals, in a network including a tube operating on an E_g-I_p curve having a limb sloping upwardly from cut-off, a substantially straight flat-top portion and an oppositely sloping limb descending to cut-off, which comprises operating about a grid bias having a value represented by a limit of said portion, adjusting the values in said network so that the extreme values of the swings of the signal voltage do not extend beyond the other limit of said portion and the extremes of voltage swing due to said disturbances lie beyond said cut-off points, separating said signal from said output and eliminating the higher harmonics in said output due to those portions of said excessive amplitudes lying between the termini of said limbs.

tion of the output having the chosen signal amplitude, and eliminating from the output the said higher harmonics.

8. A method of doubling the frequency of a radio signal wave, comprising the steps of adjusting the values in a vacuum tube network so that the tube operates on an E_g-I_p curve having a limb rising from cut-off, a substantially straight flat-top portion and a limb descending from said portion to cut-off, biasing the control grid of said tube to a value represented by substantially the midpoint of said portion, and taking off as the signal those portions of the output due to input voltages lying between the termini of said limbs.

9. A method of radio reception, comprising the steps of receiving a wave train modulated at two amplitudes which shift at supersonic frequency from one of said amplitudes to the other whereby said train carries modulation envelopes of two amplitudes, changing the envelope of greater amplitude to higher harmonics and filtering out said harmonics, and utilizing said envelope of lesser amplitude at its fundamental frequency.

10. A vacuum tube network, comprising a vacuum tube having a plurality of grids, a cathode and an anode, the elements of said tube being biased to cause said tube to operate about substantially the mid-point of the descending limb of an E_g-I_p characteristic curve having an ascending limb, a saturation current portion and a descending limb, an inductance and a resistance connected in series between said cathode and ground, a variable resistance and a capacitance in parallel with said inductance and said resistance, respectively, and a grounded tuned input operatively connected to one of said grids, whereby is counteracted the degenerating effect of the internal tube capacities.

11. A vacuum tube network, comprising a vacuum tube having a plurality of grids, a cathode and an anode, the elements of said tube being biased to cause said tube to operate about substantially the mid-point of the descending limb of an E_g-I_p characteristic curve having an ascending limb, a saturation current portion and a descending limb, a grounded tuned input circuit including an inductance and a capacitance connected to said grid, a resistance and a capacitance connected in parallel to said cathode, and means connecting the other common terminal of said parallel connected resistance and capacitance to a point on said inductance.

12. A vacuum tube network, comprising a vacuum tube having a plurality of grids, a cathode and an anode, the elements of said tube being biased to cause said tube to operate about substantially the mid-point of the descending limb of an E_g-I_p characteristic curve having an ascending limb, a saturation current portion and a descending limb, a tuned input circuit connected to said grid, a resistance and a capacitance connected in parallel between said cathode and ground, means connecting said tuned input circuit to ground, a tuned output circuit including an inductance and a capacitance in parallel, a

resistance connected between said output circuit and said cathode, and a variable capacitance connected between said grid and a point on said inductance.

13. A radio network, comprising a first vacuum tube having an input circuit tuned to a fundamental frequency and an output circuit tuned to a harmonic of said fundamental frequency, a second vacuum tube having a cathode, a signal grid and an anode, means coupling the output of said first tube to the grid of said second tube including a circuit tuned to said harmonic and a circuit tuned to said fundamental connected in series, means to supply energy of said fundamental frequency to both said circuits tuned to said fundamental frequency connected to the anode of said second tube, a resistance and a capacitance in parallel between the fundamental-tuned circuit in the input of said second tube and ground, a resistance and a capacitance in parallel between said cathode and ground, a resistance connected to the said tuned output of said second tube and to a point between said cathode and the said resistance between said cathode and ground, and a resistance and capacitance in series between said tuned output of said second tube and the ground end of the resistance connected between said cathode and ground.

14. A vacuum tube network, comprising a vacuum tube having a plurality of grids, a cathode and an anode, the elements of said tube being biased to cause said tube to operate about substantially the mid-point of the descending limb of an E_g-I_p characteristic curve having an ascending limb, a saturation current portion and a descending limb, a tuned input circuit including an inductance and a capacitance connected to one of said grids, means connecting said input circuit to ground, a resistance connecting said cathode to ground, a capacitance connecting said cathode to said input circuit ground connection, an output circuit connected to said anode, a resistance connecting said output circuit to said cathode, a second resistance connecting said output circuit to a second grid, means connecting a third grid to ground, and a capacitance connecting said anode to said one grid.

15. A method of reducing the amplitude of output energy from a vacuum tube receiving network, comprising the steps of receiving signal energy having a fundamental frequency and that may be affected by non-signal energy of excessive amplitude, deriving from the energy thus received energy at said fundamental frequency and energy at a frequency that is a higher harmonic of said fundamental frequency, utilizing said energy at fundamental frequency to control an electron stream, utilizing said energy at said harmonic frequency to effect an additional control of said stream, and taking off from said stream energy at said fundamental frequency "chopped" by said harmonic energy whereby the effective power of the energy taken off is greatly reduced.

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