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BY A. P. C.

G. I. DALLOS

AMPLITUDE LIMITING CIRCUITS

Filed March 29, 1940

Serial No. 326,567

5 Sheets-Sheet 1

FIG. 1

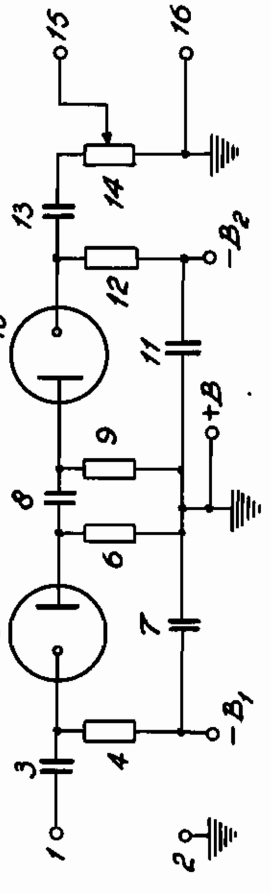

FIG. 2

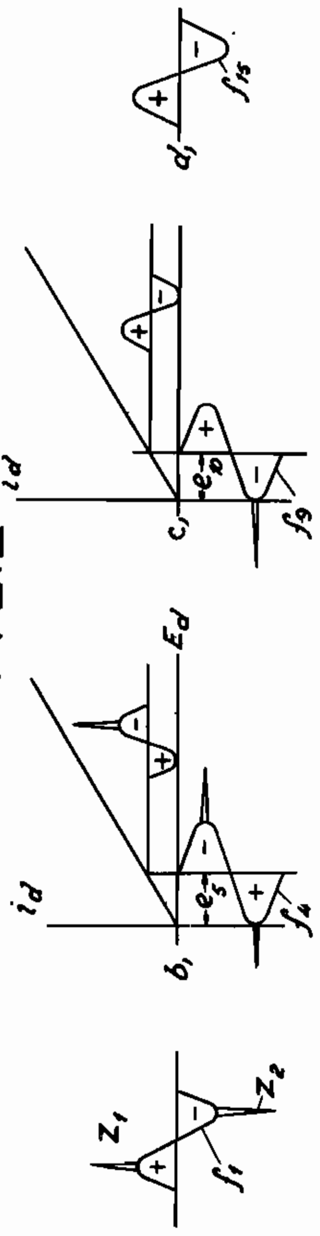

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FIG. 3

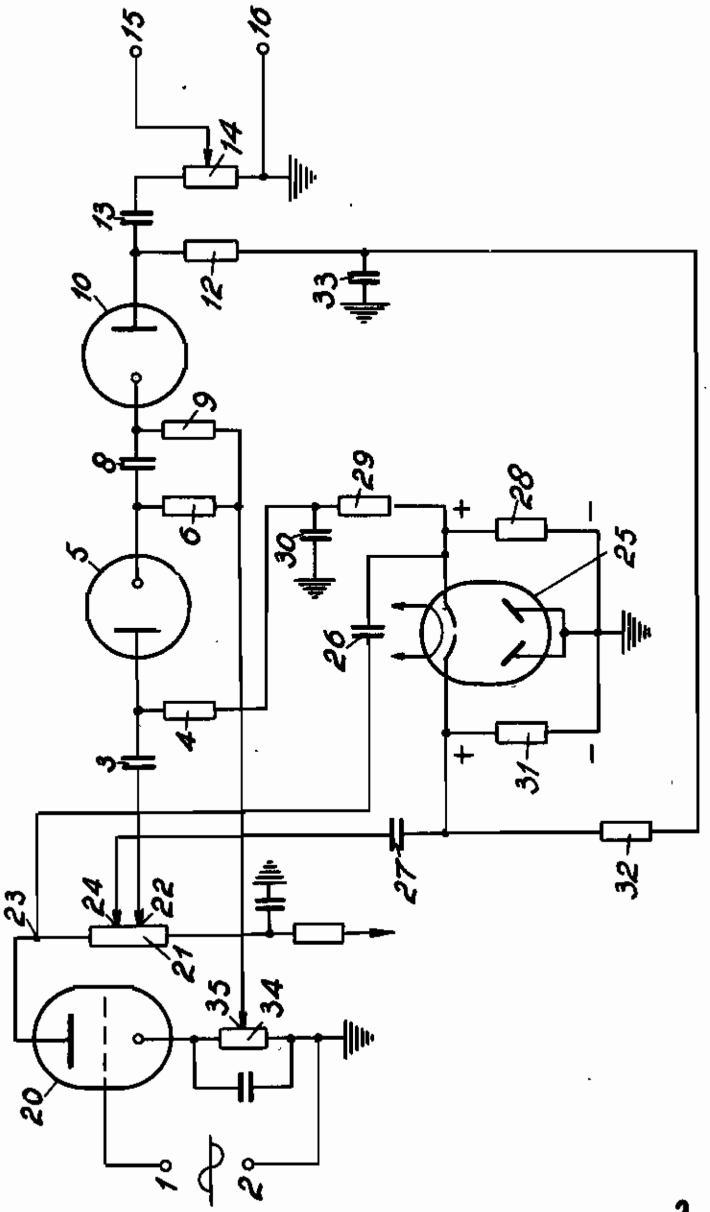

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FIG. 4

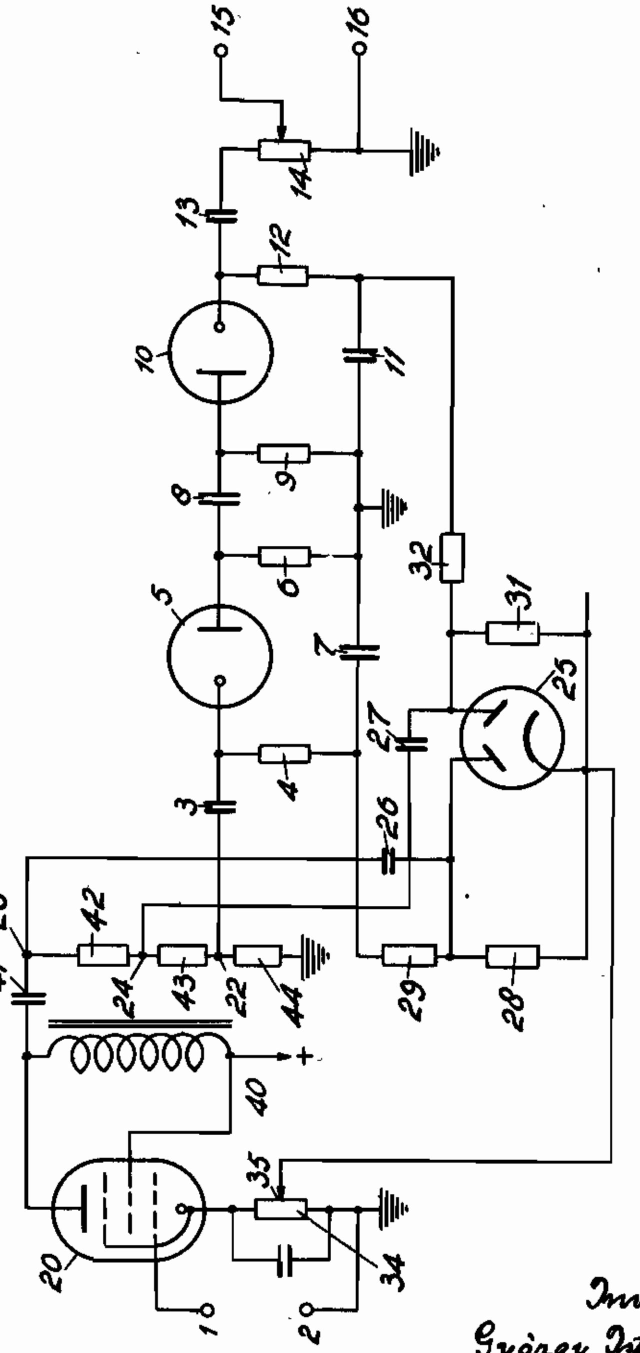

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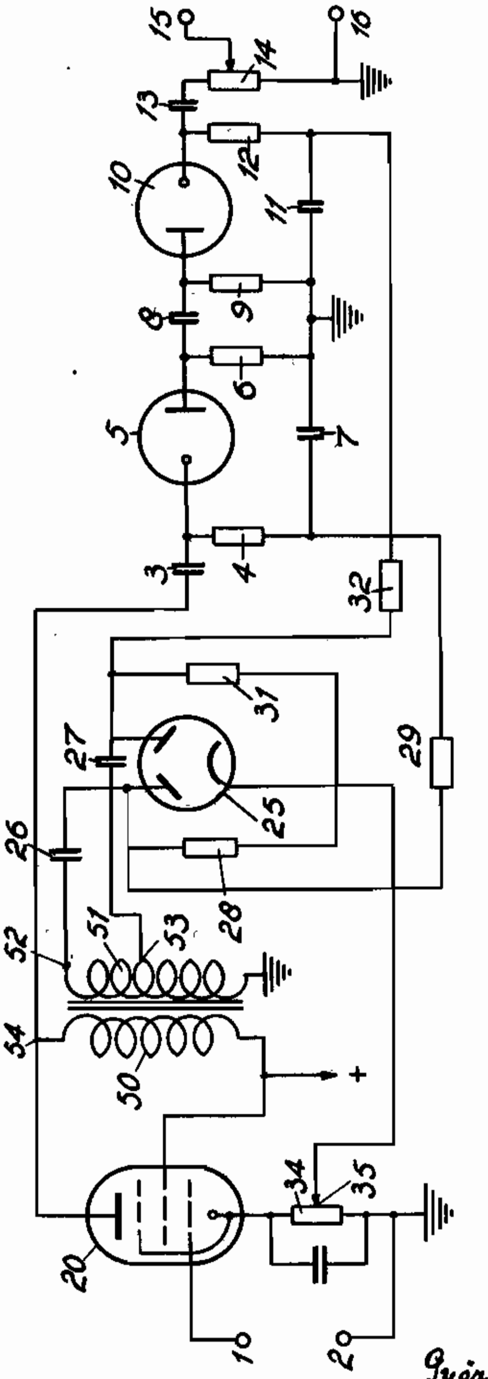
FIG. 5



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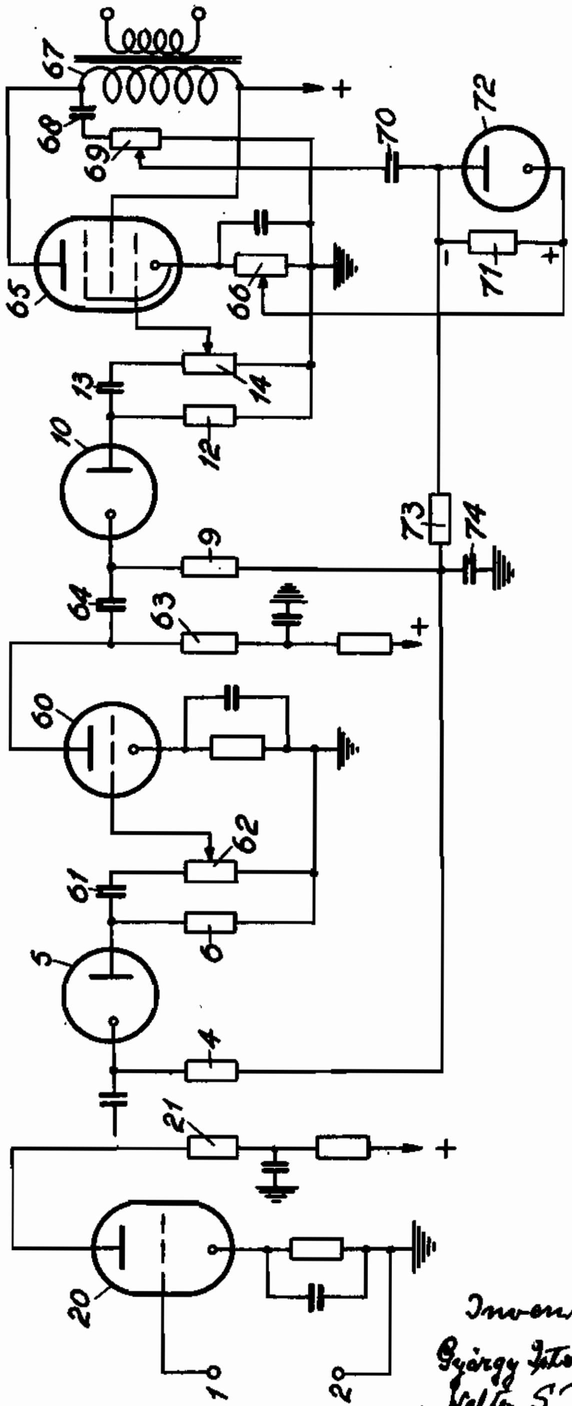

FIG. 6

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ALIEN PROPERTY CUSTODIAN

AMPLITUDE LIMITING CIRCUITS

György István Dallos, Budapest, Hungary; vested in the Alien Property Custodian

Application filed March 29, 1940

There are many known circuits for limiting the amplitude of an alternating current to a certain limiting value for the purpose of excluding interference peaks, for instance in radio reception. For this limiting action electron tubes having a grid have been proposed. These tubes have the drawback that even for signal amplitudes suited for transmission without exceeding the range of control of the tubes the curvature of the bend of the tube characteristic seriously unpairs the sharpness of the cut off, so that the harmful interference peaks are also transmitted, at least to a certain extent. It is also impossible to obtain a sharp limitation by means of those known methods in which a diode bridged across an impedance, for instance an electron tube, short-circuits said impedance on the occurrence of an interference. As the resistance of a diode is of the order of magnitude of 1000 Ohms the short circuit will not be complete. Further the sudden change of impedance may cause serious trouble. For the purpose of eliminating interference it is also known to employ a diode which is supplied with current from a rectifier and prevents transmission of the greatest signal amplitudes, for instance those exceeding 100% modulation. With circuits of this kind it is merely possible to obtain a slight reduction of interference and the distortion is usually great.

Further it has been proposed to employ amplitude limiting circuits in which the alternating current to be limited is passed through two electron tubes which are provided with control grids and are connected in tandem from an a. c. point of view. The tubes are connected in such a manner that as soon as the input voltage reaches a predetermined limiting value grid current is produced preventing the anode current from further increasing. One of the tandem connected tubes is for limiting one half wave of the alternating current and the other is for limiting the other half wave. The drawback of this circuit is that the operation is not reliable and that the limiting operation is attended by distortion.

The invention also relates to an amplitude limiting circuit of the kind in which the alternating current or voltage to be limited is passed through two tubes connected in tandem from an a. c. point of view. The invention is characterised in that the tubes referred to are diodes the d. c. and a. c. circuits of which are controlled independently, further in that the first diode is so connected to the second diode that the alternating voltage to be limited is supplied to the two diodes in opposite directions, and in that the diodes are supplied with a bias voltage (preferably proportional to the amplitude of the voltage to be limited) of such magnitude that, whereas the alternating voltage to be limited will just be passed by the diodes without rectification, the first diode will cut off the amplitude peaks exceeding the limiting value and being superimposed on one of the half waves of the voltage to be limited, and the second diode will cut off the amplitude peaks exceeding the limiting value and being superimposed on the other half wave of the voltage to be limited.

The invention enables a reliable, sharp and distortionless amplitude limitation to be obtained and, compared with other diode limiting systems, guarantees a reduction of interference of higher degree. Further the circuit is very simple.

In a preferred embodiment of the invention the diodes are so connected in tandem that either their cathodes or their anodes are interconnected by a condenser. In another favourable embodiment of the invention the diodes are connected in tandem by means of an intermediate amplifier in such a manner that the first diode is connected to the input and the second diode to the output of the amplifier. Further the diodes may be connected in tandem by means of a transformer.

The invention will be explained with reference to the drawing.

Fig. 1 shows a fundamental circuit embodying the invention.

Fig. 2 is for the purpose of explaining the operation of the circuit.

Fig. 3 shows a preferred embodiment of the invention.

Figs. 4 and 5 show modifications of this embodiment.

Fig. 6 shows another embodiment of the invention.

In all figures corresponding elements are provided with like reference characters.

Fig. 1 shows input terminals 1 and 2 connected to the first diode 5 by a condensor 3 and a resistance 4. The diode 5 is provided with an output resistance 6. The resistances 4 and 6 are interconnected by a condensor 7. The second diode 10 is connected in tandem with the diode 5 by means of a condensor 8, the arrangement being such that either the anodes or the cathodes of the two diodes are interconnected by the condensor 8. This means that the two diodes are connected in opposite directions. The second diode 10 is provided with an input resistance 9 and an output resistance 12 which are interconnected by a condensor 11. In parallel to the resistance 11 are connected the condensor 13 and the resistance 14. The output terminals 15 and 16 are connected to this resistance. The diode 5 is supplied with a bias voltage from the terminals $-B_1$ and $+B$ of a direct current source, and the diode 10 is supplied with a bias voltage from the terminals $-B_2$ and $+B$ of the same source. The voltage between $-B_1$ and $+B$ is higher than that between $-B_2$ and $+B$.

The operation of the circuit may be explained with reference to Fig. 2. Diagram *a* shows a complete oscillation f_1 of the voltage to be limited. This voltage is supplied to the terminals 1 and 2 and may have interference peaks Z_1 superimposed on the positive half wave and interference peaks Z_2 superimposed on the negative half wave. Diagram *b* shows the current-voltage characteristic of the diode 5 (i_d in terms of E_d). Diagram *c* shows the corresponding characteristic of the diode 10. As shown in diagram *b* the diode 5 is supplied with a bias voltage e_5 of such magnitude that both halves of the alternating voltage f_4 occurring across the resistance 4 are passed by this diode without rectification. The interference peak Z_1, however, which is superimposed on the positive half wave is cut off. Consequently there will be transferred from the resistance 6 through the condenser 9 to the resistance 9 an oscillation one of the half waves of which is limited. As the diode 10 is connected to the resistance 9 in a sense opposite to the connection of the diode 5 to the resistance 4 the oscillation just mentioned will be reversed with respect to the diode 10, as shown by f_9 in diagram. The diode 10 is supplied with a bias voltage e_{10} of such magnitude that the oscillation f_9 is passed by this diode without rectification but that the interference peak Z_2 superimposed on the other negative half wave is cut off. Consequently both half waves of the oscillation leaving the diode 10 are limited. From the output terminals 15 and 16 the limited oscillation, which is represented by f_{15} in diagram *d*, is passed to the following stages of the circuit.

As indicated above the first diode 5 in the circuit of Fig. 1 is supplied with a higher bias voltage than the second diode 10. The reason is that from an a. c. point of view the resistance 6 of the diode 5 is loaded by the circuits of the diode 10. In case of the diode 10, however, the high impedances 13 and 14 connected in parallel to the resistance 12 of the diode 10 merely constitute a relatively low load for this diode. Consequently the alternating voltage supplied by the diode 5 will not appear in its full value across the resistance 9. Thus, the load on the diode 5 being higher than that on the diode 10, the diode 5 is to be supplied with a higher bias than the diode 10.

The bias voltage of the diodes may be supplied by any direct current source. It is recommendable to provide a source of current comprising a rectifier operated by the voltage to be limited. In that case the bias will be proportional to the amplitude of said voltage. Circuits embodying this feature are shown in Figures 3, 4 and 5. The limiting circuit employed in these figures is substantially the same as that in Fig. 1.

In the circuit of Fig. 3 the low frequency voltage to be limited is supplied from the input terminals 1 and 2 to the amplifier tube 20. This tube is preferably one having a wide range of control. The alternating voltage produced in the load resistance 21 of the tube 20 is supplied to the limiting circuit already described by way of the tap 22 and the condenser 3.

A double diode 25 is provided for producing the bias voltages for the diodes 5 and 10. The right hand section of the double diode 25 is connected to the point 23 of the resistance 21, and the left hand section of the double diode 25 is connected to the point 24 of the resistance 21, the point 24 having a lower potential than the point 23. The two connections just described comprise condensers 26 and 27. The rectified voltage produced in the right hand section of the diode 25 is taken from the load resistance 28 through a filter circuit comprising the resistance 29 and the condenser 30, and through a resistance 4 to the anode of the limiting diode 5. The rectified voltage produced in the left hand section of the diode 25 is taken from the load resistance 31 through a filter circuit comprising the resistance 32 and the condenser 33, and through a resistance 12 to the anode of the limiting diode 10. The circuit arrangement is such that the anodes of both limiting diodes 5 and 10 will receive a positive voltage with respect to their cathodes so that the diodes will be conductive. As the point 23 of the resistance 21 is of higher voltage than the point 24 of the same resistance the diode 5 will be supplied with a higher bias voltage than the diode 10.

If the input terminals 1 and 2 do not receive any low frequency voltage, that is if there is no signal voltage, the double diode 25 will not supply the diodes 5 and 10 with bias voltages, so that there will be no current flowing in these tubes. If, however, the terminals 1 and 2 are supplied with signal voltage the limiting diodes 5 and 10 will receive a bias voltage and a signal voltage of corresponding value will be passed by these diodes in the manner described in connection with Fig. 2. The steady current of the limiting diodes, that is the diode current occurring even when there is no potential difference between the terminals 1 and 2, may be compensated for by supplying a compensating bias voltage to the diodes from a suitable point of any amplifier tube, for instance from the point 35 of the cathode resistance of the tube 20. In case the steady current may be neglected the rectifier sections in the tube 20 may be combined. In that case the lower ends of the resistances 4 and 12 are earthed and the cathodes of the limiting diodes 5 and 10 are supplied with a smoothed negative bias voltage.

The bias voltage of the limiting diodes may also be supplied by a rectifier operated by the limited signal voltage. In that case the regulation is carried out backwards. If a fine regulation is not necessary the bias voltage for the limiting diodes may be derived from a constant voltage derived from the mains. In that case a variable resistance controlling the bias voltage may be adjusted together with the member controlling the signal strength. The circuit elements supplying the bias voltage may also be made independent of the receiving channel by providing an amplifier stage in parallel to the receiving channel and by rectifying the alternating voltage delivered by this amplifier.

Figures 4 and 5 show modifications of the circuit of Fig. 3.

The circuit of Fig. 4 is different from that of Fig. 3 in that the load resistance in the anode circuit of the tube 20 is replaced by a choke coil 40 across which the resistances 41, 42, 43 and 44 are connected through a condenser 41. The required alternating voltages are taken from the points **22**, **23** and **24**. These points correspond to those bearing the same reference numbers in Fig. 3. It is an advantage of the circuit of Fig. 4 that there is no d. c. load in the anode circuit of the tube **20**, so that the useful output voltage is not reduced.

The circuit of Fig. 5 is distinguished from that of Fig. 3 and 4 in that the anode circuit of the tube **20** is provided with a transformer having a primary winding **50** and a secondary winding **51**. The voltages to be passed to the double diode **25** producing the bias voltages for the diodes **5** and **10** are taken from the points **52** and **53** of the secondary transformer winding, and the alternating voltage directly supplied to the first diode **5** is taken from the point **54**. The advantage of this circuit is that the transformer **50**, **51** causes the anode alternating voltage of the tube **20** to be stepped up so that higher bias voltages may be obtained.

It is observed that Figures 4 and 5 have the double diode **25** reversed with respect to its position in Fig. 3, so that the left hand section of the double diode produces the bias voltage for the diode **5** and the right hand section for the diode **10**.

In connection with Fig. 1 it has been stated that in view of the different alternating current loads of the two limiting diodes the first diode **5** is to be supplied with a higher bias voltage than the second diode **10**. These different loads may be prevented by providing an amplifier tube between the two diodes. The diodes will then be independent from each other so that the circuits of the second diode will not constitute an alternating current load for the first diode. The intermediate amplifier tube should preferably have a wide range of control so that even for great signal amplitudes there will be no distortion. Preferably the amplification of the intermediate tube is made substantially equal to the attenuation produced by the first diode so that this attenuation is compensated for. In that case both diodes may be supplied with the same bias voltage.

Fig. 6 shows an embodiment of a circuit having an intermediate tube. An amplifier tube **60** is arranged between the diodes **5** and **10**. The input circuit of the amplifier comprises a coupling condenser **61** and a resistance **62**, and the output circuit comprises a load resistance **63** and a condenser **64**. In Figure 6 the sense of connection of the diodes **5** and **10** is the same in view of the fact that the signal voltage is reversed in the tube **60** so that the voltage across the resistance **9** is opposite to that across the resistance **4**, which is necessary for a satisfactory operation of the limiting circuit (see Fig. 2).

Connected to the limiting diode **10** is an amplifier tube **65** for amplifying the limited alternating voltage. The tube **65** is provided with a cathode resistance **66**, and the anode circuit of the tube comprises the primary winding **67** of a coupling transformer. For the alternating current the winding **67** is bridged by a condenser **68** and a potentiometer **69**. The tap on the potentiometer **69** is connected through a condenser **70** to a rectifier **72** producing the bias voltage and having a load resistance **71**. The voltage across this resistance is smoothed by a resistance **73** and a condenser **74** and it is supplied through the resistances **4** and **9** to the cathodes of the limiting diodes. The bias voltage is thus supplied by a rectifier operated by the limited voltage, both limiting diodes receiving the same bias voltage.

In case of a limiting action depending on the degree of modulation it may be useful to have the bias voltage for the limiting diodes supplied by a rectifier connected to the anode circuit of a special amplifier tube controlled by the alternating voltage to be limited. In that case if there is no modulation the receiving channel remains completely closed, so that distortion will be prevented that might otherwise occur due to transients at the beginning of the modulation when using a bias voltage supplied backwards. In case of a limiting action depending on the degree of modulation it may also be useful to cut off the higher interference peaks, for instance those exceeding 100% modulation, in any known manner in a stage preceding the limiting diodes.

The limiting circuit according to the invention may be employed in any receiver and in any stage of a receiver. Likewise it may be employed for limiting high frequency and video frequency currents. Instead of the two electrode diode tubes shown in the figures dry rectifiers or tubes having a grid but connected as diodes may be employed.

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