

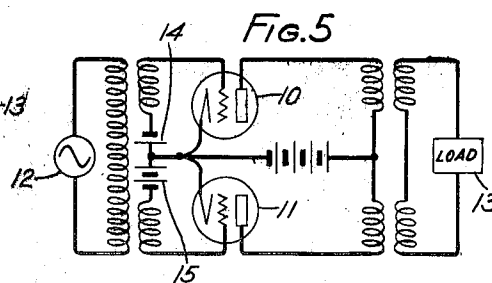
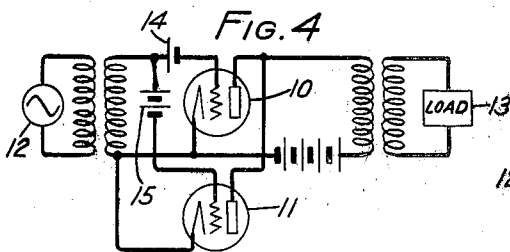
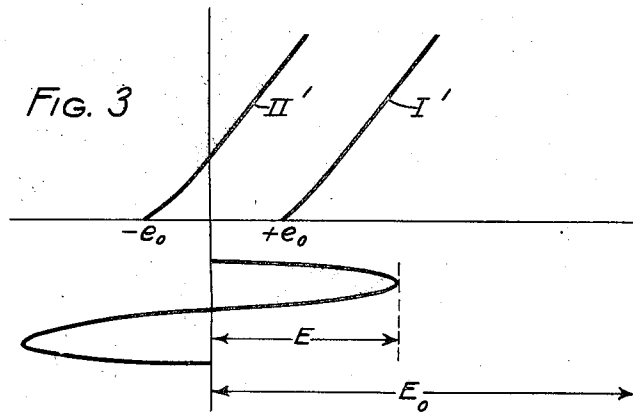
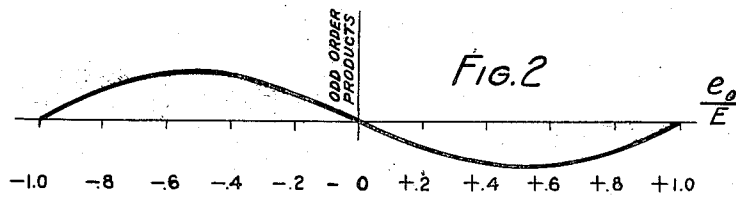
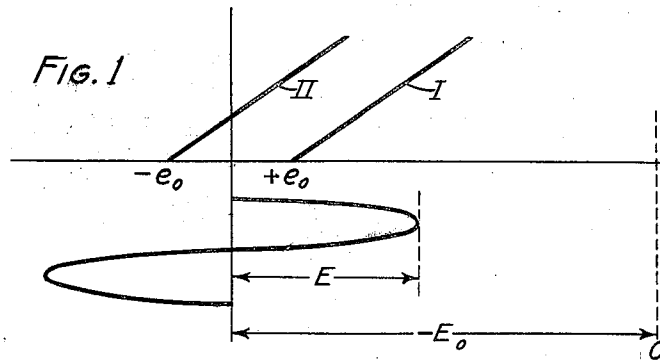
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WAVE AMPLIFYING CIRCUIT

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WAVE AMPLIFYING CIRCUIT

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The present invention relates to space discharge repeaters or amplifiers and in particular to the operation of such apparatus to reduce or eliminate undesired frequency components in the output current.

An object of the invention is to secure efficient amplification of applied waves while reducing or suppressing in the output circuit the odd order modulation products.

The invention is applicable to wave repeaters and amplifiers for any purpose, but is particularly advantageous in the amplification of high frequency signaling waves such as are utilized in radio or carrier wave transmission systems. Generally in such uses it is found that the even order products of modulation (e. g. the double frequency, etc.) fall outside the transmitted frequency range. Some of the odd order products of modulation, however, may fall within the transmitted band. For example, if we consider the amplification of two side band frequencies at 60.5 and 60.7 kilocycles respectively, the second order products comprising the double frequencies and the sum and difference frequencies are 121, 121.4, 0.2 and 121.2 kilocycles, all of which are remote from the transmitted band which would be near 60 kilocycles. The third order products are 181.5, 182.1, 181.7, 181.9, 60.3 and 60.9 kilocycles, the last two of which cannot be removed by frequency discrimination when an appreciable side band width is used. The same general effects are true for higher odd orders of modulation, that is, certain of the products will fall close to or within the transmitted frequency range.

In accordance with the present invention it has been found that two (or an even number of) high efficiency amplifiers may be associated in a manner such as to eliminate the odd orders of modulation by properly choosing the operating points on their characteristic curves. The two space discharge devices may be associated in parallel with each other or in push-pull relation, or otherwise, and are operated with their dynamic characteristics displaced a proper amount to reduce or eliminate the odd order modulation products appearing in the common output circuit. The displacement of the dynamic characteristics is controlled by the magnitude of the negative grid bias voltage, which is made unequal in the two vacuum tubes.

A more complete understanding of the invention will be had from the detailed description to follow, taken together with the attached drawing of which Figs. 1, 2 and 3 show curves explanatory

of the principle of operation of the invention, and Figs. 4 and 5 are schematic circuit diagrams of two forms of embodiment which the invention may take, in wave amplifying systems.

Fig. 1 shows two dynamic curves I and II, ideal in that they are straight rather than curvilinear in form. They serve, however, to illustrate the principle of operation of the invention. The cathode potential or zero for this diagram is shown at 0. The two tubes are biased symmetrically with respect to a valve $-E_0$, one tube (II) being biased to operate about a point on its dynamic characteristic, at voltage e , from the dynamic cut-off, and the other tube (I) to operate about a point off its dynamic characteristic by the value e . The applied alternating voltage (signal) has a peak voltage E which in practice may continually vary between wide limits.

Under these conditions, for all values of E equal to and greater than e , (abscissae) the odd order modulation products (ordinates) are given by Fig. 2, from which it is seen that these products from the two tubes are equal and opposite in sign.

In practice, dynamic curves more nearly like those of Fig. 3 are encountered, which are not straight but are more or less curved. So long as the dynamic characteristics approach linear rather than parabolic form, as is usually the case especially with large applied alternating grid voltage, it is still possible to suppress odd order modulation products by proper choice of bias for the two tubes. In this case the two bias voltages will generally need to be unsymmetrical with respect to E_0 instead of symmetrical as in Fig. 1. If symmetrical bias voltages are used for curved dynamic characteristics of the Fig. 3 type, it is found that the odd order modulation products from the two tubes have opposite phases but their amplitudes are not quite equal. These products can be suppressed by use of unsymmetrical biases, or by proper proportioning of load impedance or applied alternating voltages.

In each of the above discussed cases the fundamental components from the two tubes are in phase and hence add arithmetically.

Referring to Fig. 4, the two tubes 10, 11 are connected in parallel, to amplify waves from source 12 and impress the amplified waves on the load circuit 13. Tube 10 is supplied with a negative grid bias voltage from battery 14 and its characteristic may correspond to curve II' of Fig. 3, its bias being such as to cause operation about a point on its dynamic characteristic. Tube 11 has its grid biased negatively a greater amount by battery 15, and its characteristic may corre-

spond to curve I' of Fig. 3, its bias being great enough to cause operation about a point off the dynamic characteristic.

The fundamental components in the output circuits of tubes 10 and 11 add in phase in the load circuit.

The precise values of grid bias may be determined by trial, by supplying a test voltage at 12 and noting (by suitable filter circuits and meter) when the odd order modulation products (e. g. third order) disappear in the load circuit upon varying the values of grid bias.

In actual practice, source 12 may be any source of signal waves to be amplified. In the case of a radio or carrier system, source 12 may be a circuit carrying side band components of a speech-modulated carrier wave, and load 13 may be an antenna or line circuit, including in either case suitable selective circuit elements or filters.

Each tube 10, 11 is, of course, indicative of any number of tubes, similarly associated in groups, respectively.

In Fig. 5, the tubes 10 and 11 are shown connected in push-pull fashion. The circuit is not balanced for even order components as in the usual case of a push-pull amplifier, but is balanced for odd order modulation products by use of different values of grid bias voltages 14, 15 as explained in connection with Fig. 4.

The use of separate input and separate output couplings for the tubes 10 and 11 also permits of varying the input A. C. voltage and load impedance on the two tubes to assist in suppressing the odd order modulation products, if necessary.

The circuits and graphs are to be taken as illustrative and not as limiting the invention, since a variety of forms of embodiment are possible.

What is claimed is:

1. In a wave amplifying circuit a pair of three-element space discharge devices having a common input circuit and a common output circuit, the grids of said devices having different respective negative grid bias voltages substantially symmetrical with respect to the dynamic cut-off point.

2. In a wave amplifying circuit two three-element vacuum tubes having a common input and a common output circuit, the grid of one of said tubes being more negatively biased than the dynamic cut-off point, and the grid of the other tube being less negatively biased than the dynamic cut-off point by an amount sufficient to neutralize in the common output circuit the odd order modulation components from the first tube.

3. In a wave repeating circuit comprising two space discharge devices each having a cathode, an anode and a grid or impedance control element, a source of waves applied to the input circuits of both devices, a load circuit coupled to the output circuits of both devices in common, and means to bias the grids of said devices in the vicinity of the dynamic cut-off point by respectively different amounts sufficient to cause one device to neutralize the production by the other device in the load circuit of odd order modulation components while adding to the fundamental component output from said other device.

4. In a wave repeating circuit comprising two

space discharge devices each having a cathode, an anode and a grid or impedance control element, a source of waves applied to the input circuits of both devices, a load circuit coupled to the output circuits of both devices in common, and means to bias one grid more negatively than the dynamic cut-off and the other grid negatively by a different amount, such as to oppose the production in the load circuit of odd order modulation components arising from the first device.

5. The method of suppressing third order and higher odd order modulation products in a wave amplifier comprising amplifying the waves by a pair of similar space discharge devices, and oppositely biasing the control electrodes of said devices with respect to their dynamic cut-off voltages by an amount sufficient to make said odd order components occurring in the output circuits to have substantially the same amplitude but opposite phases.

6. In a wave repeating circuit two space discharge devices each having a cathode, an anode and a grid or control element, a common input circuit for both devices including a source of waves to be repeated, means for normally biasing the grid of one device more negatively than the dynamic cut-off point, means for biasing the grid of the other tube less negatively than the dynamic cut-off point, the respective values of grid bias on the two devices being adjusted to cause the odd order modulation products in the output of one device resulting from the application of said waves to its input circuit to oppose the odd order modulation products of said waves in the output of the other device.

7. The method of reducing third harmonics in the common load circuit of a pair of triodes consisting in biasing the control electrode of one of the triodes to a greater extent than the control electrode of the other triode, and biasing the control electrode of the latter in such a manner that third harmonics produced in said load circuit by said triodes are in phase opposition.

8. An electrical network including a pair of electron discharge tubes having a common input and a common output circuit, and means differentially biasing the control electrodes of the tubes in such a manner that undesired odd order modulation products are produced in said output circuit by said tubes in phase opposition.

9. The method of reducing undesired odd order modulation products in the common load circuit of a pair of plural-electrode tubes having grids or control elements which consists in connecting a pair of said tubes in parallel, biasing the control element of one of the tubes to a greater extent than the control element of the other tube, the bias voltages on the control elements of the respective tubes being of such values as to tend to cause production in the load circuit by the respective tubes of undesired odd order modulation products of respectively opposite phase whereby the amount of said undesired odd order modulation products present in said load circuit is the difference between the amounts of said products generated in the two tubes.

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