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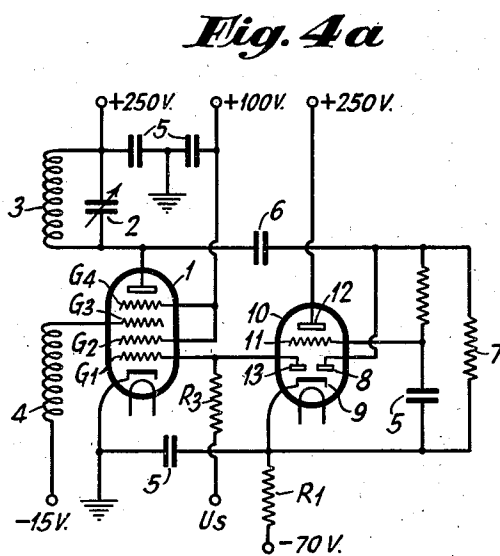
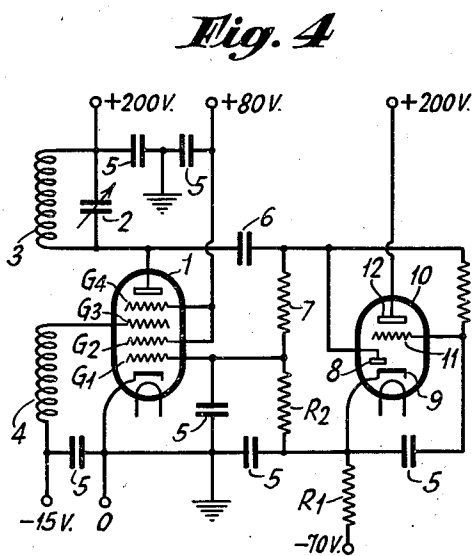
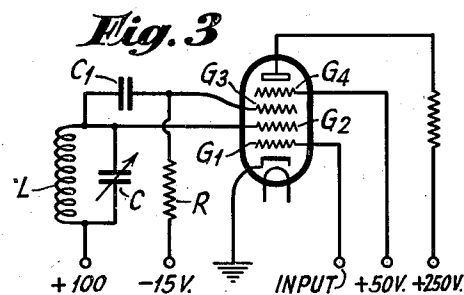
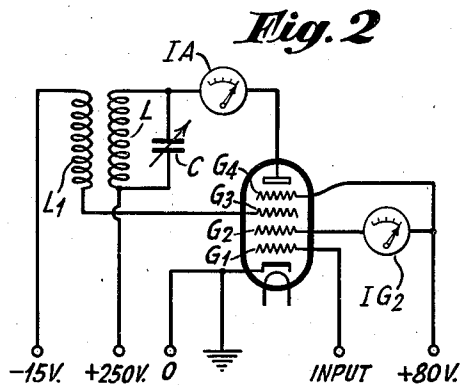
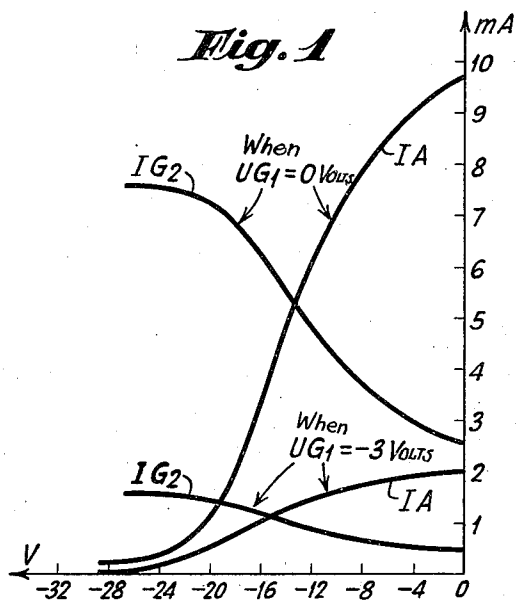
R. GOLICKE

2,264,369

OSCILLATION GENERATOR

Filed June 18, 1938

3 Sheets-Sheet 1



INVENTOR.
ROMAN GOLICKE
BY *H.S. Siver*
ATTORNEY.

Dec. 2, 1941.

R. GOLICKE

2,264,369

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3 Sheets-Sheet 2

Fig. 5

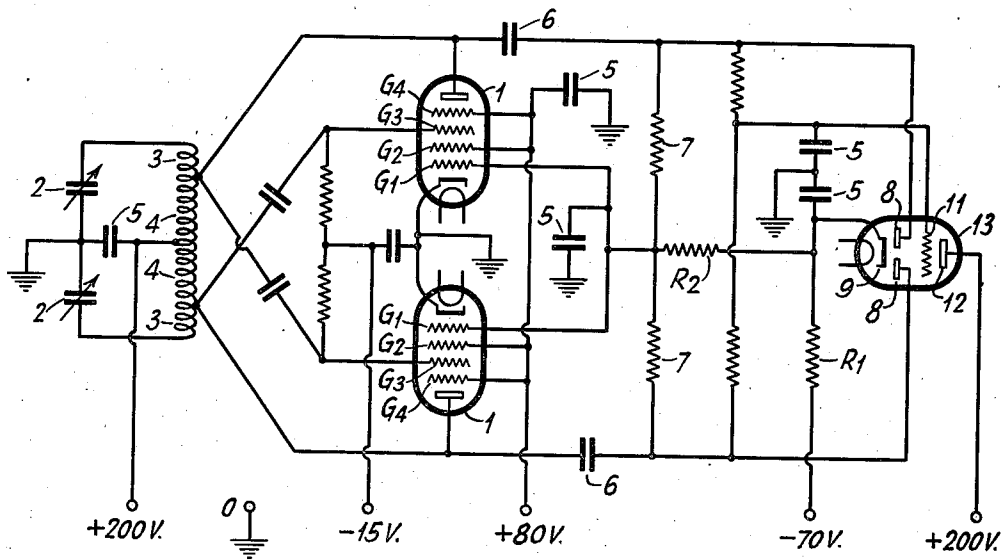
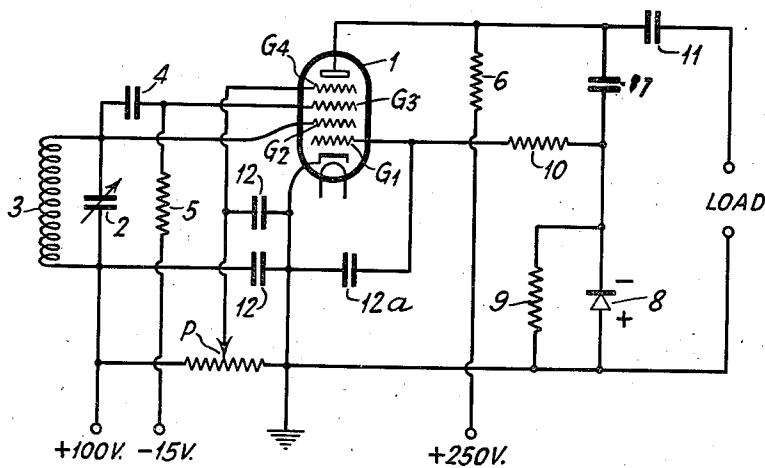


Fig. 6



INVENTOR.
ROMAN GOLICKE
BY *H.S. Grover*
ATTORNEY.

Dec. 2, 1941.

R. GOLICKE

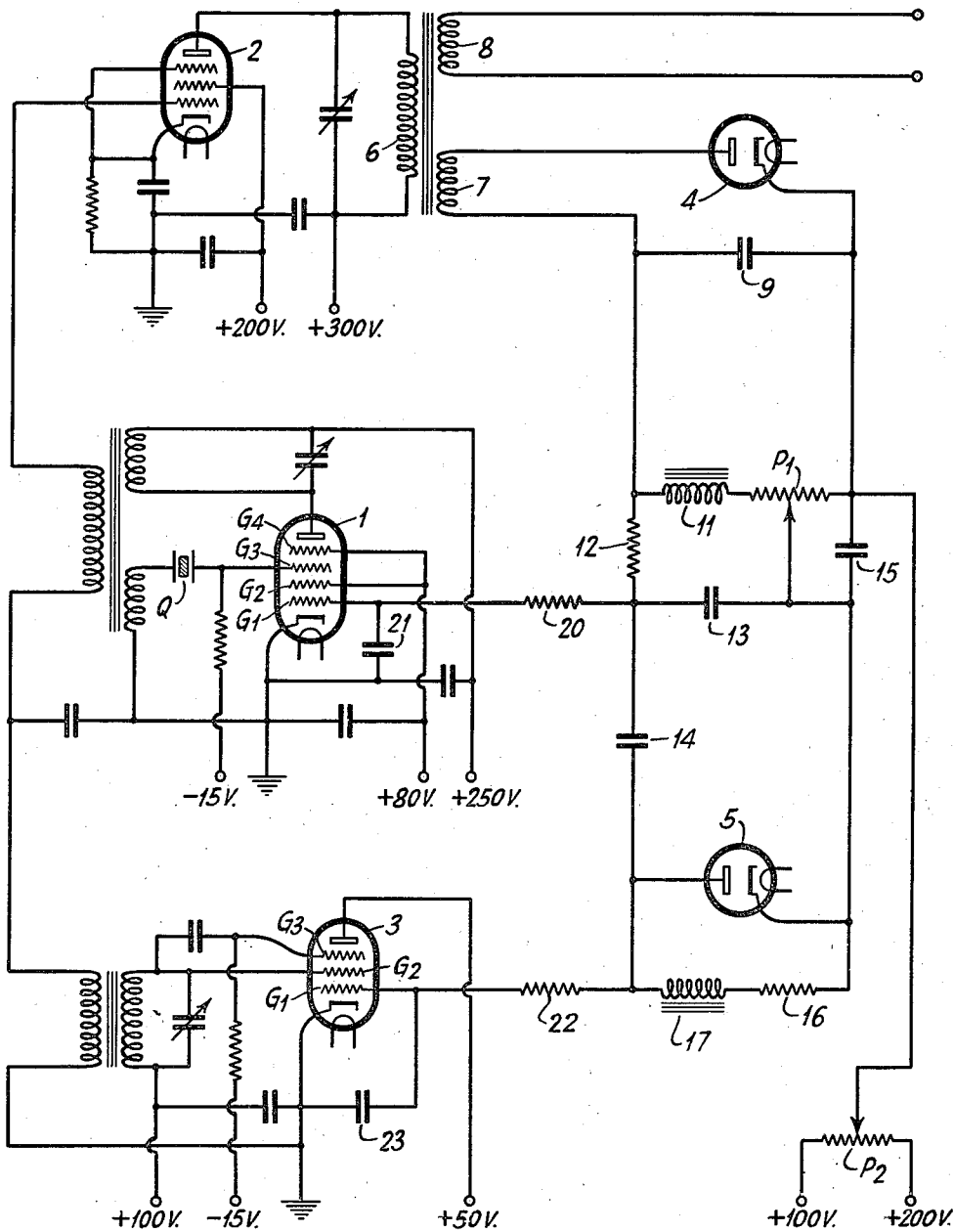
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Fig. 7



INVENTOR.

ROMAN GOLICKE

BY

H.S. Brown

ATTORNEY.

UNITED STATES PATENT OFFICE

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OSCILLATION GENERATOR

Roman Golicke, Falkenhain, near Falkensee,
Kreis Ost-Havelland, Germany, assignor to
Siemens & Halske Aktiengesellschaft, Berlin-
Siemensstadt, Germany, a corporation of Ger-
many

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It has been suggested in the prior art to stabilize the amplitude of useful or signal voltage by branching an alternating potential from the output circuit, rectifying this voltage and using it for the purpose of so influencing the biasing potential of the control grid of an oscillator tube containing one or more additional grids that with increase of output amplitude the operating point of the control grid is progressively shifted toward the negative end. What is utilized in this scheme is the dependence of the slope of the tube characteristic upon the grid biasing voltage of the control grid. The tubes that are most suitably used in the above scheme are tubes having a logarithmic characteristic. This known kind of amplitude regulation or stabilization, however, involves the draw-back that as a result of the curvature of the characteristic harmonics are produced in the oscillation generator, and the result is that the blur or rattle factor (of non-linear distortion) assumes intolerable values. Another fact is that regulation fluctuation (hunting) is difficult to avoid.

Now, according to this invention the said shortcomings are avoided by using a type of tube containing a plurality of grids in the oscillator stage, while the working point thereof is located at or near a reversal point of the characteristic of the oscillator grid. Such an S-shaped characteristic is obtained if a grid interposed between positive electrodes is used for control purposes; for instance, twin-grid tubes in space-charge connection, pentodes controlled at the suppressor or cathode grid, hexodes using the third grid, and the like may be employed. If the feed-back is made so slack that the transmitter valve becomes excited only at the steepest point of the characteristic, that is to say, in the neighborhood of the reversal point before mentioned, then the decline in slope occurring with rise of amplitude will suffice for a limitation of the generator potential. Since the reversal point of the characteristic corresponds to comparatively high negative grid biasing potentials (say, around -15 v.), and since the amplitudes may be kept low in the manner stated, it is possible to operate such a generator without causing appreciable flow of grid current, and to thus secure high frequency stability as known in the art. Since the characteristic in the neighborhood of the reversal point is practically linear, harmonics will be reduced in the presence of small amplitudes.

Amplitude limitation is insured by the S-shaped characteristic practically without any inertia or sluggishness so that no hunting or

fluctuation in the regulation process need to be feared.

If amplitudes of a certain value are to be secured, then regeneration must be adjusted to a suitable value. Now, according to another object of the invention, adjustment of an optimum degree of regeneration is obtainable automatically by variation of the slope of the oscillator tube. This is very easily accomplished by correspondingly varying the voltage prevailing at one of the grids located between the cathode and other electrodes which participate in the oscillation process, such variation being made a function of the variations of the output potential of the generator. I therefore adjust the parameters of the oscillator so that, with increase of generator amplitude, the slope and hence the gain of the multi-grid tube are automatically diminished. Automatic stabilization of the generator amplitude is thus obtainable.

In order that particularly stable or constant voltages may be obtained it will be found expedient to include an amplifier in the circuit or path comprising generator, rectifier and regulator circuit. This amplifier may be a D. C. amplifier of an additional stage. In this manner it is possible to obtain a comparatively steep control slope with simple means. However, in such an arrangement, changes may occur such as caused by aging of the tube used in D. C. amplifier, and these changes will affect the generator potential.

If constant and stable output potentials are to be secured for appreciably long periods, it will be found more convenient and practical to choose the dimensions of the amplifier adapted to the frequency to be generated, and to interpose the same between the generator and the rectifier. It is then feasible to impress alternating potentials of any amplitude upon the control rectifier and to obtain correspondingly high control potentials. Now, a fixed D. C. voltage may be made to operate in opposition to such a regulator or control voltage; and by such a compensating circuit organization the slope of the automatic control action is improved, as well known in the art. If the control rectifier consists of a diode designed for operation in a peak rectifier organization this assures particularly satisfactory constancy of the regulated or controlled potential with the time, since in such a diode the emission may recede to a small fraction of its original value before any harmful variation of the rectification factor, that is, the ratio of impressed alternating

voltage to the D. C. voltage delivered becomes noticeable.

In a control circuit organization of the invention, it is possible to produce a comparatively steep control slope, in other words, great constancy of controlled potential and freedom from hunting is obtainable. This advantage may be ascribed to the double action of the regulation, this being explained in the following manner:

1. The automatic amplitude limitation due to the S-shaped characteristic of the oscillation tube covers only a limited range of regulation, but it is free from inertia and thus not susceptible to hunting.

2. The second control action in which the slope of the oscillator tube is controlled through the intermediary of a further grid in dependence upon the output potential provides that the comparatively narrow range in which the first regulation occurs under optimum conditions will not be departed from. Hence, it is feasible to resort inside the circuit securing the second control action, to high gains and to introduce any desired time-constants for the regulator action above a certain minimum value. The minimum time-constant in the control action is predicated upon this rule, namely, that the generator frequency should not reach the control or regulator grid of the oscillator tube through the rectifier and the filter means. The control range of the assembly may be maximized by choosing suitable dimensions for the second control.

The time-constant of the second regulation, according to another object of the invention, may be chosen so small that even fast (say, tone-frequency) fluctuations of the generator amplitude can be compensated. For instance, an annoying hum modulation of the transmitter may be greatly weakened if the limiting frequency for the regulation is chosen higher than the frequencies of the hum.

If such a regulated or stabilized transmitter is to be modulated, then it will under certain circumstances be suitable to choose the time-constant of the control action so high that even the lowest occurring modulation frequencies will not be compensated, that is, be weakened.

The invention will now be described in more detail, reference being made to the accompanying drawings in which:

Figure 1 shows a curve diagram of tube characteristics, particularly those of a conventional hexode discharge tube, the use of which is explained in carrying out the invention;

Figs. 2 and 3 show circuit diagrams including a hexode tube, these diagrams being referred to hereinafter in explaining the theory of operation of the invention;

Fig. 4 shows a circuit diagram of a preferred embodiment of the invention; Fig. 4a being a slightly different scheme.

Fig. 5 shows a modification wherein push-pull operation of two hexode tubes is exemplified;

Fig. 6 shows another embodiment of the invention wherein the chief aim is to obtain great frequency stability; and

Fig. 7 shows still another modification adapted for use as a self-modulated radio frequency transmitter. In the several figures of the drawings like parts are given like references.

Referring to Fig. 2, a standard hexode tube is shown, this tube being included in the circuit organizations to be later discussed. Suppose that grid G_1 is impressed with the amplitude-regulating or pilot potential, and grid G_3 with the oscil-

lation feed-back potential, and that grids G_2 and G_4 are impressed with a positive biasing potential of 80 v. The tube characteristics are shown in Fig. 1, where the shape of the plate current I_A and the screen grid current I_{G_2} are plotted as a function of the voltage UG_3 at the control grid G_3 for different regulator or pilot potentials UG_1 at the regulator grid G_1 . The S-shaped characteristic of the plate current and of the screen grid current as well as the variation of the slope as a function of the regulator or pilot potential will be noted. The shape of the graphs is hereinafter discussed more fully in connection with an examination of the circuit organizations disclosed in the other figures.

The oscillator stage of the generator may be connected in various ways according to the particular use to which it is to be put. Fig. 2 shows the conventional scheme in which the oscillatory circuit L, C is associated with the plate, whereas the feed-back is insured through a distinct coil L_1 coupled with the coil L . The oscillation grid is impressed with a fixed biasing voltage which is so chosen as to locate the operating point at the reversal of the S-shaped characteristic.

Another generator circuit organization which is particularly advantageous (Fig. 3) is obtained by connecting the oscillation circuit with the control grid mounted between the positive screen grid and the plate. As can be seen from Fig. 1, both the plate current and also the screen grid current (I_{G_2}) are varied to the fullest extent in response to variations in the potential applied to the control grid (G_3). Inasmuch as the screen grid current declines as the control grid G_3 becomes less negative, it is possible to get along without any distinct tickler coil (for phase reversal); in fact, all that is necessary is to connect the screen grid G_2 through a condenser C_1 with the next control grid G_3 this being what is known as a negadyne scheme of circuit connection. Inasmuch as the UG_3 - I_{G_2} characteristic has a reversal point for negative control grid potentials, and as the slope of this characteristic may be adjusted through the control grid G_1 located below the screen grid, it is possible to build automatically regulated and stabilized generators of the kind described at the outset in an oscillatory circuit organization as shown in Fig. 3. Contradistinct to the known negadyne circuit scheme, the grid leak resistance R in conjunction with the grid blocking condenser C_1 serves to furnish a fixed grid potential rather than to insure automatic grid biasing potential, the said fixed grid potential in turn being so chosen that the operating point is located near or at the reversal point, in other words, at the steepest portion of the UG_3 - I_{G_2} characteristic. Inasmuch as the amplitudes are kept inside low ranges by virtue of automatic regulation no grid current will flow in R .

One advantage of the circuit organization last described is simplicity of construction. No tickler coil is needed, the feed-back is of proper phase provided that the frequencies are not so high as to produce unfavorable electron transit time phenomena and provided further that the values of C_1 and R are chosen sufficiently high. High frequency-stability is thus obtained.

Since the grids G_2 and G_3 associated with the oscillatory circuit are at the same A. C. voltage, the share of the oscillation circuit capacity of the tube, contradistinct to the conventional feed-back organization is low and permits of a large frequency range of operation with standard vari-

able condensers. If the transmitter output is united with the plate, then the reactions of the output end upon the generator frequency are slight just as is the case with an electron coupled transmitter. This freedom from reaction is still further improved by the shielding effect of the second screen grid G_4 impressed with a fixed potential.

If the positive potentials acting on the screen electrodes located on the two sides of the control grid G_3 are altered, it is discovered that the generator frequency is influenced in the opposite sense according whether the same change is effected at the one or at the other electrode. If both voltages are derived from a potentiometer, and if a definite relation of the potentials be set, it is possible to render the generator frequency independent of the plate potential fluctuations. These two potentials, when a hexode is used, are applied upon the screen grids G_2 and G_4 . The choice of the plate voltage is at will. Hence, by the use of higher plate voltages it is possible to secure larger powers at the plate-end output.

In stabilized transmitters with D. C. amplifiers for the control or pilot potential it may, under certain circumstances, be necessary to guard the oscillator tube from overloads; indeed, a contingency like that may happen whenever the voltage of the regulator grid is shifted too far toward the positive end. In the second regulator organization to be disclosed further below shown in Fig. 4 a resistance R_2 is provided for the said object. As soon as the grid current at the regulator grid G_1 assumes a certain magnitude which should not be exceeded because of the risk of an overload, then the regulator tube 10 is blocked or cut off by virtue of the fact that a negative voltage will be impressed upon its grid 11 as a result of the drop of potential across R_2 .

If the blocking of regulator action is to be brought about in the presence of any desired negative voltage at the regulator grid rather than to cause it to occur only upon the incipient flow of grid current, it will be found expedient to resort to a circuit organization of the kind shown in Fig. 4a. In this case, the pilot potential produced at the cathode 9 of the control tube 10 is impressed through the second diode path 9-13 upon the regulator grid G_1 . The regulator grid moreover is united through a high-ohm resistance R_3 with a fixed negative potential U_s of reduced value. If the cathode 9 of the regulator tube is negative in comparison with U_s , then the resistance of the diode path 9-13 is small compared with R_3 and the regulator action will operate normally. If the cathode 9 becomes positive in reference to U_s then the diode path 9-13 is blocked and automatic regulation ceases. By suitable choice of U_s the point may be set to which the oscillator valve may be regulated, and when this critical point is exceeded overloading occurs.

In Fig. 4 is shown an exemplified embodiment of the invention. In this scheme a hexode 1 is used in the oscillator stage. The oscillation feed-back control grid thereof is denoted by G_3 and the amplitude-regulating grid by G_1 . The grids G_2 and G_4 surrounding the control grid are impressed with a fixed biasing potential of, say, +80 v., whereas the plate is connected with a D. C. voltage of +200 v. The oscillation circuit consists of the variable condenser 2 and the coupled coils 3 and 4. The condensers designated by 5 are blocking condensers, the purpose of which is to keep the D. C. and the A. C. circuits apart. In parallel relation to the output circuit

are connected through a condenser 6 the two resistances 7 and R_2 . Further connected in parallel to 7 and R_2 is the rectifier circuit 8, 9 of a tube 10. With growth of the output amplitude the current in the rectifier circuit 8, 9 grows, the circuit being made through the resistances R_2 and 7. Growth of current in the rectifier results in a reduction of the potential at the grid 11 of the tube 10, with the result that the current at the plate 12 of the tube 10 is diminished. The resistance R_2 is so dimensioned that the regulator tube 10 is cut off as soon as the grid current at grid G_1 of the oscillator tube 1 attains a size which should not be exceeded because of inherent risk of overload. Inasmuch as the cathode 9 is united through a resistance R_1 with a negative biasing potential (-70 v.) and since by the fall of potential of the plate current across resistor R_1 this potential is essentially compensated so that the cathode 9 under operating conditions has a potential in the neighborhood of zero v., it will be seen that, in case of a reduction of the plate current as before mentioned, the potential of the cathode 9 of tube 10 and thus the potential of the grid G_1 of tube 1 is gradually shifted into the negative region, say, from zero to -4.5 v. The resistance R_1 is regulable and makes it possible to set the operating point of tube 10 to a suitable value.

As can be seen from Fig. 1, the said shift of the biasing voltage at the grid G_1 results in a change of I_A-UG_3 , that is, the current-voltage characteristic in this manner that the slope of the said characteristic is essentially diminished with increase in the negative biasing voltage at grid 1. This implies a drop of the gain of tube 1 in the same measure, and the result is that the output amplitude is thus automatically stabilized to a constant voltage value.

In an arrangement as hereinbefore disclosed it is readily possible to connect the grid G_3 directly with a fixed negative biasing potential, say, -15 v. without any series resistances. Since inside the working range extending from -10 to -20 v., according to Fig. 1, the plate-current characteristic is practically linear, it follows that inside the drive range between -10 and -20 v. the amplitude of the generator will be stabilized without departure from the straight portion of the plate current characteristic.

Fig. 5 shows another exemplified embodiment of the invention. This embodiment differs from the one shown in Fig. 2 essentially insofar only as two tubes 1 are connected push-pull and that in a common or joint tube rectification and amplification of the pilot D. C. is effected for both tubes.

In Fig. 6 is shown a further illustrative embodiment. In this scheme the chief aim is to obtain great frequency stability. Automatic regulation through the first grid G_1 serves primarily to so set the slope of the oscillator that through the control grid G_3 no objectionable grid current will flow. Rectification of the generator potential is effected in a low-capacitance copper oxide type rectifier 8 which through a condenser 7 is connected with the electron-coupled output of the transmitter. The regulator or pilot potential produced at the rectifier, without any further amplification, is impressed through the filter chain 10, 12, upon the regulator grid G_1 of the hexode 1. The resistor 10 and the capacitor 12a in combination constitute a low time constant circuit. By suitable adjustment of the voltage divider tap P, the dependence of the fre-

quency upon the working voltages may be minimized as hereinbefore outlined in more detail.

Fig. 7 is a further exemplified embodiment of a self-modulated RF transmitter in which both the output potential as well as the modulation percentage are automatically stabilized. The oscillation stage is subject to crystal monitoring and stabilizing action and includes a hexode 1 in the conventional regenerative circuit organization. The RF is further amplified in a pentode 2 and thus is fed to the tuned output transformer 6, 8, 7. Modulation is effected in the output stage by way of the control grid of the pentode. The modulation frequency is produced in an AF generator in which is used a pentode 3 predicated upon current-distribution control by way of the suppressor or cathode grid G₃. In addition to the output winding 8, the output transformer comprises an additional winding 7 in which high potentials are set up and fed to the RF regulator diode 4. Across the terminating resistance P₁ of the RF diode are set up voltages which, while largely compensated by a fixed potential derived from the potentiometer P₂ are passed through the filters 20, 21, the regulator grid G₁ of the RF oscillator tube 1, thereby insuring automatic stabilization of the RF amplitude.

The AF furnished from the RF regulator diode is rid of its RF components in the RF filter chain 9, 12, 13, whereupon it is fed through the coupling condensers 14, 15, to the AF diode 5. Across the terminating resistance 16 of the AF diode arise potentials which after being smoothed in filter 22, 23 are impressed upon the regulator grid G₁ of the AF generator 3. A fixed compensation potential for the AF regulator potential is required. For this purpose a portion of the D. C. voltage is derived from the diode 4 and is made adjustable by the aid of the potentiometer P₁. The modulation percentage is preserved in the output potential by the aid of the potentiometer P₂. The desired degree of modulation may be adjusted within certain limits by the aid of the potentiometer P₁. In order to provide a high impedance load in the terminating resistances of the diode circuits, audio frequency choke coils 11 and 17 having a high ohmic impedance value are used.

The invention is not confined to the illustrative forms of construction hereinbefore described by reference to the drawings, but it concerns all arrangements in which the oscillations of a transmitter are limited in their amplitude, in the absence of inertia, by the use of tube characteristics presenting a suitable curvature. The essential feature of the invention is that the oscillations are automatically preserved and stabilized by impressing a regulator potential proportional to the amplitude upon a grid of the oscillator tube which does not participate in the oscillatory process. Thus, upon an increase in the amplitudes, the slope or mutual conductance of this tube is diminished. The regulator voltage is tapped at a point of the circuit organization where the amplitudes are to be

stabilized so as to insure an unvarying magnitude.

I claim:

1. An oscillation generator comprising an electron discharge tube having a cathode, an anode and a plurality of grids including an oscillation feed-back grid mounted between two others of said grids that are positively biased with respect to said cathode, a source of negative grid bias potential applied between the cathode and said oscillation feed-back grid, said plurality of grids also including an amplitude-regulating grid, means for deriving a rectified output component from said tube, and means under control of said component for so stabilizing the bias potential applied to said amplitude-regulating grid as to fix the operating point of said tube adjacent the inflection point of the tube characteristic.

2. An oscillation generator comprising an electron discharge tube having a cathode, an anode and a plurality of grids including a control grid, a source of negative grid bias potential applied between the cathode and control grid, means including certain electrodes of said tube other than the anode for generating oscillations, means within said tube and including said anode for amplifying an output current component, means for rectifying said output component, and means under control of said amplified and rectified current component for applying an automatic bias control potential to another control grid, thereby to stabilize the frequency of oscillation generation.

3. An oscillation generator comprising an electron discharge tube having a cathode, an anode, and a plurality of other electrodes two of which are positively biased with respect to the cathode and a third of which intervenes between said two and constitutes an oscillation feed-back grid, and a fourth one of said grids constitutes an amplitude control grid, means for causing oscillations to be generated and amplified within said tube, and means for rectifying an output component from said generator, and for applying the same as an oscillation stabilizing potential to said amplitude control grid, said means including a low time constant circuit.

4. A self-modulated oscillation generator system for a radio transmitter, comprising a hexode discharge tube, high frequency crystal monitoring means connected between the cathode and one grid of said hexode, an electronic amplifier stage fed with output energy from said hexode, means for rectifying an output component from said amplifier stage, a modulation frequency generator having output circuit means for mixing its oscillations with those of said hexode, means for utilizing a rectified portion of said output component to regulate a control potential applied to said hexode, and means for utilizing another rectified portion of said output component to regulate the degree of modulation energy derived from said modulation frequency generator.

ROMAN GOLICKE.