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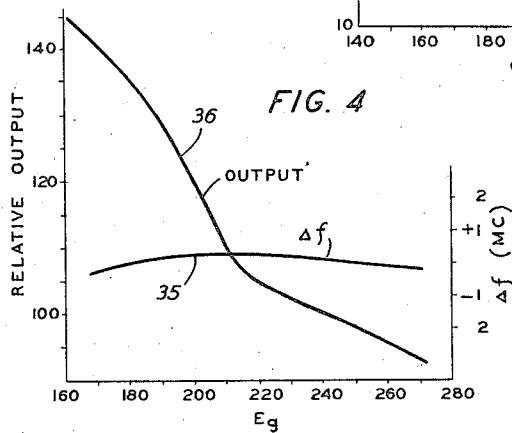
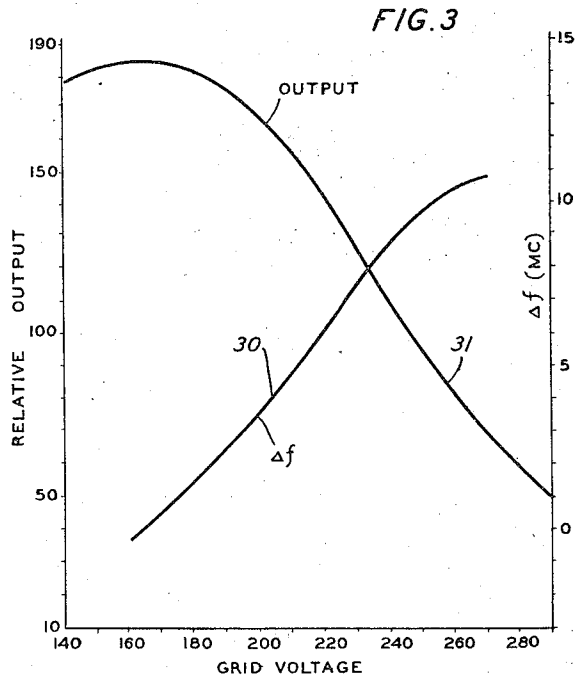
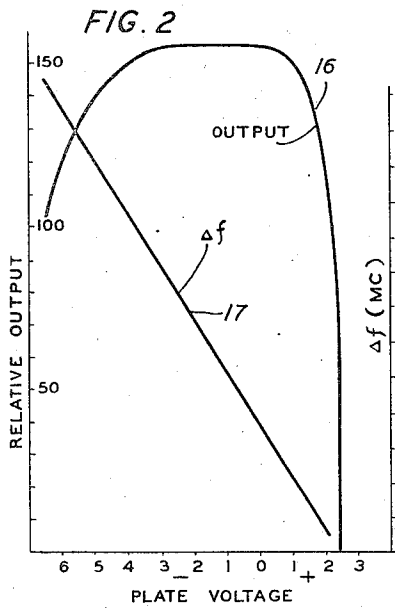
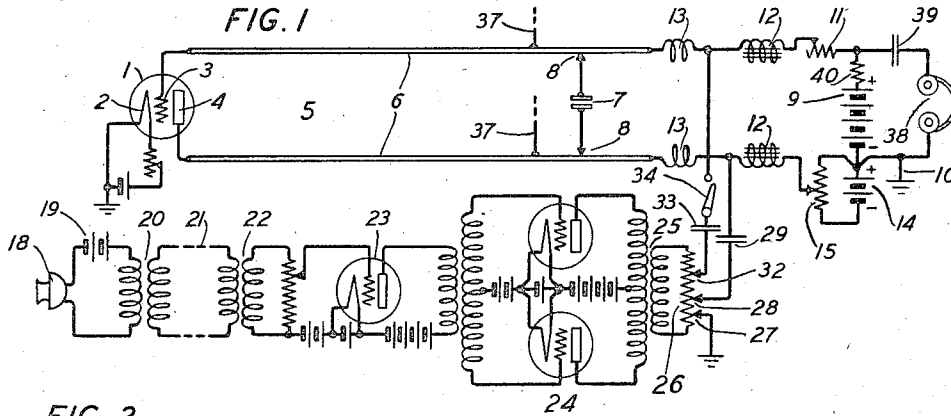
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MODULATING SYSTEM FOR ULTRA SHORT WAVES

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2 Sheets-Sheet 1



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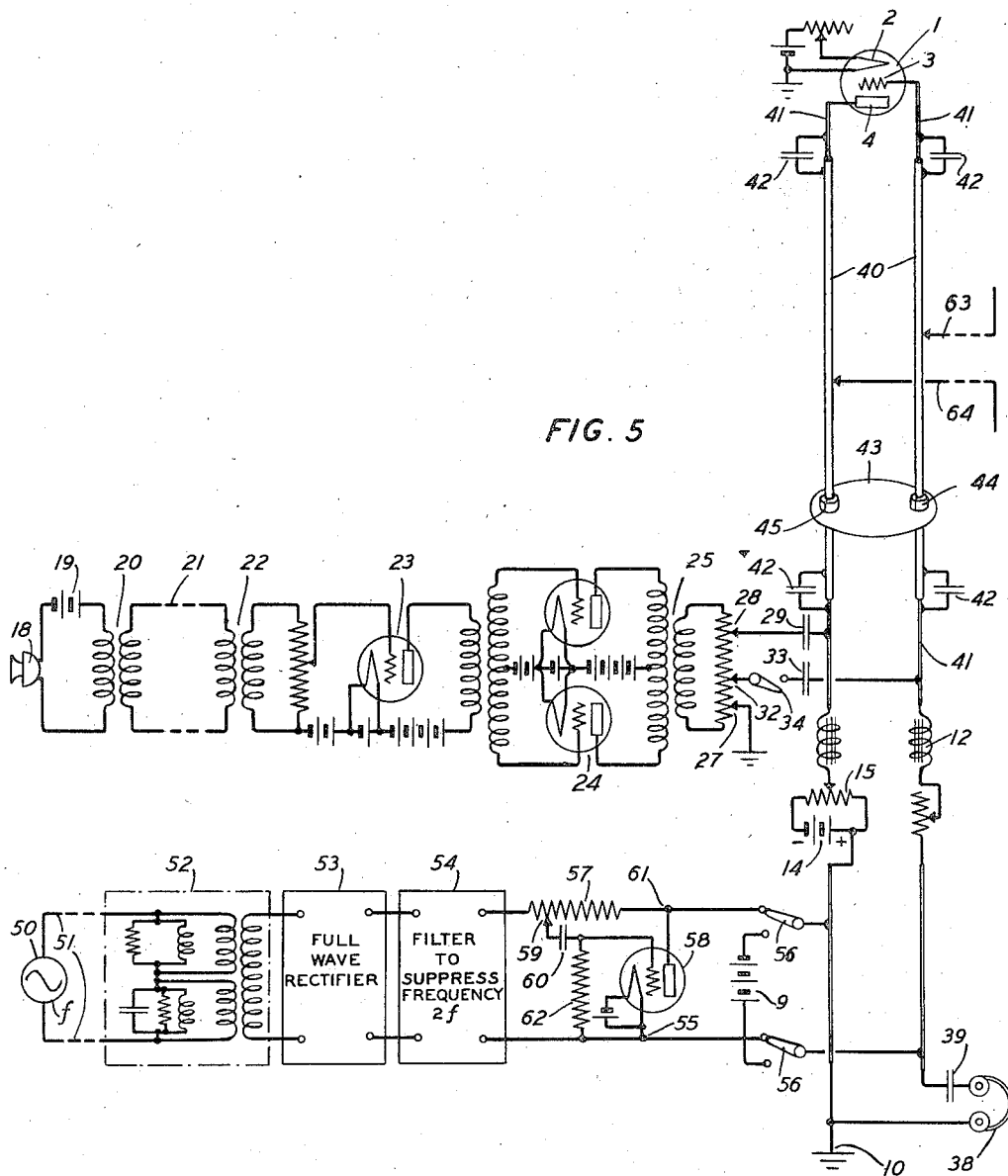
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MODULATING SYSTEM FOR ULTRA SHORT WAVES

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2 Sheets-Sheet 2



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MODULATING SYSTEM FOR ULTRA
SHORT WAVES

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3 Claims. (Cl. 179-171)

This invention relates to monitoring in modulating systems and particularly to apparatus for indicating the quality of modulation of modulated ultra short wave oscillations such as are produced by electron discharge oscillators of the Barkhausen type.

An oscillator of the Barkhausen type comprises in its most usual form an electron tube having an anode, a cathode and a grid element. Associated with these electrodes are external circuits and sources of E. M. F. for heating the cathode, for polarizing the grid to a potential highly positive with respect to the cathode, and for polarizing the anode to a potential which is low with respect to that of the grid and is in the usual case slightly negative with respect to the cathode but may in some cases be somewhat positive or at zero potential with respect to the cathode. It is customary also to associate with the electrodes, usually by direct connection to the grid and anode, an oscillation circuit, preferably of the Lecher or standing wave type.

In order to modulate carrier wave oscillations produced by an electron tube oscillator a source of modulating oscillations or currents may be associated with the external circuits of the oscillator in such manner as to apply modulating E. M. F.'s to its electrodes. It is found, however, that with oscillators of the Barkhausen type not only does the amplitude of the carrier waves vary in accordance with the modulating potential but the carrier wave frequency varies as well, thus giving rise to a result which is a combination of amplitude modulation and frequency modulation.

A principal object of the invention is to insure that at all times the oscillations produced by an ultra short wave oscillator are being efficiently modulated and that any distortion in the transmitter of which the oscillator forms a part may be readily observed.

Another object is to provide a modulation quality indicating system which will not interfere with the modulation operation and which will remain effective while desirable adjustments in the operating condition of the modulating system are being effected.

It has been discovered that in operation of electron oscillators with grids normally polarized highly positive with respect to the cathode and with the anodes at a low potential, e. g. slightly negative that if the anode be given a suitable normal polarizing potential, modulating E. M. F.'s. of limited amplitude may be impressed on the anode circuit to cause the anode

potential to rise and fall in accordance with signals or other modulating forces and thus to produce modulation of the oscillations generated with substantially no change in amplitude of the high frequency oscillation. The frequency of the oscillations does, however, vary so that there results substantially pure frequency modulation of the oscillations. The normal anode potential may be set at such a point in the tube characteristic that with the modulating E. M. F.'s applied to the anode circuit pure frequency modulation results. An analogous condition may be set up in the grid circuit so that substantially pure frequency modulation may be obtained by application of the modulating E. M. F. to the grid circuit alone.

It has also been found in all cases which have been observed that an increase in the normal positive grid biasing potential produces a change in frequency of the oscillations generated in an opposite sense to that produced by a change of normal anode potential of like polarity. Accordingly, modulating E. M. F.'s of the same wave form and phase are simultaneously applied to both the grid and anode circuits, these E. M. F.'s being so related in magnitude as to cause changes in oscillation frequency which are equal and which consequently neutralize each other. The result is, therefore, that substantially pure amplitude modulation takes place.

The invention may be best understood and an appreciation of its various objects and features had from a consideration of the following detailed description taken in connection with the drawings in which

Fig. 1 is a schematic of the circuit embodying the invention.

Figs. 2, 3 and 4 are graphs illustrating various characteristics of a three-electrode electron discharge device operating with a highly positive normal grid potential as an ultra short wave oscillator.

Fig. 5 illustrates a modification of the circuit of Fig. 1.

Referring to Fig. 1 an electron discharge device 1 having a cathode 2, a grid 3 and an anode 4 is shown connected to a Lecher circuit 5 of well-known type, comprising two parallel conductors 6 connected respectively to the grid and anode. A condenser 7 of relatively large capacity is connected to the conductors 6 by means of sliding connectors 8 to tune the Lecher circuit. A grid polarizing source 9 has its negative terminal connected to earth at 10 and its positive terminal connected to grid 3 through series resistances 40

and 11, coil 12 having high impedance for modulating frequency currents, a radio frequency choke 13 presenting high impedance at the frequency of the ultra short waves generated, and one of the conductors 6. Resistance 11 is made variable for the purpose of adjusting the grid biasing potential. An anode polarizing source 14 is connected to a potentiometer 15 from which a path leads by way of a variable tap, a modulating frequency choke coil 12, radio frequency choke coil 13 and a conductor 6 to anode 4. The source 14, the positive terminal of which is connected to ground 10, serves to impress upon the anode 4 a potential which is negative with respect to that of the cathode 2. The circuit so far described is essentially that modification of the Barkhausen oscillator known as the Gill-Morrell circuit.

It has been found that the characteristic of a certain short wave electron oscillator such as is represented in Fig. 1 with varying anode potential, is as illustrated in Fig. 2 in which curve 16 shows the relation between amplitude of oscillations plotted with ordinates at the left and anode voltage plotted as abscissae, the normal grid bias potential remaining fixed at 170 volts. In the particular apparatus to which the graph refers the circuit corresponded substantially to that of Fig. 1, the normal oscillation frequency being of the order of 500 megacycles, corresponding to a wave length of 60 centimeters. If the normal anode biasing potential is set at -1.5 volts a change in that potential of 1.5 volts in the positive direction or 1.5 volts in the negative direction produces substantially no change in amplitude current and hence no amplitude modulation. Curve 17 of Fig. 2 shows the decrease in frequency which occurs with increase in anode voltage. The set of ordinates at the right indicates increment of frequency with respect to the normal frequency occurring at an anode biasing potential of -1.5 volts and the abscissae indicate anode voltages as before. It will be apparent, therefore, that if a modulating alternating E. M. F. of not in excess of 1.5 volts peak be applied to the anode circuit alone with a normal anode potential at -1.5 volts substantially no change in amplitude of the oscillations will take place but a change in frequency which is in approximately linear relation to the change in anode potential will occur. In this case switch 34 is open as shown in Fig. 1 and no modulating E. M. F. is applied to the grid circuit.

Referring again to Fig. 1, a microphone 18 and unidirectional current source 19 are associated to produce modulating currents which are transmitted by transformer 20, line 21, transformer 22, vacuum tube amplifier 23, push pull amplifier 24 and transformer 25 to a potentiometer 26 having a variable tap 27 connected to ground. Then with tap 27 set at the lower end of potentiometer 26, variable tap 28 on the potentiometer is so positioned that the maximum potential impressed therefrom on the anode through blocking condenser 29 of large capacity amounts to approximately 1.5 volts. This will vary with the tube characteristic and will in general be determined by the extent of the substantially flat portion. Accordingly, as the normal anode potential as determined by source 14 and potentiometer 15 is -1.5 volts and the switch 34 is open, the amplitude of the oscillations produced is not varied in consequence of the modulating E. M. F. applied to the anode circuit from tap 28 but the frequency of the oscillations is varied as indi-

cated by curve 17, Fig. 2 rising as the net potential of the anode falls and falling as the anode potential increases toward that of the grid. This enables frequency modulation to take place substantially free from amplitude modulation.

Referring to Fig. 3, curve 30 plotted with frequency increment as ordinates and grid voltage as abscissae with a fixed anode voltage of -2.25 volts indicates that with variation of grid voltage from 140 volts to 270 volts, the frequency increases by approximately 11 megacycles. Over substantially the same range of grid voltage, say from 170 volts up to 290 volts the relative output as indicated by curve 31, the ordinates of which are shown at the left-hand of the figure, plotted in arbitrary units of output energy falls from about 180 to 50 units. In other words, an increase in grid voltage causes the frequency to rise and the relative output to fall. It is, therefore, apparent that an increase in grid voltage which tends to increase the oscillation frequency will oppose an increase in plate voltage or a more positive plate voltage, since as shown by curve 17 of Fig. 2 an increase in plate voltage tends to produce a decrease in frequency of the oscillations generated. It is accordingly possible to take advantage of these effects by impressing simultaneously on the grid and anode circuits modulating voltages of the same wave form and same instantaneous polarity so proportioned in their relative amplitudes as to maintain substantially constant the frequency of the generated oscillations.

Referring again to Fig. 1 it may be noted that a variable tap 32 on potentiometer 26 leads to a blocking condenser 33 the opposite terminal of which is connected by way of normally open switch 34 to a point in the grid polarizing circuit between choke coils 12 and 13. Upon closure of the switch 34 a modulating E. M. F. may be applied to the grid 3. Since this modulating E. M. F. and that applied to the anode circuit are both derived from the potentiometer 26 their wave form and phase will be identical with tap 27 positioned, as shown. It is, therefore, merely necessary to so adjust the taps 28 and 32 as to apply modulating voltages of the proper relative magnitudes to the anode and grid. It is also possible by proper adjustment of the taps to apply to the grid and the anode modulating E. M. F.'s that are either in phase with each other or, should circumstances require, in phase opposition.

Curve 35 of Fig. 4 indicates the effect of applying modulating voltages to both the grid and anode circuits when the modulating voltages are properly proportioned. As is indicated in that curve a change of grid voltage throughout the range of 170 to 270 volts may be effected with a corresponding change in anode voltage with relatively little effect on the frequency of the generated oscillations. The curve represents the results of tests made with the circuit of Fig. 1 using the same apparatus and circuits as were used to obtain the results graphically shown in Figs. 2 and 3. The modulating voltage applied to the grid was made approximately 13 times that applied to the anode. Throughout this range of applied modulating voltages the change in frequency of the oscillations generated did not exceed $\frac{1}{2}$ megacycle as compared with approximately twenty times that change in frequency indicated in the curve 30 of Fig. 3. Curve 36 of Fig. 4 indicates the variation in output which takes place with variation of the applied modulating voltage.

It will, therefore, be seen that with the switch 34 closed and the circuit adjusted as described, substantially pure amplitude modulation is obtained.

As is indicated in Fig. 3 the curve of output vs. grid voltage is of the same general shape as the curve of output vs. plate voltage in Fig. 2 in that it exhibits a maximum at a certain grid voltage with a substantially constant portion at each side of that point. Thus it will be seen that it is possible to obtain substantially pure frequency modulation by adjusting the grid voltage to about 160 volts and applying a limited amount of modulating voltage to the grid alone. In this case switch 34 would be closed and tap 28 would be made to coincide with tap 27.

A load circuit which may be an antenna may be connected by means of a transmission line 37 to the oscillation circuit. The conductors of the transmission line are preferably positioned at right angles to the Lecher conductors to reduce electromagnetic coupling between them and the Lecher circuit to a minimum.

In order to monitor the modulation circuit a device 38 such as an ordinary telephone receiver, indicator or recorder is connected through an insulating condenser 39 to the terminals of the high potential grid biasing source 9. Impedance element 40 represents the internal impedance of the grid voltage generating source or may even represent added impedance in case the former is inadequate. The receiver 38 is sufficiently isolated by choke coils 13 and 12 from the Lecher circuit and the output circuit of amplifier 24 to introduce no undue load or dissipating path. Although the choke coils 12 are, of course, not of infinite impedance for audio frequency currents, they do prevent the production of sound in the receiver 38 by the E. M. F.'s produced from the potentiometer 26 in the absence of production of ultra-short wave oscillations. In other words, the speech frequency E. M. F. supplied from the potentiometer 26 undergoes sufficient attenuation by the choke coils 12 to prevent appreciable speech frequency currents reaching the receiver 38. When, however, ultra-short wave oscillations are produced and modulated, the audio frequency variations in the grid current which result from the modulation are very much larger than any voice frequency currents coming directly from the potentiometer 26. During the modulation, the total audio frequency energy is sufficiently high so that even though only an extremely small portion of it is diverted through the receiver 38, it is sufficient to actuate the receiver and to give the necessary indication of the quality and quantity of the modulation. It has been found that the quality of the sound which is heard in telephone receiver 38 during modulating is a measure of the amplitude distortion which is taking place during the process of modulating the oscillator. Thus observation of the quality of speech observed in receiver 38 is of great assistance in securing optimum adjustment of the oscillator for good amplitude modulation. Moreover, if amplitude modulation is effected by impressing audio frequency E. M. F. on the anode only switch 34 being open, the receiver 38 does not function. However, if amplitude modulation is produced by operating on the sloping portion of the Fig. 2 output curve, the monitoring receiver 38 functions satisfactorily by virtue of the small amount of grid current variation which reaches it.

An added advantage of this system of monitoring is that it is an integral part of the radio transmitter and is not affected by external factors which have a profound influence upon the operation of the usual type of rectifier-monitor which may be placed several feet from the oscillator.

The circuit of Fig. 5 is in general similar to that of Fig. 1 but differs therefrom in the features of the Lecher circuit and the means for polarizing the grid. In lieu of the conductors 6 which serve both as the Lecher circuit and to conduct polarizing potentials to the tube electrodes, tubular conductors 40 are used for the Lecher circuit with insulated leads 41 passing thru them to connect the grid 3 and anode 4 to their respective polarizing sources. Blocking condensers 42 serve to connect the conductors 40 to the grid, anode and ground for ultra high frequency oscillations but to exclude from conductors 40 both the D. C. polarizing E. M. F.'s, and the signal frequency modulating E. M. F.'s. Tuning of the Lecher circuit is effected by a conducting disc 43 having integrally connected therewith split sleeves 44 and 45 which slide in contact with the conductors 40. Disc 43 when adjusted to the proper position serves in well-known manner to tune the Lecher circuit by introducing a short circuit at the ultra high frequency between two points in the conductors 40. The disc also serves to shield that portion of the conductors 40 on the side remote from the tube thus eliminating undesired radiations and losses which they might otherwise introduce.

The polarizing circuit for the grid and anode employs rectified alternating current derived from the ordinary public service mains. This is especially advantageous as the high D. C. polarizing potentials required for the grid involve elaborate and expensive current supply systems if alternating current supply circuits are not available as the ultimate source. The alternating current supply source 50 is connected by mains 51 to the polarizing circuit which consists of an alternating current voltage regulator 52, a full wave rectifier 53, a filter 54 to suppress the double frequency harmonic of the alternating current supply frequency and a D. C. regulator 55 to suppress any small ripples that may otherwise remain. A double pole double throw switch 56 serves to connect either the polarizing circuit just described or a D. C. source 9 at will.

The regulator 52 may be of any suitable type which will hold the voltage of its output current substantially constant independent of fluctuations in the voltage across line 51. A device which has proved satisfactory is that described by Cairns in the Proceedings of the Radio Club of America, Vol. 6, No. 5, May 1929, Fig. 6, page 57. The full wave rectifier 53 and the suppression filter 54 may be of conventional types.

The regulator 55 comprises a resistance 57 in series with the line and an electron discharge device 58 whose discharge path is shunted across the output terminals of the direct current supply circuit and whose input or grid cathode circuit is connected between a point 59 in the resistance element 57 and the opposite side of the supply circuit. A grid leak resistance 62 is provided to connect the grid of the electron discharge device 58 to its cathode. Ripples occurring in the direct current traversing resistance 57 set up varying potentials at the variable contact point 59. These potentials are impressed through a blocking condenser 60 on the grid of the electron discharge device and serve to vary

the impedance of the electron discharge path in such fashion as to cause the path to shunt more or less current therethrough. The constants of the electron discharge device and the magnitude of the resistance 57 are so related that any tendency to change the potential at point 59 results in a change of current through the series resistance 57 of such magnitude as to cause the potential at point 61 to remain substantially constant. This circuit is useful in removing any clicks or pulses which may be transmitted over the power supply mains.

It will be appreciated that it is extremely important to be able to maintain the polarizing potentials constant in magnitude and free from ripples since variations will introduce distorting modulations in the system. It is for this reason that the alternating current voltage is regulated and that the rectified current after filtering out ripples is subjected to an additional regulation.

The conductors of a transmission circuit 63 are connected to oscillation circuit 40 to transfer modulated oscillations therefrom to an antenna 64. Preferably, the conductors of the transmission circuit are connected at right angles with respect to those of the oscillation circuit 40 to reduce coupling therebetween to a minimum.

What is claimed is:

1. In combination, an electron discharge device having a cathode, an anode, and a grid positioned therebetween, means for normally biasing said grid at a potential highly positive with respect to that of said cathode and said anode at a potential which is relatively close to that of said cathode, a Lecher oscillation circuit comprising parallel conductors connected respectively to said grid and said anode, the means for biasing said anode and grid being connected thereto by means of said respective Lecher conductors, and a monitoring circuit including a receiver connected through high impedance ele-

ments in shunt across the terminals of said Lecher circuit conductors which are remote from said anode and said grid.

2. In combination, an electron discharge device having a cathode, an anode and an impedance control element, a Lecher oscillating circuit comprising two conductors having terminals respectively connected to said anode and said impedance control element, means for polarizing said anode and said impedance control element respectively connected to the opposite terminals of said Lecher circuit conductors, a monitoring receiver and a capacity element connected in series between said opposite terminals and means presenting very high impedance at audio frequencies connected between each of said opposite terminals and said polarizing means to prevent any substantial diversion from said Lecher circuit of audio frequency currents impressed thereon.

3. In combination, a Barkhausen oscillator circuit including an electron discharge device having a cathode, an anode and a grid, a unidirectional current source connected to said cathode and grid to polarize the grid to a high positive potential with respect to the cathode, means for polarizing the anode to a potential in proximity to that of the cathode, means connected to the oscillator circuit for modulating the oscillations produced thereby, a monitoring device comprising a telephone receiving instrument permanently connected to said oscillator circuit and in a path in shunt to the unidirectional current source for polarizing the grid to give an indication of the quality and amplitude of the modulation produced, and means having a relatively high impedance at the frequencies of the modulations connected between the monitoring instrument and the modulating means to prevent said monitoring device from affecting said modulating means.

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