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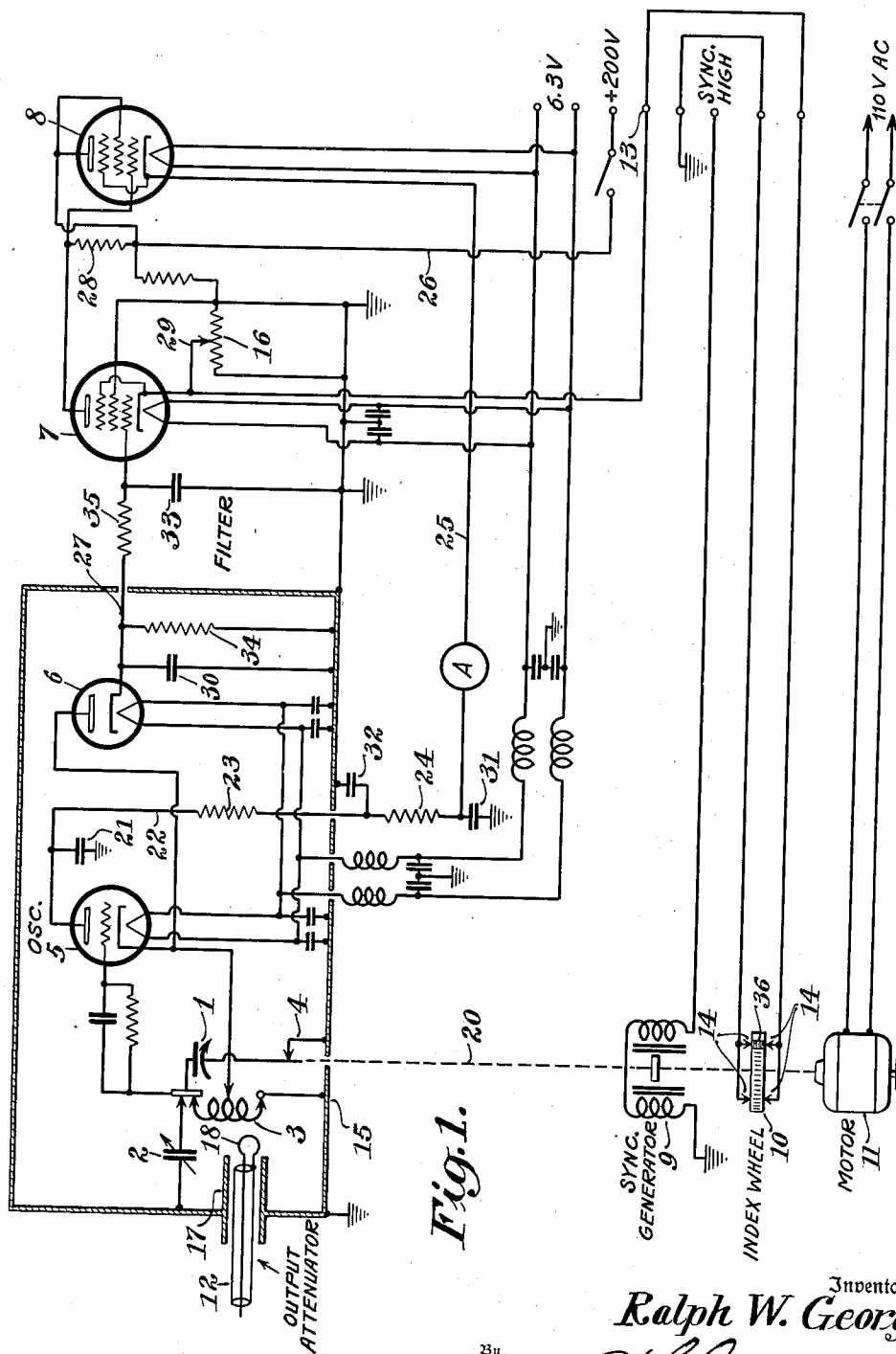
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OSCILLATION GENERATOR

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OSCILLATION GENERATOR

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The present invention relates to improvements in signal generators, and more particularly to a signal generator adapted especially for use in connection with wide band radio frequency equipment.

Although it is known to use signal generators in testing and tuning radio frequency equipment, such known signal generators have been used mainly at relatively low radio frequencies and in connection with narrow frequency band equipment. Such signal generators, however, are not suitable for use at ultra high frequencies employing wide frequency band equipment, due to difficulties experienced at the ultra high frequencies. One such difficulty resides in the variation of output of the signal generator over the frequency range due to the fact that the efficiency of the circuit elements varies with frequency.

One of the objects of the present invention is to provide an improved signal generator for use at ultra high frequencies which has a constant output over a wide frequency range, and an output frequency which can be made to vary periodically over a desired range of frequencies.

Other objects of the present invention include the provision of improved signal generators for use at ultra high frequencies less than 30 megacycles to over 500 megacycles, and which have a constant output amplitude for frequency deviations up to 20 megacycles and higher.

A feature of the present invention is the electron discharge device circuit arrangement which serves to maintain the radio frequency voltage of the oscillator at a constant level as the frequency is varied periodically.

Other objects and features will appear from the following description of the invention in conjunction with the drawings, wherein Figs. 1 and 2 illustrate two different embodiments of the invention given by way of example only.

Fig. 1 shows one form of my improved signal generator comprising a vacuum tube oscillator 5 having in circuit therewith a tunable oscillatory circuit 1, 2, 3, a diode 6 connected to the oscillator, and a pair of amplifier vacuum tubes 7 and 8 coupled to the diode, the tubes 6, 7 and 8 functioning to assure constant output from the oscillator as the frequency of the oscillator periodically varies, in a manner to be described later. The oscillatory circuit for the oscillator 5 includes an inductance 3 and a pair of variable condensers 2 and 1 connected in shunt to the inductance. The cathode of the oscillator 5 is connected to a point intermediate the terminals

of the inductance 3, such that the oscillator forms in effect a Hartley circuit. Condenser 1 is driven from the shaft 20 of a motor 11. This condenser has a controllable maximum value of capacity, and this is achieved either by having a number of selectable rotary plates or by varying the spacing of the plates. The contact 4 in circuit with the shaft 20 serves to properly ground the rotary plates of the condenser 1 as close to the terminals of the oscillatory circuit as possible. Condenser 2 is an auxiliary padding condenser which, taken together with condenser 1 and inductance 3 enables the operator to obtain a large variety of variable frequency ranges. The arrows on the terminals of inductance 3 indicate that this element is removable (plug-in type, if desired) and may be of any suitable size necessary to produce a desired frequency from the oscillator 5 and a desired frequency range in connection with the shunt condensers 1, 2. This construction permits a useful frequency range of greater than 50 megacycles to 150 megacycles by a suitable selection of inductance 3 and values for the condensers 2 and 1. Since all the values of the circuit elements which determine the frequency of the oscillator are under the control of the operator, any desired frequency deviation is available at a wide range of selectable frequencies.

The oscillator tube 5 has its anode grounded for radio frequency potentials by means of condenser 21, the anode being supplied with a suitable direct current positive polarizing potential through lead 22 over a path extending through resistors 23 and 24 in series, lead 25, the space discharge path of vacuum tube 8, lead 26 to the terminal of a source of unidirectional voltage labeled herein +200 v. It will thus be apparent that the magnitude of the potential applied to the anode of the oscillator is determined to a large extent by the impedance of the space path through the tube 8, or putting it another way, by the voltage drop in the tube 8. By making the impedance of the space path of tube 8 depend upon the radio frequency voltage of the oscillator 5, I am able to assure constant output of the oscillator. The oscillator 5 and the diode 6 are enclosed within a metallic shield box 15 which is grounded, and to which one terminal of each of the elements 1, 2 and 3 of the oscillatory circuit is connected, as shown.

The output attenuator 12 located within a metallic sleeve 17, the latter being connected to the shielded box, serves to derive output energy from the oscillator. This attenuator comprises a

coaxial line having at one end a loop 18 (which may be a single turn loop or a plurality of turns), this loop being inductively coupled to the low voltage end of the inductance 3. This attenuator is movable within the sleeve 17 for adjustment of the output obtained from the oscillator. The attenuator 12 is arranged to supply output energy from the oscillator to the radio frequency equipment under test through a suitable transmission line, the output of this radio frequency equipment in turn being observable in conventional manner on an oscilloscope, the trace of the oscilloscope showing the response characteristic of the equipment under test and being synchronized with the periodical variation of the frequency of the signal generator. In order to properly utilize the constant output of the signal generator of the present invention, it is necessary to properly terminate the load end of the transmission line connected to the attenuator 12, such that no reflection is produced on the transmission line circuit by the load (radio frequency equipment under test). The reason that the attenuator is coupled to the low voltage end of the inductance 3 is to assure as little electrostatic coupling as possible and a substantially pure electromagnetic coupling between the oscillatory circuit and the attenuator. In one embodiment actually tried out in practice, the output attenuator 12 included a 40 ohm coaxial line, although it will be obvious that the impedance of the line may vary at the will of the operator. If desired, a two-wire balanced output attenuator coupling system can also be used.

In order to insure constancy of output voltage from the oscillator 5, there is provided an electron discharge device circuit arrangement including the diode 6 and the direct current amplifiers 7 and 8. The diode 6 is connected to the cathode of the oscillator 5, this cathode in turn being connected to a point on the inductance 3. In this way the diode obtains radio frequency voltage from the oscillator 5, the rectified voltage or output from the diode being passed on to the control grid of the amplifier 7. Diode 6, of course, is designed to have a constant input-output characteristic over the periodically varying frequency range of the oscillator 5. It should be noted that the cathode of the diode 6 is positive with respect to ground and by-passed to ground for radio frequency energy through a condenser 30. Thus, an increase in the radio frequency voltage of the oscillator results in an increase in the output voltage of the diode with a consequent increase of the positive potential on the cathode of the diode. This latter voltage is supplied over lead 27 to the control grid of the amplifier 7, and if increased causes an increase in the anode current of tube 7 which increase in anode current in turn reduces the positive voltage on the control grid of amplifier tube 8. It should be noted that the positive polarizing potential for the anode of tube 7 and for the control grid of tube 8 is supplied through resistor 28 and lead 26. Hence, any increase or decrease in the anode current of tube 7 will cause a corresponding decrease or increase respectively in the positive potential on the control grid of tube 8 with a consequent change in internal impedance (anode-cathode resistance) of amplifier tube 8. Because of the change in the internal impedance of the vacuum tube 8, there will be a corresponding change in the magnitude of the polarizing voltage applied to the anode of the oscillator 5 with a consequent change in the

radio frequency voltage of the oscillator. It will thus be apparent that by suitable selection of the constants of the circuits, the tubes 6, 7 and 8 tend to maintain the radio frequency voltage of the oscillator at a constant level. The potentiometer 16 in circuit with the amplifier tube 7 provides means for adjusting the voltage level at which the oscillator 5 is operated. By means of the tap 29 on the potentiometer 16 the cathode bias of the tube 7 is adjusted and a suitable operating condition for the oscillator is obtained.

Condenser 21 in circuit with the anode of oscillator 5, condenser 30 in circuit with the cathode of diode 6, condensers 31 and 32 in circuit with the leads 22 and 25, and condenser 33 in circuit with the grid of amplifier 7, and resistors 23, 24, 34 and 35 constitute elements of a filter network which allows the circuits to function at a fast enough rate to maintain the output of the signal generator constant as the frequency is varied periodically, while at the same time preventing the occurrence of spurious oscillations.

Associated with the shaft 20, which is linked to the variable condenser 1, is a drive motor 11, a synchronizing generator impulse 9 and an index indicator 10. The indicator 10 comprises a wheel having a metal bar 36 at a point on its circumference, this bar functioning to short circuit in succession pairs of contacts 14, 14 as the bar passes them in rotation. These contacts can be adjusted so that they are short-circuited at any desired frequency, such as the two frequencies in or at the sides of the pass band of the radio frequency equipment under test. They can thus be employed to provide marks on the oscilloscope trace corresponding with the frequencies for which they are set. One way of doing this is shown in Fig. 1 by connecting the terminal 13 in circuit with the cathode of amplifier vacuum tube 7 to one contact of each of the pair of contacts, and connecting the other contact of each of the pair to ground. It will thus be evident that as the index wheel rotates, the cathode of vacuum tube 7 will be connected to ground as each pair of contacts 14 is passed over by the metal bar 36 on the index wheel, and, in this way the bias on the cathode of tube 7 will be short-circuited, causing tube 7 to draw increased current which results in an increase in impedance in tube 8 with a consequent decrease in the anode current of the oscillator. If desired, series resistance may be inserted in this circuit between the contacts 14 and the cathode of the tube 7 in order to reduce the size of the mark obtained on the oscilloscope trace. The mark is obtained by virtue of the sudden change in the potential of the cathode of the tube 7 which operates to give a sudden and rapid change of the direct current potential applied to the anode of the oscillator. In order to obtain a satisfactory mark (without too much broadening) the filter elements mentioned before have such values as will give not only a sudden and rapid change in the direct current potential of the oscillator but also restore the normal operating condition of the oscillator quickly and immediately after the index contacts are opened. The synchronous generator 9, which is linked to the shaft 20, serves to provide a pulse to synchronize the horizontal sweep rate of the oscilloscope, the oscilloscope being in circuit with the output of the radio frequency equipment under test.

The general method employed in using the signal generator of the invention for testing ra-

radio frequency equipment will now be briefly described. Assuming that it is desired to check the pass band of a television receiver having a band width of 8 megacycles (plus and minus 4 megacycles), the television receiver under test will be connected as a load to the output end of the attenuator 12. A rectifying device should be connected to the output of the television receiver and the vertical deflecting plates, let us say, of the oscilloscope connected to the rectifying device. The oscillator 5 is adjusted to provide or supply a deviation of plus and minus 6 megacycles (overall 12 megacycles) about the mid frequency corresponding to the approximate mid band frequency of the receiver under test. The deviation used for the signal generator is so chosen that the oscilloscope trace will give a true picture of a frequency versus response characteristic and will show the entire pass band of the equipment under test, and also the sloping sides of the characteristic as far as it is desired to study the characteristic. Obviously, for different equipment under test the deviation will vary depending upon the pass band and also the frequency about which the deviation occurs. The synchronizing generator 9 is coupled to the sweep circuit in circuit with the horizontal deflecting plates of the oscilloscope, and is used to synchronize the horizontal sweep rate with the rotation of the variable condenser 1. The index wheel system will be adjusted so that the contacts 14, 14 close at positions corresponding with the desired frequencies, for instance the extreme frequencies or the mid frequencies of the band pass of the equipment under study. Of course, the output of the signal generator is designed in the manner mentioned above to provide a constant input voltage to the receiver under test at all frequencies to be studied. This method of connecting a signal generator to a radio frequency equipment to be studied is known in the art and adequately described in the literature, for which reason it is not believed to be necessary to enter into a more detailed discussion of methods of testing equipment.

Although the general arrangement of the system of the invention shown in Fig. 1 is designed primarily for use in the ultra high frequency range ranging approximately from frequencies less than 10 megacycles to around 300 megacycles, the principles of the invention are applicable to signal generators which cover a wider and higher frequency range.

Fig. 2, given by way of example, is a modification of the system of Fig. 1 and shows a signal generator suitable for use at ultra high frequencies in the range from about 200 megacycles to 500 megacycles and higher. Since the principles involved in both Figs. 1 and 2 are the same and similar circuit elements are employed, the elements of Fig. 2 which are equivalent to those of Fig. 1 are given the same reference numerals, and where they differ in construction but have the same function as the corresponding elements of Fig. 1 the reference elements of Fig. 2 have been given prime designations.

In Fig. 2 the oscillator tube 5 and the diode 6 are both shown shielded from each other and from the oscillatory circuit 1', 2', 3'. The cathode of the oscillator is shown connected to a hollow tubular inductance 41 surrounding the heater leads for the filament, the cathode being tuned by means of a slider 40 which is movable over the length of the tubular inductance 41 and contacts both the outer surface of the tubular in-

ductance 41 and the inner surface of the grounded shield box 42 and serves as a means for varying the inductance of the cathode lead. Further tuning of the cathode is obtained by adjustment of the tuning condenser 43 which connects the cathode to the grounded shield box 42. If desired, at certain frequencies, the slider 40 can be fixed in position and tuning of the cathode circuit accomplished by the tuning condenser 43. The oscillatory circuit is here shown as a type of concentric line resonator having an inner conductor 3', this inner conductor being movable in length by a screw thread 44, thus providing an inductance variable over a limited range. The inductance 3' is shown surrounded by a shield 45 in which is a capacitor 2' comprised of a variable capacitive plate 46 which cooperates with the free end of the inductance 3' to extend the low frequency range of the oscillatory circuit. The variable condenser 1' comprises a pair of spaced semicircular plates, one of which is connected to the inductance 3' and the other of which is grounded through the by-pass capacitor 4'. The maximum value of condenser 1' can be varied by varying the space between its plates, a procedure which is necessary to obtain various degrees of frequency variation, as desired. It should be noted that the rotary plate of condenser 1' is linked to an inner cylinder of condenser 4', which inner cylinder is rotatable within but spaced from another slightly larger cylinder. Capacitor 4' need only be several times greater in value than the capacitor 1' in order to make the capacitor 1' effective. It should be noted that in Fig. 2 the shaft 20 is insulated by means of a suitable coupling 46 from the capacitor 4'. Tapping leads 47 and 48 extending respectively to the grid of the oscillator 5 and to the diode 6 are adjustable over part of the length of the inductance 3' for satisfactory operation. The filter elements of Fig. 2 have different values from those of Fig. 1 in order to obtain the desired results.

It should be distinctly understood that the specific arrangements of the circuit elements of Figs. 1 and 2 are illustrative but not limitative of the present invention, and that the values of the circuit elements may vary and change when used for a specific range of ultra high frequencies.

What is claimed is:

1. In combination, an oscillator of radio frequency oscillations, means for continuously and periodically varying over a desired radio frequency range the frequency of the oscillations produced by said oscillator, rectifying means coupled to said oscillator and having a constant input-output characteristic over said range, a connection supplying a polarizing potential to the anode electrode of said oscillator, a control electron discharge device whose anode-cathode resistance is in series with said connection, said discharge device being coupled to and responsive to variations in the output of said rectifying means, whereby the magnitude of the polarizing potential supplied to said oscillator anode changes in accordance with the change in the output of said rectifying means, and there is obtained an automatic control of the amplitude of the oscillations produced by said oscillator.

2. A system in accordance with claim 1, characterized in this that filtering means are in the anode electrode circuit of said oscillator.

3. In combination, an oscillator having an oscillatory circuit, means for periodically varying

the constants of said oscillatory circuit, a capacitor connecting the anode of said oscillator to ground for radio frequency potentials, first and second amplifier tubes each having an anode, a cathode and a control grid, a connection from the anode of said first amplifier to the control grid of said second amplifier, a resistor having one terminal connected to said connection and another terminal connected to a source of polarizing potential, said last terminal of said resistor being directly connected to the anode of said second amplifier, a rectifier having one electrode coupled to said oscillator and another electrode coupled to the control grid of said first amplifier tube, and a path for supplying the anode of said oscillator with a suitable polarizing potential, said path including a connection from the anode of said oscillator to the cathode of said second amplifier, whereby the anode of said oscillator is energized through the space of said second amplifier tube and the magnitude of the polarizing potential supplied to the anode of said oscillator depends upon the anode-cathode resistance of said second amplifier tube.

4. A system in accordance with claim 3, including filter circuit elements connected to the anode of said oscillator, the control grid of said first amplifier tube, and the cathode of said second amplifier tube for preventing spurious oscillations.

5. A signal generator including a vacuum tube oscillator having a parallel tuned circuit of an inductor and a shunt rotary capacitor, connections from the anode and grid of said oscillator to opposite terminals of said inductor and a connection from an intermediate point on said inductor to the cathode of said oscillator, a capacitor for grounding the anode of said oscillator for radio frequency potentials, a motor, a shaft for said motor linked to said shunt rotary capacitor for periodically varying over a desired range the frequency of the oscillations produced by said oscillator, a shield box enclosing said oscillator, an output circuit coupled to the low voltage end of said tuned circuit through an aperture in said shield box, a rectifier, first and second amplifier tubes each having an anode, a cathode and a control grid, a connection from one electrode of said rectifier to the tuned circuit of said oscillator, a connection from the cathode of said rectifier to the control grid of said first amplifier, a connection from the anode of said first amplifier to the control grid of said second amplifier, a resistor connected between said last connection and the positive terminal of a source of unidirectional potential, a connection from that point on said resistor which is connected to said terminal to the anode of said second amplifier, and a direct current connection from the anode of said oscillator to the cathode of said second amplifier, whereby the anode of said oscillator is supplied with a polarizing potential through the anode-cathode resistance of said second amplifier, and a potentiometer for adjusting the bias on the cathode of the first amplifier with a consequent adjustment of the voltage level at which the oscillator operates.

6. A signal generator in accordance with claim 5, including means for grounding the rotary plates of said shunt rotary capacitor.

7. A signal generator including a vacuum tube oscillator having an oscillatory circuit comprised of a rod-like inductance element of uniformly distributed constants, a grounded shield surrounding said oscillator tube and a grounded

shield surrounding said inductance element, a connection from the grid of said oscillator tube to a point on said inductance element intermediate its ends, means for tuning the cathode circuit of said oscillator, a rotary capacitor in shunt to at least a portion of said rod-like inductance element, said capacitor having a stationary and a rotary plate, means for grounding the rotary plate of said capacitor including a rotatable element connected to said rotary plate and being located within a larger stationary hollow element, said hollow stationary element being grounded, and a motor having a shaft linked to said rotatable element for periodically varying the capacity of said rotary capacitor.

8. A signal generator including a vacuum tube oscillator having an oscillatory circuit comprised of a rod-like inductance element of uniformly distributed constants, a grounded shield surrounding said oscillator tube and a grounded shield surrounding said inductance element, a connection from the grid of said oscillator tube to a point on said inductance element intermediate its ends, means for tuning the cathode circuit of said oscillator, a rotary capacitor in shunt to at least a portion of said rod-like inductance element, said capacitor having a stationary and a rotary plate, means for grounding the rotary plate of said capacitor including a rotatable element connected to said rotary plate and being located within a larger stationary hollow element, said hollow stationary element being grounded, a motor having a shaft linked to said last rotatable element for periodically varying the capacity of said rotary capacitor, an output circuit coupled to the low voltage end of said inductance element, and means for maintaining the radio frequency voltage of said oscillator at a constant level over the range of frequencies produced by said rotary capacitor comprising a rectifying means coupled to said inductance element and having a constant input-output characteristic over said range, a connection supplying a polarizing potential to an electrode of said oscillator, an impedance element in series with said connection, said impedance element being coupled to and responsive to variations in the output of said rectifying means, whereby the magnitude of the polarizing potential supplied to said oscillator electrode changes in accordance with the change in the output of said rectifying means, and there is obtained an automatic control of the amplitude of the oscillations produced by said oscillator.

9. A signal generator for testing ultra high frequency equipment comprising a radio frequency vacuum tube oscillator circuit including an oscillatory circuit having a variable reactance, an output circuit having a variable coupling element to which the equipment under test is adapted to be connected coupled to said oscillatory circuit, means linked to said variable reactance for continuously varying its value to cause said oscillator to produce oscillations which continuously vary in frequency over a predetermined radio frequency range, rectifying means having a constant input-output characteristic over said range and coupled to said oscillatory circuit, and means responsive to the rectified voltage for automatically controlling the level of the radio frequency voltage of said oscillator over said frequency range, said last means including a vacuum tube for amplifying the rectified voltage and whose space current path is in series with the space current path of said oscillator.

10. A signal generator for testing ultra high frequency equipment comprising a radio frequency vacuum tube oscillator circuit including a tunable cathode circuit and also an oscillatory circuit having a variable reactance, an output 5 circuit having a variable coupling element to which the equipment under test is adapted to be connected coupled to said oscillatory circuit, means linked to said variable reactance for continuously varying its value to cause said oscil- 10 lator to produce oscillations which continuously vary in frequency over a predetermined radio frequency range, rectifying means having a constant input-output characteristic over said range and coupled to said oscillatory circuit, and means 15 responsive to the rectified voltage for automatically controlling the level of the radio frequency voltage of said oscillator over said frequency range, said last means including a vacuum tube 20 for amplifying the rectified voltage and whose space current path is in series with the space current path of said oscillator.

11. In combination, an oscillator having an oscillatory circuit, means for periodically varying

the constants of said oscillatory circuit, first and second amplifier tubes each having an anode, a cathode and a control grid, a connection from the anode of said first amplifier to the control grid of said second amplifier, a resistor having one 5 terminal connected to said connection and another terminal connected to a source of polarizing potential, said last terminal of said resistor being directly connected to the anode of said second 10 amplifier, a rectifier having one electrode coupled to said oscillator and another electrode coupled to the control grid of said first amplifier tube, and a path for supplying the anode of said os- 15 cillator with a suitable polarizing potential, said path including a connection from the anode of said oscillator to the cathode of said second amplifier, whereby the anode of said oscillator is energized through the space of said second am- 20 plifier tube and the magnitude of the polarizing potential supplied to the anode of said oscillator depends upon the anode-cathode resistance of said second amplifier tube.

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