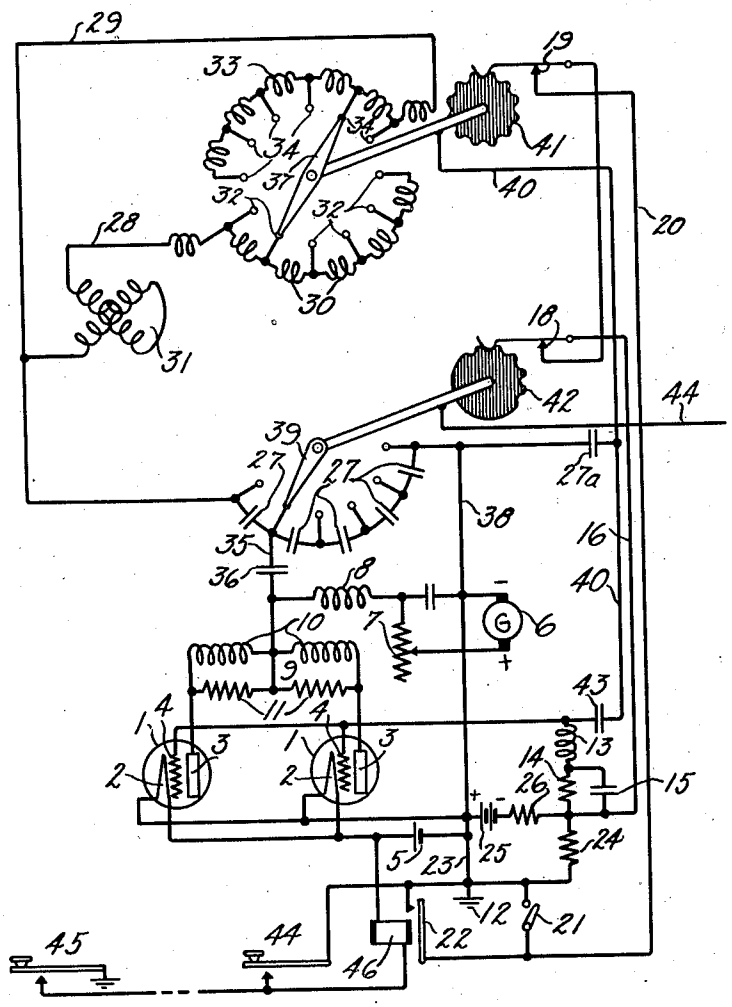
June 1, 1926.

1,586,580

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OSCILLATING SYSTEM

Filed August 20, 1925



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Patented June 1, 1926. 1,586,580

UNITED STATES PATENT OFFICE.

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OSCILLATING SYSTEM.

Application filed August 20, 1925. Serial No. 51,515.

This invention relates to oscillating systems and more particularly to arrangements of this type including space discharge devices.

A feature of this invention concerns a tuning unit comprising sectionalized inductances, a sectionalized capacity and a continuously variable inductive element for determining the frequency of the oscillations, the sectionalized inductances being adjusted to vary the resonance frequency of the tuning unit in steps and by equal increments, and the additional variable inductance being used to continuously vary the resonance frequency of the tuning unit over the range identified by each of the steps.

Another feature concerns the association, with the switches for controlling the inductance and capacity of the tuning unit, of means for protecting the discharge device.

In accordance with this invention, the oscillating system comprises a three-electrode space discharge device having its electrodes connected to different potential points of a tuned frequency determining circuit, which comprises a tuning loop consisting of three paths, one including a sectionalized capacity, the second a sectionalized inductance and a variometer in series, and the third a sectionalized inductance. For controlling the constants of the tuning unit stepwise there is provided a switch which operates to simultaneously increase or decrease the number of inductance sections included in the two inductive paths. A second switch is provided for cutting in and out different portions of the capacity to control the degree of coupling between the oscillator and the load circuit. Each of the control switches is provided with an auxiliary or protective switch which serves, when either control switch is actuated, to cause the impression upon the control electrode of the discharge device of a negative potential of such value that the system is in a non-oscillatory condition.

The description given in the preceding paragraph, while serving to indicate the nature of the invention, is not to be taken as identifying its scope. Novel combinations and features believed to be present in the invention will be pointed out with particularity in the attached claims.

For a complete understanding of the invention, reference should be made to the following description read in conjunction with the attached drawing in which the single figure illustrates an oscillating system to which the invention is applied.

Referring to the drawing, there are shown two space discharge devices 1, each including a cathode 2, an anode 3, and a control electrode or grid 4. The similar electrodes of the devices 1 are connected in parallel with reference to the external circuits including the usual current supply sources and hence operate as a single device.

Heating current is supplied to the cathodes or filaments 2 by the source 5.

Space current is supplied to the devices 1 by source 6 over the following circuit: from the positive terminal of source 6 through the resistance 7, choke coil 8, to an intermediate point of the reactive element 9, comprising an inductance 10 connected in parallel with resistances 11, from the terminals of element 9 to the anodes 3 of the respective devices 1, across the space within them to their cathodes 2 and thence to the negative terminal of source 6.

The devices 1 are provided with a leak path which extends from the parallel connected grids 4 to their cathodes. This path includes coil 13, resistance 14 shunted by a condenser 15, conductor 16, switches 18 and 19, conductor 20, switch 21 or 22, one of which is closed when oscillations are being generated, and conductor 23 to the cathodes 2.

In shunt to the contacts of switches 21 and 22 is a resistance 24 supplied with current by a source 25. The circuit including the source 25 and resistance 24 may be traced as follows: from the negative terminal of source 25, resistance 26, resistance 24, conductor 23 to the positive terminal of source 25. Under certain conditions of operation of the system to be hereinafter described, the voltage drop across the resistance 24 is impressed upon the control electrodes 4 to render them so negative with reference to their cathodes 2 that no oscillations are generated by the system.

Associated with the device is a tuning unit for determining the frequency of oscillations generated. This unit comprises a capacity path including series condensers 27 and 27A connected with an inductive path consisting of two shunt connected portions 28 and 29. Portion 28 includes a sectionalized inductance 30 in series with a variometer 31. The

section points of the inductance 30 are connected by leads to switch contacts 32. Portion 29 includes a sectionalized inductance 33 having its section points connected to switch contacts 34. Inductance 33 is shown as having the same number of sections as inductance 30, although under some circumstances it may be desirable to use unequal numbers of sections.

The tuning unit has one terminal connected by conductor 35 to the intermediate points of the reactive element 9, the terminals of which are connected to the anodes 3. A blocking condenser 36 is included in the conductor 35. This condenser serves to prevent the application of potential from generator G to the tuning unit or to the load through 39. The other terminal of the tuning unit is connected through the movable switch 37, conductor 40 and condenser 43 to the control electrodes 4. The switch contact 37 cooperates with the contacts 32 and 34 to control the number of sections of inductances 30 and 33 connected in parallel with each other and in parallel with the condensers 27 and 27^A of the capacity path.

The common plates of condenser 27^A and the adjacent condenser 27 are connected by a conductor 38 to the cathodes 2. Switch 39 is provided to control the number of condensers 27 included between earth connection 12 and output lead 44, thus varying the coupling between the oscillator and the load.

The movable arm 37 of the inductance control switch is provided with a cam or serrated arrangement 31 adapted to open and close the switch 19. Similarly, the movable contact of switch 39 is provided with a cam or other arrangement 42 adapted to open and close the switch 18. The cams 41 and 42 may either be of insulating material, or they may be insulated from the switch contacts 37 and 39, respectively.

The control electrodes 4 of the devices 1 are connected through the conductor 40 to one plate of the condenser 27^A, while, as noted above, their cathodes are connected to the opposite terminal of this condenser by the conductor 38.

The switch arm 39 is connected through conductor 44 to a load circuit (not shown).

The oscillating system described above is similar to the Colpitts type of oscillator discussed in Professor L. A. Hazeltine's paper entitled "Oscillating Audion Circuits," proceedings of the I. R. E. for April, 1918, Fig. 3^c, page 69, to which reference may be made for a description of its method of operation.

The reactance element 10 prevents the generation of oscillations of undesired frequencies in the circuits associated with the parallel discharge devices 1.

The condenser 43 is included in the conductor 40 to prevent the flow of direct current from the grid polarizing source 24—25 through the inductive paths of the tuning unit.

With the switch 21 closed, the system continuously generates oscillations of a frequency determined largely by the constants of the tuning unit.

When oscillations modified in accordance with signals are to be supplied to the transmission circuit, the switch 21 is open and the oscillating system is controlled by actuating the switch 22 in accordance with the signal impulses to be transmitted. Switch 22 may be controlled by actuating either key 44 or key 45 to control the supply of current from the source 5 to the relay winding 46. With both keys open, the potential across the resistance 24 is impressed between the cathodes 2 and control electrodes 4 of the devices 1. This potential is of such value as to prevent the generation of oscillations by the system. However, when the switch 22 is closed, the resistance 24 will be short-circuited and the potential impressed upon the control electrodes 4 will be reduced to such value that oscillations are generated in the system and supplied to the transmission circuit.

To vary the frequency of the oscillations produced by the system, switch 37 is adjusted to change the value of the inductance included in the tuning unit. As the switch 37 is moved counterclockwise from the position shown, to successively engage the diagrammatically opposed pairs of contacts 32 and 34, sections of inductances 30 and 33 will be successively connected in parallel with each other and with the condensers 27 and 27^A. In the limiting position, all of the sections of the inductances 30 and 33 will be in parallel with each other. By moving the switch 37 clockwise, the number of sections of inductances 30 and 33 connected in parallel with each other will be decreased and, in the limiting position, but one section of each of the inductances will be connected in parallel relation. The sections of the inductances 30 and 33 respectively are so related to each other that as the switch 37 is moved from one pair of contacts 32—34 to the next succeeding pair of contacts 32—34, the resonance frequency of the tuning unit will be varied by equal increments.

The variometer 31 is adapted to continuously vary the resonance of the tuning unit over the frequency range identified by the different settings of the switch 37.

The tuning unit described above is designed to produce a variation of the frequency of oscillations generated over a relatively wide range.

If, as contemplated with the present arrangement, the single variometer is used to continuously vary the resonance frequency over each of the equal range increments

identified by the different settings of the switch controlling the sectionalized inductances, it is desirable to use parallel inductances and a variometer the inductance values of which bear a definite relation to one another.

Consider the case in which a total frequency variation of 100% is desirable, i. e. where the upper limiting frequency generated f_1 is to be twice the lowest frequency f_2. As is well known, frequency f of an oscillator determined by a tuned circuit is approximately equal to

$$\frac{1}{2\pi\sqrt{CL}}$$

where C represents the capacity and L the inductance included in the circuit. The capacity being constant this expression may be written $f=aL^{-1/2}$ where a is a constant and as before L represents the inductance. The rate of variation of frequency with change of inductance may be expressed as,

$$\frac{df}{dL} = -{}^{1}/_{2}aL^{-3/2}.$$

If, as suggested above, $f_1=2f_2$, then

$$L_1=\frac{1}{4}L_2,$$

where L_1 represents the inductance at f_1 and L_2 represents the inductance at f_2. The ratio of the two derivatives representing the rates of change of frequency near frequencies f_1 and f_2 is

$$\left(\frac{L_2}{L_1}\right)^{3/2},$$

and is equal to $4^{3/2}$ or 8. Thus the inductance variation at the lowest frequency must be 8 times that at the highest frequency for a given frequency difference. For other relative values of the limiting frequencies the ratio

$$\left(\frac{L_2}{L_1}\right)^{3/2}$$

will be different.

For the tuning unit under consideration the ratios refer to the variation of the resultant inductance of the two parallel paths, consequently the variometer must be 8 times as effective at the lowest frequency as it is at the highest frequency in varying the combined inductance of the two paths. Should the inductance in the path 29 be too low relatively to the sectionalized inductance in the path 28 the variometer will be ineffective to produce the required frequency change, while, if the reverse is the case, changes in frequency will be largely determined by the path 28.

However, by properly proportioning the sectionalized inductances in paths 28 and 29 and the variometer relatively to one another, it is possible to provide a tuning unit adapted to vary the frequency over a wide range by equal frequency intervals and to employ the variometer to change the frequency continuously within these intervals. The constants of a resonant circuit adapted to satisfy the above mentioned conditions may be determined as follows: If L_v equals the maximum inductance range of variometer 31, L_s the inductance of 30 plus the minimum of the variometer and L_p the inductance of 33, and if the resultant capacity of 27 is C, then it can be shown that the frequency f_1 when the variometer is set at maximum is related to the frequency f_2 when it is at minimum by the following expression:

$$f_2-f_1=\frac{L_v}{4\pi^2CL_s(L_v+L_s)}\cdot\frac{1}{f_2+f_1}$$

Hence if f_2 and f_1 are specified and if L_v and C are determined by other conditions, L_s can be calculated. The value of L_p is then obtained by means of the expression:

$$f_1^2=\frac{(L_v+L_s+L_p)}{4\pi^2CL_p(L_v+L_s)}$$

If either of the main switches 37 or 39 is actuated the auxiliary switches 19 or 18 will be opened prior to the opening of the main switches to impress upon the control electrodes 4 the voltage drop across the resistance 24. In this manner, the system is rendered non-oscillatory before the circuit of the tuning unit is opened, so that damage to or destruction of the discharge device or switch points is prevented.

While in the preceding description, the invention is described as applied to a particular type of oscillating system including a plurality of space discharge devices and specific details have been set forth with the object of completely and clearly disclosing the nature of the invention, it is to be understood that this invention is of general application. It may, therefore, be used with any type of oscillator employing a tuned circuit for determining the frequency of the oscillations generated. Obviously, a single space discharge device may be used and the discharge of current across the space within the device may be effected by means of an ionized gas path or electronically, that is, independently of gas ionization. The anti-singing reactance element 9 may be omitted without affecting the principles of this invention and any suitable type of control and auxiliary switches may be employed.

Furthermore, the principles of this invention may be applied to the situation in which unequal frequency changes are produced by the different switch adjustments.

What is claimed is:

1. An oscillatory system comprising a space discharge device, coupled input and

output circuits therefor including a tuned frequency determining circuit comprising a capacity shunted by a plurality of parallel connected sectionalized inductances, and means for simultaneously varying the number of sections of inductances connected in parallel with each other.

2. An oscillatory system comprising a space discharge device, coupled input and output circuits therefor including a tuned frequency determining circuit comprising a capacity, a plurality of parallel connected sectionalized inductances, and means for simultaneously determining the number of sections of the respective inductances connected in parallel with each other and in parallel with said capacity.

3. An oscillatory system comprising a space discharge device, coupled input and output circuits therefor including a tuned frequency determining circuit comprising a capacity having connected in shunt thereto a pluralty of parallel connected inductive paths, one of which includes a sectionalized inductance while the other path includes a sectionalized inductance in series with a continuously variable inductance, means for simultaneously varying the number of sections included in said respective paths in shunt to said capacity, and means for adjusting said continuously variable inductance.

4. An oscillatory system comprising a space discharge device, coupled input and output circuits therefor including a tuned frequency determining circuit comprising a capacity having connected in shunt thereto a plurality of parallel connected inductive paths, one path including a sectionalized inductance while the other path includes a sectionalized inductance in series with a continuously variable inductance, a switch for simultaneously varying the number of sections of inductances included in said respective paths in shunt to said capacity to change the frequency of the oscillations by equal increments, and means for adjusting the continuously variable inductance whereby the frequency of the oscillations may be continuously varied over the range determined by the adjustments of said switch.

5. An oscillatory system comprising a space discharge device having a grid, a cathode and an anode, coupled input and output circuits therefor including a tuned frequency determining circuit, comprising a capacity having connected in shunt thereto a plurality of parallel connected inductive paths, one path including a sectionalized inductance while the other path includes a sectionalized inductance in series with a continuously variable inductance, a switch for simultaneously varying the number of sections of inductances included in said respective paths in shunt to said capacity to change the frequency of the oscillations by equal increments, means for adjusting the continuously variable inductance whereby the frequency of the oscillations may be continuously varied over the range determined by the adjustments of said switch, a switch for adjusting the value of said capacity included between said cathode and said anode, and auxiliary means associated with said switches to control the application of a blocking potential to said device when either of said switches is actuated.

6. An oscillating system comprising a space discharge device having an anode, a cathode and a grid, coupled input and output circuits therefor including a tuned frequency determining circuit consisting of sectionalized capacities shunted by a plurality of parallel connected sectionalized inductances, a switch for varying the number of sections of capacity included between said cathode and said anode, a switch for simultaneously varying the number of sections of inductances connected in parallel in said tuned circuit, and auxiliary means associated with each of said switches for controlling, when either of said switches is operated, the impression of a blocking potential upon said grid.

In witness whereof, I hereunto subscribe my name this 14th day of August A. D., 1925.

JOHN C. SCHELLENG.