April 19, 1949. R. W. GEORGE 2,467,736

SUPPRESSION OF PARASITIC OSCILLATIONS

Filed Feb. 24, 1945

Fig. 1.

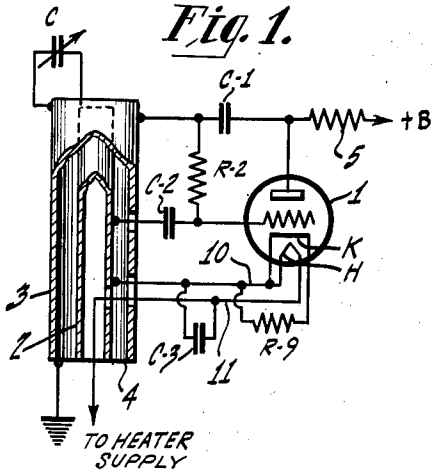


Fig. 2.

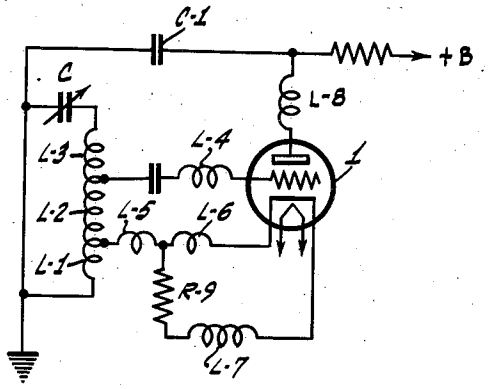


Fig. 3.

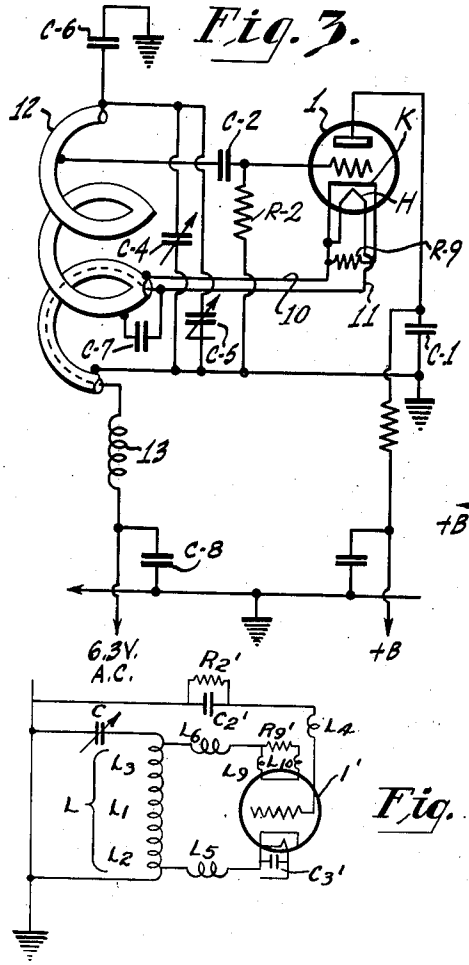


Fig. 4.

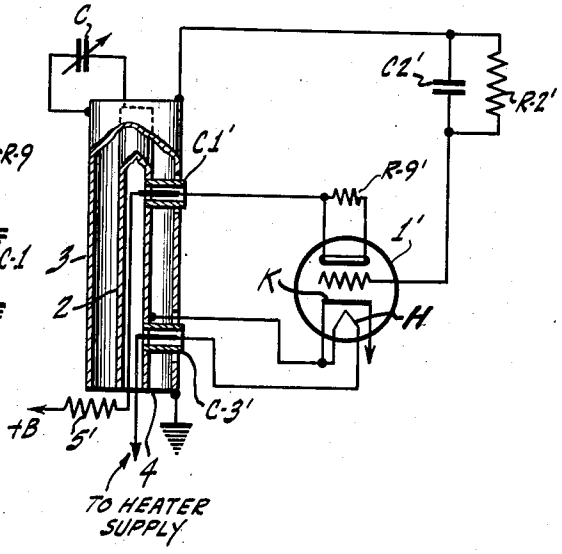


Fig. 5.

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SUPPRESSION OF PARASITIC OSCILLATIONS

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6 Claims. (Cl. 250—36)

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This invention relates to electron discharge device circuits and has particular reference to the prevention, elimination or reduction of parasitics in such circuits.

At the very high frequencies, particularly above 100 megacycles, the leads connecting the electrodes of an electron discharge device to associated circuit elements, no matter how short these leads may be, represent some value of inductance which often combines with the distributed interelectrode and external lead capacities to produce a resonance effect giving rise to undesirable parasitic oscillations. This difficulty has been experienced, by way of example, with electron discharge device circuits using vacuum tubes of the indirectly heated type in which the cathode has two terminals.

In accordance with one aspect of the present invention, this difficulty is overcome by connecting a relatively low value of resistor across the two terminals of the cathode of an indirectly heated tube operating at very high frequencies.

A more detailed description of the invention follows in conjunction with a drawing, wherein:

Fig. 1 illustrates one embodiment of the invention used as an oscillator at such high frequencies that the electrode leads have appreciable reactance;

Fig. 2 shows the equivalent radio frequency circuit of the system of Fig. 1;

Fig. 3 illustrates another oscillator embodiment of the invention using lumped inductance elements instead of the linear inductance elements of Fig. 1;

Fig. 4 illustrates a modification of the oscillator system of Fig. 1, in which the resistor is placed in the anode leads; and

Fig. 5 shows the equivalent radio frequency circuit of the system of Fig. 1.

Referring to Fig. 1, there is shown an oscillation generator comprising an indirectly heated type of triode vacuum tube 1 whose electrodes are coupled to a coaxial line resonant circuit comprising a hollow inner conductor 2 and a hollow outer conductor 3. Conductors 2 and 3 are connected together at one end by means of a metallic plate 4 which is grounded, as shown. The other end of the inner conductor 2 is connected to the adjacent end of the outer conductor 3 by means of a tuning condenser C.

Tube 1 is connected to the resonant circuit 2, 3 in a manner similar to the well known Hartley oscillator circuit. More specifically, the anode of tube 1 is grounded or connected to the outer conductor 3 through a radio frequency by-pass

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conductor C1. The grid is connected to a point on the inner conductor 2 intermediate the ends thereof through a radio frequency coupling condenser C2, and this grid is also connected to the outer surface of the outer conductor 3 through a grid leak R2. The point on the inner conductor 2 to which the grid is connected is suitably chosen to decrease the loading on the resonant circuit caused by the resistance of the vacuum tube, to thereby provide as high a Q for the tuned circuit as possible, in order to promote frequency stability.

Tube 1 is provided with a cathode K which has two terminals as shown and also with a filament or heater H. One side of the cathode K is directly connected to one side of the heater H, and this side is connected through lead 10 to the inner conductor 2 at a suitable point to obtain the proper excitation for the oscillator. The other side of the heater is connected through lead 11 to the heater supply by virtue of a connection which extends within the interior of the hollow conductor 2. A radio frequency by-pass condenser C3 is connected across the leads 10 and 11 to by-pass radio frequency energy and prevent this energy from entering the heater supply circuit. An anode polarizing potential is supplied from the positive terminal +B of a suitable source of unidirectional potential through a filter or resistor 5.

To prevent the occurrence of parasitics in that portion of the circuit between the grid and cathode, there is provided a suitable resistor R9 which is connected across the two sides of the cathode.

The oscillator of Fig. 1 functions in the manner of a well known Hartley circuit in which the anode is connected to one end of a parallel tuned resonant circuit while the grid and cathode are connected to other spaced points on the inductance elements of the tuned circuit, such that the cathode point on the tuned circuit is located between the grid point and the anode point.

A better understanding of the oscillator of Fig. 1 may be had by referring to Fig. 2, which shows the equivalent radio frequency circuit of the system of Fig. 1. In Fig. 2 the tuned circuit has been shown as consisting of condenser C and an inductance coil comprising three portions L1, L2 and L3. This circuit is equivalent to the coaxial line resonator 2, 3, C of Fig. 1. Condenser C tunes the circuit to the desired oscillation frequency, neglecting for the moment stray and tube capacities. The coil L4 represents the total

inductance in the grid lead. A coil L5 represents the inductance between the tapping point on the tuned circuit and the vacuum tube socket terminal. The coils L6 and L7 represent the inductance in the respective cathode leads 10 and 11 which are in both the tube and the socket. Coil L8 represents the total inductance between the anode and ground. At the desired oscillation frequency, the inductances L4, L5, L6 and L7 are relatively small and have little effect. At higher frequencies, however, it has been found that the circuit including inductances L4, L2, L5, and L6, and the grid to cathode interelectrode capacity is resonant and is likely to give rise to parasitic oscillations if the frequency is not too high for the particular tube 1, and if the anode circuit is phased properly. I have been able to suppress parasitic oscillations by means of a damping resistor R9 connected across the cathode leads, as shown. This damping resistance R9, it will be noted, is introduced in that portion of the parasitic circuit which includes L6 and L7. The use of resistor R9 in the particular location shown introduces a resistive component in inductance L6 which is effective in increasing the losses in the resonant parasitic circuit without appreciably affecting the operation of the oscillator circuit at the desired frequency.

An advantage of this invention is that I have been able to introduce damping in the parasitic circuit without modifying the values of either L4 or L5, which values are thus kept as small as possible.

Fig. 3 illustrates another oscillator embodiment of the invention which is very similar to the system of Fig. 1 except that a lumped inductance element in the form of a tubular coil is used in the frequency controlling tuned circuit instead of the linear inductance element (coaxial resonant line) of Fig. 1.

This lumped inductance element is shown as a coil of tubing labeled 12. Inductance 12 is tuned by condensers C4, C5 which are connected across the terminals of the coil and also by a temperature compensating condenser C6. The grid of the oscillator vacuum tube 1 is connected at a point on the coil 12 which is tapped down from the high impedance end. This mode of connection, it should be noted, is the same as that of Fig. 1. The anode is by-passed to ground for radio frequency energy by condenser C1. Condenser C2 is the usual grid coupling condenser and resistor R2 is the usual grid leak. In order to minimize hum modulation on the cathode K from the heater H in the oscillator tube, it is necessary to connect one side of the heater H (for example, lead 10) to cathode K. The system is so constructed as to maintain both the cathode and the heater at the same radio frequency potential. This is achieved by bypassing the heater lead 11 to the cathode tap on coil 12 via condenser C7. Lead 11, it should be noted, extends through a portion of the tubular coil 12 and is brought out of the grounded end of the coil 12, and from this end extends to a suitable heater supply through a filter circuit comprising a choke 13 and a condenser C8. Choke coil 13 also serves to tune this lead 11 to a low frequency which, of course, is considerably different from the very high oscillator frequency.

Again, as in Fig. 1, there is provided a resistor R9 across the cathode terminals to suppress parasitic oscillations. In one embodiment of the invention, the tube 1 was a miniature triode RCA

type 9002 tube and the system operated in a range from 200 to 220 megacycles. Resistor R9 had a relatively low value of ten ohms, although other values for resistor 9 may be found to be suitable. The frequency controlling circuit was a coaxial resonant line having a length of about four or five inches. The diameter of the inner conductor was about five-eighths of an inch, while the diameter of the outer conductor was approximately one and one-half inches. The tuning condenser C for the coaxial resonant line had a value of about 15 $\mu\mu$f, and was chosen as to take into account the interelectrode capacity of the triode tube 1. This system is substantially shown in Fig. 1. Actually, the outer conductor 3 in the embodiment tried out in practice was rectangular in shape rather than cylindrical, although both shapes can be used.

It should be understood that the invention is not limited to the use of a resistor across the two cathode leads of an indirectly heated tube and that the invention is equally applicable to any vacuum tube in which two leads are brought out from any electrode of the tube. For example, if the anode is connected to an external circuit through two leads extending from different parts of the tube envelope, a suitable value of resistor may be connected across these two anode leads to provide damping in the circuit connected to the anode, thus suppressing parasitic oscillations. In this last case, the tube need not be an indirectly heated type of tube. The principles of the invention are such that the damping resistor can be applied to the circuits involving two electrodes in which each of these electrodes has connected to it two leads extending from different portions of the tube envelope. Thus it is possible to suppress oscillations by using a damping resistor R9 across the cathode leads, and also a similar damping resistor across the two anode leads of the same vacuum tube.

Fig. 4 shows an oscillation generator of the invention having the same basic circuit shown in Fig. 1, the essential differences being first in the use of the damping resistor R9' placed across the two anode terminals of the vacuum tube triode 1', and secondly in the interchange of the coupling points from the grid and anode to the coaxial line tuned circuit 2, 3. The same reference numerals appearing in Figs. 1 and 4 represent the same elements, while those reference numerals of Fig. 4 having prime designations represent equivalent elements to those of Fig. 1 without the prime designations. More specifically, Fig. 4 is similar to Fig. 1 except that the R.–F. ground potential point of the oscillator circuit is changed to the grid side by interchanging the anode and grid connections. Anode supply is obtained by bringing the D. C. anode lead through the zero R.–F. potential zone inside the inner conductor 2 to the R.–F. tapping point where the R.–F. anode lead is by-passed by condenser C1' to the inner conductor inductor 2. The grid of the tube is by-passed to the R.–F. ground potential point by C2'.

Fig. 5 shows in greater detail, the function of the damping resistor R9', as embodied in Fig. 4. L1, plus L2, plus L3 is equivalent to L in Fig. 4 and is tuned by C to the desired frequency. L4 is the total inductance in the grid lead which is by-passed to ground by C2' which in turn is shunted by the usual grid resistor R2'. L5 is the inductance between the tap on L and the cathode terminal. The inductance of the leads from the cathode terminal to the cathode will

be neglected in this case as it has been described in Fig. 2. L6 is the inductance of the lead from L to the anode terminal. Two anode terminals are shown with inductances L9 and L10 between each terminal to the anode proper. A parasitic resonant circuit may be formed which includes the basic elements, L5, L1, and L9 tuned by the anode to cathode capacity and stray capacities. R9' is the damping resistor connected between the two anode terminals, thus damping L9 and L10. The parasitic resonant circuit is thus damped by virtue of the included L9 (and to a lesser extent, L10) which is damped by R9'. The parasitic circuit so damped, has less tendency to oscillate. The damping so imposed has negligible effect on the stability of the desired oscillation frequency because it is not an appreciable part of the frequency determining circuit.

What is claimed is:

1. An evacuated electron discharge device operating at a frequency above 100 megacycles, including an anode electrode having two terminals therefor adjacent said device which extend out from spaced parts of the tube envelope, the connections from said two terminals to said anode having appreciable inductance at the frequency of operation of said device, and a relatively low value resistor connected directly across said two terminals for suppressing parasitic oscillations.

2. A vacuum tube oscillator operating at a frequency above 100 megacycles including a cathode and a heating filament within an envelope, said cathode having a pair of terminals connected to different points on said cathode and extending from spaced parts of said envelope, and a damping resistor directly connected across said two terminals.

3. An oscillation generator comprising a vacuum tube having grid, an indirectly heated cathode and an anode, means including a frequency determining circuit coupled to said electrodes in such manner as to excite said electrodes in the proper phase so as to produce oscillations, at least one of said electrodes having two terminals which connect with different points on said one electrode and extend from spaced parts of the tube envelope, and a relatively low value of resistor connected directly across said terminals to damp parasitic oscillations.

4. An oscillation generator for use at frequencies of the order of 100 megacycles and higher, comprising a vacuum tube having a grid, an

indirectly heated cathode and an anode, means for supplying said electrodes with polarizing potentials, a tuned circuit coupled to said electrodes for determining the frequency of oscillations, said indirectly heated cathode having leads from opposite ends thereof extending through spaced parts of the tube envelope, and a damping resistor directly connected across said terminals for suppressing oscillations.

5. An oscillation generator for use at frequencies above 100 megacycles comprising a triode vacuum tube having a grid, an indirectly heated cathode, and an anode, means for supplying said electrode with suitable polarizing potentials, a resonant circuit coupled to said electrodes for controlling the frequency of oscillations, a radio frequency by-pass condenser coupling said anode to a point of fixed radio frequency potential, said indirectly heated cathode having leads from opposite ends thereof extending through spaced parts of the tube envelope and forming appreciable inductance at the frequency of operation, and a damping resistor directly connected across said terminals for suppressing oscillations.

6. An electron discharge device circuit operating at high frequencies comprising a vacuum tube having an anode electrode provided with two terminals which connect to different points on said electrode and extend from spaced portions of the tube envelope, the connections from said two terminals to said anode having appreciable inductance at the frequency of operation of said circuit, and a resistor directly connected across said two terminals for damping parasitic oscillations.

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