

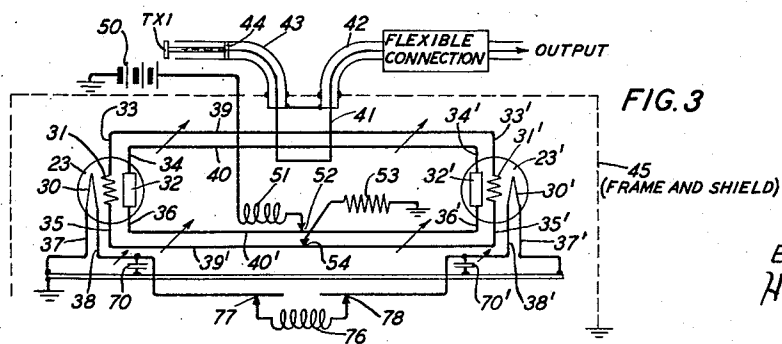
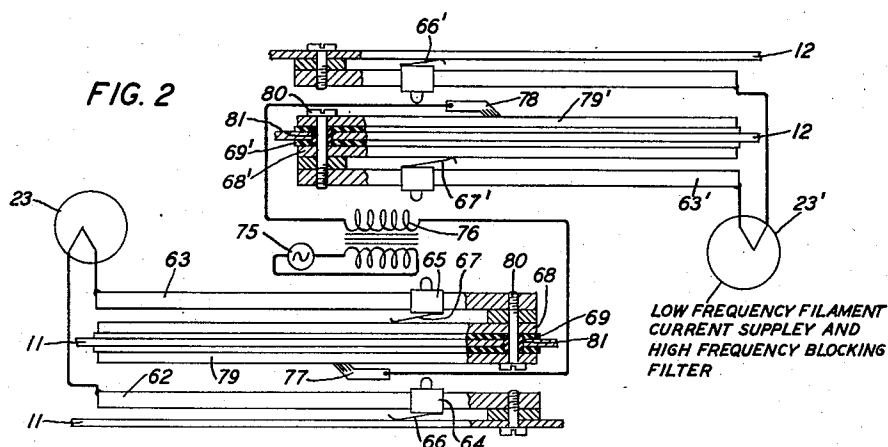
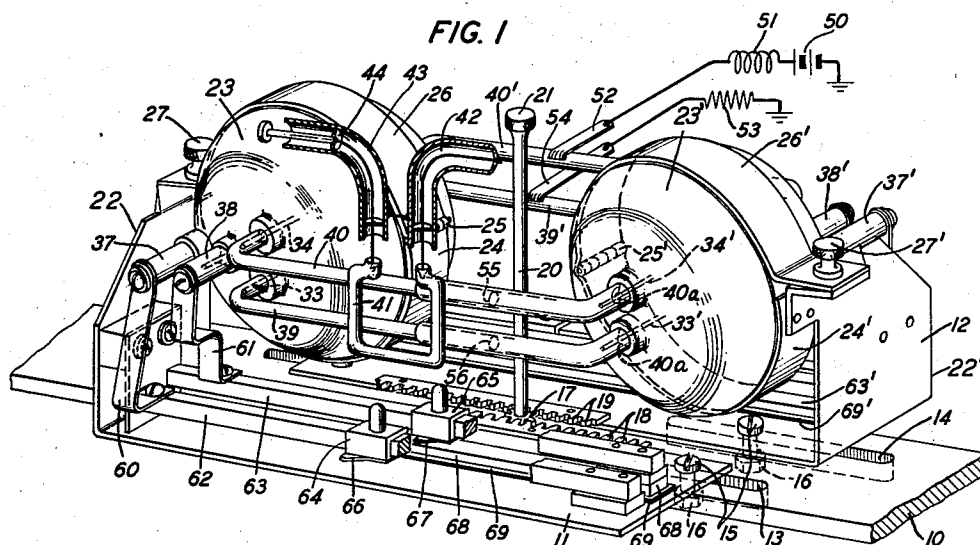
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RADIO FREQUENCY OSCILLATOR

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RADIO FREQUENCY OSCILLATOR

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This invention relates to radio frequency apparatus and particularly to a generator of ultra-high frequency electrical oscillations.

An object of the invention is to provide a radio frequency oscillation generator of improved simplicity, compactness and ruggedness.

A related object is to provide a radio frequency oscillation generator in which the internal dissipation of energy is minimized with resulting improved efficiency.

Another object is to provide a radio frequency oscillation generator whose oscillations may be readily tuned or adjusted with precision to a desired frequency within a wide range.

Another object is to provide a radio frequency oscillation generator so constructed that such parts thereof as are necessarily delicate or subject to deterioration may be readily replaced.

To these ends there are provided in accordance with the invention a novel radio frequency circuit arrangement which is compounded of a push-pull circuit and a parallel circuit. Among the principal components of this circuit are two preferably matched electron discharge devices, for example vacuum tubes of "double-ended" construction characterized by the fact that the electrodes of chief importance in the generation of oscillations, for example control grid and anode, are provided with lead connections extending from both ends thereof and leading, preferably by short, symmetrically arranged paths, to the outside of the envelope of the device. The grid and anode electrodes are preferably arranged within the envelope with a suitable symmetry, for example they are arranged side by side and parallel to each other with their long dimensions extending lengthwise to the shortest dimension of the envelope. Thus a grid terminal and an anode terminal protrude through one wall of the envelope and a like pair of terminals protrude through the opposite wall. From the low frequency viewpoint the two grid terminals are connected in parallel and the two anode terminals are connected in parallel, though of course this is not necessarily true at ultra-high radio frequencies.

In accordance with the invention advantage is taken of the symmetrical arrangement of the electrodes of these devices and of their external terminals to enable the connection thereto of the doubly balanced parallel push-pull circuit of the invention. Thus, the tubes being arranged with their axes parallel, the "near side" grid and plate terminals of one tube are connected, respectively, to the "near side" grid and

plate terminals of the other tube while the "far side" grid and plate terminals of the two tubes are similarly connected. The connections for ultra-high frequency uses may be made through Lecher rods and the Lecher rods may be adjustable in length for tuning. The back coupling necessary to maintain oscillations may be found in the interelectrode capacitances of the tubes themselves.

With such an arrangement the radio frequency oscillations take place at the frequency for which each of the Lecher rod pairs (including the electrode terminals and leads and one-half the length of each electrode) is one-half wave-length long, so that the current nodes appear substantially at the mid-points of the electrodes.

This results in a substantial reduction of the radio frequency energy dissipated as heat in the electrodes as compared with a system in which the current nodes appear at the open ends of the electrodes, as is the case when but a single Lecher rod pair is employed. At the same time it affords the known advantages of a push-pull circuit employing a pair of tubes.

In order that the symmetry and balance of the circuit arrangement may be preserved in the course of tuning, provision is made to change the lengths of the Lecher rod pairs by bodily movement of the tubes toward or away from each other. Thus the greatest possible distance is maintained between them at all times, consistent with the half wave-length relation. This in turn results in a minimum of stray coupling between the tubes and resulting increased efficiency and stability of operation.

The invention will be more fully understood from the following detailed description of a preferred embodiment thereof taken in connection with the appended drawing in which:

Fig. 1 is a perspective view, partly in section, of the oscillation generator as assembled;

Fig. 2 is a schematic diagram of tuned filament supply circuits employed in the apparatus of Fig. 1; and

Fig. 3 is a schematic diagram showing the electrical connections of the apparatus of Fig. 1 as distinguished from its geometrical arrangement.

Referring now to Fig. 1, a base plate 10 of conductive material is provided, along which two mounting plates 11, 12 are arranged to slide. The base plate and the mounting plates are preferably of highly conductive but non-magnetic material, such as brass or a suitable non-magnetic steel alloy. To provide positive electrical contact and yet permit freedom of movement between

the mounting plates and the base plate, the upper surface of the base plate and the lower surfaces of the mounting plates may be ground, chromium-plated, and polished or otherwise finished to conform as nearly as possible to true plane surfaces. The base plate 10 is provided with slots 13, 14 and pins 15 are fixed to the mounting plates 11, 12, which pins are formed to fit snugly in the base plate slots 13, 14 so that free axial movement of the mounting plates 11, 12 is permitted relatively to the base plate while other movements are prevented. These axial movements may be governed and controlled by a pinion 17, pivoted in the base plate 10 and engaging with racks 18, 19 fixed to the mounting plates 11, 12 in the manner shown, while the pinion shaft 20 may extend to a point convenient for manipulation by an operator and may there be terminated in any convenient manner, such as a hand-knob 21. Turning this knob moves both of the mounting plates 11, 12 axially of the base plate and in opposite directions by equal amounts. The pins 15 may be terminated with nuts 16. Spring washers may be placed between the nuts 16 and the base plate 10 to assure positive contact between the plates 10, 11, 12 without binding.

Supporting members 22, 22' extend upwardly from the mounting plates 11, 12 for holding double-ended tubes 23, 23' in place. These supporting members may be of any convenient sort and may support the tubes from below, from above, or from the side as shown. They may be integral with the mounting plates 11, 12 or rigidly fixed thereto in any desired manner, as by welding.

Fixed to each of the upright supporting members 22, 22' is a semicircular metal band 24, 24' terminating in one end of its arc in a hinge 25, 25' to which is jointed a similar semicircular band 26, 26' which terminates in any easy fastening device such as a knurled thumbscrew 27, 27'. In the case of each of the double-ended tubes, the fixed band 24, 24' and the movable band 26, 26' which is hinged thereto at 25, 25' form a clasp which may grip the tube lightly but firmly about its diameter while still permitting of easy opening in case it be desired for any reason to remove the tube. To prevent injury it is preferable to place a strip of resilient or yielding material between the clasp and the tube wall. For this purpose material of low dielectric loss such as woven glass fiber tape is desirable.

The double-ended tubes themselves may have the form of somewhat flattened spheroids. The largest circumference serves as a means of support and the electrodes are mounted parallel with the shortest diameter. This arrangement makes for the shortest possible length of electrode connections within the tubes themselves.

Though multielectrode tubes may be employed, three-electrode tubes, such as those shown in Fig. 1 and diagrammatically shown in Fig. 3, are generally preferred for use at the ultra-high frequencies. Thus the tube 23 contains three electrodes, a filament 30, a grid 31 and a plate 32, the grid and plate having connections 33, 34 which extend out through the envelope wall on one side of the tube, for example the near side in Fig. 1, and symmetrically located connections 35, 36 which extend out through the envelope wall on the far side. The tube 23' may be similar, and corresponding electrodes are correspondingly indicated in Fig. 3 by like reference characters, distinguished by primes. The two filament leads may likewise extend in opposite direc-

tions, but since they do not cooperate in maintaining radio frequency oscillations to the same extent as the grid and plate connections, it is preferred that both of the filament connections extend through the one side of the tube. Such filament connections 37, 38 are shown for the left-hand tube 23 in Fig. 1, corresponding connections 37', 38' being shown on the rear side of the right-hand tube 23'.

The grid and plate connections may extend outward through opposite walls of each tube, the tube wall being thickened at the point of emergence to provide mechanical support and a perfect seal. In accordance with the invention the near side grid lead 33 of one tube 23 is connected to the near side grid lead 33' of the other tube 23', the near side plate connections 34, 34' of the two tubes being similar. Corresponding plate and grid connections 35, 35', 36, 36' are duplicated on the far sides of both tubes. The connections may conveniently be made through rods or tubes 39, 39', 40, 40' of substantial diameter each of which turns through substantially a right angle close to its end and terminates in a suitable spring clip 40a of a type well known per se which provides positive electrical connection to the protruding electrode lead and at the same time provides mechanical support for the rod itself without the assistance of any extraneous supporting means.

With this arrangement the two rods 39, 40 on the near side which connect near side grid to grid and near side plate to plate, respectively, constitute a Lecher rod pair, while the far side rods 39', 40' constitute another Lecher rod pair. While oscillations are in progress, a high frequency voltage appears between the grid and the plate of each tube, which voltage has its maximum value at the center points of these electrodes. The tubes may be operated with a phase difference of 180 degrees so that, for example, at the instant when the grid 31 of the left-hand tube 23 has its maximum positive value of potential with respect to the plate 32, the potential of the grid 31' of the right-hand tube 23' has its maximum negative value with respect to the plate 32'.

Under these conditions the current nodes or minimum values appear at the mid-points of the grids and plates, and current flows outward from the mid-point of each of these electrodes in both directions to its external terminals, increasing in magnitude away from the central node. Since the increase is only over one-half the length of the electrode, as compared with its full length in the usual single Lecher pair arrangement, this results in a substantial reduction of the power dissipated within the tubes as heat, especially in the case of the grids whose resistance is by no means negligible.

The maximum values of current appear in the neighborhood of the centers of each of the Lecher rod pairs, that is, halfway between the left-hand tube 23 and the right-hand tube 23'. This region therefore offers a convenient point for coupling to an external circuit, and to this end a coupling loop 41 may be disposed in a plane parallel with that of one of the Lecher rod pairs and with its axis coinciding with the axis of the Lecher rod pair. Energy which appears by induction in this coupling loop may be supplied to an external circuit by any convenient means, for example, a coaxial transmission line, of which one branch 42 may lead to any suitable utilization circuit, not shown, while the other branch 43 may be

constructed to exhibit a capacitive reactance at the frequency of oscillation, being tuned to resonance with the inductive reactance of the loop, as by adjustment of the position of a conductive short-circuiting disc 44. These coaxial transmission lines may be mechanically fixed and electrically connected to a suitable frame or shield such as that indicated by the broken line 45 in Fig. 3, for the apparatus as a whole and may provide mechanical support for the coupling loop 41.

The two ends of the coupling loop 41, which may be in the form of a rod or tube of enlarged diameter similar to the Lecher rods, may be provided with spring clips arranged to grasp the protruding ends of the inner conductors of the coaxial transmission lines 42, 43 and thus afford both positive electrical connection thereto and mechanical support for the coupling loop.

The center point of each of the Lecher rod pairs, which is the point of current maximum, is also a voltage node and therefore affords a convenient point at which operating plate voltage and grid bias may be supplied. Thus plate voltage is supplied from a source, for example a battery 50, through a radio frequency choke coil 51 and a wiping contact 52 to the far side plate-to-plate Lecher rod 49' while grid bias of the so-called "automatic" variety may be derived from a grid leak or resistor 53 connected between the framework 45 and a wiper 54 which makes contact with the far side grid-to-grid rod 39'. Inasmuch as the center point of each of the Lecher rod pairs is a voltage node the radio frequency choke coil 51 is not essential. It is provided to reduce the effect of any fortuitous asymmetry of the system as a whole and therefore departure of the voltage node from the center point of the Lecher rod pairs.

Each of the Lecher rods is preferably composed of two parts, the one arranged to advance or recede within the other in the manner of telescopic joints, as shown at 55, 56 of Fig. 1.

Thus as the knob 21 is turned and the mounting plates 11, 12 advance toward each other or recede from each other in the course of the tuning operation, each of the Lecher rods 39, 40, 39', 40' is extended or contracted in length. In accordance with known principles, the wavelength of oscillation is nearly proportional to the length to which the Lecher rod pairs are thus adjusted, the departure from exact proportionality being due to the finite fraction of a wavelength which appears within the tubes themselves. As the extension or contraction takes place, the plate voltage and grid bias continue to be supplied through the wipers 52, 54 to the mid-points of the far side Lecher rod pair, the rods advancing or receding with respect to the wiper contacts which remain stationary with respect to the apparatus framework.

To prevent the loss of high frequency energy of the oscillations through the filament connections, it is desirable that these shall present a high impedance at the operating frequency, looking out of the tubes. To this end, the filament leads of the left-hand tube 23 may be connected through lugs or brackets 60, 61 to rods 62, 63 along which traveler members 64, 65 bearing spring contacting elements 66, 67 are arranged to slide. The rod 62 may be connected directly to the mounting plate 11 and in a position such that the sliding contact 66 likewise makes direct connection with the mounting plate 11. In order that the filament 30 may support a direct cur-

rent or low frequency voltage, the slider rod 63 should be insulated from the mounting plate 11 itself and may be connected to a metal strip 68 placed parallel with it and with which the wiping element 67 makes contact. The insulation may consist of a sheet of mica 69 or other thin sheet insulating material in a manner such that the metal strip 68 is coupled to the mounting plate 11 through a condenser 70 (Fig. 3) which presents a negligible capacitive reactance at the operating radio frequency. An identical arrangement may be provided for the filament leads of the tube 23', so that one filament leg is connected directly to the mounting plate 12 and the other is coupled to it through a condenser 70' formed by the plate 12, the mica strip 69' and the metal strip 68'. As the frequency of oscillation is adjusted by advancing or withdrawing the tubes 23, 23' toward or away from each other, the position which the filament sliders 64, 65, 64', 65' occupy should preferably be readjusted manually to maintain the radio frequency impedance of each filament circuit at its optimum high value.

Current may be supplied to heat the filaments of the tubes in any desired manner but, in accordance with the invention, advantage is taken of the very high oscillation frequency to permit the employment of an extremely simple arrangement. To this end alternating current of a low frequency, for example, commercial power frequencies of 60 cycles per second or so is supplied from a source 75 through a transformer 76 to two wiping contacts 77, 78 which make connection to a plate or strip 79, 79' which is directly connected, as by bolts 80 passing through insulating sleeves 81, to the insulated leg of the filament of each tube. For convenience of mechanical arrangement these strips 79, 79' may be mounted immediately below the mounting plates 11, 12 or at any other suitable point. Indeed, if desired, the strips may be dispensed with, the filament supply wiping contacts making connection directly with the insulated rods 63, 63'. The wipers 77, 78 are provided in order that contact may be maintained independent of the position occupied by the tubes 23, 23' for the desired frequency of oscillation.

The oscillations may be utilized without modification or they may be modulated or otherwise modified to suit particular uses in accordance with any desired plan.

The apparatus of the invention thus provides a compact and convenient tunable electric oscillation generator for use at the ultra-high frequencies with extremely low internal dissipation of energy and a high degree of flexibility.

What is claimed is:

1. A high frequency electric oscillation generator which comprises two symmetrical electron discharge devices each having an anode and a control electrode, each of said electrodes having oppositely located external terminals, a Lecher rod pair connecting an anode terminal and a control electrode terminal, respectively, of one of said devices to the corresponding terminals of the other device, another Lecher rod pair connecting the oppositely located terminals of said first-named device to the corresponding terminals of said second-named device, and means for altering the electrical separation of said devices without disturbing said Lecher rod connections.

2. A high frequency electric oscillation generator which comprises two symmetrical electron discharge devices each having a heater element,

an anode, and a control electrode, said anodes and control electrodes having oppositely located external terminals, a Lecher rod pair connecting an anode terminal and a control electrode terminal, respectively, of one of said devices to the corresponding terminals of the other device, another Lecher rod pair connecting the oppositely located terminals of said first-named device to the corresponding terminals of said second-named device, each of said heater elements being connected to a separate tunable Lecher rod pair, means for supplying current to said heater elements, and means for altering the geometrical separation of said devices without disturbing said Lecher rod connections or said heater current supply connections.

3. A high frequency electric oscillation generator which comprises two symmetrical electron discharge devices each having at least two electrodes, each of said electrodes having oppositely located external terminals, said devices being connected in push-pull through one terminal of each of said electrodes, said devices being independently connected in push-pull through the opposite terminal of each of said electrodes.

4. A high frequency electric oscillation generator which comprises two symmetrical electron discharge devices each having at least two electrodes, each of said electrodes having oppositely located external terminals, said devices being connected in push-pull through one terminal of each of said electrodes, said devices being independently connected in push-pull through the opposite terminal of each of said electrodes, all of said connections being alike in length.

5. A high frequency electric oscillation generator which comprises two symmetrical electron discharge devices each having at least two

electrodes, each of said electrodes having oppositely located external terminals, said devices being connected in push-pull through one terminal of each of said electrodes, said devices being independently connected in push-pull through the opposite terminal of each of said electrodes, all of said connections being adjustable in length.

6. A high frequency electric oscillation device which comprises two symmetrical electron discharge devices each having an anode and a control electrode, each of said electrodes having oppositely located external terminals, a Lecher rod pair connecting an anode terminal and a control electrode terminal, respectively, of one of said devices to the corresponding terminals of the other device, another Lecher rod pair connecting the oppositely located terminals of said first-named device to the corresponding terminals of said second-named device, and a utilization circuit coupled to one of said Lecher rod pairs.

7. A high frequency electric oscillation device which comprises two symmetrical electron discharge devices each having an anode and a control electrode, each of said electrodes having oppositely located external terminals, a Lecher rod pair connecting an anode terminal and a control electrode terminal, respectively, of one of said devices to the corresponding terminals of the other device, another Lecher rod pair connecting the oppositely located terminals of said first-named device to the corresponding terminals of said second-named device, and a utilization circuit inductively coupled to one of said Lecher rod pairs and disposed substantially midway between said devices.

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