Dec. 21, 1948. C. M. SLACK ET AL 2,456,896

ULTRA HIGH FREQUENCY DEVICE

Filed Aug. 8, 1944

Fig. 1.

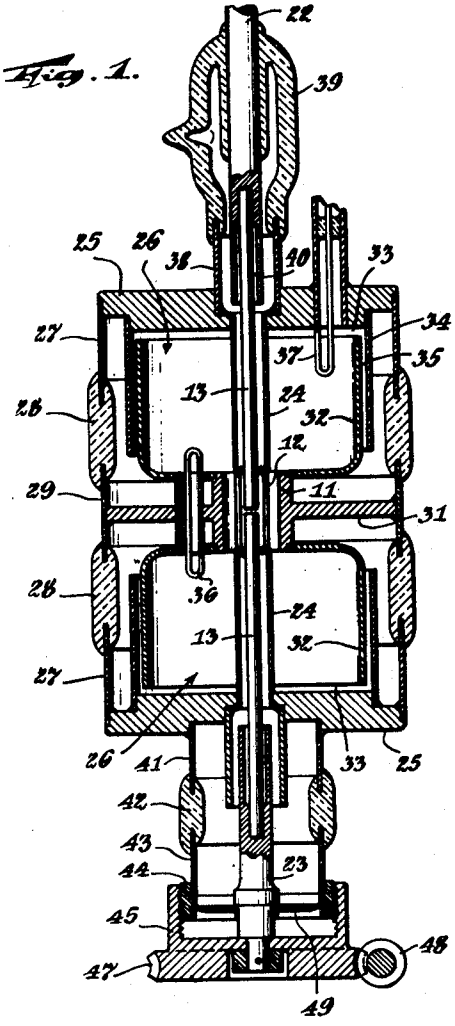


Fig. 2.

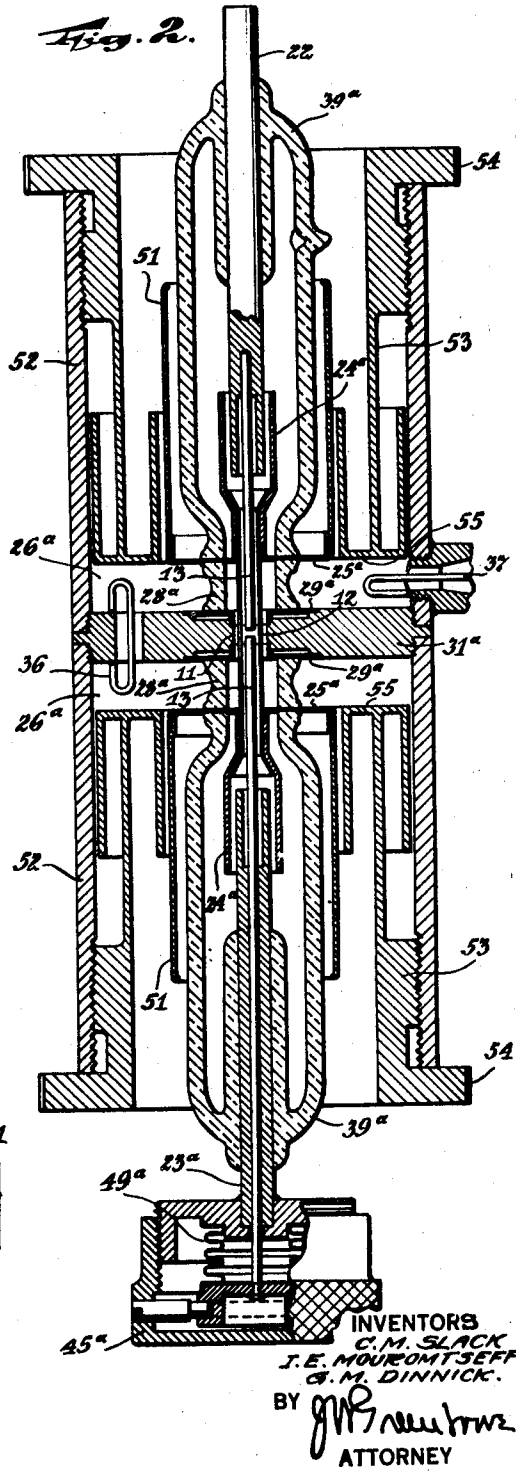
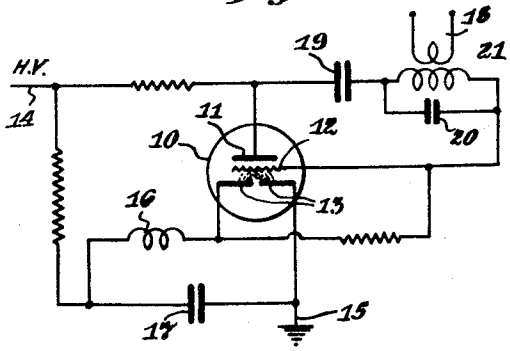


Fig. 3.



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ULTRA HIGH FREQUENCY DEVICE

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7 Claims. (Cl. 315—5)

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This invention relates to ultra-high frequency devices, and more particularly to pulsed oscillators.

In prior application of Charles M. Slack et al., Serial No. 412,566, filed September 27, 1941, and assigned to the same assignee as this application, and now U. S. Patent No. 2,409,716, granted October 22, 1946, two electrodes are employed for "cold emission" with incidental formation of an arc for instigating emission from one of the two electrodes. The functioning of the device of that disclosure is based upon the fact that, due to high potential gradient between the two electrodes, field emission of electrons occurs from one to the other, and consequential upon the resulting electrostatic field, a minute arc is formed between the two electrodes which is apparently due to evolved metallic particles, a positive ion bombardment results therefrom, said arc forming a cathode spot and a reduction in space charge. This causes the impedance of the device to be so reduced that an electron discharge is almost instantaneously initiated from one of the said electrodes, which then constitutes a cathode, to a third electrode or anode.

The present invention, while likewise utilizing field emission for arc-starting purposes, is directed to obtaining higher output, and especially in an oscillator, and at the same time to obtaining a pulsed ultra high frequency output.

More specifically, an object of the invention is to utilize a metallic arc in an oscillator as the source of electron emission.

Another object of the invention is to provide an improved means and inherent circuit for obtaining ultra high frequency oscillation with a metallic arc functioning as the cathode.

A further object of the invention is to utilize the arc as an automatic timing means for pulsing the output of the device.

Still further objects of the invention will appear to those skilled in the art to which the invention appertains as the description progresses, both by direct recitation thereof and by inference from the context.

Referring to the accompanying drawing in which like numerals of reference indicate similar parts throughout the several views:

Figure 1 is a longitudinal sectional view of an electronic device by which oscillation generation and pulsing may be effected in accordance with the present invention;

Figure 2 is another longitudinal sectional view of a modified construction of electronic device by

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which oscillation generation and pulsing may be effected; and

Figure 3 is a diagrammatic view of an ultra high frequency oscillating circuit and pulsing means embodying the invention.

In the specific attainment of the invention illustrated in said drawing, and referring initially to the schematic showing of Figure 3, a pulser tube of the present invention is shown with an enclosing envelope 10 within which is mounted an anode 11 associated grid 12 and a two-membered electrode 13 occupying approximately the usual cathode position. The members of the electrode 13 are separated and arranged in appropriate proximity to each other to provide a gap therebetween that a discharge may be obtained therebetween due to "cold" or "field" emission, such discharge being converted practically instantaneously into a metallic arc. It is this arc which constitutes the cathode for the aforementioned grid and anode. An external source of electrical energy, as from power line 14 and ground 15, connects with an inductance 16 and capacitance 17 arranged in electrical parallel to each other and through the electrodes 13, these several elements in combination functioning as a relaxation oscillator for establishing high frequency oscillations to an output 18 suitably protected against low tension D. C. current flow by series and parallel condensers 19, 20 associated with output transformer 21.

The periodic charge of condenser 17 and its discharge through the cathode parts produces an intermittent supply of electrons. This cold or field emission is promptly converted into a metallic arc in said gap between the members of electrode 13, and that arc rapidly increases in volume, expanding laterally, and very soon (of the order of a microsecond) comes in contact with the grid 12. Expansion of the arc or arc boundary travels with a velocity of approximately two or three millimeters per microsecond. Each time the arc starts, the conductive path in the two part electrode is completed and oscillations are set up in the circuit attached to the device. When expansion of the arc boundary brings the arc in contact with the grid, the arc constitutes a short between the grid and cathode and thereby interrupts oscillation. The device is thus adapted to generate pulsed oscillations of ultra high frequency and of the highest possible intensity during a very short interval, say 1 microsecond out of every 100 microseconds, or even with less than 1% duty cycle.

The grid-cathode distance is indicative of the longest possible duration of the impulse. In fact, oscillations will actually exist only during a part of the time required by the arc to travel across the grid-cathode gap, because both the transit time of electrons and the grid-to-cathode capacitance vary while the arc travels. With a fixed oscillating circuit, only definite combination of these three factors will correspond to clear-cut oscillations.

The tube of Figure 1 is of hollow body or resonant cavity type for fixed oscillation period but with an adjustable arc-forming electrode member for compensating for loss of electrode material and to maintain proper spacing of the electrode members where forming the arc gap.

The construction shown comprises aligned electrode members 13, 13 in the form of rods, one of which is carried by a fixed rod-like support 22, which also constitutes a lead-in for the high voltage supply. The other electrode member 13 is carried by a longitudinally adjustable rod-like support 23 suitably grounded electrically.

In the region around the contiguous arc-forming ends of the members of electrode 13, is a cylindrical grid 12 having close spacing to said electrode 13. The ends of the grid are secured to inner ends of tubes 24 arranged coaxially to the respective members of electrode 13. The outer or remote ends of these tubes 24 are carried in metallic headers 25, which also constitute end walls for resonator chambers 26. These headers likewise form part of the device envelope, and as further part of the envelope, cylindrical wall portions 27 are secured at the outer peripheries of the headers, these wall portions extending toward each other from their respective headers. Each cylindrical wall portion is sealed at its edge away from the header to the end margin of a glass ring 28, of which there are accordingly two, and between said glass rings is another or middle cylindrical wall portion 29 of the same diameter as those wall portions which are attached to the headers. Preferably, said cylindrical wall portions 27, 27 and 29 are of a material which will form an adequate seal with glass. A material sold in the trade under the name "Kovar" and having composition set forth in patent to Howard Scott No. 2,062,335 of December 1, 1936, for said wall portions and a boro-silicate glass also defined in that patent are preferably used in the present construction.

An anode 11 of appropriate size and material and of cylindrical configuration is interposed between and coaxial to said middle wall portion 29 and the grid 12, said anode and the perforate portion of said grid being of substantially equal length. The anode is supported by a washer-like body or plate 31 interposed between the anode and the above-described middle cylindrical wall portion 29 of the envelope, which accordingly functions as a lead-in connection for the anode.

At each end of the anode 11 is secured the basal portion of a cup-shaped resonator wall 32, the skirt portion of which extends in a direction away from the anode and to a plane close to the header at the end of the envelope, being separated by a gap 33 from that header for maintaining electrical discontinuity for low tension potentials. Around said skirt portion of each resonator wall 32 is a coaxial collar 34 separated from said wall 32 by a gap 35, thereby capacitatively coupling the said wall and collar. Each collar is secured to the respective header at an end of the envelope and the region within the cup-shaped wall limited by said header constitutes the aforementioned resonant chamber 26. If desired, a suitable coupling loop 36 may be passed through the anode body or supporting plate 31 to connect the resonant fields of both resonant chambers. An output loop 37 from one chamber is the equivalent of the output connection 18 described above and shown in Figure 3. It may likewise be here added that inductance 16 and capacity 17 of Figure 3 are not shown in Figure 1 but are external to the tube and applied, as indicated in Figure 3, to the external connections for electrodes 13, 13.

It is of course necessary to introduce the arc-forming electrode members 13, 13 through the resonant chambers free of contact from the headers, and this desideratum is accomplished by extending a sleeve 38 outward from the header through which the fixed member of the electrode 13 extends. A glass cap 39 is sealed at its rim to the outer end of the sleeve, said cap also being sealed around lead-in support 22. The inner end of said support is preferably provided with a recess 40 at its inner end for forming a high frequency choke for the lead. A similar choke is provided for the other or adjustable electrode member where passing out of the header.

Adjustable mounting for the adjutable cathode part is accomplished by the construction now to be described. A collar 41 projects from the outer face of the header 25 coaxially to the said arc-forming electrode member, the outer margin of the collar having a glass ring 42 sealed at one end thereto. Another collar 43 of equal diameter to the one 41 just mentioned has one end sealed in the other end of said glass ring so the second-mentioned collar 43 is electrically insulated from the first mentioned collar 41. These collars are preferably of the aforementioned material identified as "Kovar" and the glass is of boro-silicate character, all as described in the said Howard Scott patent, supra.

The second-mentioned or outermost collar 43 has a ferrule 44 sealed thereon at its end margin, this ferrule being threaded on its outer periphery and in mesh with the threaded interior of an adjusting knob 45, which is held upon and rotatable with respect to the support 23 for the arc-forming electrode 13. Rotation of the knob 45 will accordingly move the support 23 and arc-forming adjustable member of electrode 13 longitudinally for adjustment of the gap between said electrode members. Rotation of the knob may be automatically accomplished, if desired, in accordance with showing in application Serial No. 459,777, filed September 26, 1942, in the names of Charles M. Slack, Clarence E. Dawley and Andrew Pfeiffer, joint inventors, and assigned to the same assignee as the present application and now U. S. Patent No. 2,408,004, granted September 24, 1946. As indicative of this possible automatic adjustment, the knob 45 is shown provided with worm teeth 47 in mesh with a power driven worm 48. A flexible washer-like diaphragm 49 is sealed at its outer periphery to said ferrule 44 and at its inner periphery to the adjustable support 23, thereby maintaining vacuum within the device and concomitantly permitting longitudinal adjustment of the support.

It is deemed within the scope of the invention to make the resonant chambers tunable. As a convenient accomplishment of this desideratum, the resonant chambers are in part exterior to the evacuated region and the moving parts for tuning purposes likewise outside of the evacuated region. Reference is made to Figure 2 illustrating such a physical embodiment of the invention.

As before, the invention as here shown, provides an arc-forming electrode 13 consisting of aligned rod-like electrode members separated by a gap and surrounded by a grid 12 radially beyond which is an anode 11. One member of electrode 13 is fixed and the other adjustable, the fixed one being carried by a rod-like support 22, and the adjustable one is longitudinally slidable in a fixed support 23a and protruding therefrom so as to have an external knob 45a for effecting movement thereof in conjunction with a sealing flexible diaphragm 49a, shown here as of the bellows type.

The ends of the body of grid 12 are secured to and within the inner ends of tubes 24a arranged coaxially to the respective members of electrode 13. Said tubes 24a are carried by metallic headers 25a, which also constitute fixed end wall portions for the resonator chamber 26a. In this showing, glass rings 28a are interposed between the headers and the radially projecting part of the anode. For obtaining a good seal of the glass, which is preferably boro-silicate, metal facings 29a are secured to the anode body, said facings as well as said headers being made of the aforementioned "Kovar." To the face of each header opposite from glass ring 28a, is sealed an elongated glass cap 39a, which also seals to the support for the electrode member passing through the cap.

From the periphery of each header extends, in a direction away from the anode, a metallic cylinder 51, constituting a part of the inner wall of the resonator chamber. Each said cylinder is coaxial with one of the members constituting electrode 13. Spaced radially outward from the inner cylinder wall 51 is an outer cylindrical metallic wall 52. Contiguous ends of the outer walls 52 are carried, as by screw threaded engagement, at the outer periphery of the anode body 31a. Both said outer cylindrical walls are internally threaded at their outer ends, each receiving a threaded piston sleeve 53, both of which protrude beyond the cylindrical walls and are there provided with finger-grip flanges 54. The inner ends of the piston sleeves have annular pistons 55 thereon, the heads whereof are preferably toward and form part of the resonant cavity wall and the skirt portions whereof are in parallelism to the inner and outer cylindrical walls 51, 52 and have a depth of substantially a quarter wave length of the resonant frequency of the chamber so as to present capacitative coupling of low impedance at the planes of the piston heads. A coupling loop 36 through the anode supporting body and an output coupling loop 37 from one chamber may be provided as described in connection with the previous showing.

It may now be appropriately observed that in all views the cathode is constituted by the arc, which forms in the gap between the contiguous ends of the members forming electrode 13, and that the grid is closely spaced to the said members. The arc formed between the electrode members instigates electron discharge to the anode and an oscillatory output governed by the inherent capacity and inductance of the resonant chamber. The cathode arc expands toward the grid and is extinguished by contact therewith, which stops oscillation until the arc is again instigated. This accordingly results in a pulsed ultra high frequency output wherein the interval between pulses is comparatively long and the pulse is infinitesimally short, of the order of a microsecond.

We claim:

1. An ultra high frequency device comprising an anode and a grid in proximity thereto, and a pair of electrode members between which an arc is adapted to form and constitute the cathode, said members providing a gap therebetween within which said arc may form and from which said arc may expand laterally, said members being located on the opposite side of the grid from the anode in at least as close proximity to said gap as the proximity of the grid to said members and within range of expansion of the arc to said grid from said gap.

2. An ultra high frequency device providing an arcing region comprising means for producing an arc in said region and electron emission therefrom, an anode for receiving the electron emission, and arc-shorting means around said region and within said anode and within range of expansion of the arc thereto for automatically and periodically interrupting emission.

3. An ultra high frequency device comprising a pair of closely spaced electrode members insulated from each other for providing a potential gradient therebetween and by which a metallic arc will be struck across the space between said members, said arc being electron emissive and constituting a cathode, and arc expansion limiting means in proximity to the closely spaced portions of said members for limiting expansion of said arc and interrupting electron discharge therefrom.

4. An ultra high frequency device comprising a pair of closely spaced electrode members providing a gap therebetween, said members being insulated from each other for providing a potential gradient therebetween and by which a metallic arc will be struck across the gap between said members, said arc being electron emissive and constituting a cathode, an anode opposed to the gap between said electrode members for receiving electron discharge from said arc, and arc expansion limiting means around said gap and members in at least as close proximity to the gap as to the members for limiting expansion of said arc and interrupting electron discharge therefrom.

5. A hollow body resonator having means therein for producing a metallic arc and an ultra high frequency oscillating output, and means around the arc producing means at the part thereof where the arc is produced and within range of lateral expansion of the arc thereto in said hollow body resonator for pulsing the output therefrom.

6. A hollow body resonator having means therein for producing a metallic arc and an ultra high frequency output, and means around the first said means in the region of said arc for limiting lateral expansion of the arc and thereby interrupting electron emission therefrom and pulsing the output from said hollow body resonator.

7. A hollow body resonator having an anode therein and having a pair of electrode members spaced from the anode and from each other providing a gap therebetween and for producing an arc in said gap between said electrode members with the arc functioning as a cathode and cooperating with the anode and resonator body for producing an ultra high frequency output, and means in said resonator body around said gap and within range of lateral expansion of the

arc to said means for pulsing the said ultra high frequency output.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,309,704	Stoekle	July 15, 1919
1,365,157	De Forest	Jan. 11, 1921
1,565,659	Lilienfeld	Dec. 15, 1925
2,079,248	Fritz	May 4, 1937
2,111,263	Fritz	Mar. 15, 1938
2,404,116	Wolowicz et al.	July 16, 1946
2,412,751	Rochester	Dec. 17, 1946