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COOLED RADIOFREQUENCY APPARATUS

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Fig. 1

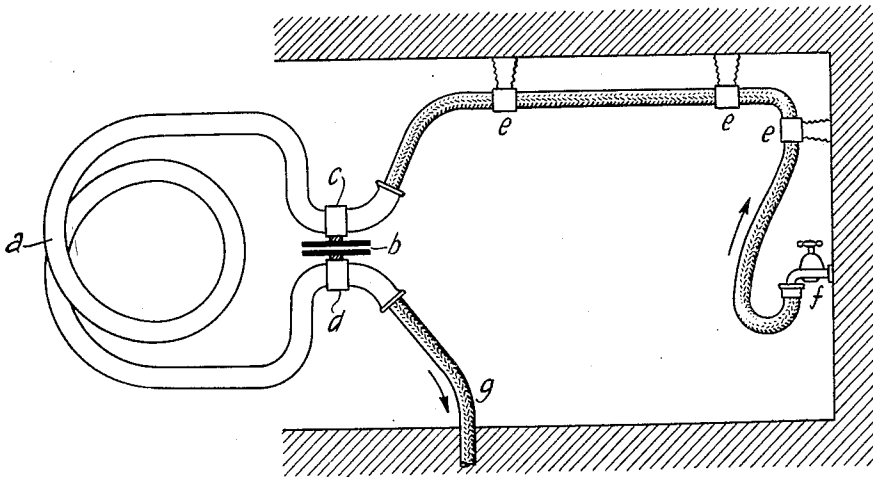
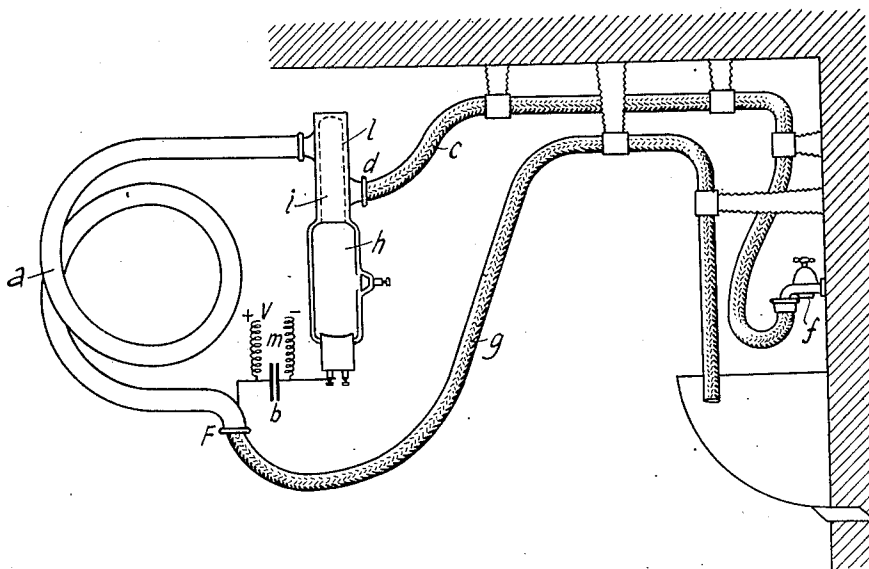


Fig. 2



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COOLED RADIOFREQUENCY APPARATUS

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February 7, 1930.

My invention relates to radio frequency apparatus, and particularly to such apparatus designed for high powers at extremely high frequencies.

5 An object of my invention is to provide a water-cooled radio frequency inductance.

Another object of my invention is to provide, in combination, a water-cooled radio frequency inductance with a high power vacuum
10 tube device.

Another object of my invention is to provide, in combination, a water-cooled radio frequency inductance and a water-cooled high power vacuum tube device.

25 In the construction of devices for the production of oscillations at frequencies above 100 kilo-cycles and in powers above 2 to 5 kilowatts, difficulty has been encountered in the radiation of heat resulting from the unavoidable transformation losses. Of these, the
30 largest and the most difficult to dissipate is the heat liberated at the anode of a vacuum tube generator. The difficulty, has, however, been avoided by the development, through
35 energetic, scientific activity, of vacuum tubes having water-cooled anodes. The next most serious difficulty lies in the development of heat in the connected radio frequency tuning inductance, while relatively little difficulty
40 with liberation of heat is encountered in the tuning capacitance.

At moderate powers and relatively moderately high frequencies the liberation of heat in the tuning inductance has been minimized
35 by the use of stranded and subdivided wire cables, such as "litz" but at frequencies much above 100 kilo-cycles, the use of stranded cable has not proven to be a remedy for heating difficulties.

40 Furthermore, the relatively small dimensions of the ultra high frequency oscillation circuits concentrate the heat energy into a relatively small amount of material having relatively small radiating surface, and thus
45 complicates the cooling problems. Furthermore, an increase in power output is not followed by an increase in physical dimensions, and therefore, heat difficulties increase very rapidly with an increase in power.

50 The difficulties cannot be avoided by mak-

ing all of the apparatus of heat resistant materials and allowing the temperature to rise to its equilibrium value, since if the apparatus rises in temperature by even a small amount the change in physical dimensions due to thermal expansion seriously changes the resonant frequency. Nor is it possible to place the inductance coil bodily into a cooling liquid, first, because there is no reasonably available cooling liquid which will stand the im-
60 posed high stress without corona losses, and chemical changes, and because streaming of portions of the fluid of different temperatures will produce uneven temperature distribution and disturb the oscillation frequency setting.

My invention avoids these difficulties by providing inductances formed of tubular conductors. At the ultra high frequencies now in common use, the "skin effect", causes the current flowing in the conductor to be practically all on the surface, and therefore, as far as conductivity is concerned, at these frequencies, a tubular conductor is equivalent to a solid conductor. The interior of the tubing is then supplied with a cooling fluid, either gas or liquid as most convenient. If the temperature of the entering fluid, and the entering volume, be kept constant, the temperature distribution of the coil quickly assumes an equilibrium condition, which remains constant with sufficient accuracy to avoid difficulties from frequency changes.

If an insulating fluid such as oil or air is used for cooling, no difficulties with insulation problems appear.

85 It is, also, readily possible to use a conducting cooling liquid such as water. This may be done by conveying the conductive cooling fluid to and from the tubular conductor through a relatively great length of small insulating tubing. It is further possible by my invention to connect the tuning inductance directly to the anode of the vacuum tube, and when such anode is water-cooled to use the same cooling fluid for both
90 anode and inductance coil.

By this means I am enabled to produce an inductance, and a vacuum tube and inductance combination, in which provision is made for artificial cooling of the structures,
100

thereby avoiding undue heating and changes in physical dimensions, and the corresponding frequency variations.

Other objects and structural details of my invention will be apparent from the following description when read in connection with the accompanying drawings, wherein:

Fig. 1 is a view in vertical elevation of an embodiment of my invention and

Fig. 2 is a view in elevation of another embodiment of my invention containing a vacuum tube device.

Referring to the figures, an inductance coil is provided, which may preferably be of copper tubing. A condenser *b* is associated with the ends thereof by any convenient connecting means. The coil *a* and condenser *b* thus form a resonant oscillation circuit.

A supply of cooling fluid, which may be water from the tap, is provided as indicated at *f*. A conduit *c* preferably of rubber tubing and of a substantial number of feet in length is provided and connected between the fluid source *f* and the inlet of the tubing coil *a*. A second conduit *g* is provided, preferably of the same material and similar in size and length with the conduit *c*, and is connected to the outlet of the coiled inductor tube *a* and led to drain. The insulating conduits may preferably be supported by any convenient form of insulating supports *e*.

Referring to Fig. 2 a water-cooled inductance in combination with a vacuum tube is shown. In the figure similar reference characters indicate similar parts. As before, a coiled inductance *a*, preferably of copper tubing is provided, and also a water-cooled vacuum tube device *h* having an anode *i* surrounded by a cooling jacket *l*. A source of cool fluid *f* is provided as before, and a similar fluid conduit *c*. The conduit *c* is connected to the inlet of the cooling jacket *l* surrounding the anode *i* of the tube *h*. The metallic anode *i* and the metallic container jacket *l* are preferably connected together. The inlet of the coiled tube *a* is then connected to the outlet of the metallic jacket *i* and thereby connected metallically to the inductance *a*. The outlet conduit *g* as previously described is then connected to the outlet of the tube *a* and led to the drain. A condenser *b* is provided as before and connected in any convenient way, in combination with suitable voltage supplies and choke coils *v* and *m* as indicated.

By my construction, as described, I am enabled to provide an oscillation generating device which is adapted to much higher powers at much higher frequencies than those previously constructed, and I have incorporated therein means for maintaining accurate physical dimensions, and thereby, constancy of high frequency.

While I have shown but two embodiments of my invention, it is capable of modifica-

tions therefrom without departing from the spirit thereof, and it is desired, therefore, that only such limitations shall be imposed thereon as are required by the prior art, or indicated in the appended claims.

I claim as my invention:—

1. In an oscillation circuit in combination a cooled tubular inductance coil having inlet and outlet ends and a cooled vacuum tube having an anode, a metallic jacket surrounding said anode having an inlet and outlet, metallic means for connecting said anode and said metallic jacket, a source of cooling fluid and means for connecting said second named inlet to said source and metallic means for connecting said inductance inlet end to said jacket outlet whereby said connecting metallic means acts as an electric path and as a cooling fluid path.

2. In a fluid cooled vacuum tube oscillation circuit a cooled vacuum tube, a cooled tubular inductance coil and a source of cooling fluid, means comprising a continuous path for running cooling fluid from said source through one of said cooled devices and from thence through said other cooled device, said means also serving as an electric path for connecting said two devices.

3. A fluid cooled vacuum tube oscillation circuit including a cooled vacuum tube having a cooling fluid inlet and outlet, a cooled tubular inductance coil and a source of cooling fluid, means comprising a current conducting path for connecting said inductance to said fluid outlet said path also serving to conduct cooling fluid from said cooled vacuum tube through said tubular inductance.

4. In combination with radio apparatus including an electron emission tube having an anode cooled by a circulating fluid, an electrical circuit for said anode including an impedance comprising a conduit conductor which is electrically and flow-connected to said anode and means for circulating cooling fluid through said impedance to maintain the electrical characteristics thereof constant.

5. A high frequency apparatus including a thermionic tube having a cathode and a fluid cooled anode, a fluid cooled oscillation circuit connected between said cathode and said anode, a source of cooling fluid, and a nonconductive path between said fluid source and said anode and said fluid source and said oscillation circuit, whereby the impedance of said oscillation circuit remains constant.

6. In combination with a thermionic oscillation generator having an electrode thereof cooled by a circulating fluid, a source of cooling fluid, and an oscillation circuit including an impedance comprising a conduit conductor which is electrically connected to said electrode and flow-connected to said source, whereby the frequency of the oscilla-

tion generated by said generator remains constant.

7. The method of generating high frequency oscillations at a constant frequency by means of a thermionic tube having an anode, a cathode and a control electrode and an oscillation circuit connected between said anode and cathode which consists in maintaining the physical dimensions of said anode cathode circuit constant during operation.

8. The method of generating high frequency oscillations at a constant frequency by means of a thermionic tube having a fluid cooled anode and cathode, and an oscillation circuit connected between said anode and cathode, consisting in maintaining the impedance of said anode cathode circuit constant during operation.

9. Radio apparatus comprising, an electron discharge device having an anode and a cathode, the anode of said device having a fluid cooling chamber, an output circuit for said device comprising an inductance, said inductance being formed of a tubular metallic coil flow connected to said chamber and conductively and electrically connected to said anode, and means for causing cooling fluid to flow through said coil and chamber.

10. In radio apparatus, a thermionic tube having a water cooled anode, and a cathode, a power circuit comprising a continuous tubular metallic conductor electrically and flow connected at one end to said anode, an electrical connection between the other end of said conductor and said cathode, said conductor providing inductance in the anode cathode circuit of said tube, and means for causing cooling water to flow through said conductor and said anode.

11. In radio apparatus, a thermionic tube having a water cooled anode, an electrical circuit connected with said anode comprising, a continuous tubular metallic conductor electrically and flow connected to said anode, said conductor providing substantial inductance in the output circuit of said tube, and means for causing cooling water to flow through said tubular conductor and said anode whereby the electrical characteristics of said circuit are maintained substantially constant.

12. The combination with an electron emission tube having an anode cooled by a circulating fluid, of an impedance comprising a conduit-conductor which is electrically and flow connected to said anode.

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