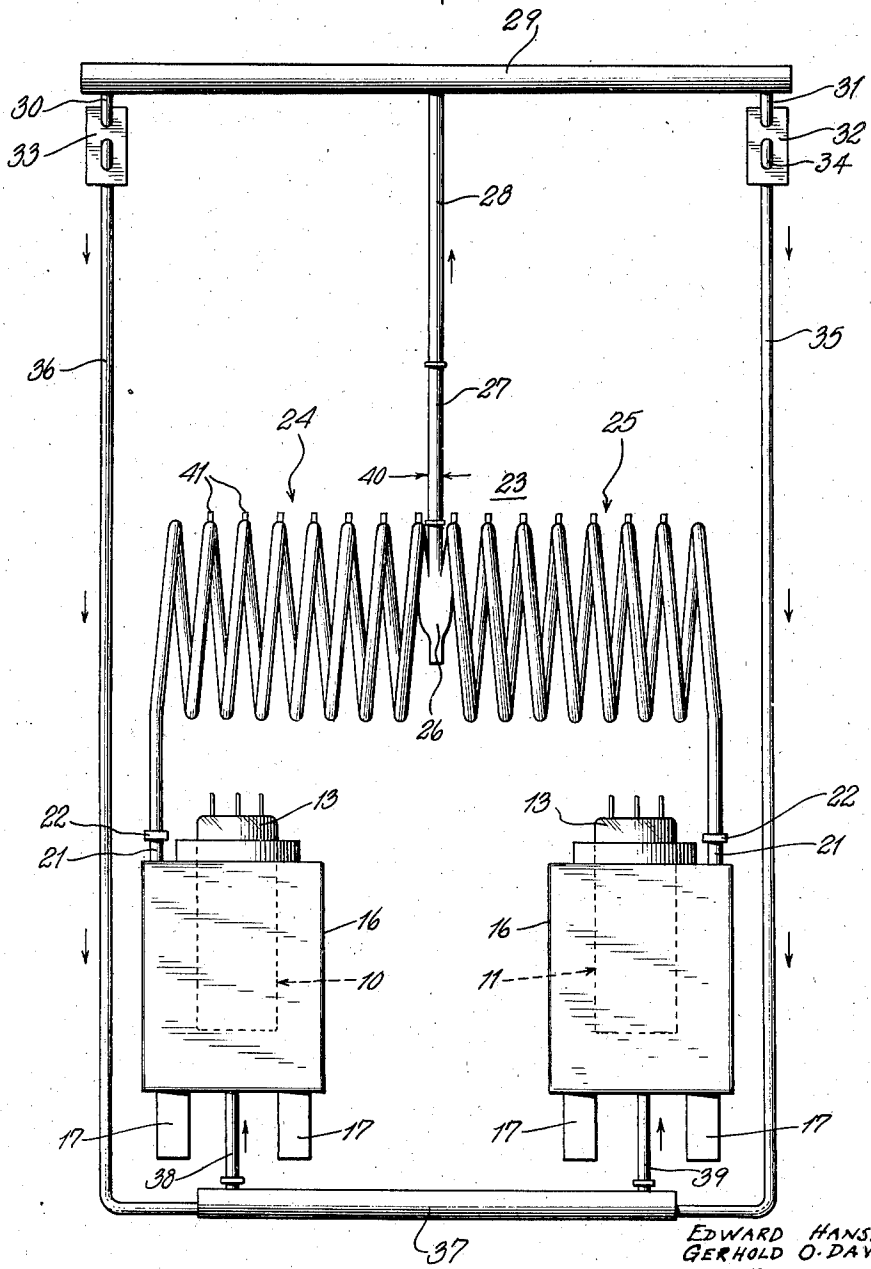
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HEAT DISSIPATION FOR ELECTRONIC TUBE APPARATUS

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Fig. 1.



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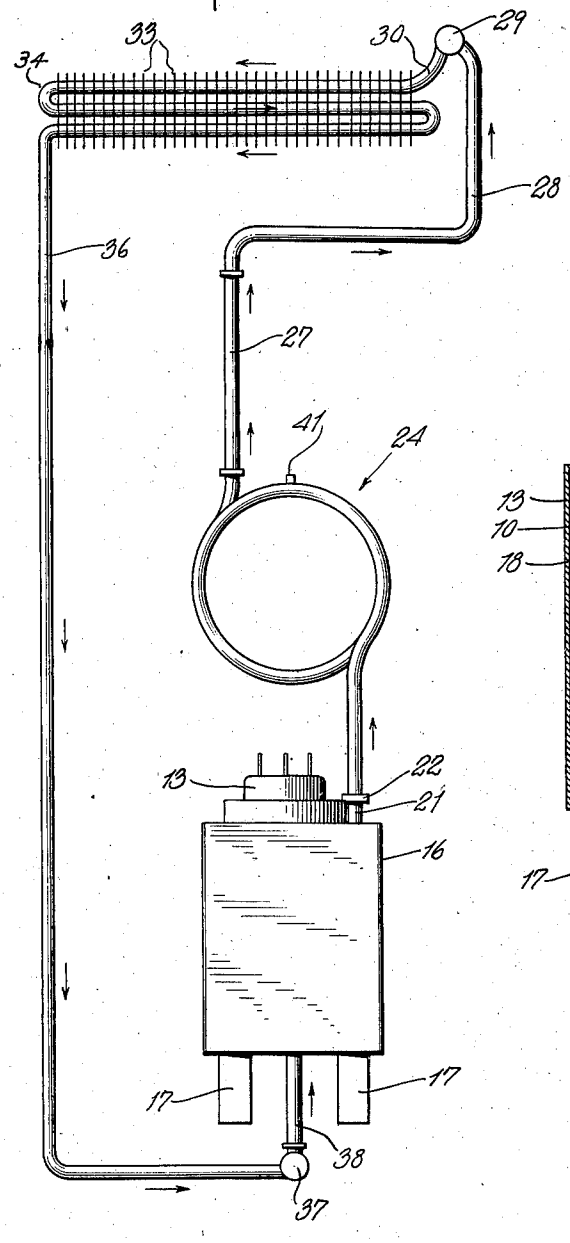
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Fig. 2.



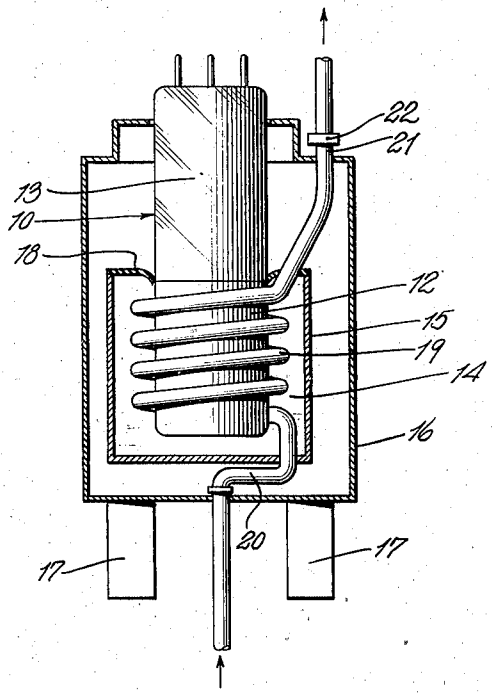


Fig. 3.

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HEAT DISSIPATION FOR ELECTRONIC TUBE APPARATUS

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Application June 11, 1946, Serial No. 675,853

6 Claims. (Cl. 250—27.5)

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This invention relates to electron tube systems and more especially to systems wherein a great amount of power in the form of a heat is to be dissipated from one or more of the electron tubes.

A principal object of the invention is greatly to increase the power output efficiency of such devices as radio transmitters, induction heaters and the like, which employ one or more high power electron tubes.

One of the serious limitations in the useful power output of such devices as radio transmitters, is the amount of heat wattage that can be dissipated per unit time. In large power output transmitters, it is customary to employ either special air cooling, or special water cooling systems, for the electron tubes which are required to handle the power output. In the case of air cooling, special blowers are required for directing an air blast or stream around the tube or its associated heat radiator. Apart from the initial expense and the maintenance costs of these blowers, is the fact that for any given adjustment of the blowing system, there is only one maximum amount of heat that can be safely dissipated. If the tube or tubes are subjected to sudden or accidental overloads, the air blowing system may not be capable of supplying the necessary cooling blast, with the result that the tube may break down. Furthermore, with such air blowing systems, the heat dissipation is dependent to a certain extent upon the ambient temperature of the air intake to the blower, and in dusty or humid environments, special precautions may have to be taken to prevent deposition of dust layers or droplets on parts of the apparatus associated with the tube. The second conventional method of cooling is to employ so-called water cooled tubes, the anodes of which are usually part of the tube envelope, and which are immersed in a water bath which is connected with a suitable water circulating system. However, water cooling has a number of disadvantages amongst which are:

1. Very elaborate plumbing and water supply fixtures must be employed.

2. Special rate-of-flow gauges must be provided to insure that the proper water circulation is maintained.

3. Special water control valves must be employed.

4. Unless pure water is available, there is danger of electrolysis or deterioration of the circulating system.

5. A sudden power overload on the power output tubes requires a corresponding rapid change in the rate of flow of the water.

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We have found that by employing a closed cooling system employing a vaporizable refrigerant, it is possible greatly to increase the useful power output of existing electron tube equipment. Thus for example, a radio transmitter designed to produce 50 kilowatts maximum output with a water cooling arrangement, can have its power output increased to 55 kilowatts by using the cooling arrangements according to this invention.

Accordingly, it is another principal object of this invention to provide a system employing power output electron tubes, which system is free from the above-noted and other disadvantages of water or air cooling arrangements.

A feature of the invention relates to an electron tube power output arrangement having a closed cooling system which automatically regulates the amount of heat dissipated in accordance with the power output of the tube or tubes.

Another feature relates to a self-circulating liquid cooling system for an electron tube wherein the heat of the tube itself determines the rate of circulation of the cooling medium.

A further feature relates to a closed cooling system for electron tubes employing a refrigerating medium which is normally in a liquid phase at some predetermined temperature and whose vapor pressure varies in response to a heat exchange with the electron tube; the vapor pressure serving to control the rate of circulation of the refrigerant with respect to the electron tube.

A further feature relates to a heat dissipating arrangement for electron tubes and the like, wherein the tube is mounted in heat exchange relation with a circulating refrigerant in a closed system, the flow of refrigerant being automatically controlled by its vapor pressure and by gravity.

A still further feature relates to an electron tube circuit employing at least one electron tube and an associated circuit inductance in the form of a tubular coil, the coil also serving as a conduit for a special refrigerating medium in a closed refrigerating system, wherein the rate of heat dissipation is automatically controlled by the output load of the electron tube.

A further feature relates to a novel cooling arrangement for electron tubes of the type wherein the anode forms part of the tube envelope and whereby uniform cooling of all parts of the anode and the associated seal is obtained.

A still further feature relates to the novel or-

ganization, arrangement and relative interconnection of parts which cooperate to provide an improved electron tube cooling system.

Other features and advantages not particularly enumerated will be apparent after a consideration of the following detailed descriptions and the appended claims.

In the drawing which illustrates a preferred embodiment,

Fig. 1 is a front elevational view of a portion of a power amplifier and cooling system according to the invention.

Fig. 2 is a side view of Fig. 1.

Fig. 3 is a sectional view of a portion of Figs. 1 and 2.

Referring to the drawing, there are shown two electron tubes 10, 11, which, for example, may be of the so-called external anode type, wherein the anode 12 is in the form of a cup-shaped metal member which is vacuum-tight sealed to the glass bulb 13. Such tubes are well-known in the radio art and are generally referred to as water cooled tubes. Such tubes when used as high power amplifiers are required to dissipate a great amount of heat, and it has been the usual practice to immerse the anode 12 in a water bath which in turn is connected to a water circulating system. One of the difficulties encountered with these prior arrangements is that of insuring that the anode is kept at a uniform temperature throughout its extent, and especially at the sealing region with the glass 13. According to one feature of the invention, the tube is mounted so that the anode 12 is immersed in a bath 14 of brine solution or in an oil bath containing powdered graphite in suspension, or any other solution whose freezing point is below the lowest temperature reached by the cooling coil to be described. These baths are contained in vessels 15 which are suitably supported within respective metal housings 16 which housings are rigidly supported on insulator columns 17 on a suitable platform (not shown) which also supports the remainder of the equipment, preferably a liquid tight seal in the form of a suitable gasket 18, surrounds the tube where it emerges from vessel 15.

Located within each vessel 15 is a cooling or evaporating coil 19 of metal tubing, this coil having an inside turn diameter sufficient to surround closely the anode 12. Each coil is connected respectively to inlet and outlet pipes 20, 21, which pass respectively through the lower and upper walls of housing 16. Supported on the ends of the pipes 21, for example by metal fittings 22, is an inductance coil 23 in the form of hollow metal tubing having two symmetrical half portions 24, 25, which are reversely wound with respect to each other for purposes described in detail in application Serial No. 532,084, filed April 21, 1944, now abandoned. The adjacent inner ends of the two coil sections are connected to a common bulb-like portion 26. Bulb 26 is connected through a length of insulating tube 27, such as ceramic tubing, to a metal pipe 28 which in turn is connected to a gas manifold 29 which extends parallel to the longitudinal axis of the coil 23. Each end of the manifold is provided with an outlet pipe 30, 31, which connects to the inlet of a condenser 32, 33. Each of these condensers may be in the form of a convoluted metal pipe 34 (Fig. 2) having heat radiating fins 33 integrally united thereto. The outlet end of each condenser is connected by a respective metal pipe 35, 36, to a reservoir 37, containing a suitable refrigerant of any well-known type such as employed in household refrigerators and the like. Reservoir 37 is connected through respective ceramic or other suitable insulator pipes 38, 39, to the inlet pipes 20 of the respective evaporator coils 19 above described. The cooling system is filled with the refrigerant to a level indicated by the arrows 40, just slightly above the upper periphery of the inductance coil 23. As described in detail in said application Serial No. 532,084, the coil 23 is provided with a series of aligned integral metal lugs 41, which can be short-circuited by suitable connector bars so as to determine the effective number of turns to be included in the inductance coil.

From the foregoing description, it will be seen that the coil 23 not only serves the purpose of the usual electrical inductance which is connected to the tubes 10 and 11 as described in detail in said application Serial No. 532,084, but also it forms a part of the closed refrigerating system. As a result, the refrigerant not only serves to maintain the anodes 12 of the electron tubes at a uniform temperature, but it also serves to cool the inductance coil 23. As a result of the heat developed at the anodes 12, the refrigerant is vaporized and causes the evolved vapor or gas to rise into the manifold 29. The pressure of the gas in this manifold together with the force of gravity, causes the liquid refrigerant to circulate as indicated by the arrows. Consequently, the rate of circulation of this liquid will be a function of the gas pressure in the system which in turn will be a function of the temperature of the anodes 12. Consequently, if these anodes rise above a certain predetermined temperature, the rate of circulation of the refrigerant will be accordingly increased, thus tending to restore the anodes to their predetermined temperatures.

While one particular embodiment has been described herein, it will be understood that various changes and modifications may be made without departing from the spirit and scope of the invention.

While the invention has been described in connection with the cooling of a so-called water-cooled or external anode type of tube, it will be understood that the invention can equally well be applied to any other kind of high power electron tube such as those ordinarily referred to as air-cooled types.

What is claimed is:

1. Electronic tube apparatus comprising, an electron tube, a closed refrigerating system having a cooling coil in heat exchange relation with a power output electrode of said tube, a refrigerating liquid reservoir mounted beneath said tube, a gas manifold mounted above said tube, said reservoir and manifold being connected to said cooling coil.

2. Electronic tube apparatus comprising, a pair of similar electron tubes, an inductance coil in the form of a hollow tube connected in balanced relation across the output electrodes of said tubes, a reservoir for refrigerating liquid, a pair of connections from said reservoir to the tubular interior of said inductance coil, each of said connections including in series therewith a cooling coil mounted in heat exchange relation with one of said tubes, a common conduit for said refrigerating liquid connected substantially to the middle point of said inductance, and a pair of return conduits connected to said common conduit and to the said reservoir.

3. Apparatus according to claim 2 in which a heat radiator and condenser unit is connected in circuit with each of said pair of return conduits,

4. A high power amplifier comprising a pair of electron tubes, a pair of tubular inductance coils reversely wound with respect to each other and having a common central connection, cooling coils connected respectively to the outer ends of each of said inductance coils, a conduit connected to said central connection between said inductance coils, a reservoir for liquid refrigerant connected to the other ends of said cooling coils, said cooling coils being mounted in heat exchange relation with respect to the output electrodes of said tubes, a gas manifold having a connection from its central portion to said conduit, and connections from the said reservoir to the ends of said manifold.

5. An amplifier according to claim 4 in which the conduit connecting the central center point of said inductances to said manifold includes a section of insulator tubing, and the connections between said reservoir and said other ends of said cooling coils also include a section of insulator tubing.

6. Electronic tube apparatus comprising, a reservoir for liquid refrigerant, a pair of refrigerant evaporating coils connected in parallel to said reservoir, an electrical inductance coil in the form of a hollow tube, said inductance coil having its end sections connected to said reservoir through said evaporating coils, a common return conduit connected to the central section of said inductance, a gas manifold connected to the end of said conduit, and a pair of return conduits connected to the ends of said manifold and thence to said reservoir.

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