July 13, 1937. J. EVANS 2,086,905

RADIO TRANSMITTER APPARATUS

Filed Nov. 30, 1934 2 Sheets-Sheet 1

Fig. 1.

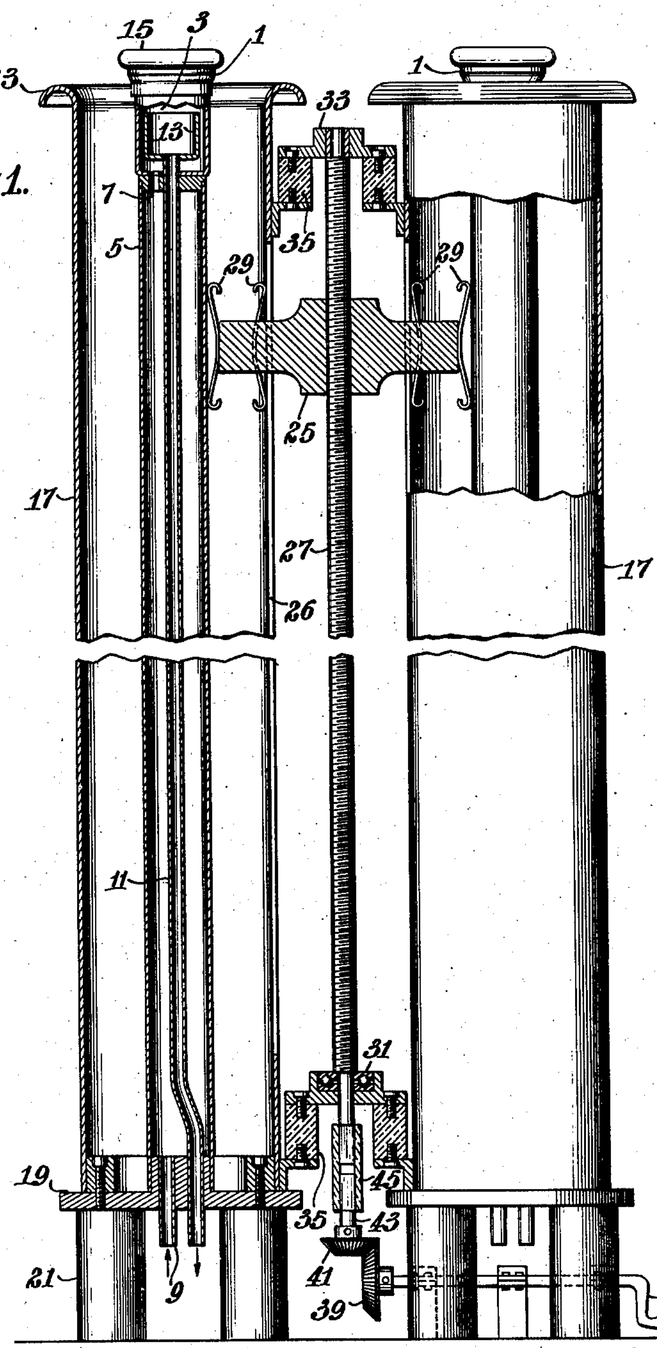

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Fig. 2.

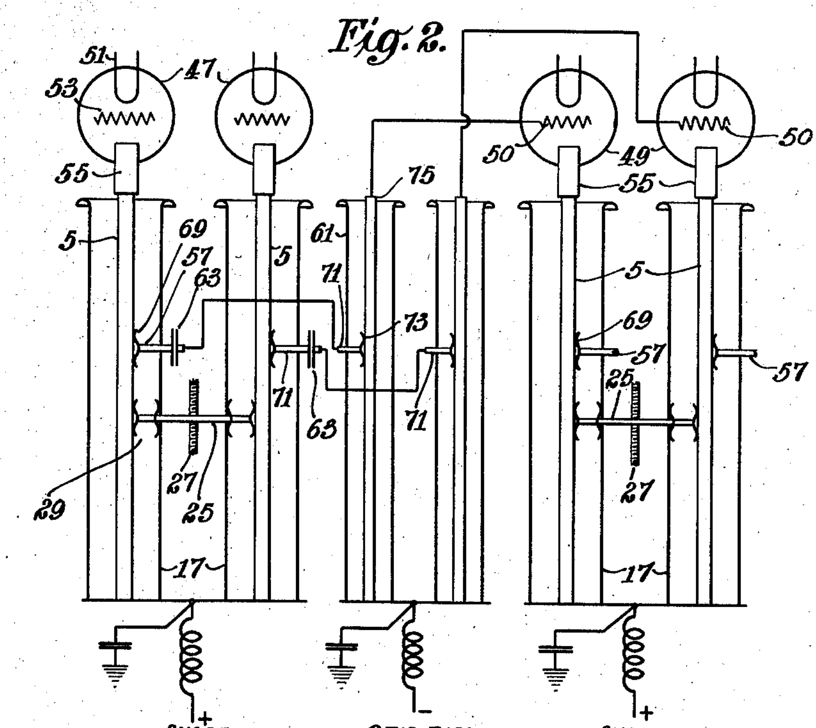
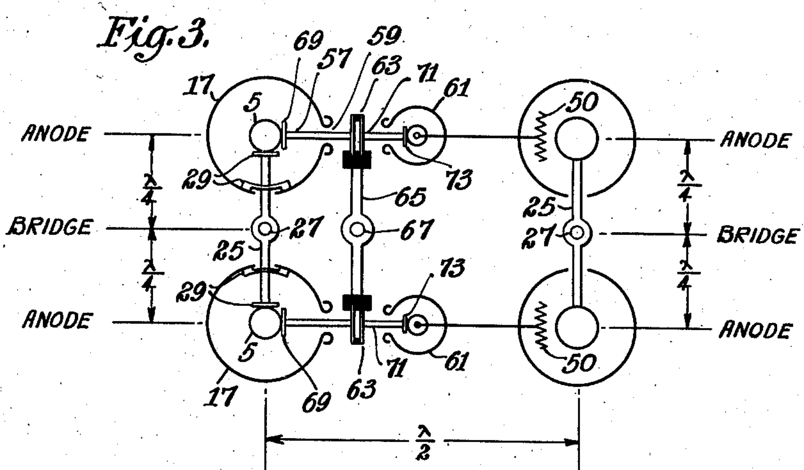


Fig. 3.



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RADIO TRANSMITTER APPARATUS

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Application November 30, 1934, Serial No. 755,393

6 Claims. (Cl. 250—27)

This invention relates to high frequency radio transmitting systems and more particularly to apparatus having an improved form of construction for supporting and interconnecting high power electron discharge tubes.

I have found that ultra-short waves, say of the order of 30 to 80 megacycles, may be generated and amplified by means of electron discharge tubes having water cooled anodes. The ultra high frequency energy thus produced can be utilized under optimum conditions of efficiency, provided proper precautions are taken to obtain resonant circuits between stages and to so dispose these circuits that they shall be properly shielded at the same time that they are suitably coordinated in length with respect to the operating wave length.

Accordingly, it is among the objects of my invention to provide apparatus of the character above suggested in which electrical connections between stages of electron discharge tube networks are made adjustable to resonant conditions at the same time that they are properly shielded and insulated.

A further object is to provide a supporting pedestal for an electron discharge tube in which may be disposed any desired portion of an anode cooling system.

Another object of my invention is to so arrange the output circuits from a pair of water cooled thermionic tubes that such tubes may be suitably operated in a push-pull manner and with a maximum efficiency of output energy.

Another object is to provide hollow pedestals for tuning and shielding purposes whereby the necessary interconnecting circuits between successive stages of push-pull operated tubes may be obtained, while avoiding some of the serious energy losses which were heretofore inherent in the conventional means for insulating and shielding such circuits.

Another object of my invention is to provide convenient adjusting means for obtaining the necessary electrical lengths of the conductors which are used between two anodes of a push-pull pair of electron discharge tubes and to provide further length-adjusting means for the conductors constituting an output circuit for such tubes.

Among the advantageous features of my invention the following may be mentioned,—(1) a tuned circuit is provided which has an extremely high power factor; (2) the dissipation of high frequency energy by "creepage" over ceramic or other conventional insulators is voided; (3) radiation losses in the network are made negligible by suitable shielding; (4) inductances and capacitances are efficiently distributed instead of being lumped, thereby avoiding over-heating of the conductors; and (5) a wide range of operating frequencies may be had without departing from an optimum ratio of inductance to capacitance of the network.

The foregoing and other objects and advantages of my invention will be more clearly understood upon reference to the following detailed description when taken in connection with the accompanying drawings, in which

Figure 1 is a view, partly in section and somewhat fragmentary, of two pedestals which are adapted for supporting high power electron discharge tubes;

Fig. 2 is a diagram which is referred to in the specification for explaining the theory of operation of my invention; and

Fig. 3 is still another diagram presenting more or less in plan view the arrangement of six pedestals which may be suitably assembled with apparatus for obtaining the necessary tuning adjustments as between stages of two pairs of electron discharge tubes operated in a push-pull manner.

Some of the mechanical details of the apparatus herein disclosed correspond closely to those which have been described in my Patent No. 2,051,520, August 18, 1935, and assigned to the assignee of the instant application. In that application there was disclosed a system of pillars having internally disposed conductors and a bridging member which could be adjusted upwardly and downwardly in order to obtain a resonant electrical length between terminals of the conductors in two respective pillars. The specific objects of that invention differ, however, from those hereinabove set forth in relation to the instant application.

Referring to Fig. 1, I show a pair of pedestals for high power radio tubes the details of construction of the pedestals being as follows: Tube sockets 1 are mounted each at the top of a cooling chamber 3. The cooling chamber in turn is positioned at the top of a stand-pipe 5. An opening 7 is made between the stand pipe and the cooling chamber for admittance of a cooling fluid such as water. An intake pipe 9 serves to establish connections between any suitable source of cooling fluid and the interior of the stand-pipe 5. An outlet pipe 11 is disposed within the stand-pipe and runs the full length thereof for carrying away the water which has absorbed heat from the anode of the radio tube. This pipe 11 terminates at the top in a receptacle 13 for the anode. Any suitable clamping device such as the ring 15 may be provided for holding the electron discharge tube in position and for sealing the anode within the cooling chamber. Surrounding the stand-pipe 5 is a shielding member 17 made of metal and having a base 19 formed of any suitable material. The base is supported by insulators 21. The top end of the tubular shield 17 is rolled over as shown at 23 in order to avoid the corona effect which might otherwise occur in the operation of a high power electron discharge tube.

In order to adjust the output circuit for satisfactory operation of two electron discharge tubes connected in a push-pull manner, I prefer to utilize a bridging member 25, the height of which is determined under control of a threaded rod 27, which, in turn, is vertically disposed mid-way between two of the pedestals. The bridging member 25 extends through slots 26 in the shields 17 and has suitably mounted at each end a set of resilient brushes 29. Certain of these brushes bear against the outer wall of each stand-pipe 5, while others of the brushes bear against the inner wall of each shielding column 17.

The lead screw 27 is preferably supported at the bottom thereof by a thrust bearing 31 and at the top by an ordinary bearing 33. The bearings 31 and 33 are supported on insulators 35, these insulators being attached in any suitable manner to the shielding members 17.

Upward and downward adjustment of the bridging member 25 is obtained by means of a crank 37 the shaft of which carries a bevel gear 39 meshing with a bevel pinion 41. The pinion 41 is carried on a shaft 43 which is socketed in an insulating member 45. The lead screw 27 is also socketed in this insulating member 45. The metallic parts of the crank and transmission members are thus insulated from the lead screw 27.

In the operation of the device shown in Fig. 1, assuming that two electron discharge tubes are mounted on the pedestals for a push-pull stage of oscillation generation or amplification, the bridging member 25 will be so adjusted that standing waves will be formed between the anodes of the two tubes. High frequency currents traverse the upper portions of the stand-pipes 5, also the brushes 29 and the shielding members 17. At the center of the bridge 25 a node of energy is also developed. The high frequency energy which traverses the interior walls of the shielding members 17 above the bridging member reacts both inductively and capacitively upon the opposing walls of the stand-pipes 5. This inductance and capacitance constitute an essential part of the tuned circuit, while the bridging member and the other elements which conductively interconnect the anodes of the two tubes form a balancing circuit having a nodal point at its center of symmetry, which is also the center of the bridging member 25. Below the bridging member there is substantially no leakage of high frequency currents. Furthermore, the so-called "skin effect" at the frequencies for which my apparatus is intended to be worked is so great that substantially no high frequency currents are developed on the exterior walls of the shielding member 17.

In order to supply suitable anode potentials to the electron discharge tubes which are supported by my pedestals, as shown in Fig. 1, any suitable connection (not shown) may be made at the bottom of each stand-pipe, say by strapping a conductor to the intake pipe 9. Usually, rubber hose connections are made with each of the pipes 9 and 11 so that suitable insulation is provided between all metal portions of the stand-pipes and pedestals with respect to ground for the steady anode potential.

In Fig. 2, I have illustrated diagrammatically how several pairs of my pedestals may be assembled with means providing the necessary supports for two pairs of electron discharge tubes working in a push-pull manner. I also show how interstage connections may be made and so adjusted to the working frequency that the circuits may be satisfactorily tuned. In this diagram there appear two electron discharge tubes 47 constituting a first stage, and two more tubes 49 constituting a second stage. These tubes are somewhat conventionally represented as having each a cathode 51, a grid 53 and an anode 55. As is usual in high power transmission networks, the anode 55 extends outwardly from the glass envelope of the vacuum tube in order that it may be properly cooled in a water jacket. The tubes 47 are indicated as mounted upon two of the pedestals such as those shown in Fig. 1. In this case, however, a modification is made in the pedestals in that, in addition to the bridging member 25, individual conductors 57 are provided having brushes thereon which contact only with the stand-pipes 5. Slotted openings are made in the shielding members 17 as shown at 59 (Fig. 3). The metal of the shielding member is rolled back so as to eliminate the possibility of corona discharge across the gap in which the conductor 57 is positioned.

In an embodiment of my invention which has been built, I have made the shield 17 with a longitudinal opening 59 approximately one inch across. The conductor 57 is about one-fourth of an inch in thickness so that an air gap of three-eighths of an inch is maintained on either side of the conductor where it emerges from the interior of the shielding member 17.

A second pair of pedestals having each a shielding member 61 and a centrally disposed cylindrical conductor 75 constitutes means for intercoupling the output circuit for each of the tubes 47 with the input circuit for one of the tubes 49, respectively. A simple and effective form of condenser is composed of electrostatic plates 63, these being suitably separated from one another by an air gap and by insulating material. Two sets of condensers are carried on a supporting member 65 which may be raised or lowered at will.

It is desirable to tune the circuit connections between stages. For this purpose a lead screw 67 is provided in cooperation with the support 65. A crank with transmission gearing similar to that shown in Fig. 1 is also supplied, controlling the upward and downward movement of the support 65 through the rotation of the lead screw 67. Details of this structure have not been shown because they may be well understood from the showing of the crank and gearing in Fig. 1. It will be seen, however, that the two condensers 63, as well as the conductors connecting their opposing plates, are all supported through insulating means on one carrier 65, so that they can be raised and lowered together. Brushes 69, mounted on the conductors 57, engage with the stand-pipes 5 at some suitable elevation for taking off output energy from the discharge tubes 47. This energy is transmitted through the condensers 63 and thence through the conductors 71 to other brushes 73 which contact with tubular posts 75 within the next pair of pedestals. From the tops of these posts 75 short flexible leads are carried to the grids 50 of the tubes 49 respectively. By virtue of the adjustability of the elevation of the condensers 63 and bridging conductors 57 and 71 it is possible to provide optimum impedances beween the anodes of the tubes 47 and the grids 50 of the tubes 49.

Each tube 49 is preferably mounted on still another pedestal as shown in Figs. 2 and 3. These pedestals may also be provided with bridging members 25 interconnecting the stand-pipes, and may be further supplied with conductors 57 contacting through brushes 69 with the stand-pipes 5 so that energy may be taken off and applied either to a further stage of amplification, or to an antenna system.

I have found that in the operation of the apparatus, as herein shown and described, numerous advantages are to be derived from the preferred structural arrangements. For example, when operating such a system to produce and transmit oscillations of a frequency of upwards of ten megacycles, and where it is desirable to apply some thousands of volts as direct current anode potential, this voltage is very satisfactorily isolated from ground and at the same time the high frequency energy is also kept within bounds. My apparatus is so designed that no radio frequency voltages are developed in the region of the intake and outlet hose connections of the cooling system. Prior to the development of my invention, considerable trouble was experienced because of electrolysis taking place at the rubber hose connections. The rubber itself was actually disintegrated after a comparatively short term of service. Since in my apparatus no high frequency energy is dissipated below the bridging member 25, no such electrolysis can take place at the bottom of the stand-pipe, or at the hose connections. So far as high frequencies are concerned, the base of the stand-pipe and the base of the shielding member 17 are both non-conductors. The two tubes 47 being worked in phase opposition to one another develop currents which must of necessity neutralize each other across the bridge 25, provided this bridge is adjusted to the proper level.

Many other advantages result from the carrying out of my invention in the manner herein taught. Although I have shown a certain specific embodiment and have illustrated my invention in its application to transmitters having push-pull operated electron tubes, it is to be understood that many modifications may be made therein without departing from the spirit and scope of the invention. I do not intend, therefore, to be limited except in-so-far as is necessitated by the prior art and by the spirit of the appended claims.

I claim as my invention:

1. In a device of the class described, in combination, a pair of electron discharge tubes having fluid cooled anodes, a fluid chamber surrounding each of said anodes, tubular risers connecting with said chambers for supplying a cooling fluid thereto, outlet pipes contained within said risers, metallic walled pedestals surrounding said risers and constituting electrostatic shields therefor, said pedestals being longitudinally slotted, and means for establishing a high-frequency output circuit from the anode of one of said electron discharge tubes down a portion of the exterior of the tubular riser connected thereto and out through the slot therein and to the other tubular riser and anode connected thereto.

2. A device in accordance with claim 1 further characterized in that means are provided for impressing direct current anode potentials upon said tubular risers, and both the risers and the pedestals are provided with insulating supports.

3. In a device of the class described, in combination, pairs of electron discharge tubes, each of said tubes having a cathode, a grid, and a fluid-cooled anode; shielding pedestals for said tubes; tunable circuits each comprising, at least in part, a conductive stand-pipe shielded by said pedestal; and anode circuit including connections from said anodes to said stand-pipes; adjustable bridging means connecting said stand-pipes for adjusting said anode circuit in at least one pair of said discharge tubes to resonance; and means adjustable on said stand-pipes for coupling portions of said anode circuits to the grids of another of said pairs of discharge tubes whereby energy is transferred from the anodes of one of said pair of tubes to the grids of another of said pair of tubes.

4. In a device of the class described, in combination, a pair of electron discharge tubes, each of said tubes having a cathode, a grid, and an anode; shielding pedestals for said tubes; a conductive stand-pipe disposed within each of said pedestals; a tunable anode circuit for said pair of tubes comprising said stand-pipes, connections from the anodes of said pair of tubes to said stand-pipes, and bridging members having resilient brushes adapted to slidably contact said stand-pipes; the shielding portions of said pedestals being longitudinally slotted to permit insertion therein of said bridging members, and having the edges of said slots rolled into a bead for minimizing corona effect; and means for establishing a high-frequency connection to the stand-pipes within said shielding pedestals.

5. A device in accordance with claim 3 and having male and female threaded means for so adjusting the positions of said bridging members as to obtain conditions of resonance between the anodes of said tubes.

6. A device in accordance with claim 4 and having male and female threaded means for so adjusting the positions of said bridging members as to obtain standing waves in said anode circuit.

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