

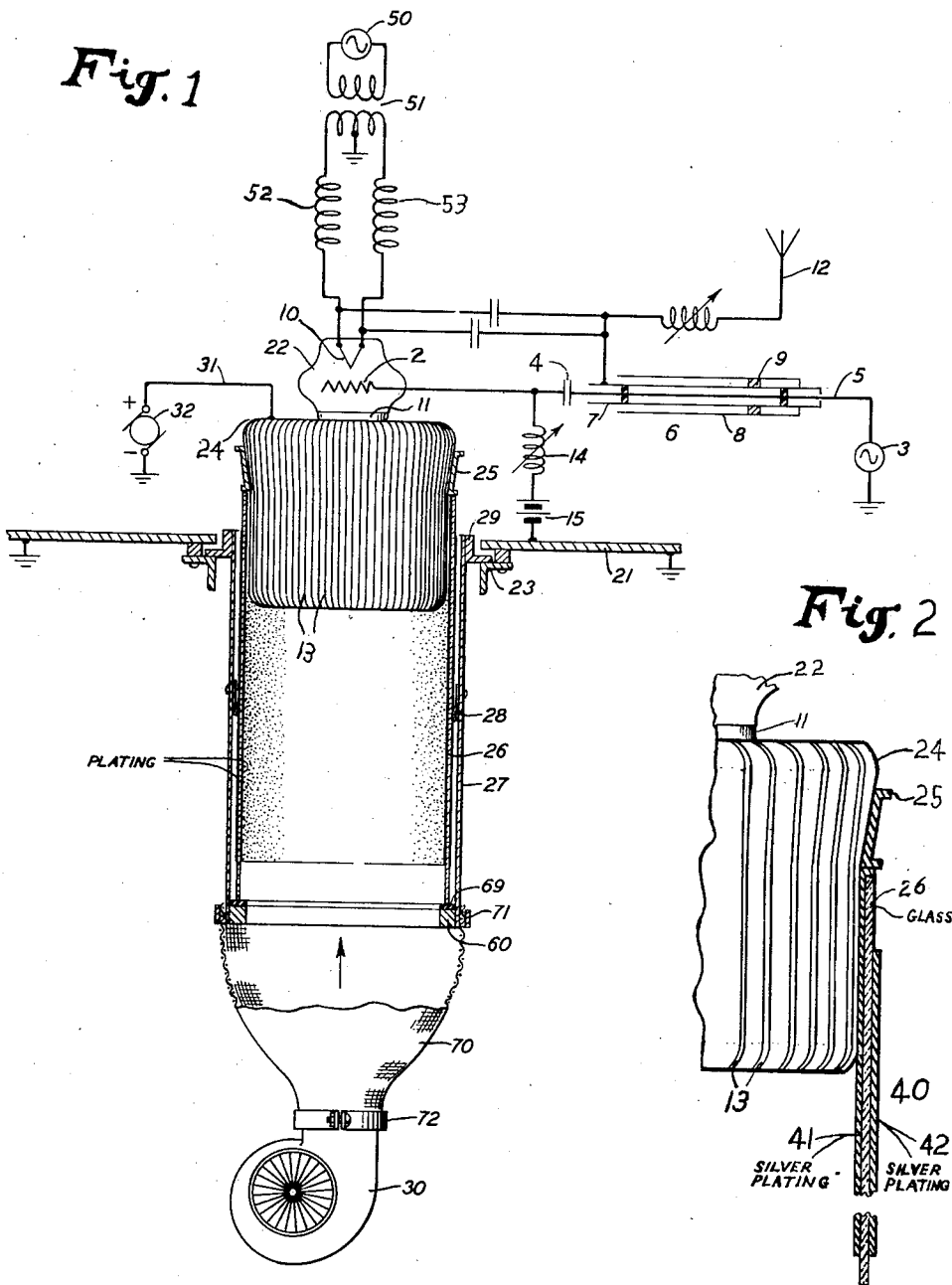
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AIR-COOLED POWER AMPLIFIER

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AIR-COOLED POWER AMPLIFIER

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This invention relates to power amplifiers and, more particularly, to air cooling means for use with a vacuum tube power amplifier having an anode with a large extended air-cooled surface external to the envelope of the tube.

Objects of the invention are to improve the efficiency and operating characteristics of power amplifiers at ultra-high frequencies; to reduce the number and length of high-frequency leads in power amplifiers; to diminish the amount of parasitic currents originating in high-frequency leads in power amplifiers; and to obtain compactness of construction in power amplifiers.

In the operation of vacuum tube amplifiers at frequencies of the order of 40 megacycles or greater, the efficient delivery of the high-frequency energy requires that the connected load should present a resistive impedance of the same order of magnitude as the resistance of the space path within the amplifier tube. Reactances in shunt with this resistive load should be of sufficient magnitude to limit the current through them, and hence the losses, to a reasonable value. When the vacuum tube is operated in the customary manner with the cathode at ground potential for radio frequencies, the capacity of the anode to ground acts as a reactive shunt to the load or utilization circuit and, in general, because of the relatively large capacity and consequent low reactance, results in large shunt currents and losses. Where large power outputs are required, the anode must have an external area that is large enough to permit the dissipation of a substantial amount of energy, and, because of this, its capacity to ground becomes correspondingly large.

It has been found that the effects of the anode capacity of the vacuum tube can be substantially diminished by operating the tube with its anode at ground potential for radio frequency currents. This grounding of the anode for radio frequency currents effectively removes its direct capacity to ground from the output circuit and leaves as a shunt to the connected load only the relatively small direct capacity which exists between the anode and the cathode. This capacity is very small and its reactance can be readily neutralized without introducing large shunt reactances and currents or unduly sharpening the selectivity of the amplifier.

In accordance with one application of this invention, the anode cooling fin assembly of a power tube in a grounded anode amplifier is inserted into a cylindrical air duct which is so constructed as to also constitute a by-pass con-

denser for connecting the anode to ground for alternating currents. Due to the anode being mounted inside the combined air duct and condenser, it is possible to place the anode in direct contact with one of the plates of the condenser thereby reducing the number and length of high-frequency leads employed in the amplifier and also diminishing the amount of parasitic currents that tend to originate in these leads. Compactness of construction in the amplifier is obtained from this combined air duct and condenser.

These and other features of the invention are explained more fully in connection with the following detailed description of the above-mentioned embodiment of the invention with reference to the drawing which shows in Fig. 1 a power amplifier having a thermionic tube with its anode cooling fin assembly mounted partially inside a combined condenser and air duct. The amplifier is represented schematically for purposes of explanation and certain of its elements have been omitted for the sake of clarity. Fig. 2 is a magnified view of a portion of Fig. 1 showing more clearly certain features of the invention.

The power amplifier is shown to comprise essentially a triode amplifier tube 22 having a control grid 2, at least one cathode 10, and an anode 11 having a large extended surface external to the envelope of the tube 22. In order to radiate and dissipate the heat generated in the anode 11, the anode 11 is equipped with an assembly 24 of a plurality of metallic cooling fins 13—13 for forced air cooling. A conductor 31 extends from the top portion of the anode cooling fin assembly 24 to a suitable high voltage source 32 for supplying anode current. High-frequency signal modulated oscillations from a source 3 are fed along a conductor 5 and through a condenser 4 to the control grid 2 of tube 22. The conductor 5 constitutes the inner conductor of a coaxial line section 6 having an inner tubular conductor 7 and an outer tubular conductor 8. The line section 6 thus constitutes a shielded transmission line for isolating the grid circuit from the anode circuit. The effective length and reactance of the tubular conductors 7 and 8 can be varied by adjusting the location of the movable short-circuiting slider 9 thereby permitting tuning of the output circuit of the amplifier. A source 50 of heating current is connected through a transformer 51 to the cathode 10 of tube 22 through suitable high-frequency choke coils 52 and 53. The cathode 10 is connected for radio frequencies to an output load or utilization circuit represented by the antenna 12. Neutralization

is accomplished by a variable inductance 14, connected as shown, which also serves to conduct the grid bias voltage from the source 15 to the grid 2 of the tube 22.

The combined condenser and air duct 40 includes a cylinder 26 of suitable dielectric material, such as glass, having one electrically conductive covering 41 on its inner surface and another electrically conductive covering 42 on its outer surface. These two coverings 41 and 42 form the two plates of the condenser 40 and they may be of any appropriate electrically conductive material, such as coatings of a silver compound that has been suitably applied to the glass cylinder 26 and properly heat treated to produce silver platings. If desired, a thin coating of copper may be plated on top of the silver platings and a thin plating of nickel may be applied to the copper platings. This construction favors a uniform distribution of current over the conducting plates and has a form that presents no assembly difficulty in attaining a satisfactory product. It can be seen from the drawing, particularly in Fig. 2, that the outer plating 42 ends a short distance from the top of the cylinder 26 whereas the inner plating 41 extends over the top edge of the dielectric cylinder 26. Both platings terminate a short distance from the bottom edge of the cylinder 26.

The dimensions of the dielectric cylinder 26 together with its platings 41 and 42 are of such size as to permit much of the anode cooling fin assembly 24 to be inserted snugly into the condenser 40. The anode 11 is suspended in the vertically disposed cylindrical condenser 40 by means of a flanged corner ring, or strip, 25 which surrounds part of the upper portion of the anode fin assembly 24 as shown in the drawing. The flange of ring 25 rests upon the plating 41 on the top edge of the cylinder 26, as can be seen clearly in Fig. 2, thereby serving to electrically connect the anode 11 to the inner plate 41 of condenser 40. In this way, high-frequency connecting leads for the by-pass condenser 40 are eliminated with an attendant reduction in the amount of parasitic currents originating in such leads. It can also be seen that this design of the condenser 40 as a sheath for a portion of the anode 11 together with its cooling fin assembly 24 enables the condenser 40 to occupy only a minimum amount of space in the amplifier assembly and presents an efficient compact structure.

The glass cylinder 26 is protected by an encompassing metallic cylindrical shield 27 having a diameter slightly greater than the diameter of the condenser 40. Attached to the lower inner portion of the shield 27 is a flange 60, or ring, for supporting the condenser 40 in a vertical position. A washer 69 of resilient material, such as cork or rubber, may be interposed between the bottom edge of the condenser 40 and the top surface of the flange 60 to protect the glass cylinder 26 from chipping. Secured to the top portion of the metal cylinder 27 is a flanged ring 29 which is adapted to be slidably mounted on rails 23 attached to the under surface of a supporting shelf 21. Thus, the cylindrical shield 27, together with the condenser 40, is suspended from the supporting shelf 21 by means of the flanged ring 29 and the rails 23.

A plurality of contacting instrumentalities, such as spring fingers 28, are secured to the inner surface of the cylindrical shield 27 and are adapted to press against the outer plate 42

of the cylindrical condenser 40. Since the supporting shelf 21 is connected to ground, as is shown in the drawing, and since the fingers 28, shield 27, ring 29, rails 23, and shelf 21 are each composed of electrically conductive material, a by-pass circuit for alternating currents is thus completed from the anode 11 to ground.

An air blower 30, located beneath the anode-condenser assembly, generates a forced flow of air and is connected to the tubular shield 27 by a canvas sleeve 70. Clamping bands 71 and 72 insure that the conduit connections are substantially airtight. After passing through the combined air duct and condenser 40, the forced flow of air generated by the air blower 30 disperses through the spaces between the tops of the anode cooling fins 13-13. Thus, the cylindrical condenser 40, in addition to serving as an anode by-pass condenser, also serves as a duct for confining and guiding the forced flow of air to the cooling fin assembly 24 of the anode 11. This provides an efficient and compact design for dissipating the heat arising in the anode 11 and its cooling fin assembly 24.

What is claimed is:

1. In combination, a thermionic tube comprising an anode having a cooling fin assembly in which heat is generated external to the envelope of the tube, a condenser for connecting the anode to ground for alternating currents, said condenser being constituted by a cylinder of dielectric material having an electrically conductive covering on its outer surface and another electrically conductive covering on its inner surface, connecting means for connecting one covering of said cylinder to the anode and the other covering to ground, holding means for holding at least a portion of the anode cooling fin assembly within the confines of said cylinder, generating means for generating a flow of air from an outlet, and joining means for connecting said outlet to the cylinder for causing the cylindrical condenser to serve as a duct for guiding the flow of air to the anode fin assembly for dissipating the heat generated in said assembly.

2. A high-frequency amplifier including in combination a vacuum tube comprising an anode having a large extended surface external to the envelope of the tube, a cylindrical by-pass condenser for connecting said anode to ground for alternating currents, said cylindrical condenser being constituted by a vertically disposed cylinder of dielectric material having an electrically conductive covering on its outer surface and another electrically conductive covering on its inner surface extending over the top edge of the dielectric cylinder, a flanged strip of electrically conductive material secured to the extended external surface of the anode for suspending a portion of said extended anode within the confines of the cylindrical condenser, said flanged strip being adapted to rest its flange on the electrically conductive covering on the top edge of the dielectric cylinder for electrically connecting the anode to the inner conductive covering of the cylindrical condenser, and means for connecting the outer conductive covering of the cylindrical condenser to ground.

3. A high-frequency amplifier including in combination a vacuum tube comprising an anode having a large extended surface external to the envelope of the tube, a cylindrical by-pass condenser for connecting said anode to ground, said cylindrical condenser being constituted by a vertically disposed cylinder of dielectric material

having an electrically conductive covering on its outer surface and another electrically conductive covering on its inner surface extending over the top edge of the dielectric cylinder, a flanged strip of electrically conductive material secured to the extended external surface of the anode for suspending a portion of said extended anode within the confines of the cylindrical condenser, said flanged strip being adapted to rest its flange on the electrically conductive covering on the top edge of the dielectric cylinder for electrically connecting the anode to the cylindrical condenser, a metallic cylinder surrounding said cylindrical condenser for protective purposes, supporting means for supporting said cylindrical condenser within said metallic cylinder, a supporting shelf connected to ground, instrumentalities for electrically connecting the metallic cylinder to the supporting shelf and for suspending the metallic cylinder from said supporting shelf, and means within the metallic cylinder for electrically connecting the metallic cylinder to the electrically conductive covering on the outer surface of the dielectric cylinder for completing a path for alternating currents to pass from the anode to ground.

4. In combination, a vacuum tube having an electrode external to the tube in which heat is generated, a cooling fluid duct of dielectric material for conveying a cooling fluid to said electrode for dissipating the heat generated therein, and a condenser connecting said electrode to ground, said condenser comprising said dielectric duct and coatings of electrically conductive material applied to opposite sides of said duct.

5. In combination, a space discharge device having an electrode in which heat is generated, cooling means for dissipating said heat by circulating a cooling fluid around said electrode, said

cooling means including a duct for conveying said cooling fluid, said duct having a core of dielectric material with a layer of electrical conductive material on each of its sides for constituting a condenser, each of said layers constituting one plate of the condenser, means for connecting said electrode to one of said plates, and other means for connecting the other plate to ground.

6. In combination, a vacuum tube having an anode with a fin assembly in which heat is generated, cooling means for dissipating said heat by circulating a cooling fluid around said fin assembly, said cooling means including a duct for conveying said cooling fluid, said duct having a core of dielectric material with a layer of electrically conductive material on each of its sides for constituting a condenser, each of said layers constituting one plate of the condenser, at least a portion of said fin assembly being adapted to be inserted into said duct in direct contact with one of said plates, and means for connecting the other plate to ground.

7. In combination, a space discharge device having an electrode in which heat is generated, cooling means for dissipating said heat by circulating a cooling fluid around said electrode, said cooling means including a cylindrical duct for conveying said cooling fluid, said duct having a cylindrical core of dielectric material with a cylindrical coating of electrically conductive material on its inner surface and another cylindrical coating of electrically conductive material on its outer surface for constituting a condenser, means for connecting one of said cylindrical coatings to said electrode, and other means for connecting the other cylindrical coating to ground.

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