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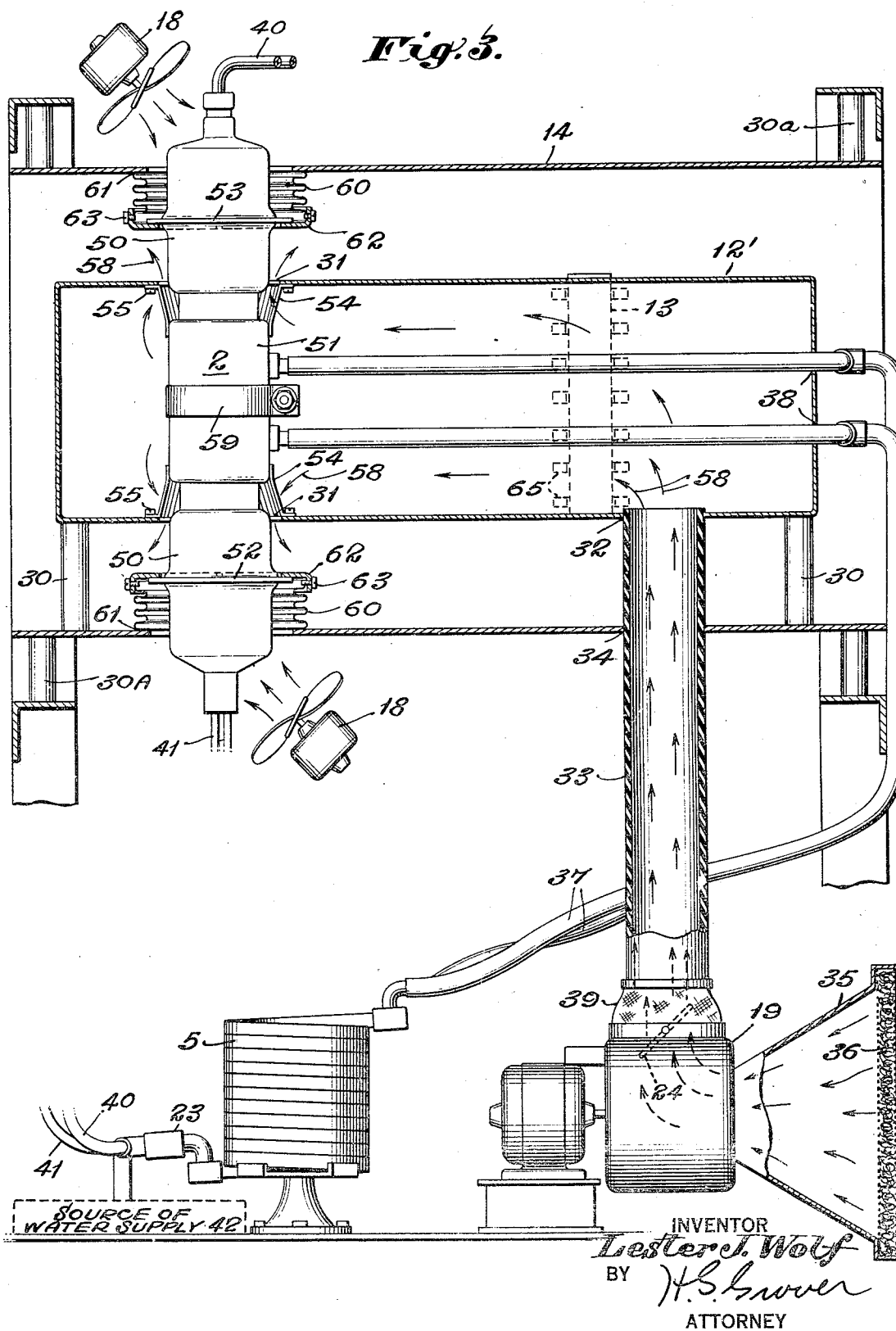
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HIGH FREQUENCY APPARATUS

Filed Nov. 25, 1942

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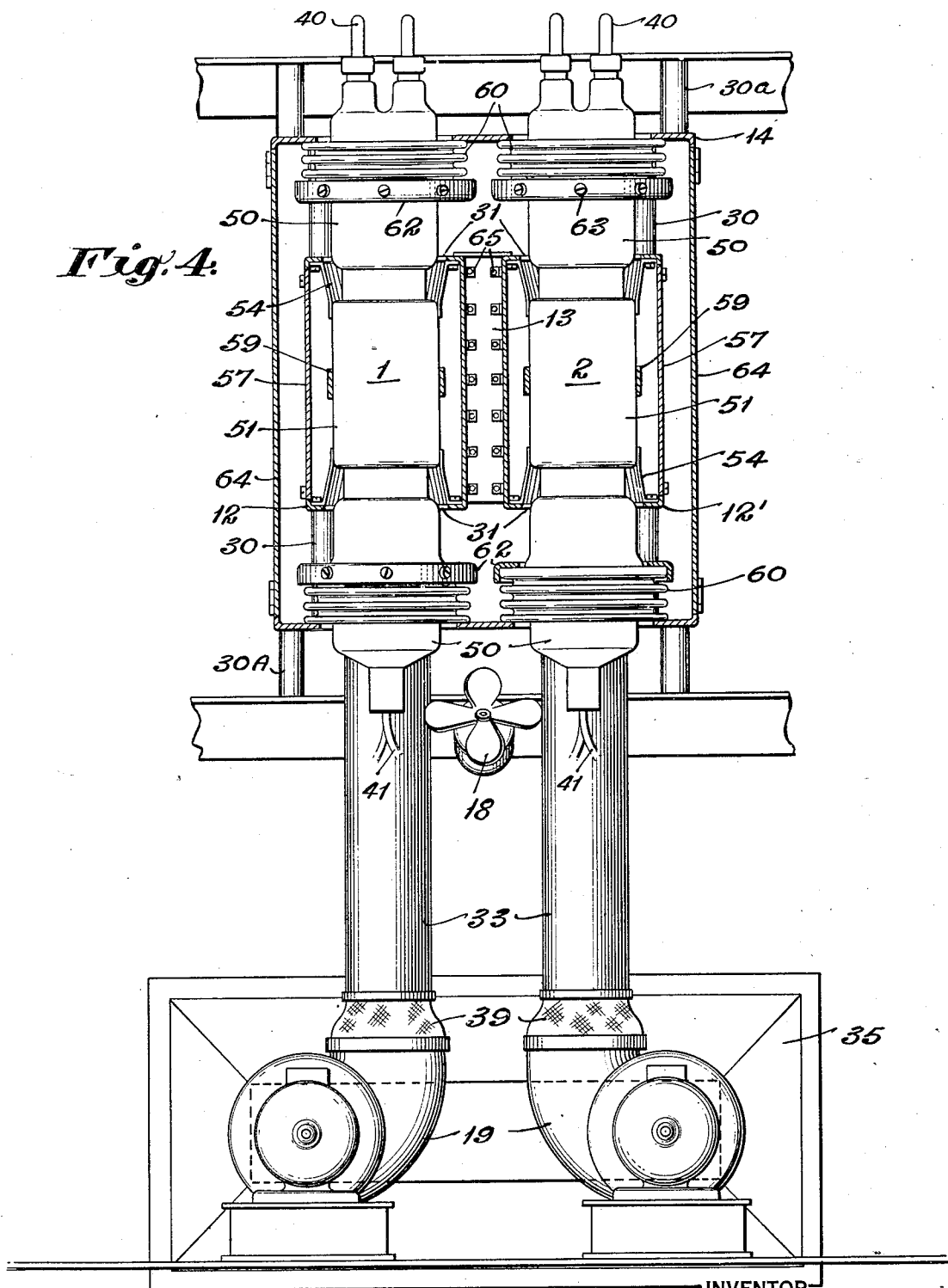
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Fig. 4.



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HIGH-FREQUENCY APPARATUS

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Application November 25, 1942, Serial No. 466,879

18 Claims. (Cl. 315—38)

This invention relates to new and useful high frequency apparatus, and is particularly directed to high power push-pull amplifiers, with novel cooling and mounting arrangements of the amplifier tubes.

An object of this invention is to provide a compact and highly efficient composite cooling system for a high frequency high power amplifier.

Another object of this invention is to provide an improved location, mounting and securing arrangement of the amplifier tubes so as to provide combined flexible mounting means for holding the tubes and cooling the anode electrode, also the grid and filament seals thereof, and to provide easy access to the tubes for inspection or removal.

Still another object of this invention is to provide both circulating water and air for cooling the anode, cathode and grid electrodes of the electron discharge devices.

A feature of this invention is the insertion of a pair of electron discharge devices within closed metallic chambers, which chambers form a part of the amplifier tank circuit of a radio transmitter, and also a fluid or air cooling duct for cooling certain portions of the electron discharge devices, the fluid cooling duct being combined with an additional air blast arrangement and a water cooling system.

This invention will best be understood by referring to the accompanying drawings, in which

Fig. 1 is a schematic circuit diagram of the amplifier portion of a radio transmitter;

Fig. 2 is a cross-sectional view of the amplifier, the section being taken through the center of the tubes;

Fig. 3 is a longitudinal cross-section of the amplifier, the section being taken at line 3—3 of Fig. 2.

Fig. 4 is a rear view of the amplifier partly in section.

Referring now in detail to Fig. 1 of the drawings, the push-pull amplifier circuit comprises a pair of electron discharge devices 1 and 2 of the RCA #2027 type. This tube will be found, described in detail, in the Zottu et al. Patent #2,113,671, issued April 12, 1938. The anodes 3 and 4 are of the water-cooled type, and each tube is cooled by a ceramic helical tubular water communicating member 5. (For the sake of simplicity in the circuit diagram, only one helical cooling member is shown, although it is to be understood that each anode has its separate cooling helix.) Within the envelope of tubes 1 and 2 there are located control grids 6 and 7, and

although these members are shown in the conventional form, it will be noted by referring to the above mentioned Zottu et al. patent that the control grids are concentrically arranged with respect to the anodes. Screen grids 8 and 9 are provided within the envelopes of the tubes, and are likewise concentrically arranged with respect to the anodes. The cathodes 10 and 11 are located in the central axis of the tubes.

The amplifier of this invention is particularly adapted for short-waves in the order of $2\frac{1}{2}$ meters, and because of the high frequencies involved; namely, the order of 112 to 116 megacycles, it is necessary that the capacities involved in the circuit elements be maintained at a low maximum value. Likewise, because of the high power handled, and high voltages involved, I have conceived the idea of mounting the tubes within the actual circuit elements which form inductances and capacities for a tuned circuit, and screening them by a metallic compartment which is insulated from ground, the construction of which will be described in more detail later.

The radio frequency tank portion of the circuit elements, which is divided into two portions in the form of separate metallic tuning chamber portions 12 and 12', acts as inductance and capacitance members, and is tuned by means of a sliding tuning device, or shorting bar, 13 and is insulated from the other circuit elements by means of insulators sufficient to properly maintain the plate potential at approximately 10,000 volts. Surrounding tuning members 12 and 12' is a metallic screen compartment 14, which is connected to screen grids 8 and 9, and insulated from the structural or radio frequency ground potentials of the amplifier at 1000 volts. The cathode leads adjacent the tuned radio frequency portion of the amplifier are connected to tubes 1 and 2, and are shielded to prevent hum, by means of two metallic tuned lines 15 and 16 constructed of copper tubing, the outer portion of the line being terminated at $\frac{1}{2}$ a wave length by means of shorting bar 17. The tuned lines 15 and 16 are tuned to $\frac{1}{2}$ the operating wave length to prevent feedback, which causes parasitics as the cathodes are at radio frequency ground potential.

Each of the copper tubes 15 and 16 has a bypass condenser connected to them and the filament leads. With this arrangement the filament current travels in the two leads, and the radio frequency travels in tubes 15 and 16. Because of the high temperatures involved, it is necessary that grid and filament metal-to-glass seals be maintained at a low temperature, otherwise heat-

ing will tend to localize itself at one point and thus injure the tube. Therefore, in accordance with this invention, there is provided, in addition to the conventional water-cooling device 5, a fan 18 and a blower 19. (To simplify the showing on the circuit diagram only one fan 18 and one blower 19 are shown, although, as will be explained in more detail later, there are two fans and two blowers provided for the cooling of the electron discharge devices.) The air cooling devices 18 and 19 are operated from a power supply device 20, the circuit of which is controlled by means of power switch 21. The filaments supplying the cathode voltage are maintained at the proper heating temperature by means of a Scott-wound transformer 22, which arrangement places the currents 90° out of phase with respect to each other. It will be noted that the primary winding is broken by means of a plurality of series-arranged switches, including a water interlock switch 23 and an air vane operated interlock switch 24, which will break the current operating cathodes 10 and 11. It will be noted, by referring to the circuit diagram of Fig. 1, that the cathode heating circuit is broken by several interlocks. These interlocks may be connected in series with a relay winding, not shown, and the main power supply circuit. The relay has contacts for breaking the circuit of the transformer primary winding. The arrangement of this circuit is such that in case of failure of either the water or air supply, the filaments are automatically disconnected. There are also provided additional circuit elements not shown in Fig. 1, which will delay the connection of, and also remove, the voltage supply on both the screen and anode circuits, but will not be described in this application because they do not form a part of the invention.

An air vane interlock switch of a type which may be employed in this invention is shown and described in a J. L. Finch Patent #2,285,504, issued June 9, 1942, or in J. L. Finch Patent #2,259,104, issued October 14, 1941. A water interlock switch, which may be employed in this invention, is shown and described in an Usselman Patent #2,148,395, issued February 21, 1939.

Referring now to the amplifier structural arrangement shown in Figs. 2, 3 and 4: (For reasons of a clearer description, the panel and structural frame-work of the power amplifier will not be shown or described.)

The metallic anode tuning chamber portions 12 and 12' are shown symmetrically arranged within the metallic screen compartment 14, but insulated therefrom by means of ceramic insulators 30. The screen compartment is insulated from the grounded frame structure of the amplifier by insulators 30A. Located at the left of each metallic chamber portion 12 and 12' of the anode tuning member there is a large aperture 31 provided in both the upper and lower walls, the diameter of which is substantially larger than the outside diameter of tubes 1 and 2. To the right of each metallic chamber portion 12 and 12' of the anode inductance member there is an aperture 32, through which passes a relatively long tubular insulating air duct member 33, which also passes through an aperture 34 in the wall of screen member 14, and terminates directly below in the outlet duct of blower 19. The tubular duct 33 also insulates members 12, 12' and 14 from ground. A flexible fabric ring 35 connects duct 33 and blower 19 to prevent vibrations from being transmitted to other portions of the amplifier. The inlet portions of

each one of the blowers 19 are connected to a common inlet duct 35, the front portion of which is provided with an air filter 36, which is composed of spun glass wool, or any other suitable filtering material, to filter the air before it passes through the blowers. The air from blowers 19 cools substantially the entire tube and, likewise, the metal-to-glass seals, as will be described in more detail later. The anodes 3 and 4 are also water cooled by means of twin helical insulating members 5, which are located adjacent blowers 19, and are connected to the anodes by means of a flexible rubber hose 37, which passes through apertures 38 in the tuning portions 12 and 12'. The blowers 19 are mounted by spring elements to the framework of the amplifier to absorb vibrations. The cathode and grid portions of the tube are cooled by means of fans 18, one of the fans being located in the upper portion of the amplifier, centrally, between tubes 1 and 2, and set at such an angle as to direct a blast of air upon the cathodes of both tubes. The other fan is located in the central portion of the amplifier and set in such a position as to direct a blast of air upon the grid portions of amplifier tubes 1 and 2. In addition to the aid blast from the fans 18, there are provided rubber hose connections 40 and 41, which connect to the insulating pipes leading from the source of water supply 42, and are arranged in such a manner that there is internal cooling of both the cathode and grid electrodes.

Because of the high power and high frequency involved in the amplifier circuits of the push-pull amplifier of this invention, a great amount of heat is developed. Therefore, in addition to the above mentioned water cooling system of the anodes, grids and cathodes, I have found it necessary to depart from the customary cooling methods, and to also cool the tubes locally, particularly at the grid and filament seals. The point on the screen grid portion of the tube, at which the glass envelope 50 is sealed to the outer metallic anode portion 51, also develops localized heat. Therefore, in order to cool the tubes at this point, I have provided cooling means different from those employed in the ordinary prior art amplifiers used in short-wave radio transmitters. Also, the RCA #2027 tubes have screen grid connections in the form of concentric rings 52 and 53 located at both the upper and lower portions thereof, therefore additional cooling means have to be provided to dissipate the heat generated at these points.

In accordance with several of the other advantages and features of this invention, there are provided a plurality of metallic spring contact clips 54, which are radially spaced and secured to the lower portion of chambers 12 and 12', by means of screws, or rivets, 55. These clips are so arranged that approximately one-half the number of spring contact members are secured to the top and bottom walls of chambers 12 and 12', and the other half are secured to a removable metallic base member 56, which is in turn secured to a removable door 57, through which access to the tube is made. The location and arrangement of the spring contact members 54 is made such that they bear against the outer metallic anode portion 51 to make good electrical contact therewith. Additional contact is made to the anode by means of a removable clip 59, which is secured to the inner walls of members 12 and 12' by suitable means, such

as nuts and bolts. The spacing of clips 54 is such that the blast of cooling air, as indicated by arrows 58, passes through the spaces and around the envelope portion of tubes 1 and 2, the blast of air continuing to flow down through apertures 31 to cool the screen grid portion 52. The reason for this arrangement is that in the prior art practice, particularly in the ultra high frequencies, there was a tendency for the tubes to heat up in a localized spot at some point along the metallic anode to glass seal, and it will be noted that by this novel arrangement the blast of air is broken up into a plurality of small, divided paths, which prevent the formation of heat in such localized spots.

One of the novel mounting advantages of this invention is an arrangement wherein expansion due to the large amount of heat developed within the metallic chambers causes expansion and contraction of the metallic chambers, and its associated relationship between tubes 1 and 2. Therefore, by this invention, each one of the tubes is flexibly mounted within apertures 31 by means of two flexible metallic bellows 60, which are soldered to the top and bottom portions of screen grid chamber 14 at a point 61. Each one of the ends of the tubes 1 and 2 pass through the bellows 60. At the free, unsoldered ends of the bellows, which are opposite securing points 61, there are provided metallic rings 62, which are split into two halves and arranged to be fastened to the metallic bellows by means of screws 63, and clamped to the screen grid electrodes. The rings 62 are split so as to facilitate the easy removal of the tubes. The flexible bellows also prevent vibrations being transmitted to the tubes 1 and 2.

The screen grid chamber 14 is provided with two hinged doors 64, which permit access to the removable doors 57, through which the tube passes when it is found necessary to inspect, make replacements, or to change tubes in the amplifier.

The radio frequency shorting bar 13 has a plurality of contact fingers 65 to insure a perfect sliding contact to the walls of chambers 12 and 12'. The plate voltage is connected from a lead 66 to a plate supply 67, which is grounded at 68. The screen voltage supply is connected to a positive B voltage at 69.

Although this invention has been described in connection with the cooling of a push-pull power amplifier circuit, it is to be distinctly understood that this improved cooling method will also be equally applicable to other short-wave-high power apparatus, such as is used with oscillator and modulating circuits. Therefore, this invention should not be limited precisely thereto.

What is claimed is:

1. An ultra high frequency system having in combination an electron discharge device having at least a cathode, an anode, grid, and screen grid, a high frequency circuit including a hollow metallic element electrically connected to said anode, a metallic screen surrounding said hollow metallic element and electrically connected to said screen grid, and means for forcing air through said hollow metallic element and against said electron discharge device.

2. An ultra high frequency system having in combination an electron discharge device having at least a cathode, an anode, grid, and screen grid, a high frequency circuit including a hollow metallic element electrically connected to said anode, a metallic screen surrounding said hollow metallic element and electrically connected to said screen grid, water cooling means for circulating

ing water around said anode, and means for forcing air through said hollow metallic element and against said electron discharge device.

3. An ultra high frequency system having in combination an electron discharge device having at least a cathode, an anode, grid, and screen grid, a high frequency circuit including a hollow metallic element having substantially straight walls, said hollow metallic element electrically connected to said anode, a rectilinear metallic screen surrounding said hollow metallic element and electrically connected to said screen grid, and means for forcing air through said hollow metallic element and against said electron discharge device.

4. An ultra high frequency push-pull amplifier system having in combination a pair of electron discharge devices, each one having at least a cathode, an anode, a grid, and screen grid, a high frequency circuit including a hollow metallic element electrically connected to said anodes, a metallic screen surrounding said hollow metallic element and electrically connected to said screen grid, said high frequency circuit comprising a hollow conductive system, and means to force air through said system and against said anodes.

5. An ultra high frequency amplifier system having in combination a pair of electron discharge devices, each one having at least a cathode, an anode, grid, and screen grid, a high frequency circuit connected to said anodes, said high frequency circuit comprising a hollow conductive system including a pair of hollow metallic conductors, adjustable tuning means interposed between and electrically connected to each one of said hollow metallic conductors, a metallic screen surrounding said hollow metallic conductors and electrically connected to said screen grid, and means to force air through said hollow metallic conductors and against each one of said anodes.

6. An ultra high frequency amplifier system having in combination a pair of electron discharge devices, each one having at least a cathode, an anode, a grid, and screen grid, a high frequency circuit connected to said anodes, a water cooling system to cool the jackets of said anodes, said high frequency circuit comprising a hollow conductive system including a pair of hollow metallic conductors, adjustable tuning means interposed between and electrically connected to each one of said hollow metallic conductors, a metallic screen surrounding said hollow metallic conductors and electrically connected to said screen grid, and means to force air through said hollow metallic conductors and against each one of said anodes.

7. An ultra high frequency amplifier system comprising an electron discharge device, a metallic screen surrounding a substantial portion of said electron discharge device, a hollow metallic variable inductive tuning element having a plurality of apertures therein, said hollow metallic tuning element located within said metallic screen, said electron discharge device located within some of the apertures of said hollow metallic tuning element, a source of cooling fluid supply for said electron discharge device, and fluid communication means being connected between said source of cooling fluid supply and one of the other apertures of said hollow metallic tuning element, the arrangement being such that the cooling fluid passes and surrounds said electron discharge device.

8. An ultra high frequency amplifier system comprising an electron discharge device, a me-

tallic screen insulated from ground and surrounding a substantial portion of said electron discharge device, a hollow metallic variable inductive tuning element having a plurality of apertures therein, said hollow metallic tuning element located within said metallic screen, said electron discharge device located within some of the apertures of said hollow metallic tuning element, a plurality of contact fingers surrounding some of said apertures and arranged in spaced relationship with each other, a source of cooling fluid supply for said electron discharge device, and fluid communication means being connected between said source of cooling fluid supply and one of the other apertures of said hollow metallic tuning element, the arrangement being such that the cooling fluid passes and surrounds a portion of said electron discharge device, then flows through the spaces between said contact fingers, continuing through said apertures to cool the other portions of said electron discharge device.

9. An ultra high frequency amplifier system having in combination a pair of electron discharge devices, each one having at least anode, grid and cathode electrodes, a high frequency circuit connected to said anodes, said high frequency circuit comprising a hollow conductive system including a pair of hollow metallic conductors, adjustable tuning means interposed between and electrically connected to each one of said hollow metallic conductors, water cooling means for said anode, grid and cathode electrodes of each one of said electron discharge devices, means to force air through said hollow metallic conductors and against each one of said anodes, and means to force air on said grid and cathode electrodes of each electron discharge device.

10. Ultra high frequency apparatus in combination an electron discharge device having at least anode, grid, screen grid and cathode electrodes, a high frequency circuit including a hollow metallic element having substantially straight walls, said hollow metallic element electrically connected to said anode, a hollow metallic element electrically connected to said screen grid electrode surrounding the first mentioned hollow element, means for forcing air through both of said hollow metallic elements and against said electron discharge device, and water cooling means for said anode, cathode and grid electrodes.

11. An ultra high frequency amplifier system comprising an electron discharge device having at least anode, grid, screen grid and cathode electrodes, a first hollow metallic tuning element having a plurality of apertures therein, a second hollow metallic tuning element having a plurality of apertures therein, said electron discharge device located within some of the apertures of both said first and second hollow metallic tuning elements, a source of cooling fluid supply for said electron discharge device, said first metallic tuning element electrically connected to said anode electrode, said second metallic tuning element electrically connected to said screen grid electrode, and fluid communication means passing through one of the other apertures in said second metallic tuning element and being connected between said source of cooling fluid supply and one of the other apertures of said first hollow metallic tuning element, the arrangement being such that the cooling fluid passes and surrounds said electron discharge device.

12. An ultra high frequency amplifier system comprising an electron discharge device having

at least anode, grid, screen grid and cathode electrodes, a first hollow metallic tuning element having a plurality of apertures therein, a second hollow metallic tuning element having a plurality of apertures therein, said electron discharge device located within some of the apertures of both said first and second hollow metallic tuning elements, said electron discharge device being flexibly mounted to permit heat expansion thereof relative to the first and second metallic elements, a source of cooling fluid supply for said electron discharge device, said first metallic tuning element electrically connected to said anode electrode, said second metallic tuning element electrically connected to said screen grid electrode, and fluid communication means passing through one of the other apertures in said second metallic tuning element and being connected between said source of cooling fluid supply and one of the other apertures of said first hollow metallic tuning element, the arrangement being such that the cooling fluid passes and surrounds said electron discharge device.

13. An ultra high frequency amplifier system comprising an electron discharge device having at least anode, grid, screen grid and cathode electrodes, a first hollow metallic tuning element having a plurality of apertures therein, a second hollow metallic tuning element having a plurality of apertures therein, said electron discharge device located within some of the apertures of both said first and second hollow metallic tuning elements, said electron discharge device being flexibly mounted to permit heat expansion thereof relative to the first and second metallic elements, a source of cooling fluid supply for said electron discharge device, said first metallic tuning element electrically connected to said anode electrode, said second metallic tuning element electrically connected to said screen grid electrode, fluid communications means passing through one of the other apertures in said second metallic tuning element and being connected between said source of cooling fluid supply and one of the other apertures of said first hollow metallic tuning element, the arrangement being such that the cooling fluid passes and surrounds said electron discharge device, and water cooling means for said anode, grid and cathode electrodes.

14. A push-pull ultra high frequency high power amplifier comprising a pair of electron discharge devices, each one having at least anode, grid, screen grid and cathode electrodes, a pair of hollow metallic tuning elements having straight walls and a plurality of apertures therein, an adjustable tuning member interposed between said hollow metallic tuning elements, a hollow metallic tuning element having a plurality of apertures therein, each one of said electron discharge devices located within some of the apertures of both said first and second mentioned hollow metallic tuning elements, said electron discharge devices being flexibly mounted to permit heat expansion thereof relative to the first and second mentioned metallic elements, a source of cooling fluid supply for said electron discharge devices, said first mentioned metallic tuning elements electrically connected to said anode electrode, said second mentioned metallic tuning element electrically connected to said screen grid electrode, fluid communication means passing through one of the other apertures in said second metallic tuning element and being connected between said source of cooling fluid supply and one of the other apertures of said first mentioned hol-

low metallic tuning elements, the arrangement being such that the cooling fluid passes and surrounds said electron discharge devices, and water cooling means for said anode, grid and cathode electrodes for each one of said electron discharge devices.

15. A push-pull ultra high frequency high power amplifier comprising a pair of electron discharge devices, each one having at least anode, grid, screen grid and cathode electrodes, a pair of hollow metallic tuning elements having straight walls and a plurality of apertures therein, an adjustable tuning member interposed between said hollow metallic tuning elements, a hollow metallic tuning element having a plurality of apertures therein, a plurality of contact fingers surrounding some of said apertures and arranged in spaced relationship with each other, each one of said electron discharge devices located within some of the apertures of both said first and second mentioned hollow metallic tuning elements, said electron discharge devices are each flexibly mounted to permit heat expansion thereof relative to the first and second mentioned metallic elements, a source of cooling fluid supply for each one of said electron discharge devices, and fluid communication means being connected between said source of cooling fluid supply and one of the other apertures of at least one of said hollow metallic tuning elements, the arrangement being such that the cooling fluid passes and surrounds a portion of each one of said electron discharge devices, then flows through the spaces between said contact fingers, continuing through said apertures to cool the other portions of each one of said electron discharge devices.

16. An ultra high frequency amplifier system comprising an electron discharge device of the type having a cylindrical anode, a glass bulb sealed to each end of said anode, a grid electrode connection located at one end of said glass bulb, a cathode electrode connection located at the other end of said glass bulb, a hollow metallic tuning element having a plurality of apertures therein, said electron discharge device located within some of the apertures of said hollow metallic tuning element, water cooling means for cooling said anode, cathode and grid electrodes, a plurality of contact fingers surrounding some of said apertures and arranged in spaced relationship with each other to make electrical contact between said anode and said hollow metallic tuning element, a source of cooling air supply for said electron discharge device, a spun glass air filter for said cooling air supply, and fluid communication means being connected between said source of cooling air supply and one of the other apertures of said hollow metallic tuning element, the arrangement being such that the cooling air passes around and surrounds a portion of said electron discharge device, then flows

through the spaces between said contact fingers, continuing through said apertures to cool the other portions of said electron discharge device.

17. An ultra high frequency amplifier system comprising an electron discharge device of the type having a cylindrical anode, a glass bulb sealed to each end of said anode, a grid electrode connection located at one end of said glass bulb, a cathode electrode connection located at the other end of said glass bulb, a screen grid having two external connection members, each one of which is located intermediate said anode and an end of said tube, a hollow metallic tuning element having a plurality of apertures therein, said electron discharge device located within some of the apertures of said hollow metallic tuning element, water cooling means for cooling said anode, cathode and grid electrodes, a plurality of contact fingers surrounding some of said apertures and arranged in spaced relationship with each other to make electrical contact between said anode and said hollow metallic tuning element, a source of cooling fluid supply for said electron discharge device, and fluid communication means being connected between said source of cooling fluid supply and one of the other apertures of said hollow metallic tuning element, the arrangement being such that the cooling fluid passes around and surrounds a portion of said electron discharge device, then flows through the spaces between said contact fingers, continuing through said apertures to cool the other portions of said electron discharge device.

18. An ultra high frequency amplifier system comprising an electron discharge device of the type having a cylindrical anode, a glass bulb sealed to each end of said anode, a grid electrode connection located at one of said glass bulbs, a cathode electrode connection located at the other end of said glass bulb, a screen grid having two external connection members, each one of which is located intermediate said anode and an end of said tube, a hollow metallic tuning element having a plurality of apertures therein, said electron discharge device located within some of the apertures of said hollow metallic tuning element, water cooling means for cooling said anode, cathode and grid electrodes, a source of cooling fluid supply for said electron discharge device, and fluid communication means being connected between said source of cooling fluid supply and one of the other apertures of said hollow metallic tuning element, the arrangement being such that the cooling fluid passes around and surrounds a portion of said electron discharge device, then flows through the spaces between said apertures and said electron discharge device, continuing through said apertures to also cool the glass bulb portions of said electron discharge device where they join the anode.

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