Nov. 29, 1938. N. E. LINDENBLAD 2,138,181

SHORT WAVE SIGNALING

Original Filed Jan. 14, 1933 2 Sheets-Sheet 1

Fig. 1

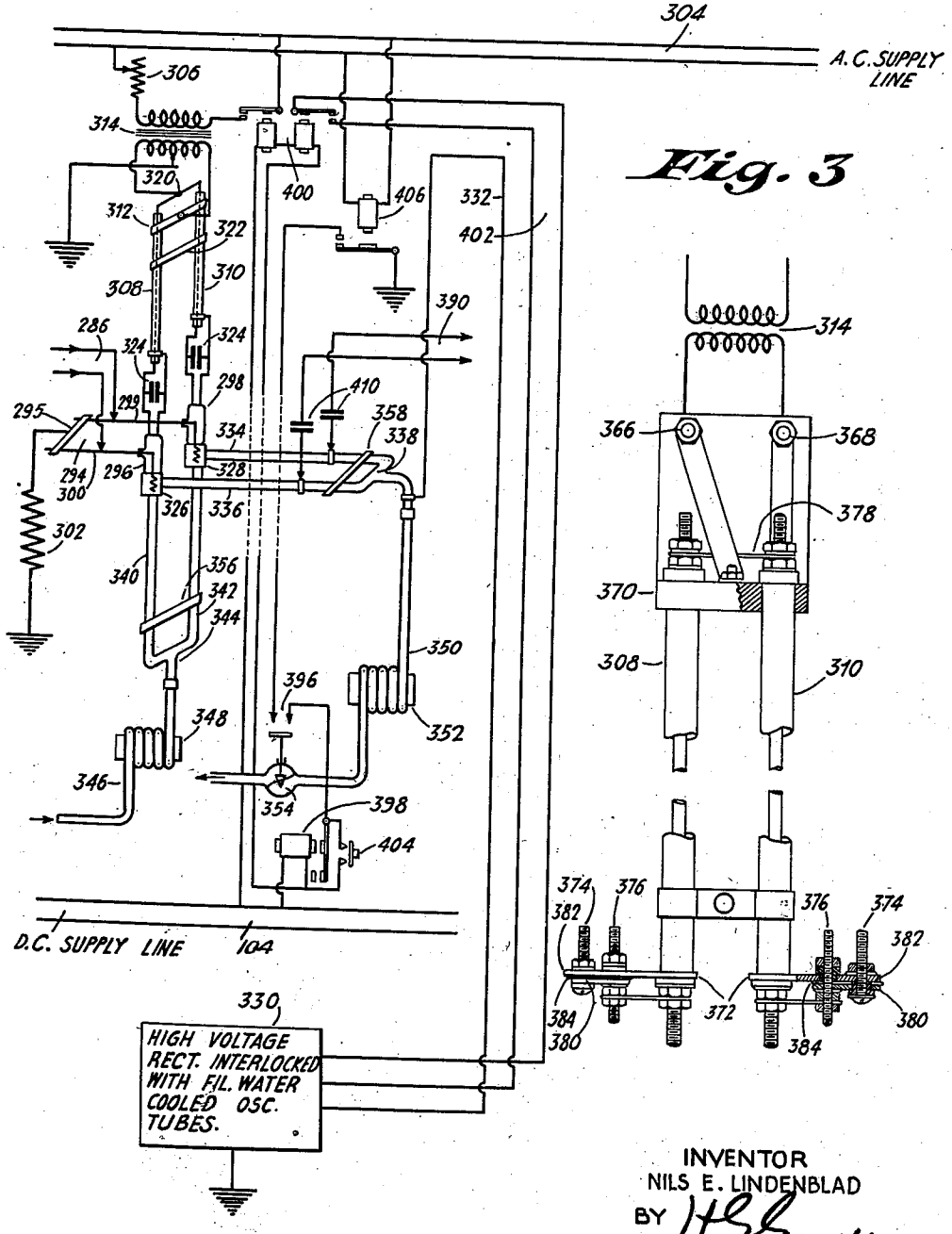


Fig. 3

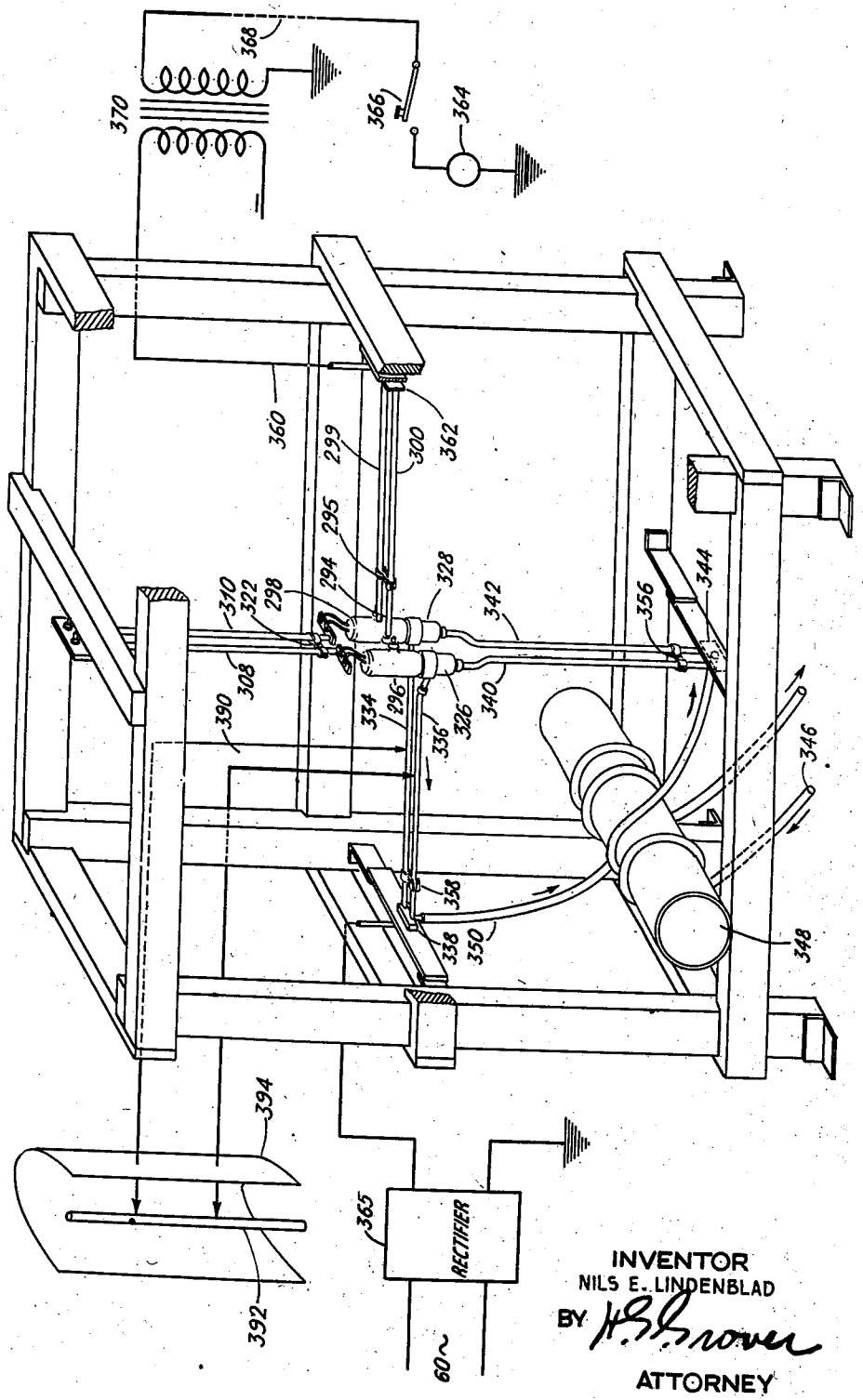
INVENTOR
NILS E. LINDENBLAD
BY H. S. Lowen
ATTORNEY

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Fig. 2



INVENTOR
NILS E. LINDENBLAD
BY H. G. Grover
ATTORNEY

Patented Nov. 29, 1938

2,138,181

UNITED STATES PATENT OFFICE

2,138,181

SHORT WAVE SIGNALING

Nils E. Lindenblad, Port Jefferson, N. Y., assignor to Radio Corporation of America, a corporation of Delaware

Original application January 14, 1933, Serial No. 651,809. Divided and this application December 23, 1933. Serial No. 703,850

27 Claims. (Cl. 250—27)

My present invention, which is a division of my copending application Serial Number 651,809, filed January 14, 1933, now United States Patent No. 2,052,888, granted September 1, 1936, has for one of its objects, the provision of means for the production of short waves at very high power. A further object of my present invention is to provide a fluid or water cooled amplifier and/or oscillator system especially adapted for the high powered amplification of very short waves.

An important feature of my water cooled system is the provision of circuits which serve the dual function of acting as high frequency circuits and also as means for conducting cooling fluid to and away from the tubes forming the amplifier and/or water cooled oscillation generator. My water cooled amplifier and/or oscillation generator is further characterized by the fact that the circuits are arranged in such a way that no radio frequency insulators are required and in this manner increases the efficiency of the short wave system to say nothing of the presentation of many mechanical advantages.

As a further feature I have provided an interlocking system for the water cooled amplifier and/or oscillator which serves to shut down the oscillator electrically should the filament current, plate voltage, or water supply fail.

Still other objects, as well as advantages and features of my present invention, will become apparent as the more detailed description thereof proceeds. This detailed description may best be understood by referring to the accompanying drawings wherein the same parts are represented by the same reference numerals.

In the drawings:

Figure 1 illustrates my improved fluid cooled system and an interlocking arrangement therefor,

Figure 2 illustrates in greater detail the mechanical construction of my water cooled high frequency amplifier of Figure 1 and also shows how that amplifier may be used as an oscillation generator in a short wave transmission system; and,

Figure 3 shows in detail the mechanical construction of the filament heating circuit used for the water cooled amplifier of Figures 1 and 2.

Referring to Figure 1, a suitable source of energy (not shown) feeds, through transmission line 286, the tunable output or grid circuit 294 of the fluid or water cooled tubes 296, 298. The input circuit 294 as shown, is formed of two conductors having uniformly distributed inductance and capacity tuned by adjustment of slider 295 in contact with the input conductors 299, 300 forming the input circuit. Grid or control electrode bias for the grids of tubes 296, 298 is obtained due to rectification action by the use of resistor 302 connected to the conductor slider 295. The filaments of the tubes 296, 298 are energized from the A. C. supply line 304, filament temperature control being obtained by means of variable resistor 306.

The filament or cathode circuit of the tubes 296, 298 consists of the conductor tubes 308, 310 connected through short circuiting strap 312 to one terminal of the secondary winding of filament transformer 314. The low frequency A. C. heating energy, therefore, passes from the right-hand terminal of the secondary winding of transformer 314 over the outer surfaces of tubes 308, 310, through the righthand filament leads and is returned through the inner conductors within the tubes 308, 310 to the other terminal of the secondary winding of transformer 314 through connection 320. The impedance of the filament circuit is adjusted by means of slider 322, and the filament heating conductors for each tube are arranged to act in parallel for the high frequency currents by virtue of by-passing condensers 324.

The electrodes of the tubes 296, 298 are enclosed by the fluid cooling or water cooling chambers 326, 328 in turn supplied with high voltage direct current potential from rectifier 330 through conductor 332 and the linear hollow tubes of conductive material 334, 336, which, in turn, may be longer than, equal to, or as long as an appreciable fraction of the operating wave length. The hollow conductors 334, 336 are electrically and fluid flow connected together by means of a header or T-shaped element 338 to which the voltage supply lead 332 is connected. The high voltage supply, consequently, is fed to a point of minimum radio frequency potential, or, putting it another way, to the electrical center of the U-shaped water cooled anode conductor structure comprising the linear tubes 334, 336. The linear tube structure, forming part of the high frequency circuits are of appreciable length relative to the operating wave length so that there is an appreciable fall in potential across portions thereof at the operating frequency.

In similar fashion, tubes 340 and 342 also linear or substantially straight, hollow, and made of conductive material such as copper, are electrically and fluid flow connected to the fluid cooling chambers 326, 328. The tubes 340, 342 are also connected together to form a U-shaped con-

ductive loop by the header or T-shaped element 344, in turn supplied with cooling fluid, such as water, through the coiled rubber pipe 346 which is wrapped about a suitable form 348 of insulating material. The cooling fluid therefore flows through the insulating coil 346 preferably of rubber, through the T-shaped header 344, through the pipes or tubes 340, 342, through the fluid cooling chambers 326, 328 electrically as well as flow associated with the anodes of the tubes 296, 298. From the fluid cooling chambers, the fluid cooling water flows through the tubes 334, 336 through header 338 and through rubber hose 350 coiled about form 352, out through valve 356. This cooling water flowing out from valve 354 may then be suitably cooled by means of a condenser (not shown) and repumped, if desired, through tube 346 by a suitable pump not shown. If desired the flow of water may be reversed. The impedance or tuning of each of the U-shaped cooling circuits for the anodes of the water cooled amplifier tubes 296, 298, is separately adjusted by means of the conductive sliders 356, 358.

By suitable adjustment of the sliders and potentials applied to the water cooled amplifier, it can be made to act either as an oscillation generator in which case it may be locked into step with the oscillations supplied through high frequency transmission line 286, or it can be made to act as a suitable amplifier supplying oscillations in its output circuit formed of conductors 334, 336, only when input potentials are applied to the input circuit 294.

The mechanical construction of my fluid cooled short wave system may be more clearly observed by referring to Figures 2 and 3, in the former of which it is illustrated as a self oscillation generator. Thus, referring to Figure 2, the tubes 296, 298 are connected to the water cooling chambers 326, 328. Cooling water is supplied through the rubber hose water inlet pipe 346 wrapped about form 348. This cooling water is then fed to the T-shaped header 344 from whence the water divides and flows up tubes 340, 342 into the bottom of the cooling chambers 326, 328. The cooling water and fluid then flows through the pipes or tubes 334, 336 where it is joined in the T-shaped header 338 and removed by way of rubber hose 350 wrapped about the common form 348.

The grid circuit 294, as shown in Figure 2, consists of the two tubes or conductors 299, 300. The slider 295, of course, may be moved along the length of the conductors 299, 300 for tuning purposes, and grid biasing potential is supplied through conductor 360 connected to the brass terminal 362, in turn connected to the grid conductors. As shown in Figure 2, in addition to the negative potential, there is superimposed upon the grids a keyed tone derived from source 364 and key 366 which tone is supplied over land line 368 and transformer 370 to the grids of the tubes. Plate potential is supplied from rectifier 365 and applied to the T-shaped header 338 through conductors 334, 336 to the plates of the tubes 296, 298.

The filament heating and tuning circuit may best be traced by referring to Figure 3. As shown diagrammatically in Figure 3, the secondary of transformer 314 is connected to the filament supply terminals 366, 368. Heating current may then flow from terminal 366 and the brass conducting piece 370 down the filament tubular conductors 308, 310 into the filaments by way of the metal straps 372 and filament terminals 374. The return current from the filaments passes through the terminals 376, the conductors within the tubes 308, 310 through conductive connection 378 to the other filament supply terminal 368. The condensers 324 shown in Figure 1 may be formed by the capacity existing between the copper straps or metallic connectors 380 and 382 which, of course, are separated by some suitable insulation such as the mica bushings 384.

The filament tuning strap 322, as shown in Figure 2, is, for longer waves, placed as closely to the tubes as possible forming a fairly direct short circuit between the filaments or cathodes. When shorter waves are to be produced, this slider is located further away but not necessarily a half wave length away from the filaments, although successful operation will be obtained even at that adjustment.

Either of the tubular plate circuits arranged at right angles to one another may be used as an output circuit. One pair may, if desired, be adjusted as a high impedance support and all of the tuning accomplished by adjustment of the slider on the other pair of tubular conductors, or, both circuits may be tuned and worked in parallel. Also, if desired, it is not necessary that the water tube circuits be arranged at right angles, but, a single pair of tubes or pipes may be used, each tube of the set being longitudinally divided into two compartments so that the same tube provides for inlet and outlet fluid flow. Also, if desired, although not preferable, the plate water cooling circuits may be arranged at an angle other than at right angles either obtuse or acute, and if desired may be arranged to run parallel to each other.

As shown in Figure 2, the output energy is fed through transmission line 390 to a half wave radiator 392 provided with a parabolic reflector 394 for unidirectional propagation.

The T-shaped headers on the anode tubes and the brass terminal piece 362 on the grid tubes, as well as the connections such as 312 (see Figure 1) for the filament tubes are voltage nodal points for the high frequency currents and this construction offers decided mechanical and electrical advantages. That is, these points, need only be insulated for the D. C. potentials, and may be held at ground for the radio frequency potentials besides serving as points for mechanically supporting the entire arrangement.

Thus, as shown in Figure 2, the tubes are firmly supported at point 362, at the water headers 344 and 338 and by the filament supply circuit by attachment to the wooden framework, or, if desired, suitably insulated metallic supports.

The various sliders may be used for adjusting the various circuits to various impedances or desired tunings. Output energy is taken from a point away from the plate sliding tuner on the horizontal conductors 334, 336 shown in Figure 2 at points such that the impedance of the hollow conductors between the tapping points and the slider equals the surge impedance of the transmission line 390, or as shown in Figure 1, equal to the surge impedance of the transmission line 390 which may feed the final frequency multiplier and amplifier.

To repeat, because of the unique construction of the water cooled amplifier, no radio frequency insulators are required, and this, as already indicated, is an important advantage inasmuch as one of the most troublesome features in the high frequency field is the problem of providing suitable radio frequency insulation.

There has also been provided, as shown in Figure 1, an interlock system to prevent the destruction of the tubes in the water cooled amplifier stage due to failure of either cooling fluid or electrical energy. In the event of water failure, the valve armature of valve 354 will drop, opening contacts 396. The opening of contacts 396 will consequently break the circuit from the bus 104 through electromagnet 398. Simultaneously, electromagnets 400 will become deenergized as a result of which the primary of transformer 314 will be opened causing the deenergization of the filaments of the water cooled amplifier. At the same time deenergization of the electromagnet 400 will open circuit 402 causing deenergization of the high voltage rectifier 330 thereby removing plate potential from the water cooled amplifier. Upon a return of cooling water supply the system must be manually reinstated by means of push button 404.

Assuming the alternating current source 304 for the high voltage rectifier 330 and for the filaments of the water cooled amplifier to fail, then, electromagnet 406 will become deenergized and successively electromagnets 398 and 400 will become deenergized causing the action as described above. Here again, return of the source of alternating current at 304 will not cause the system to start up, but manual reinstatement must be made by means of push button 404. It should be obvious, of course, why this interlock is provided, for failure of water supply would cause the rapid deterioration of the expensive water cooled tubes 296, 298; and, if the filaments were energized with the high plate potential on, they would be subjected to high undesirable stresses in their relatively cold condition.

The input to the high frequency water cooled amplifier from transmission line 286, is fed to the conductors of the input circuit 294 at points so spaced away from the short circuiting strap 295 that the portions of the conductors included between the tapping points and the short circuiting strap have an impedance substantially equal in value to the surge impedance of transmission line 286 to prevent dissipation of power.

The transmission line 390 need not be tapped on to the conductors 336, 334 through blocking condensers 410, but may be spaced from short circuiting or tuning strap 358 so as to suitably load the power amplifier.

Many minor changes may, of course, be made in the arrangements which I have described. Accordingly, my present invention is not to be limited by the exact illustrations or specific descriptions given herewith but is to be given the full scope and breadth indicated in the appended claims.

Having thus described my invention, what I claim is:

1. An ultra high frequency system comprising an electron discharge device having a fluid cooled chamber, a linear conductor electrically and flow connected to said chamber for supplying cooling fluid thereto, another linear conductor electrically and flow connected to said cooling chamber for removing cooling fluid therefrom, one of said conductors forming a portion of a high frequency circuit and being a substantial fraction of the operating wave length long, and means for varying the effective electrical length of one of said conductors.

2. A fluid cooled ultra high frequency system comprising a hollow linear conductor of appreciable length relative to the operating wave length of the system, means for causing cooling fluid to pass therethrough, means for causing currents of the desired operating wave length to flow thereover, and means for varying the effective electrical length of said conductor.

3. An ultra high frequency system comprising a plurality of electron discharge devices each having a cooling chamber, a linear conduit system electrically and flow connected to said chambers, the linear portion of said conduit system being of appreciable length relative to the operating wave length, means for causing cooling fluid to pass through said conduit system, means for causing high frequency currents to flow over said conduit system, and means for varying the effective electrical length of said conduit system.

4. A cooled ultra high frequency system comprising a circuit consisting of a pair of hollow linear conductors having appreciable length relative to the operating wave length, means for causing cooling fluid to pass through said linear conductors, means for causing the flow of high frequency currents in said conductors, and means for varying the effective electrical lengths of said hollow conductors.

5. A cooled ultra high frequency system comprising a pair of electron discharge devices each having a fluid cooled chamber, a pair of hollow linear conductors electrically and flow connected to said chambers, means for causing cooling fluid to pass through said conductors and said chambers, means for causing high frequency currents to flow in said conductors whereby throughout a portion of the length of said conductors there is an appreciable fall in potential at the operating frequency and means for varying the effective electrical lengths of said conductors.

6. A cooled ultra high frequency system comprising a pair of electron discharge devices each having a fluid cooled chamber, a hollow U-shaped conductor system connected to said chambers, another hollow U-shaped conductor system also connected to sad chambers, and means for causing the flow of cooling fluid through said U-shaped conductors and chambers, the legs of said U-shaped conductors being each at least as long as an appreciable fraction of the operating wave.

7. A cooled ultra high frequency system comprising a pair of electron discharge devices each having a fluid cooled chamber, a hollow U-shaped conductor system connected to said chambers, another hollow U-shaped conductor system also connected to said chambers, and means for causing the flow of cooling fluid through said U-shaped conductors and chambers, and a strap connected across the legs of one of said U-shaped conductors for adjusting the impedance thereof, said last U-shaped conductor having a length at least equal to an appreciable fraction of the operating wave.

8. A cooled ultra high frequency system comprising a pair of electron discharge devices each having a fluid cooled chamber, a hollow U-shaped conductor system connected to said chambers, another hollow U-shaped conductor system also connected to said chambers, means for causing the flow of cooling fluid through said U-shaped conductors and chambers, and a strap connected across the legs of each of said U-shaped hollow conductor systems for tuning same, said U-shaped conductors having a length at least equal to an appreciable fraction of the operating wave.

9. A cooled high frequency system comprising a pair of electron discharge devices, each having a fluid cooled chamber, a hollow U-shaped con-

ductor system connected to said chambers, another hollow U-shaped conductor system at an angle to said first U-shaped conductor system also connected to said chambers, and means for causing the flow of cooling fluid through said U-shaped conductors and chambers.

10. A cooled high frequency system comprising a pair of electron discharge devices each having a fluid cooled chamber, a hollow U-shaped conductor system connected to said chambers, and another hollow U-shaped conductor system at right angles to said first hollow U-shaped conductor system also connected to said chambers, and means for causing the flow of cooling fluid through said U-shaped conductors and chambers.

11. High frequency apparatus comprising a pair of tubes each having an anode, a grid, and a cathode, a U-shaped conductor connected between said cathodes, a U-shaped conductor connected between said grids, and a U-shaped conductor connected between said anodes, the conductors connected between said anodes and cathodes being arranged in a vertical plane and the conductors connected between said grids being arranged in a horizontal plane.

12. Apparatus as claimed in claim 11 characterized by the fact that means are provided for mechanically supporting said tubes and circuits at the conductor portions connecting together the legs of one or more of said U-shaped conductors.

13. A cooled ultra high frequency system comprising a pair of electron discharge devices each having a fluid cooled chamber, a U-shaped hollow conductor system electrically and flow connected to said chambers, means for causing cooling fluid to pass through said hollow conductor and said chambers, and means for varying the effective electrical length of said U-shaped conductor system, said U-shaped conductor having a length equal to at least an appreciable fraction of the operating wave.

14. High frequency apparatus comprising a pair of tubes each having an anode, a cathode, and a grid, a U-shaped conductor connected between said anodes, a U-shaped conductor connected between said grids, and a U-shaped conductor connected between said cathodes, said U-shaped conductor connected between said grids being arranged in a plane perpendicular to the plane or planes in which said other U-shaped conductors lie, and an additional U-shaped conductor connected between said anodes, said additional U-shaped conductor being arranged in a plane parallel to the plane of the U-shaped conductor connected between said grids.

15. In combination, an electric discharge device having an electrode, a circuit connection adapted to be traversed by alternating currents connected to said electrode, said circuit connection providing a passage for the circulation of fluid, and means for supporting said connection at a voltage nodal point for said alternating currents.

16. In combination, an electron discharge device having an anode electrode, a circuit connection comprising a hollow conductor providing a passage for the circulation of fluid and adapted to be traversed by high frequency currents connected to said anode, and means for supporting said hollow conductor at a voltage nodal point on said conductor.

17. In combination, an electron discharge device having an anode electrode, a pair of hollow conductors each providing a passage for the circulation of a cooling fluid connected to said anode electrode, said conductors being traversed by high frequency currents, one of said conductors being an inlet passage and the other an outlet passage for said fluid, and means for supporting each of said conductors at a voltage nodal point thereon for said high frequency currents.

18. A system as defined in claim 15, including a slider in direct contact with said connection for tuning the effective electrical length of said connection.

19. An electron discharge device having a filamentary cathode, a U-shaped connection for feeding heating energy to said cathode, said connection being traversed by high frequency currents employed by said device, and means for supporting said connection at the junction of the legs of said U at a voltage nodal point thereon for said high frequency currents.

20. Apparatus in accordance with claim 19, including a slider in direct contact with the legs of said U-shaped connection for tuning the effective electrical length thereof.

21. A pair of electron discharge devices each having anode, cathode and grid electrodes, individual U-shaped connections coupling corresponding electrodes of said devices together, and means for supporting each of said U-shaped connections at a voltage nodal point thereon for the high frequency currents traversing same.

22. A system in accordance with claim 21, characterized in this that said U-shaped connections are tubular conductors, and said means support said conductors at the electrical centers of said U-shaped connections.

23. In combination, a pair of electron discharge devices each having anode, cathode and grid electrodes, individual connections coupling corresponding electrodes of said devices together, the connection between said grids comprising a U-shaped connection, a circuit including a pair of wires connected to the two legs of said U-shaped connection at tapping points, an adjustable short-circuiting strap connected across the legs of said U-shaped connection and located between said tapping points and the trough of said U, the impedance of said strap and the portion of said legs located between said strap and said tapping points being equal to the impedance of said pair of wires.

24. In combination, a pair of electron discharge devices each having anode, cathode and grid electrodes, individual connections coupling corresponding electrodes of said devices together, the connection between said anodes comprising a U-shaped connection, a circuit including a pair of wires connected to the two legs of said U-shaped connection at tapping points, an adjustable short-circuiting strap connected across the legs of said U-shaped connection and located between said tapping points and the trough of said U, the impedance of said strap and the portion of said legs located between said strap and said tapping points being equal to the impedance of said pair of wires.

25. In combination, a pair of multi-electrode electron discharge devices, a U-shaped connection coupling one electrode of one of said devices to the corresponding electrode of the other device, a circuit including a pair of wires connected to the two legs of said U-shaped connection at tapping points, an adjustable short-circuiting strap connected across the legs of said U-shaped connection and located between said tapping points and the trough of said U, the impedance

of said strap and the portion of said legs located between said strap and said tapping points being equal to the impedance of said pair of wires.

26. A high frequency system comprising an electron discharge device having a filament, an anode, and a fluid cooled chamber, one or more sources of energy for supplying heating current to said filament and a polarizing potential to said anode, an inlet and an outlet for said chamber to enable the cooling fluid to flow therethrough, and means responsive to failure of said fluid to flow to said chamber for removing the heating current from said filament and the polarizing potential from said anode.

27. A system in accordance with claim 26, characterized in this that said fluid is water, and said means responsive to the failure of said water to flow to said chamber includes a water valve in the water supply system, and a relay whose operativeness depends upon the position of said valve.

NILS E. LINDENBLAD.