July 5, 1960 R. L. WALTER ET AL 2,944,187

ELECTRON TUBE APPARATUS

Filed June 14, 1955 8 Sheets-Sheet 1

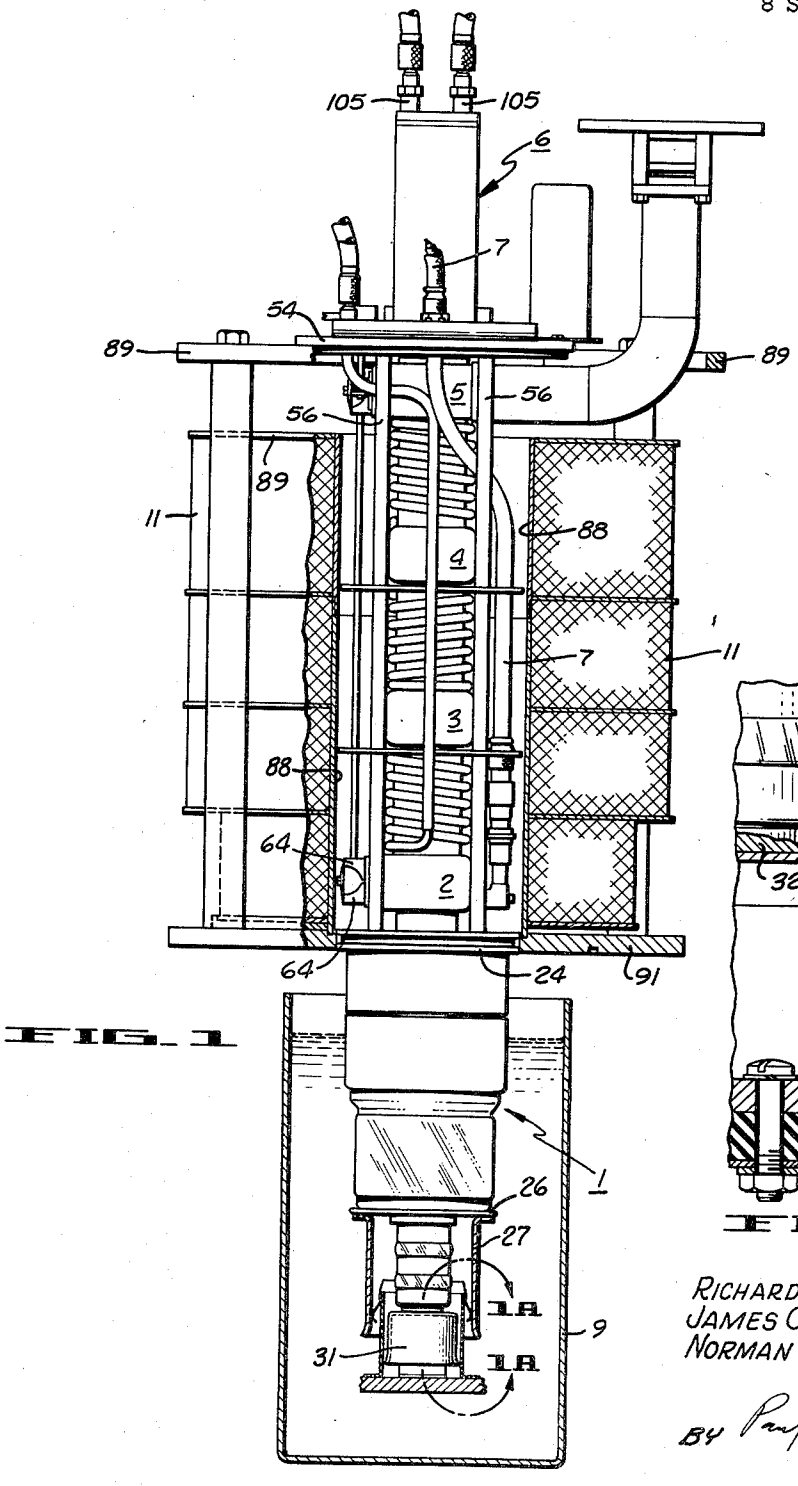


FIG. 1

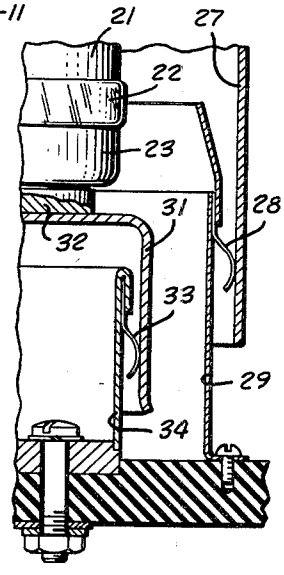


FIG. 1A

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ELECTRON TUBE APPARATUS

Filed June 14, 1955 8 Sheets-Sheet 2

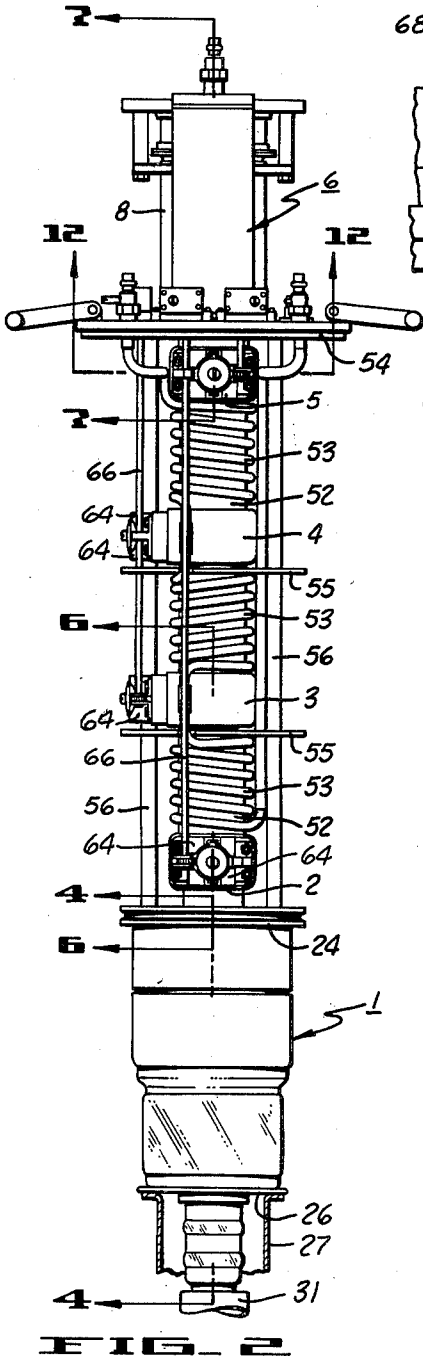


FIG. 2

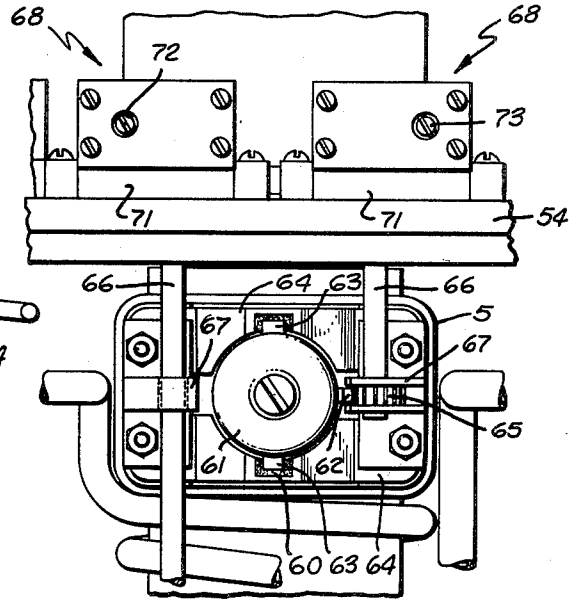


FIG. 3

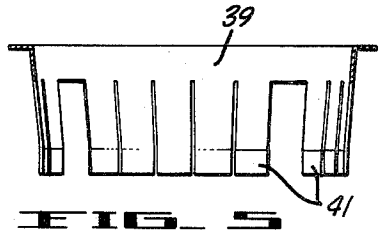


FIG. 5

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ELECTRON TUBE APPARATUS

Filed June 14, 1955 8 Sheets-Sheet 3

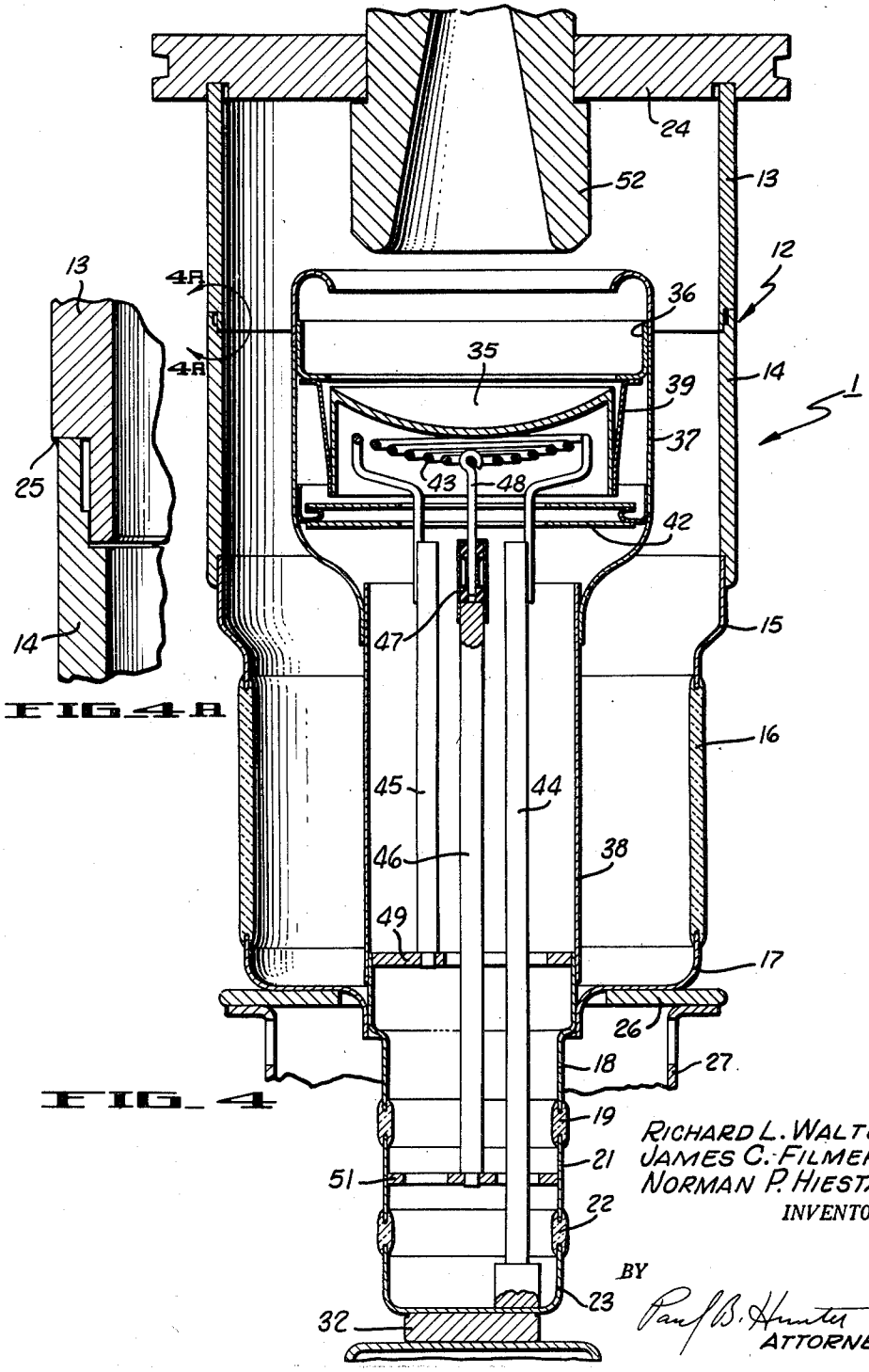


FIG. 4A

FIG. 4

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ELECTRON TUBE APPARATUS

Filed June 14, 1955 8 Sheets-Sheet 4

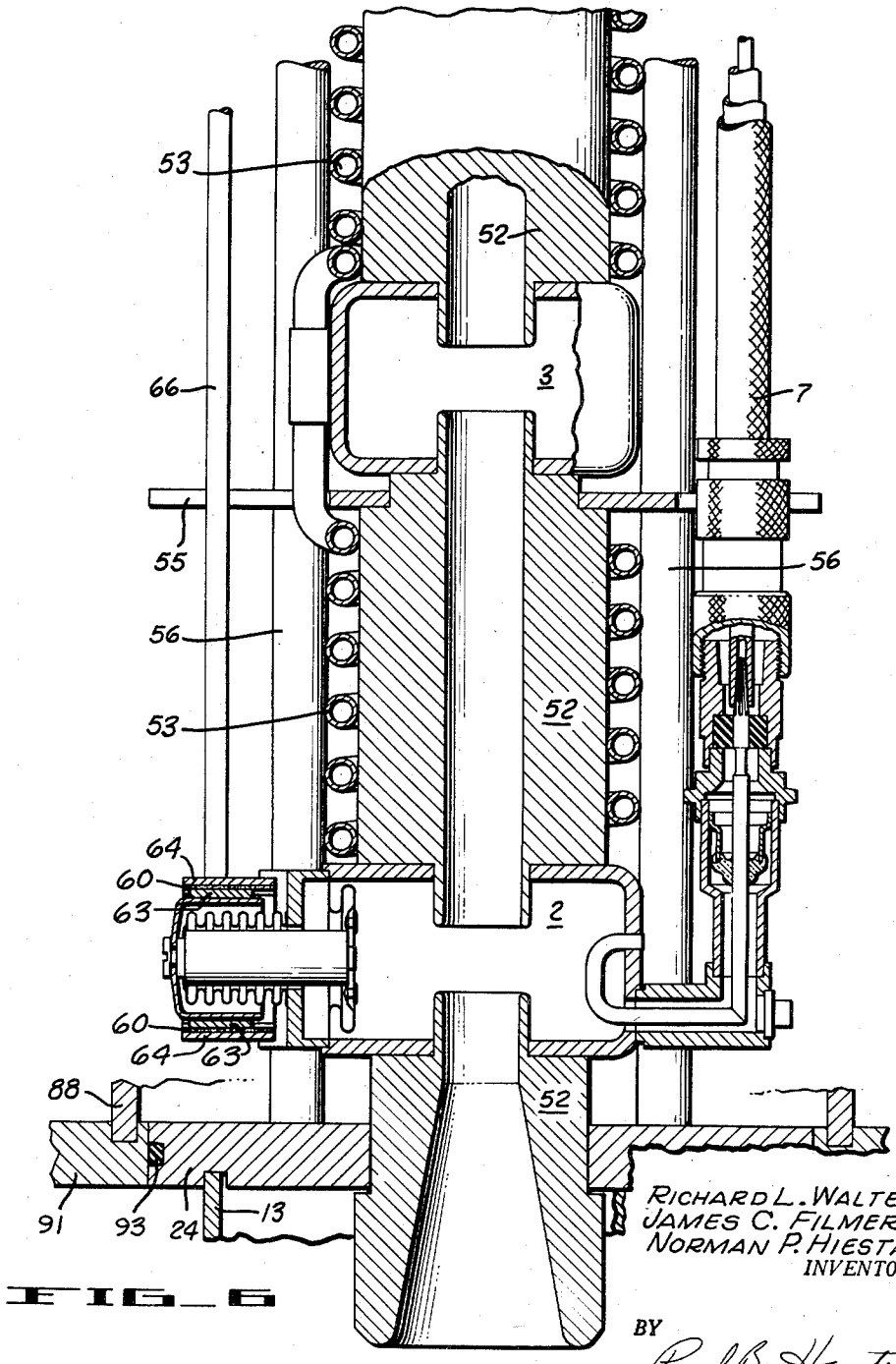


FIG. 6

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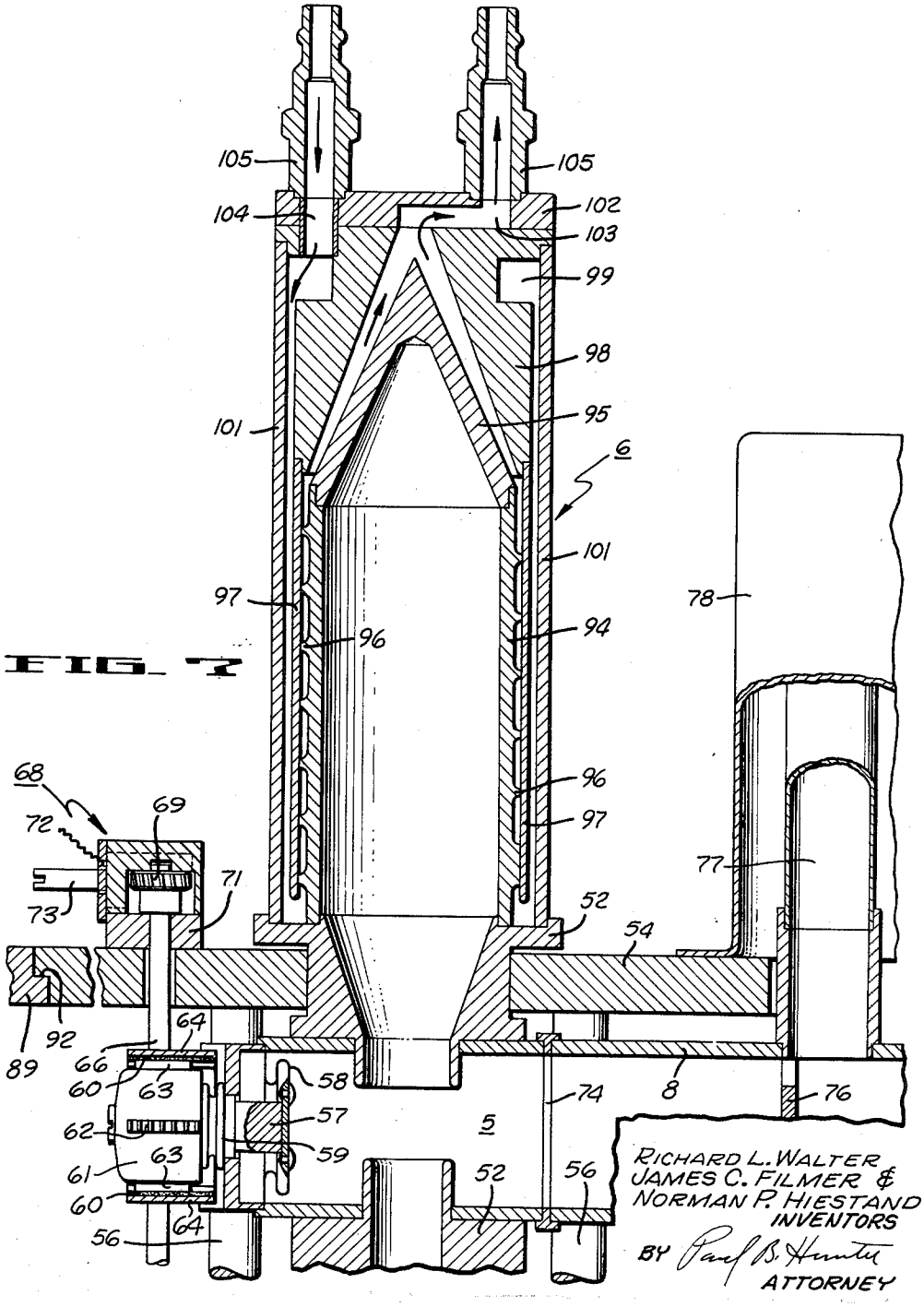
July 5, 1960 R. L. WALTER ET AL 2,944,187

ELECTRON TUBE APPARATUS

Filed June 14, 1955

8 Sheets-Sheet 5

FIG. 2



July 5, 1960 R. L. WALTER ET AL 2,944,187

ELECTRON TUBE APPARATUS

Filed June 14, 1955

8 Sheets-Sheet 6

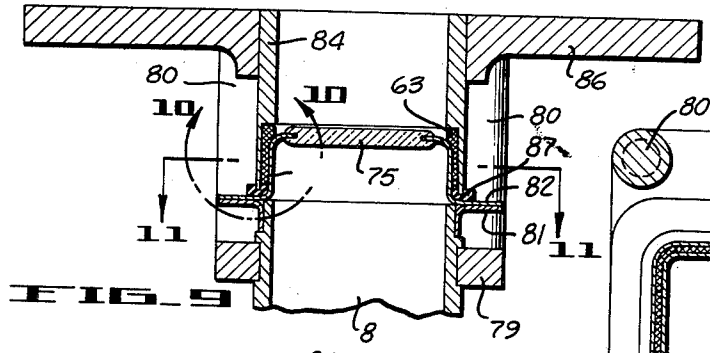


FIG. 9

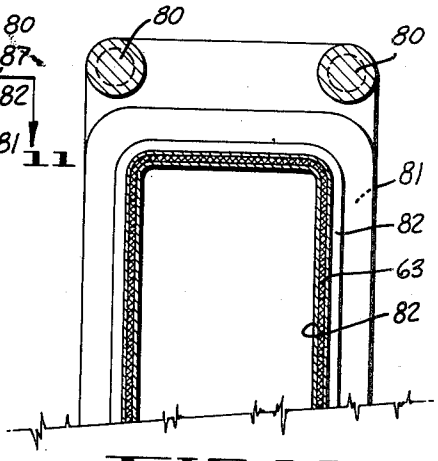


FIG. 11

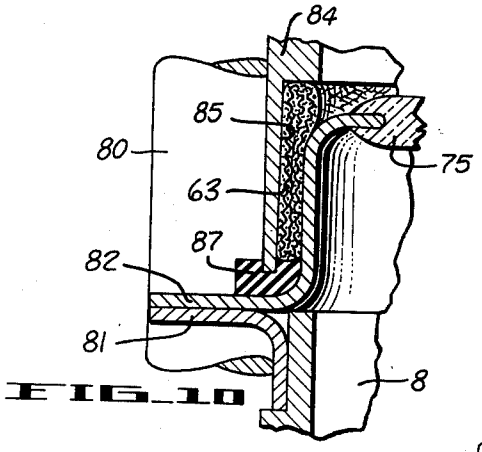


FIG. 10

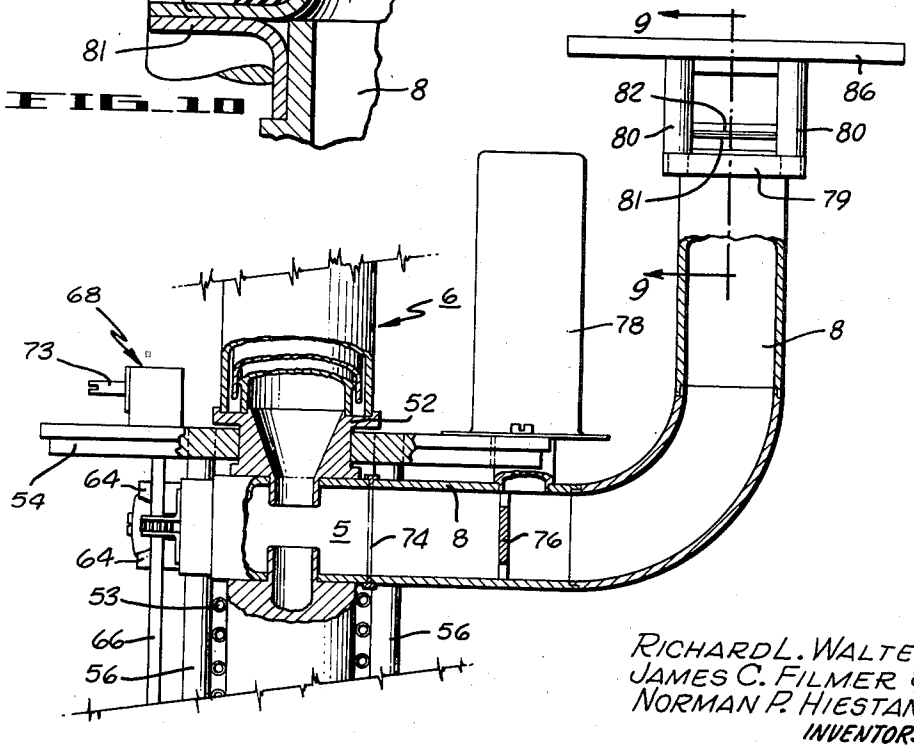


FIG. 8

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ELECTRON TUBE APPARATUS

Filed June 14, 1955

8 Sheets-Sheet 7

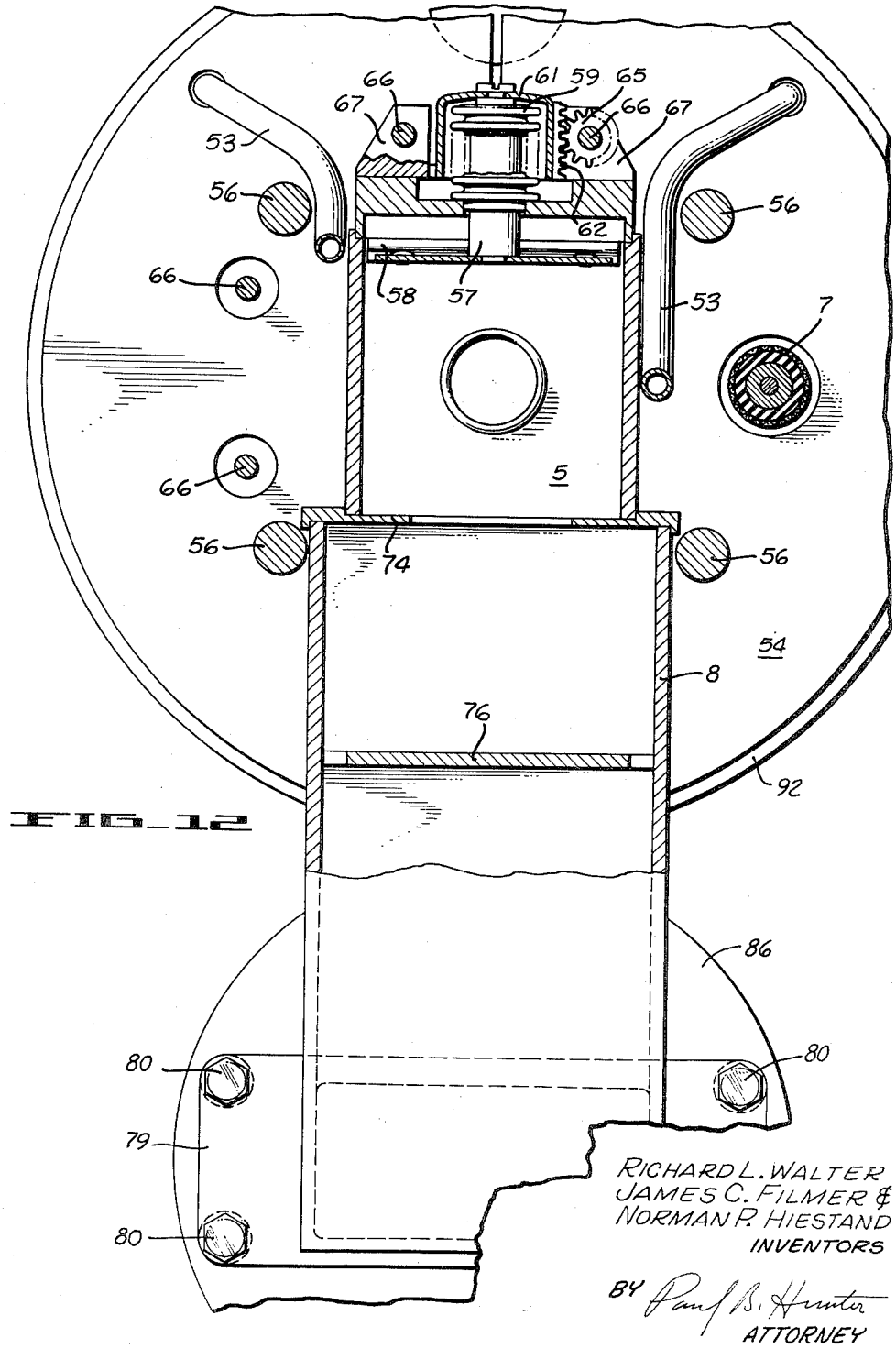


FIG. 12

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ELECTRON TUBE APPARATUS

Filed June 14, 1955 8 Sheets-Sheet 8

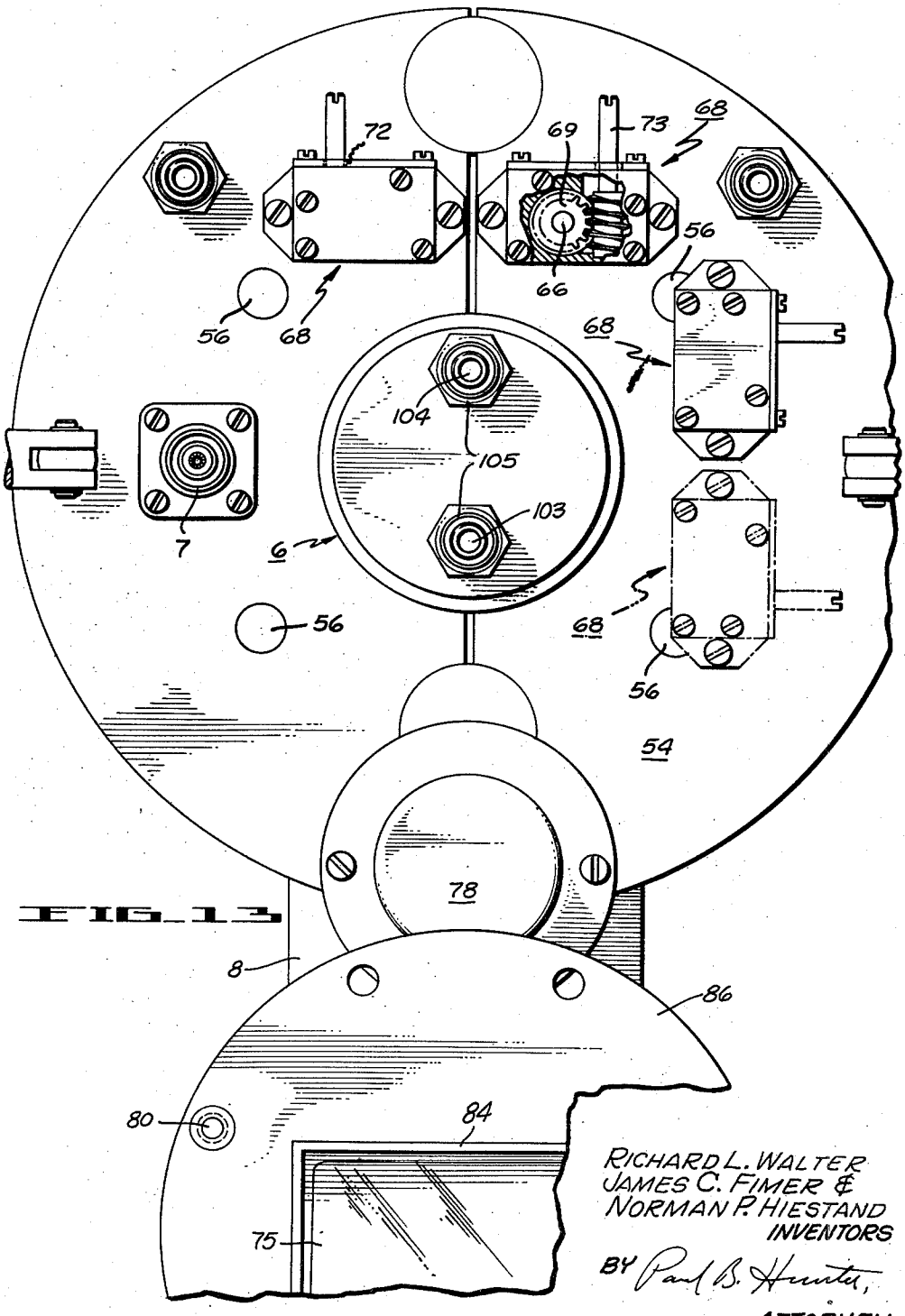


FIG. 13

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United States Patent Office 2,944,187 Patented July 5, 1960

2,944,187

ELECTRON TUBE APPARATUS

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Filed June 14, 1955, Ser. No. 515,327

3 Claims. (Cl. 315—39)

This invention relates, in general, to electron tube apparatus and, in particular, to novel electron tube apparatus of the type employing cavity resonators such as, for example, high power klystron tubes utilized in systems found in radar, navigation beacons and linear accelerators, etc.

In the art of high frequency amplification, for example, that range of frequencies between 2500 and 4000 mc. there has been lacking a pulsed amplifier that would provide high gain, that is, 55 db or over; high power, that is 1 megawatt or more with an average power of 2 kw. at the same time combining reliability and long life (1000 hours) with ease of operation.

Accordingly, it is the object of this invention to provide a novel high power, high gain, electron tube apparatus offering ease of operation, long life, and electrical stability.

One feature of this invention is a novel cathode electrical socket comprising a plurality of spring fingers arranged such as to receive and make electrical contact with a corresponding tube contact thereby facilitating rapid replacement of tubes.

Another feature of this invention is an output window assembly which allows the output window to be pressurized and at the same time maintain a good electrical connection under conditions of expansion and contraction of the electrical contact members without the use of high temperature solders thereby substantially increasing the operating life of the tube.

Other features and advantages of this invention will become apparent from a perusal of the specifications taktn in connection with the accompanying drawings wherein,

Fig. 1 is an elevational view partly in section showing the assembled electron tube apparatus of this invention,

Fig. 1–A is an enlarged fragmentary view of a portion of the structure of Fig. 1,

Fig. 2 is a fragmentary side elevation of the structure of Fig. 1,

Fig. 3 is a fragmentary end view of a cavity resonator and associated parts,

Fig. 4 is a cross sectional elevational view of the cathode assembly taken along line 4—4 of Fig. 2,

Fig. 4–A is a fragmentary view of Fig. 4 showing the cathode take-apart joint,

Fig. 5 is an enlarged fragmentary view of the novel cathode button support.

Fig. 6 is an enlarged part sectional view taken along line 6—6 of Fig. 2 looking in the direction of the arrows,

Fig. 7 is an enlarged cross sectional view taken along line 7—7 of Fig. 2 looking in the direction of the arrows,

Fig. 8 is a fragmentary side view partly in section showing the location of the output window assembly,

Fig. 9 is a sectional view taken along line 9—9 of Fig. 8,

Fig. 10 is a fragmentary view taken along line 10—10 of Fig. 9 showing the electrical contact and pressure seal of the output window assembly,

Fig. 11 is a fragmentary top view of the output window assembly taken through line 11—11 of Fig. 9,

Fig. 12 is a sectional view taken along line 12—12 of Fig. 2 looking in the direction of the arrows,

Fig. 13 is an end view of the apparatus looking in from the collector end.

The construction of the novel electron tube apparatus will now be described followed by a description of the operation and function of the apparatus.

Referring now to Fig. 1, the novel tube apparatus comprises a cathode structure 1, resonators 2, 3, 4 and 5 and a collector assembly 6. Signal energy to be amplified is supplied to the first resonator 2 via a concentric line input 7 and amplified in successive resonators 3 and 4. The amplified signal is extracted from the output resonator 5 and propagated to the load through waveguide 8. The cathode is immersed in an oil bath contained within a tank 9 to prevent arc-overs in the external cathode region. Surrounding the resonators is an electrical coil 11 for creating a strong magnetic field to confine the electron beam in the resonator region.

Referring now to Fig. 4, a source of electrons is supported from and contained within an evacuated cathode envelope 12. Comprising the cathode envelope are a plurality of tubular segments 13, 14, 15, 16, 17, 18, 19, 21 and 22 joined together at their ends. Of these tubular segments 16, 19 and 22 are of good insulating material as of glass to allow independent operating potentials to be applied to certain portions of the cathode assembly. Tubular segments 13 and 14 are made of materials having a high magnetic permeability as of steel to provide shielding of the cathode from magnetic fields in the cathode vicinity. The cathode envelope is closed at its lower end by a bottom cup 23 and at its upward end is securely held by pole piece 24.

To allow the cathode assembly to be replaced a novel take-apart joint between cathode envelope segments 13 and 14 is provided (see Fig. 4–A). At the joint, proper longitudinal alignment of the lower cathode structure is obtained through the upper horizontal interface. Correct transverse alignment of the cathode is obtained through the vertical interface. Interposed between these two interfaces is an area of mutually opposing surfaces which are noncontacting, that is, the opposing faces are spaced apart. These surfaces are spaced apart to create a void which destroys the capillary action tending to draw the adhesive substance 25 from its applied region through the horizontal interface and onto the vertical interface. If the void is not provided adhesive material will contaminate a greater portion of the interfaces. When the lower cathode assembly is then to be replaced, the adhesive material sticking to the aligning surfaces must be removed. Oftentimes in cleaning the adhesive from these surfaces the previously acquired alignment is destroyed. The present novel joint design allows the cathode to be removed, worked on and replaced without expending unnecessary time in cleaning the joint, meanwhile preserving the previously acquired proper transverse alignment. This take apart feature is claimed in a copending divisional application, Serial No. 831,178.

Encircling the cathode envelope at segment 17 and fixedly secured thereto is a novel annular cathode flange

26. The cathode flange is of heavier construction and serves to strengthen the more fragile cathode envelope. Furthermore cathode flange 26 serves as a bumper protector for the glass insulator 16.

The novel cathode electrical socket is shown in Fig. 1–A. Fixedly secured to the annular cathode flange 26 and downwardly extending therefrom is a tubular cathode electrical contact 27 which engages a plurality of spring type electrical wipers 28 carried upon a cylindrical support lead 29. Similarly, a cup-shaped heater contact 31 is secured to the lower extremity of the cathode envelope through heater flange 32 and extends downwardly therefrom to engage a plurality of heater wipers 33 carried upon a tubular heater supply lead 34. As the tube is inserted into the oil bath the spring type electrical wipers engage their respective contacts and because of the spring tension force themselves against the contacting surface. The leading edge of said wipers clean an area for good electrical contact. Using the present design it is readily seen that the time required to change a tube is substantially reduced.

The internal cathode structure is shown in detail in Fig. 4. Contained within the cathode envelope 12 is preferably a concave cathode emitter 35 having an annular focus ring 36 positioned slightly in front of said button and carried by a tubular focus shield 37 which in turn is supported from the cathode envelope by focus shield support 38. Fixedly secured to the cathode focusing ring 36 and extending downwardly therefrom is a novel tubular cathode emitter support 39 (see Fig. 5) having slots running longitudinally thereof thereby creating a plurality of fingers 41. Also carried by the focus shield 37 is an annular double partition heat shield 42 (Fig. 4).

The present novel cathode construction features a cathode emitter surrounded by a plurality of partitions all serving to retain the heat energy within the cathode emitter region thereby substantially increasing thermal efficiency. The cathode emitter support 39 is particularly unique in that the longitudinal slots serve to inhibit heat conduction while the finger portions 41 reflect the heat energy back to the cathode emitter. It has been found that certain fingers may be cut out to aid in evacuation of the inner cathode regions without substantially impairing thermal efficiency. A second embodiment of the novel cathode emitter support 39 has certain fingers bent outwardly a short distance to substantially a condition of constant diameter for those portions of the tubular member, leaving a plurality of inwardly convergent fingers to which the cathode emitter is affixed. This novel design further prevents heat loss by conduction since fewer fingers make contact with the cathode emitter. In all embodiments the cathode emitter 35 is rigidly secured to the extremities of certain of the button support fingers. The cathode button support feature is claimed in a copending divisional application, Serial No. 831,178.

Heating the cathode emitter 35, a double spiral wound filament 43 is supported upon three support rods, long heater lead 44, short heater lead 45 and center support 46. Since center support 46 carries no current it is insulated electrically from the heater filament 43 through insulator 47. Extending into the insulator and connecting directly to the filament, is heater support 48. Providing base supports for short heater lead 45 and filament center support 46 are two circular plates, heater support flange 49 and getter flange 51 respectively, said flanges being rigidly secured to the cathode envelope 12. Long heater lead 44 extends downwardly through noncontacting openings in heater support flange 49 and getter flange 51 and anchors on bottom cup 23.

Referring now to Figs. 2 and 6, a plurality of reentrant type cavity resonators 2, 3, 4 and 5 are spaced along thick-walled cylindrical drift tubes 52. Spiraling around the drift tubes is a cooling coil 53 through which is circulated a coolant to carry away heat generated in the drift tube vicinity. Encircling and securely affixed to the drift tube substantially at either end thereof are two magnetic pole pieces, cathode pole piece 24 and anode pole piece 54. A plurality of stiffener plates 55 likewise encircle the drift tube and are spaced apart in the drift tube midsection. Interconnecting the pole pieces and stiffener plates are a plurality of stiffener rods 56 which are rigidly secured to the stiffening plates as by brazing. It has been found that by utilization of the novel stiffener plates and rods the microphonic tendency of such an electron tube apparatus was substantially reduced. Moreover, electrical stability under high ambient temperatures was greatly enhanced. Because of the magnetic focusing, not yet fully described, the aforementioned magnetic pole pieces 24 and 54 are constructed of a material of high magnetic permeability such as, for example, iron. On the other hand, in the area between the pole pieces the magnetic field should not be perturbed, thus where possible parts should be made of materials possessing no magnetism, for example, the stiffener rods 56 and plates 55 could be constructed of a non-magnetic variety of stainless steel. This tube strengthening feature is claimed in a copending divisional application, Serial No. 831,178.

Tuning of the cavity resonators is accomplished through a plurality of tuning plungers 57 (Fig. 12) movable within the cavity resonators and extending outwardly thereof through an aperture in the resonator wall. Secured to the inward end of the tuning plunger 57 is a thin rectangular flexible metal diaphragm 58 of a good electrical conducting material, for example, copper plated Monel. The flexible diaphragm is secured to the cavity resonator wall on two opposite edges only, the remaining two edges being slightly spaced from the resonator walls. Interposed between the outside wall of the cavity resonator and the outward extremity of the plunger extension is a bellows 59 which envelops the tuning plunger. The bellows is sealed at one end to the plunger and at the other end to the outer wall of the cavity resonator thereby maintaining vacuum integrity within the cavity while at the same time allowing movement of the tuning plunger 57.

Secured to and surrounding the outward extremity of the tuning plunger is a cup-shaped tuning rack support 61 having attached to its outward wall in diametrically opposed relation two smooth rectangular bars, tuning rack support guides 63 (Figs. 3 and 7). Similarly mounted on said tuning rack support 61 and ninety degrees to said guides 63 is a toothed bar, tuning rack 62. Mounted on the outward side of the cavity end wall and extending outwardly adjacent the tuning rack support guides 63 is tuner slide block 64 having two rectangular recesses cut therein (Fig. 3) and fitted with bearing liners 60 as of, for example, tetrafluoroethylene resin to receive the tuning rack support guides 63 slidable therein. Actuating the tuning plunger through coaction with tuning rack 62 is a pinion 65 mounted on one extremity of a tuning actuating rod 66 which extends through an opening in and is held in position by a pinion mount 67. Operating pinion 65 and upwardly extending through apertures suitably provided in the stiffener plates 55, actuating rod 66 (Fig. 2) further extends through output pole piece 54 and terminals in a gear case 68 (Fig. 13). Within the gear case and rigidly affixed to the tuner actuating rod is a toothed worm gear 69. Interposed between the toothed worm gear and the output pole piece is a rectangular gear case mounting plate 71 (Figs. 7 and 3) having an aperture therein, the inner surface of the aperture forming a bearing surface for tuner actuating rod 66. Enveloping the toothed worm gear 69 (Fig. 13) is the rectangular cup-shaped gear case 68 having an opening 72 in the side outward of the tube (Fig. 7). Rotatable within the gear case 68 is a worm shaft 73 positioned to cooperate with said toothed worm gear 69 said worm shaft extending outwardly of the gear case 68 and deriv-

ing bearing support from the inner surface of the side opening **72**. Remote actuating means may be coupled to the worm shaft **73** to effectuate remote tuning of the cavity resonators. Remote tuning is often desirable in variable frequency tubes. When installed in a system gaining access to the tube may be difficult. Moreover, in some high power applications X-ray radiation from the collector can be avoided by tuning from a remote station. The cavity tuning apparatus, above-described, is claimed in a copending divisional application, Serial No. 831,777.

Output energy (Fig. 8) is extracted from the output cavity resonator **5** through output iris **74**. Whence the energy is propagated through waveguide **8** outwardly and upwardly through output window **75** (Fig. 9) to the load. Within said waveguide is a blocking iris **76** for blocking stray secondary electrons emanating from the collector drift tube. For evacuation of the tube a pump-out adapter **77** is provided outwardly of the blocking iris and protected by an adapter cover **78**.

Substantially at the end of waveguide **8** and fixedly secured thereto is the novel output window assembly comprising a rectangular flange **79** bored to receive four bolts **80** (Fig. 8). At the end of said waveguide **8** (Figs. 9 and 10) is a second end flange **81** formed to mate with a like rectangular flange portion of a window mounting frame **82** having mounted therein the output window **75**. Encircling the output window frame is a pad of good electrical conducting wire mesh **63** of sufficient thickness to cause a good electrical connection with an enveloping outer segment of waveguide **84**. Said outer segment of waveguide is recessed at its lower end to form a pocket **85** for the wire pad **83** and extends upwardly of the output window. Rigidly secured to said outer segment of waveguide **84** is an output adapter flange **86** suitably bored and tapped to receive the aforementioned four bolts **80**. Interposed between the lower extremity of said outer segment of waveguide **84** and said output window flange **82** and encircling said output window flange is a resilient gasket **87** as of, for example, neoprene. To prevent arc-overs and thereby increase the life of the output window it has been found helpful to pressurize the waveguide on the outward side of the window. Because of the wide temperature fluctuations encountered, the output window frame experiences high expansion and contraction which necessitates the above novel arrangement of wire mesh and O ring seal, which will provide good electrical contact while maintaining an adequate seal.

Comprising the magnetic focusing assembly (Fig. 1) an electrical conducting coil **11** wound upon a hollow open-ended cylinder **88** encircles the drift tube midsection and is carried between two annular plates **89** and **91**. The magnetic coil assembly may be rigidly mounted and the tube body comprising the cathode, cavity, drift tubes and collector assemblies may be slidably inserted into the center of the magnetic coils. Upper annular plate **89** (see Fig. 7) has a step provided on and encircling its inner circumference which mates with a similar step **92** provided on anode pole piece **54** whereby the tube body is suspended within the magnetic coils. Snugly fitting within the lower annular plate **91** (Fig. 6) is cathode pole piece **24**. Encircling the outer periphery of cathode pole piece **24** is a recess carrying an O ring **93** of some resilient material, for example, neoprene, to insure that water vapors from the air do not seep through and contaminate the oil bath.

Comprising the collector assembly **6** (Fig. 7) a hollow open-ended cylindrical collector **94** carried by the drift tube **52** is closed at its upper end by a conical-shaped collector cone **95**. Cut into the exterior of the cylindrical collector **94** is a helical groove thereby creating a helical land **96**. Snugly fitting over the helical land is a hollow open-ended cylindrical baffle **97** slightly spaced apart at its free end from the drift tube **52**. Carrying the baffle **97** is a cylindrical coolant distributor **98** having a conical-shaped interior enveloping and being slightly spaced from the collector cone **95**. Substantially at the upward extremity of the coolant distributor **98** is an encircling recess **99** serving as a coolant distributor ring. Carrying the coolant distributor and surrounding the collector **94** and baffle **97** is a hollow open ended cylindrical coolant jacket **101** secured to the drift tube **52** at the lower end of the said jacket. Sealed over the outward end of the coolant distributor **98** is a circular plate, collector cap **102** having water passages **103** and **104** cut therein and fitted with quick disconnect fluid adapter **105**.

In operation electrons are emitted from the cathode focused into a beam by the focusing electrode **36** and accelerated through the drift tube. The signal to be amplified is fed into the input cavity **2** where the beam is velocity modulated. As the modulated beam travels down the drift tube it is further modulated by the intermediate bunching cavities **3** and **4**, while within the drift tube the beam is confined in diameter against forces tending to spread the beam, such as space charge forces, by the magnetic field lines supplied by the focusing coils **11**, said lines of flux being parallel to the drift tube in this region. The output cavity extracts electromagnetic energy from the modulated beam and said energy is then coupled out of the output cavity through iris **74** and propagated through waveguide **8** and window **75** to the load. Tuning of the tube is obtained by a movable wall type tuning plunger which is movable within the resonator by rotation of worm shaft **73** which operates upon actuating rod **66** which in turn cooperates through pinion **65** to cause tuner rack support and attached plunger and diaphragm to move in and out of the cavity thereby changing the resonant frequency of said cavity.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. In an electron tube apparatus an output window assembly comprising a wave energy permeable material covering an opening, a flanged frame holding said permeable material, a resilient electrical conductor encircling the outer sides of said frame, a gasket encircling said frame adjacent said flange portion, an outer waveguide enveloping said resilient electrical conductor, and means for pressing said outer waveguide snugly against said gasket thereby effecting an air tight electrical conducting seal between elements which differ greatly in their expansive characteristics.

2. In a high frequency apparatus, a wave energy permeable material covering an opening, a frame holding said permeable material, a resilient electrical conducting wire mesh contacting said frame, a waveguide contacting said mesh, and sealing means providing a seal between said frame and said waveguide thereby effectuating an electrical conducting seal capable of standing high pressures without leaking between elements which differ greatly in their expansive characteristics.

3. In an electron tube apparatus a cathode electrical socket comprising a first and second hollow cylindrical conducting receptacle disposed in concentric overlapping spatial relationship and adapted to be operated at different D.C. electrical potentials in use, first and second hollow cylindrical electrical contactor means concentrically disposed in overlapping spatial relationship fixedly carried upon the electron tube and adapted to make electrical contact with certain electrodes within the cathode assembly of the electron tube, and spring fingers carried from and outwardly tensioned of said first and second receptacles whereby when said contactors and receptacles are brought together said spring fingers cause a good electrical connection to be made between said receptacles and said contactors thereby assuring stable and reliable

supply of energy to certain of the electrodes within said cathode assembly of the electron tube apparatus.

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