

Feb. 17, 1953

W. W. EITEL ET AL  
ELECTRON TUBE

2,629,066

Filed Dec. 10, 1951

4 Sheets-Sheet 1

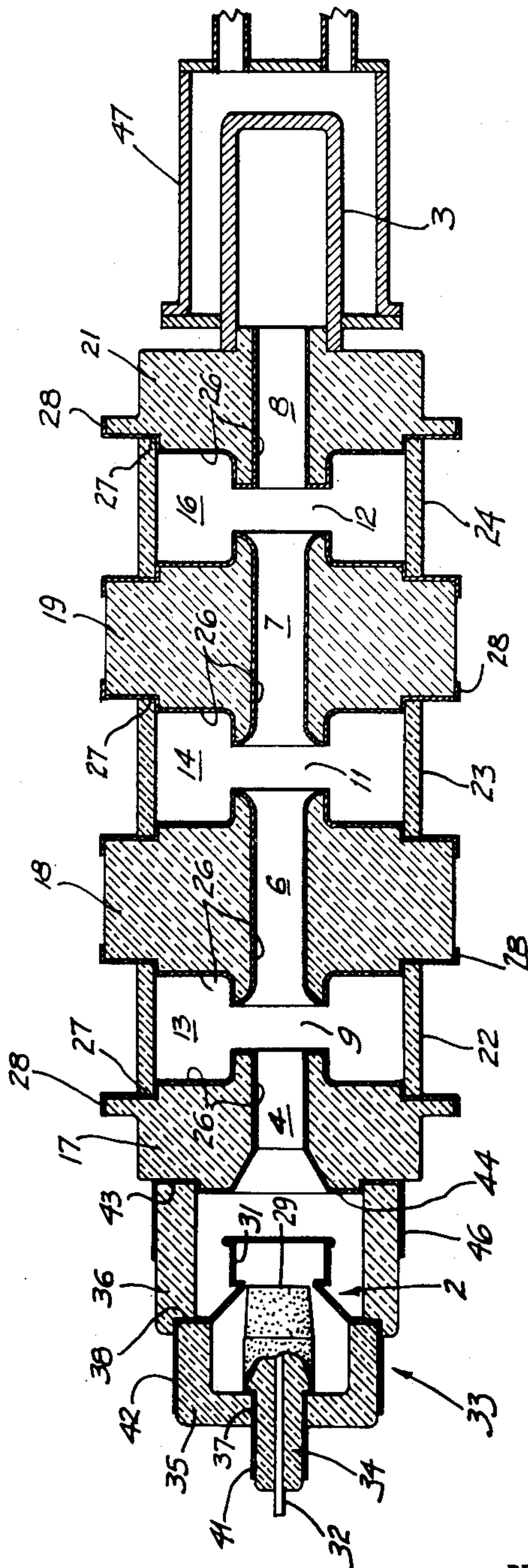


Fig. 1

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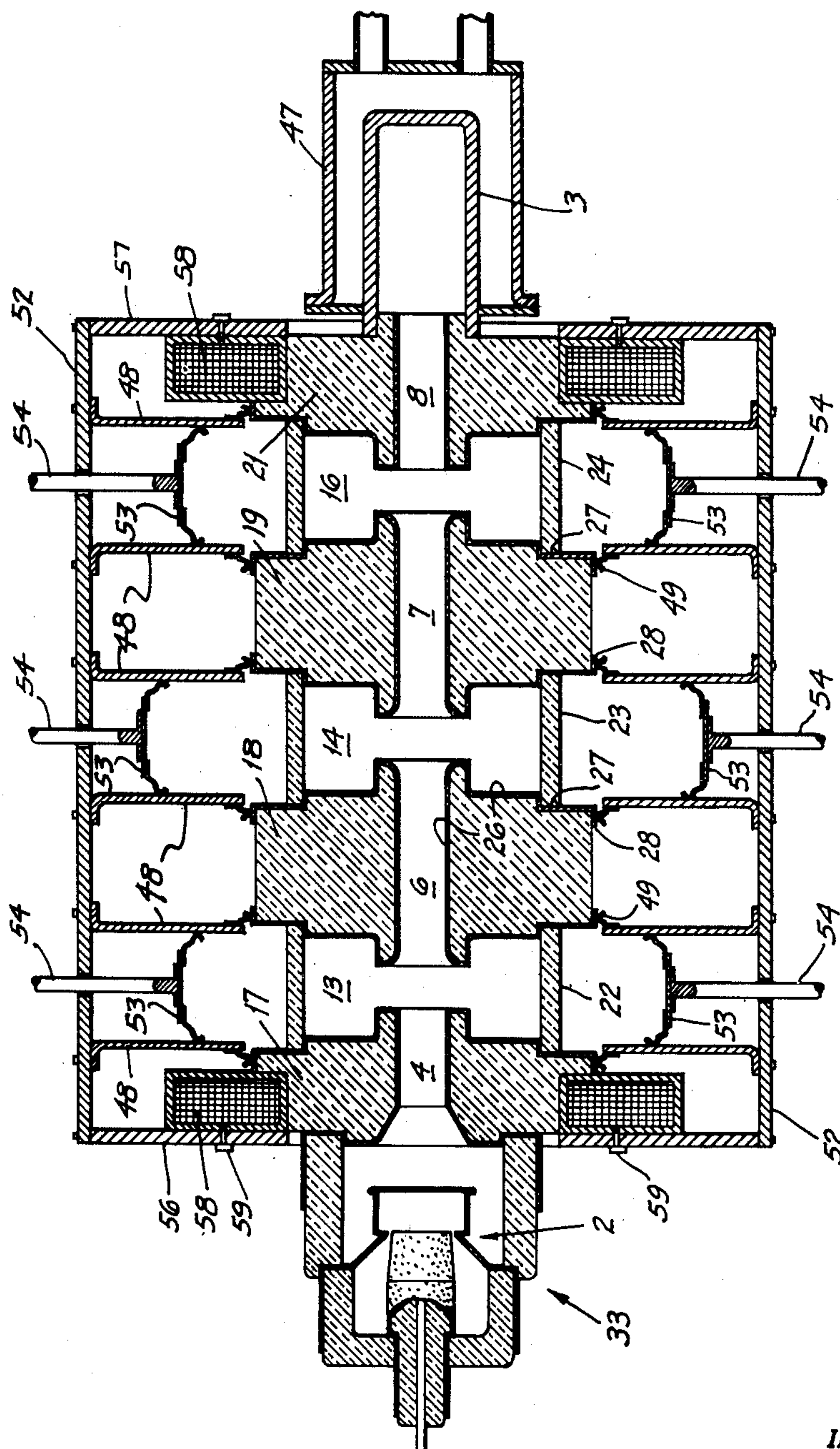


Fig. 2

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ELECTRON TUBE

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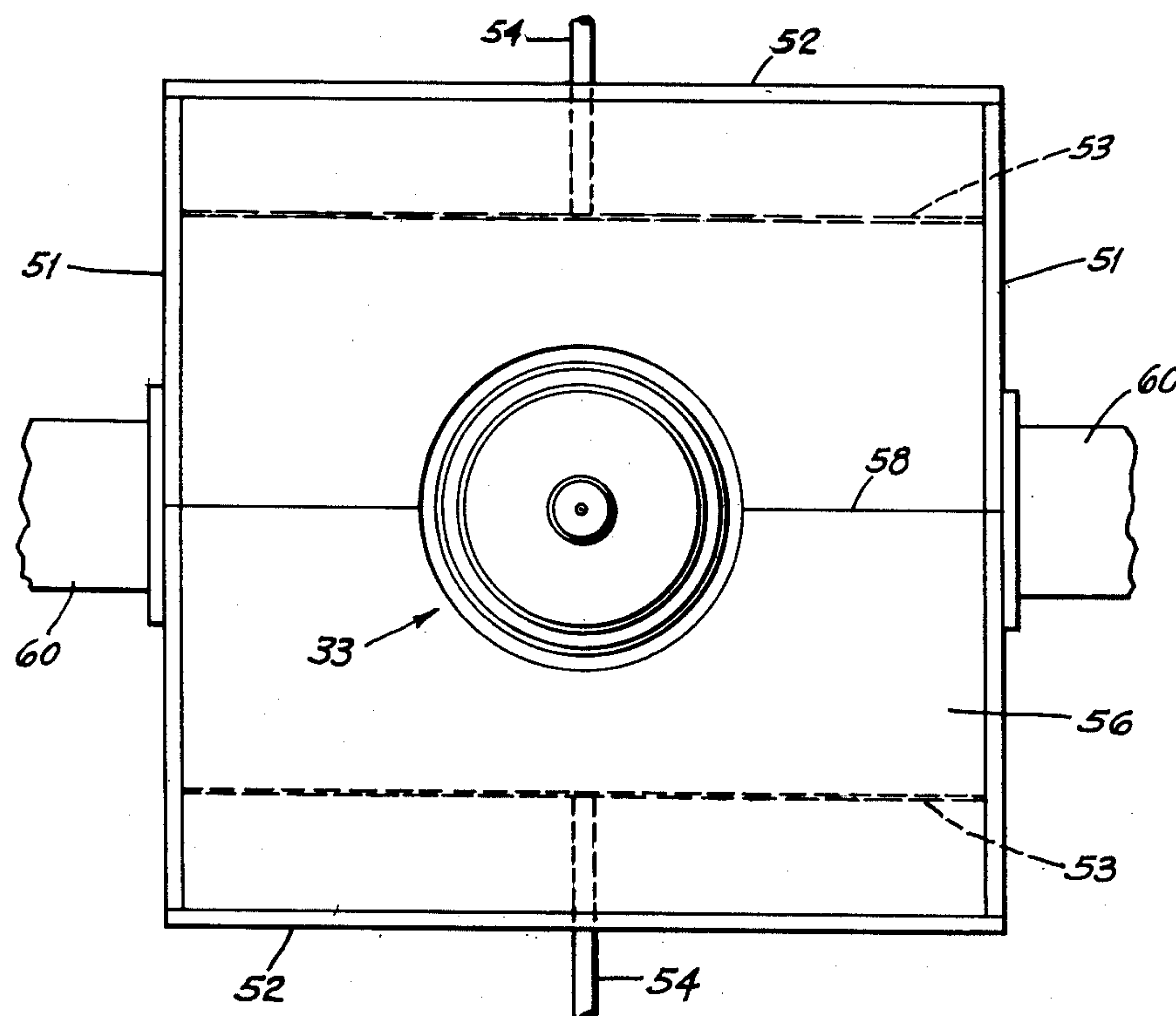


Fig. 3

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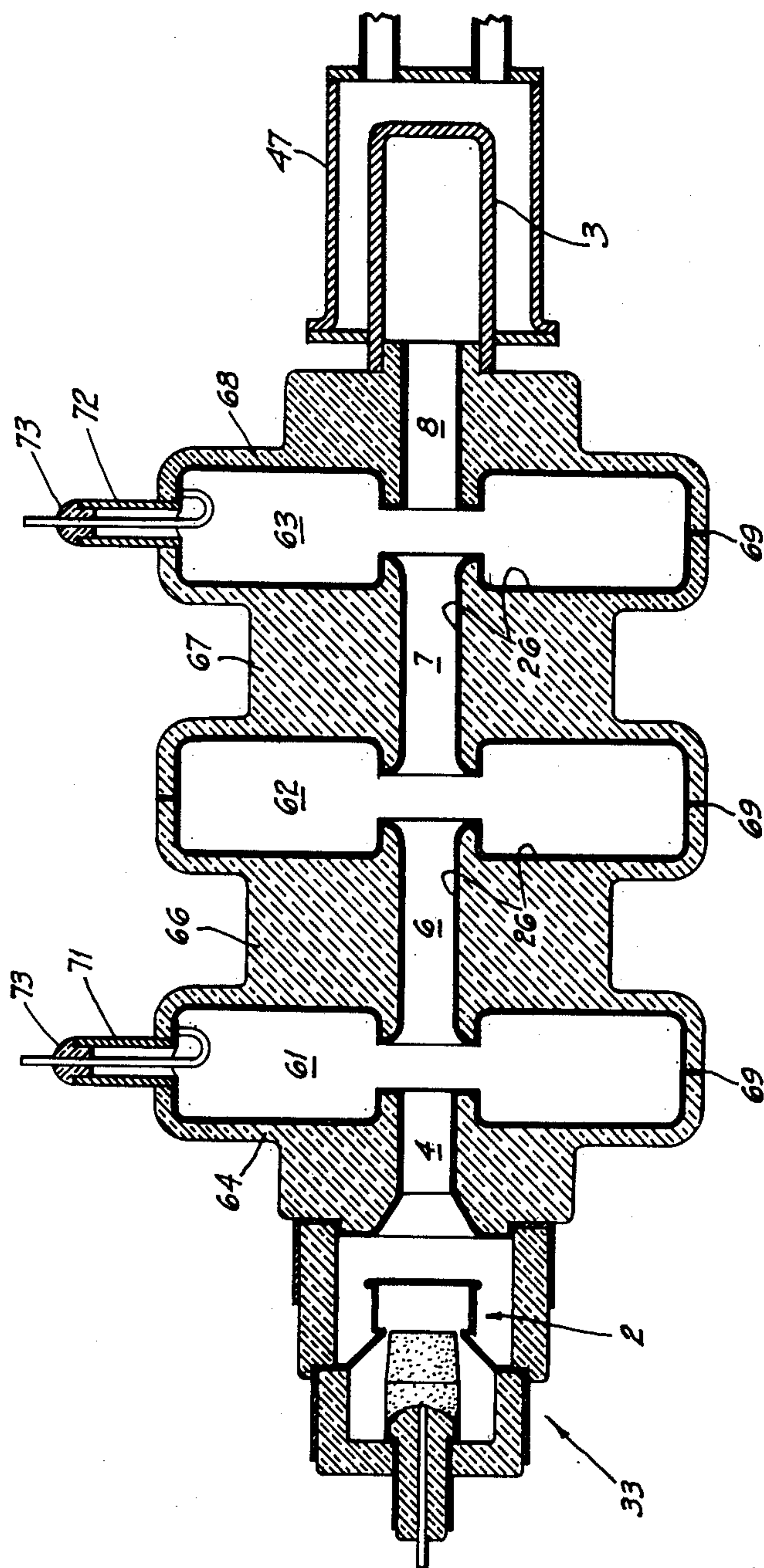
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4 Sheets-Sheet 4



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## UNITED STATES PATENT OFFICE

2,629,066

## ELECTRON TUBE

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Application December 10, 1951, Serial No. 260,922

4 Claims. (Cl. 315—5)

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Our invention relates to electron tubes having cavity resonators, and more particularly to tubes of the velocity modulation type such as klystrons.

It is among the objects of our invention to provide a tube of the character described in which the envelope is made of ceramic material shaped to form the cavity resonator, conduction along the walls of the resonator being provided by a metallic coating on inner surfaces of the ceramic.

Another object is to provide such a klystron type structure having a drift tube and cavity resonator, wherein both the drift tube and resonator are formed of ceramic and wherein the metallic coating extends along those ceramic surfaces which define the drift tube and which constitute inner walls of the resonator.

Still another object is to provide a cavity type klystron tube having a portion of the cavity resonator disposed within the evacuated envelope and another portion of the resonator arranged external to the envelope, the connection between the internal and external portions of the resonator being provided by a metallic bond uniting ceramic sections of the envelope.

The invention possesses other objects and features of advantage, some of which, with the foregoing, will be set forth in the following description of our invention. It is to be understood that we do not limit ourselves to this disclosure of species of our invention, as we may adopt variant embodiments thereof within the scope of the claims.

Referring to the drawing:

Figure 1 is an axial sectional view of a tube showing our improved ceramic envelope structure.

Figure 2 is a similar view showing external cavity portions arranged about the envelope; and

Figure 3 is an end elevational view of the device.

Figure 4 is a simplified tube structure in which the entire cavity resonator is formed as part of the ceramic envelope.

In terms of broad inclusion our improved electron tube comprises an envelope, a cavity resonator, the envelope comprising ceramic shaped to form the cavity resonator, and a metallic coating on those ceramic surfaces which constitute inner walls of the resonator. In the preferred form of our invention a portion of the cavity resonator is disposed within the evacuated envelope and another portion of the resonator is arranged external to the envelope. In this case the con-

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nection between the resonator portions is established by a metallic bond between ceramic sections of the envelope. In a modified construction embodying our improvements the entire resonator structure is formed as part of the ceramic envelope.

In greater detail, and referring to Figures 1 to 3 of the drawings, the preferred tube construction embodying the external resonator structure will first be described. Figure 1 shows the evacuated tube only and Figure 2 illustrates the tube in conjunction with the external structure. The tube per se comprises an elongated generally cylindrical envelope having an electron gun 2 at one end and a collector electrode 3 at the other end. The electron beam from the gun to the collector passes through a drift tube made up of segments 4, 6, 7 and 8 extending axially of the envelope and having gaps 9, 11 and 12 therebetween. Such gaps are bridged by annular cavity resonator structures generally designated at 13, 14 and 16.

The above elements of the electron tube function in a manner well known for klystron tubes of this type, namely, an electron beam from gun 2 passes through the drift tube, past the interaction spaces provided by gaps 9, 11 and 12, and finally terminates on collector electrode 3. The three cavity resonators 13, 14 and 16 coacting with the interaction spaces at gaps 9, 11 and 12 serve as the frequency determining elements of the device. In the tube illustrated, which functions as an amplifier, the input signal for modulating the electron stream is fed into the first resonator 13 and the radio-frequency output is taken from the third resonator 16, in accordance with the usual manner for three-cavity type klystrons.

An important feature of our tube resides in the construction of those portions of the resonators which comprise a part of the evacuated envelope. In the past it has been the practice to make klystron tubes of metal and glass, using glass-to-metal seals. These prior structures leave much to be desired both mechanically and electrically. In our improved construction we eliminate the metal and glass by making the envelope of ceramic sections, which ceramic is shaped to form the cavity resonators. Electrical conductivity is provided by metalized surfaces on the ceramic. Differential expansion between parts of the structure is therefore reduced, and electrical losses are minimized, which features are particularly important in cavity resonator type tubes.

Thus, as seen in Figure 1, the main body of



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the envelope comprises a series of circular ceramic wall sections 17, 18, 19 and 21 connected by cylindrical spacer sections 22, 23 and 24. The ceramic sections 17, 18, 19 and 21 are shaped to form the side walls of the cavity resonators and also to form the drift tube segments 4, 6, 7 and 8 the latter being preferably formed as an integral part of the envelope sections, as illustrated. A dense ceramic, such as the alumina or zircon type ceramic bodies, is satisfactory for the envelope sections. These ceramics are strong mechanically, have relatively low electrical loss properties, and can be fabricated into the desired shapes.

Electrical conductivity is provided along the inner side wall surfaces of the cavity resonators, and over the drift tube segments, by metalizing the ceramic to provide a metallic coating 26 on those ceramic surfaces which define the drift tube and constitute the resonator side walls. This metallic coating is preferably applied by first sintering a layer of metal powder to the ceramic surface and then plating a metal over the sintered areas. The first step preferably comprises applying to the ceramic a layer of finely divided molybdenum powder, or a mixture of molybdenum and iron powders or the like, and then firing the coated ceramic in hydrogen to a temperature of about 1500° C. to sinter the metal powder to the ceramic surface. This produces a thin metallic layer or film firmly bonded to the ceramic. The next step comprises electroplating the sintered area with copper, nickel or other metal of good electrical conductivity. This yields a solid, smooth metal surface which is desired for the wall surfaces of the cavity resonators and drift tube segments. The metallic coating 26 is shown as having exaggerated thickness in the drawing, which is merely for purposes of clarity, it being understood that this coating is more like a film or skin on the surface of the ceramic.

Vacuum-tight joints are provided by metallic bonds 27 between the ceramic sections, this being accomplished by metalizing the adjacent edges of the ceramic, in the manner above described, and then brazing the metalized surfaces together with silver solder or brazing alloys such as silver-copper, gold-copper or the like. This structure forms strong mechanical joints and the metallic bonds are also available to function as electrical connections between the internal and external portions of the resonators, as hereinafter described. Metalized areas 28 on the peripheral edges of ceramic sections 17, 18, 19 and 21 serve as terminal rings and are connected to the inner coated surfaces through the metallic bonds or lead-in conductors 27. The cylindrical ceramic sections 22, 23 and 24 are insulating walls and therefore are not coated on their inner surfaces.

Electron gun 2 comprises a cathode 29 and a surrounding focusing electrode 31, the cathode being heated by a suitable heater coil (not shown) connected at one end to the cathode and at the other end to a lead 32, all of which is supported by a stem generally designated at 33 forming an end of the evacuated envelope. In our tube the stem is also preferably of ceramic construction comprising coaxial ceramic sections 34, 35 and 36 joined at the metallic bonds or brazes 37 and 38. Tubular section 34 embraces the lead 32 which is brazed to the ceramic, and section 34 has its surface metalized to provide cathode terminal 41 connected to cathode 29 thru braze 37. The outer surface of section 35 is likewise metal-

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ized to provide focusing electrode terminal 42 connected to the electrode thru braze 38.

Section 36 of the stem is sealed to envelope section 17 at braze 43. The metal coating on ceramic section 17 extends thru the drift tube segment 4 and over the surface facing the electron gun 2 to provide an anode 44 to which a positive potential may be applied for accelerating the electron stream. A metalized area on ceramic section 36 provides a terminal 46 connected to anode 44 thru braze 43.

Collector 3 at the opposite end of the envelope is a cup-shaped metal electrode, say of copper, brazed to ceramic section 21 in coaxial alignment with the drift tube and electron gun. Electrode 3 may be cooled in any suitable manner as by a water jacket 47.

The above described construction completes the evacuated tube per se, including those portions of the resonators which lie within the evacuated envelope. The unique construction, wherein the cavity resonators are formed by metalized ceramic sections, has been noted.

As earlier mentioned herein the preferred tube has external cavity portions. The reason for this arrangement is to provide tuning means external of the envelope so that the tube can be tuned over a relatively wide band of frequencies. Figures 2 and 3 show the evacuated tube above described in conjunction with the external structure. The side walls of the several resonators are extended by outer rectangular wall portions 48 having circular apertures for receiving the circular wall sections 17, 18, 19 and 21 of the envelope. These external wall portions are of metal such as copper, and are detachably connected to the ceramic center wall sections by spring contact fingers 49 engaging the terminals 28. By this construction it is seen that the cavity resonators are each made up of two parts, namely, a central portion of ceramic construction forming part of the evacuated envelope and an outer rectangular portion of metal construction. The ceramic cylinders 22, 23 and 24 thus provide vacuum-tight partition members between the internal and external portions of the resonators.

The electrical continuity along the resonator walls is established by contact fingers 49, and thence thru metallic bonds 27 to the metal coating 26 on the inner wall surfaces of the ceramic sections. By this arrangement the benefit of having external resonator portions is achieved in addition to the very desirable advantage of having the internal resonator portions made out of ceramic material.

As shown in Figure 3, the other two outer walls of the resonators are formed by metal side plates 51 on the external structure. Support for the transverse walls 48 is provided by upper and lower plates 52 of the external structure.

Tuning means are provided in the external portions of the resonators. Such means preferably comprise pairs of oppositely disposed rectangular plungers 53 slidably engaging the walls of the outer rectangular portions of the resonators. These plungers are actuated by suitable plunger rods 54 whereby the sizes of the resonators may be adjusted to vary their resonant frequency.

The housing or casing provided by the external structure is completed by metal end plates 56 and 57 bolted to the lateral wall plates 51 and 52. These end plates are apertured to receive the ends of the tube. In order to insert the tube the external structure, including the transverse



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wall portions, is split lengthwise along a plane 56 axially of the tube. This permits the upper half of the structure to be removed for insertion of the tube downwardly into the lower half as a cradle.

End plates 56 and 57 and upper and lower plates 52 of the external structure are made of iron and function as elements of the magnetic circuit for the tube. The focusing magnet coils 58 encircle the envelope sections 17 and 21 and are secured to the end plates 56 and 57 of the external structure by bolts 59. In order to replace a tube the bolts 59 are first removed to release the magnets, after which the upper half of the structure is lifted off. The tube and encircling magnet coils may then be lifted out and the coils slipped endwise off the tube.

Radio-frequency power is delivered to input resonator 13 and taken from output resonator 16 by suitable transmission lines or wave guides 60 (Fig. 3) which may be coupled to the resonators by suitable means such as iris openings in the wall plates of the external resonator structure, as will be readily understood by those skilled in the art.

In event a fixed frequency tube is desired the structure becomes considerably simplified since there is no need for external resonators containing tuning means. Figure 4 shows such a simplified construction wherein the resonators 61, 62 and 63 are wholly formed as part of the ceramic envelope construction. In this case ceramic sections 64, 65, 67 and 68 are cup-shaped pieces, fitted together along planes extending midway thru the cavity resonators, and sealed together at brazes 69. The entire inner surfaces of the resonators, as well as the drift tube segments, are metalized. Suitable radio frequency input and output lines are provided such as the coaxial lines 71 and 72 terminating at loops in the input and output resonators 61 and 63. These coaxial lines are sealed-off at the glass beads 73 to provide a vacuum-tight envelope. In other respects the tube is similar to that described in Figure 1, as indicated by like reference numerals.

We claim:

1. An electron tube comprising an envelope, a cavity resonator, said envelope comprising ceramic sections, one ceramic section forming a side wall portion of the resonator, another ceramic section forming another side wall portion of the resonator, a third ceramic section providing a spacer wall between said sections, a metallic

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coating on those ceramic surfaces which define the inner side walls of the resonator, and metallic bonds uniting the side wall sections to said spacer wall.

2. An electron tube apparatus comprising an elongated evacuated envelope, a cavity resonator disposed transversely of the envelope axis and having a central portion within the evacuated envelope and an outer portion external to the envelope, said envelope comprising ceramic sections forming the internal portion of resonator, a metal coating on those ceramic surfaces which constitute the inner walls of the resonator, and a metallic bond uniting the ceramic sections and providing a connection between the internal and external portions of the resonator.

3. An electron tube apparatus comprising an elongated evacuated envelope, a cavity resonator disposed transversely of the envelope axis and having a central portion within the evacuated envelope and an outer portion external to the envelope, said envelope comprising ceramic sections forming the internal portion of resonator, a metal coating on those ceramic surfaces which constitute the inner walls of the resonator, a metallic bond uniting the ceramic sections and providing a connection between the internal and external portions of the resonator, and tuning means in the external portion of the resonator.

4. An electron tube apparatus comprising an elongated evacuated envelope, a cavity resonator disposed transversely of the envelope axis and having a central portion within the evacuated envelope and an outer detachable portion external to the envelope, said envelope comprising ceramic sections forming the internal portion of the resonator, a metal coating on those ceramic surfaces which constitute the inner walls of the resonator, and a metallic bond uniting the ceramic sections and providing a connection between the internal portion of the resonator and said detachable external portion.

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