Feb. 10, 1959 W. S. GEISLER, JR 2,873,403

ELECTRON DISCHARGE DEVICE

Filed Jan. 5, 1955 2 Sheets-Sheet 1

Fig. 1

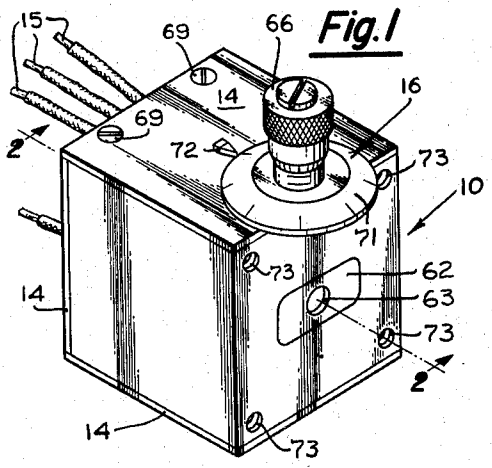


Fig. 4

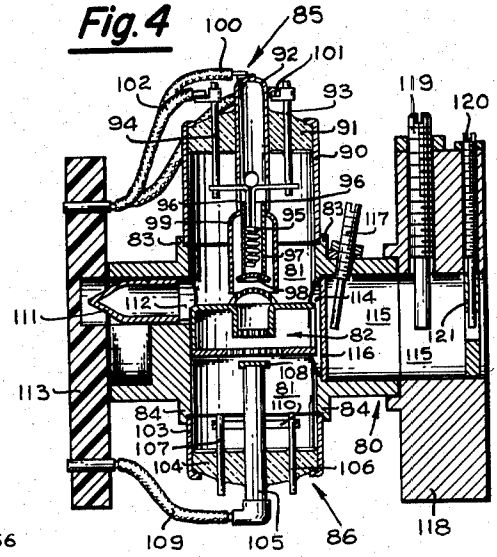


Fig. 2

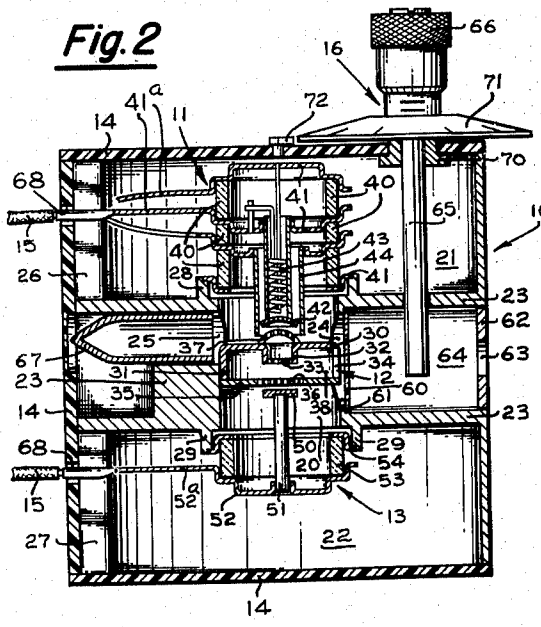
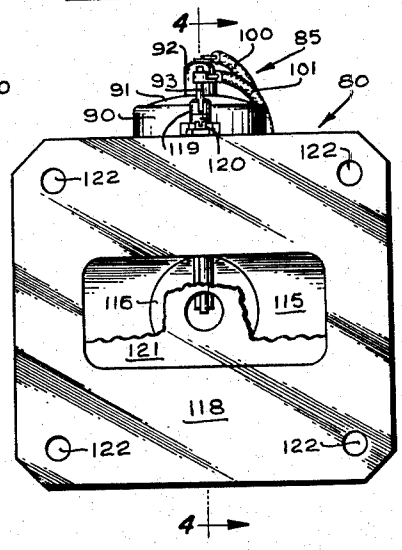


Fig. 3



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Feb. 10, 1959 W. S. GEISLER, JR 2,873,403

ELECTRON DISCHARGE DEVICE

Filed Jan. 5, 1955 2 Sheets-Sheet 2

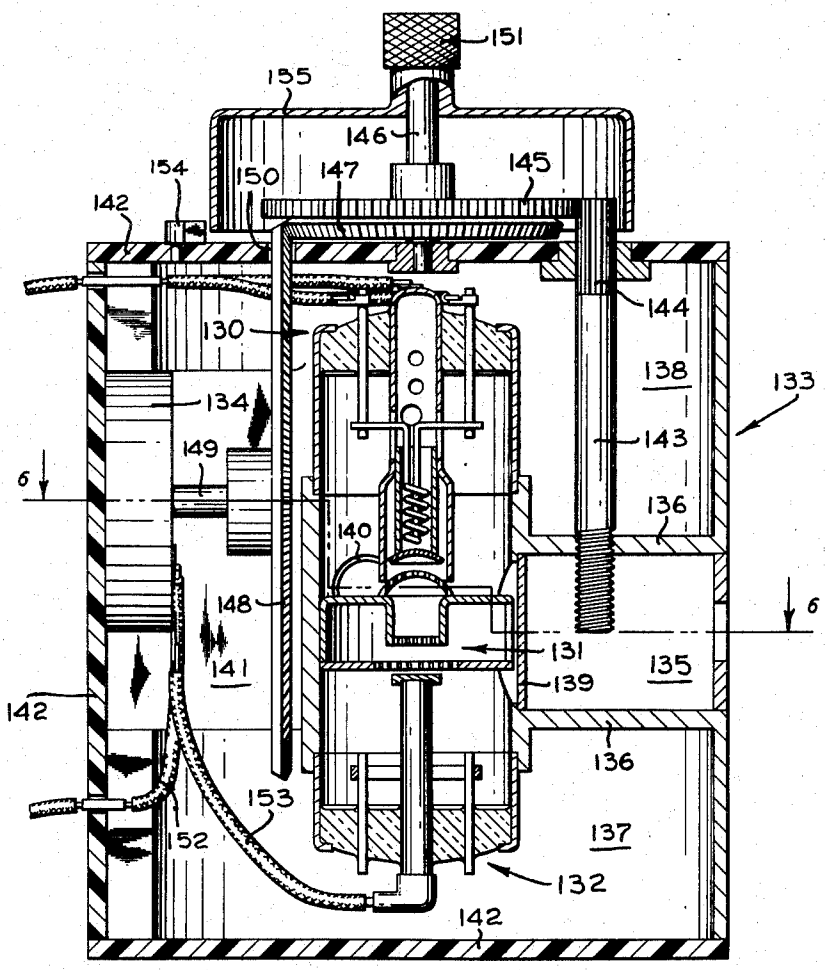

FIG_5

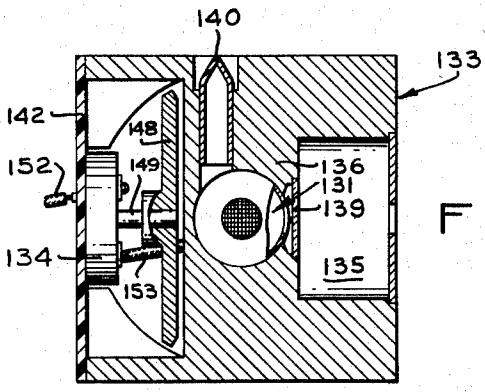

FIG_6

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ELECTRON DISCHARGE DEVICE

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Application January 5, 1955, Serial No. 479,925

14 Claims. (Cl. 315—5.21)

The present invention relates to electron discharge devices operable at microwave frequencies and more particularly to klystrons which operate at frequencies upwards of 10 kilomegacycles and to the method of their construction.

Since every klystron embodies one or more resonant cavities and the size of these cavities is inversely proportional to the operating frequency, klystrons designed to operate at or above 10 kilomegacycles incorporate resonant cavities that are exceedingly small, having dimensions which are fractional parts of an inch. Furthermore the tolerances which must be observed in the construction of such cavities are in the neighborhood of one-thousandth of an inch.

Close tolerances must also be observed when such resonant cavities are assembled with the other elements of klystrons (e. g. electron gun, reflector) so that precise spacing and alignment will be assured. Thus both construction and assembly of such high frequency klystrons becomes, from a physical standpoint, substantially a jeweler's job.

However, additional factors, which a jeweler need not face, must be considered by the engineer because of the electronic nature of the klystron. As an example, the layer of metal which conducts the current at the high frequencies hereinabove mentioned is quite thin, the thickness of the conducting layer being inversely proportional to the operating frequency. As lightness, particularly in aircraft installations, is a desirable feature, this permitted thinness of conducting material is favorable, but aircraft use also necessitates rigidity of all parts so that vibration can be withstood. As a consequence, the ultimate thickness or thinness of the metal is normally the result of a compromise between these seemingly opposed factors, weight and rigidity.

The foregoing is merely intended to indicate, at least to a slight degree, the problems encountered in the construction and assembly of klystrons which operate at or above 10 kilomegacycles and, as a consequence, partially explain the relatively high cost of such electronic devices.

It is an object of the present invention to provide a klystron which performs more effectively than those heretofore employed, particularly at the high frequencies (i. e. above 10 kilomegacycles), yet which is simple and inexpensive to construct and assemble.

A feature of the invention relates to the design of the body portion of the klystron which facilitates assembly yet provides a precise and rigid support for the electron gun, resonant cavity, and other components.

Another feature also concerns the design of the body portion rendering the same particularly advantageous in the construction of a reflex klystron embodying internal and external resonant cavities.

A further feature is directed to the structure of these cavities which simplifies their construction and assembly and, at the same time, enhances their operating efficiency.

An additional feature relates to an improved arrangement that enables maximum coupling between the internal and external cavities.

Yet another feature again relates to the design of the body portion of the klystron that enables the rigid support of different electron guns, as desired for particular purposes.

It is an additional feature to provide an improved electron gun structure that is readily adapted for incorporation in the klystron embodying the present invention and which is constructed in accordance with the principle of design simplicity and effectiveness.

Another feature of the invention concerns the body portion of the klystron which provides a support for external tuning mechanisms, dials, control rheostats and the like.

Correlative with the foregoing feature is that additional feature that provides for the construction of a small integral signal generator when suitable frequency indicating arrangements are mounted on the mentioned body portion and a reflex klystron is embodied therein.

Additional features and advantages stemming from the present invention will become apparent from a perusal of the following description of the accompanying drawings wherein:

Fig. 1 is an isometric view of a klystron embodying the present invention,

Fig. 2 is a central sectional view of the klystron taken along line 2—2 of Fig. 1,

Fig. 3 is an elevational view of a modified embodiment of the invention, certain parts being broken away,

Fig. 4 is a sectional view taken along line 4—4 of Fig. 3,

Fig. 5 is a central sectional view of another modified embodiment of the invention, and

Fig. 6 is a transverse sectional view taken along line 6—6 of Fig. 5.

A klystron or electronic tube embodying the present invention generally includes a body portion in the form of a unitary frame structure arranged to support the other components of the device in proper and precise relationship. As specifically embodied in Figs. 1 and 2, wherein is shown a reflex klystron designed principally for use as a bench oscillator, the body portion, generally indicated at **10**, is formed by a cubical block of steel which is machined so as to support sub-assemblies including an electron gun **11**, a resonant cavity structure **12** and a reflector **13** in the required physical relationship within the cubical outline of the machined block. After the mentionad sub-assemblies have been suitably secured within the machined block **10**, rectangular insulating covers **14**, as of plastic, are secured over the openings formed by the machining so as to define a generally closed cube as best shown in Fig. 1. Suitable electrical leads **15** project through one cover **14** to enable connection to the electrical elements of the klystron and a portion of a tuning mechanism **16** protrudes from another cover to enable manual adjustment of the operating frequency.

With particular reference to Fig. 2, the steel block that is adapted to form the body portion **10** of the tube, is drilled centrally to form a small bore **20**. Large bores **21**, **22**, having a diameter just less than a side dimension of the cubical block, are drilled from each end of the block concentrically with the small central bore **20**. Each of the bores **21**, **22** are drilled to a depth approximately one-third of the block thickness so as to leave an annular metal section or partition **23** therebetween which accordingly defines centrally the foreshortened small bore **20**. From each side of the block, transverse bores **24**, **25** are drilled through the block section **23** so as to intersect the small bore **20**, at substantially diametrically opposed points, and

additional milling operations are performed to enlarge the bore 24 through most of its length and the bore 25 through a smaller portion of its length into rectangular cross sections, for purposes to become apparent hereinafter. Additional milling operations provide lateral openings 26, 27 from the side of the cubical block into the described large bores 21, 22.

The previously mentioned cavity structure 12 is positioned substantially midway of the central small bore 20 and the electron gun 11 and reflector 13 are positioned at opposite ends of the small bore 20, being disposed within the enlarged bores 21 and 22, respectively. To assure proper axial alignment and longitudinal placement of these sub-assemblies, interior shoulders or seats 28, 29 for the gun 11 and reflector 13, respectively, are formed on annular projections adjacent the ends of the small bore 20 in precise concentric relationship thereto.

The cavity structure 12 constructed in accordance with the present invention includes a cavity cup 30, whose exterior diameter is just slightly less than the interior diameter of the small bore 20 so that a pressed-fit can be obtained. This cup 30 is constructed by drawing a copper blank to form the circular side wall 31 and by subsequently forming a central re-entrant tube 32 within which a grid 33 is brazed adjacent its end. Thereafter, a rectangular section of the cup side wall is cut away, to form an iris, indicated at 34, to enable energy to be withdrawn from the cavity structure 12. To the lip of the cup 30, a copper plate 35, having an integral central grid 36, is brazed to complete the cavity structure 12. This grid 36 is aligned with and spaced from the grid 33 so as to form therebetween a capacitive gap adapted to be traversed by a beam of electrons from the mentioned electron gun 11. A curved grid 37 is brazed to the base of the cup in alignment with the gap-forming grids 33 and 36 to provide for the acceleration of the electrons prior to their traversal of the capacitive gap in the cavity structure 12.

The die operations which are utilized to construct the cavity structure 12, as described, assure that close and reproducible tolerances are obtained, although the only precision workmanship required is in the actual construction of the dies. As a consequence, the cavity structure 12 can be readily fitted into the body portion 10 and defines a cavity 38 which has precisely the desired inductance and capacitance values. Additionally, because but one internal braze joint at the lip of the cup 30 interrupts the otherwise smooth, hard die-formed interior surface of the cavity, losses are minimized and a high Q is therefore assured.

The electron gun 11, as shown in Fig. 2, is secured in vacuum tight relation on the previously described annular seat 28 adjacent the one end of the small bore 20 in which the above described cavity structure 12 is mounted. This electron gun 11 is constructed in accordance with the invention disclosed and claimed in my copending application, Serial No. 441,087, filed July 2, 1954, to which reference is given for details of its construction. Briefly, the gun includes a vacuum envelope formed by ceramic rings 40 secured in alternating, insulating and vacuum-tight relationship with stepped, conducting plates 41, which latter provide support and electrical connection for a cathode 42, and a heater 43 and focusing ring 44 therefor. Tabs 41*a*, formed integrally on each of the plates 41, extend laterally toward the milled opening 26 in the block 10 to facilitate connection to the previously mentioned leads 15. The foremost plate 41 of the gun 11 is arranged to fit precisely on the annular seat 28 where it is brazed to establish a vacuum tight connection. This precise fit enables the previously mentioned accuracy of placement of the electron gun 11 relative to the cavity structure 12 so that optimum disposition of the electron beam from the gun 11 is obtained as it traverses the cavity 38.

The reflector section 13 includes a reflector button 50 mounted at one end of a stem 51 that is secured, at its other end, centrally to a stepped supporting plate 52. This plate 52 is provided with a laterally extending tab 52*a* to enable the application of the desired voltage to the button 50 so that the electron beam having traversed the cavity 38 forwardly will be reflected and returned through the cavity in the proper phase to give rise to the desired oscillations, after the normal fashion of operation of a reflex klystron. A ceramic ring 53 similar to those employed in the fabrication of the electron gun 11 provides a vacuum tight, insulating connection from the described end plate 52 to an annular mounting plate 54 that is secured to the seat 29 formed adjacent the end of the small bore 20 remote from the electron gun 11 to thus correctly position the reflector button 50 relative to the cavity structure 12.

Since the annular mounting plates 41 and 54 for the electron gun 11 and reflector 13, respectively, are formed by a die operation so as to have close and reproducible tolerances, the correct disposition of both the electron gun 11 and the reflector 13 is assured if proper tolerances are observed in the machining of the metal block 10 to provide the described seats 28 and 29. As a consequence, the block or body portion 10 of the klystron embodying the present invention functions, in effect, as a jig for final assembly of the parts. Since the assembly is thus self-jigging, the gun and reflector sub-assemblies can be correctly assembled on the body portion 10 by relatively inexperienced and consequently inexpensive labor.

The cavity structure 12, when secured within the small bore 20, is disposed so that the iris 34 in the side of the cavity cup 30 registers with the lateral bore 24. A circular ceramic window 60 is brazed immediately adjacent the iris 34 in vacuum tight relation on a shoulder 61 that is formed when the previously described milling operation is performed in the bore 24 to transform the cross-section of the remainder thereof into a rectangular configuration. At the outer end of this lateral opening, a small plate 62 is secured, as by brazing, and is provided with a small central aperture 63. Thus is formed a cavity 64 which is external to the vacuum envelope of the tube and is coupled to the internal cavity 38 through the described ceramic window 60, the latter serving to actually enhance the degree of coupling. Energy can be withdrawn from the external cavity 64 through the described aperture 63. In order to minimize losses within this external cavity, the interior walls of the lateral opening and of the plate 62 are plated with copper.

A small opening in the upper wall of the external cavity 64 permits projection thereinto of a tuning screw 65. The amount of projection and thus the frequency of the tube is accurately controlled by a micrometric adjustment nut 66 to which the screw 65 is operatively connected at its upper end.

It will be noted that the window 60 through which the internal and external cavities are coupled as well as the non-metallic elements of the vacuum envelope found in the reflector 13 and electron gun 11 are composed exclusively of ceramic to thus enable a higher "bake out" temperature during evacuation of the tube and consequently a higher degree of vacuum therein. Evacuation is accomplished through a small tubulation 67 brazed within the other lateral bore 25, previously described. After the evacuation cycle is complete, this tubulation 67 is pinched off, as shown in Fig. 2, its outermost extremity remaining within the general cubical outline of the body portion 10.

One of the previously mentioned plastic covers 14 is secured to the side of the block or body portion 10 of the tube to enclose the tubulation 67 and the milled openings 26, 27. Small apertures 68 are formed in this cover so that the electrical leads 15 can pass through the cover 14 for connection to the tabs 41*a* and 52*a*. Thus, voltage can be applied to the electron gun 11 and reflector 13 without removal of the cover 14.

Additional plastic covers 14 are placed over the large bore 22 at the reflector end and the bore 21 at the gun

end of the tube to complete the cubical outline thereof. Each of the plastic covers is held in position by suitable screws, as shown at 69 in Fig. 1, which enter threaded bores (not shown) adjacent the corners of the metal block or body portion 10. The upper plastic cover 14 supports a bearing 70 through which the tuning screw 65 extends and which rotatably supports a dial 71 having frequency indicia thereon. A pointer 72 on the cover adjacent the dial 71 indicates the output frequency of the tube as determined by the disposition of the tuning screw 65.

To enable wave guide to be positioned over the output aperture 63 in the external cavity 64, threaded bores 73 are drilled in the corners of the block at positions adapted to register with the openings through a conventional wave guide attachment flange (not shown). This quick-connection arrangement for withdrawal of energy from the tube enhances its value as a bench oscillator where frequent changes of the external circuitry (wave guide) are required to meet the varied conditions imposed by different experimental installations.

For use in guided missiles or other installations where the klystron must be considered as expendable, a modified embodiment of the invention is preferably employed, such being illustrated in Figs. 3 and 4. The body portion of this modified embodiment of the invention, generally indicated at 80, is, in effect, substantially the same as the partition 23 formed between the bottoms of the large bores 21 and 22 of Fig. 2. A central bore 81 is drilled in the body portion 80 and a cavity structure 82 substantially identical to that shown in the first embodiment of the invention is secured therein. Annular shoulders or seats 83, 84 are formed on the body portion 80 adjacent the ends of the central bore 81 to mount an electron gun 85 and a reflector 86 in substantially the same manner as described in connection with the first embodiment of the invention.

While it will be apparent that other electron gun and reflector structures such as that shown in Fig. 2 can be utilized, particularly simple but rugged, efficient, and easily assembled structures constructed in accordance with the present invention are embodied both in the tube shown in Figs. 3 and 4 and in the third embodiment of the invention as shown in Figs. 5 and 6 and described hereinafter.

As clearly shown in Fig. 4, the electron gun 85 includes a metal tube 90, of a diameter such that it can be secured in vacuum-tight relation to the above-described seat 83 on the body portion 80. A vacuum-tight closure is provided at the end of the tube 90 remote from the body portion 80 by a glass seal 91 through which pass a central stem 92 in the form of a thin elongated metal cup and a pair of eccentrically-disposed metal pins 93, 94. The stem 92 and the pins 93, 94 are in sealing engagement with the glass seal 91 and since they each pass entirely through the glass, provide for application of desired voltages to the elements or electrodes of the electron gun 85. A helical heater 95 is disposed coaxially of the stem 92, the ends of the heater being bent outwardly to pass through two of a number of openings 96 formed adjacent the inner end of the hollow stem for connection, as by spotwelds, to the described pins 93 and 94. Such connection provides both physical support for the heater 95 and for the application of voltage thereto. A cylindrical heat shield 97 as of nickel having a dished cathode button 98 mounted on one end thereof is arranged to be inserted, at its other end, a slight distance into the hollow stem 92 so as to surround the heater 95 with the cathode button 98 spaced a short distance from the end of the heater. A somewhat larger hollow metal cylinder 99 is arranged to concentrically encompass the heat shield 97, one end of this cylinder being bent inwardly to abut the shield where the latter in turn engages the hollow stem 92. A single braze at the common juncture of the stem 92, heat shield 97 and outer cylinder 99 serves to secure these elements rigidly together. This braze can be made without fear of cracking the glass seal 91 at the far end of the stem 92 because the noted openings 96 limit the heat conduction from the braze point along the stem 92, without however substantially altering the rigidity of this supporting element. When the braze joint has been made, the end of the outer cylinder 99 projects beyond the cathode button 98 a predetermined distance and when the electron gun 85 is mounted on the body portion 80 of the klystron, the cathode 98 and outer cylinder 99 are aligned with and properly spaced from the cavity structure 82.

Upon grounding of the body portion 80 of the tube and application of a negative voltage (e. g. 300 volts) to the cathode button 98 by way of a wire 100 connected to the central stem 92 and suitable voltage (e. g. 4–6 volts) to the heater 95, through wires 101, 102 connected to the described pins 93, 94, electrons will be emitted from the cathode 98 to move towards the cavity structure, being properly focused by the repelling force exerted by the outer cylinder 99 which is at cathode voltage and can be more descriptively termed a focusing ring.

The openings 96 in the stem 92 are important to the effectiveness of the operation of the electron gun 86 as well as to its construction, as explained hereinabove. While not detracting from the rigidity of the stem 92 as a supporting element, they reduce the conduction of heat from the heat shield during operation so that more of the heat from the heater 95 is employed in its intended function of heating and thus activating emission from the cathode button 98. It has, in fact, been found that the reduction in heat loss has been sufficient to enable the heater 95 to be operated at a substantially lesser voltage than in other electron gun structures (5.3 v. rather than 6.3 v.) with no decrease in the cathode emission level. As a consequence, longer life of the electron gun 85, as shown in Fig. 4, has been experienced.

The previously mentioned reflector 86 includes a metal tube 103, one end of which is secured in vacuum-tight relation to the described seat 84 on the body portion 80 of the klystron, and the other end of the tube 103 is closed by a glass seal 104 through which extend a central stem 105 and a pair of eccentrically-disposed pins 106, 107, each of which are sealed to the glass much in the manner of the seal arrangement in the electron gun 85. A reflector button 108 is supported at the inner end of the stem 105 so as to be quite close to the cavity structure 82, the precise spacing being determined by the operating frequency and voltages of the klystron. The negative voltage which is supplied to the reflector button 108 through the described stem 105 and a wire 109 connected to its end is such that electrons from the gun 85, which have passed through the cavity structure 82, will be reflected and returned therethrough in the proper phase to produce the desired oscillations.

The eccentrically-disposed pins 106, 107 support between their inner ends a suitable getter 110 which is activated by the application of voltage to the outer end of said pins during evacuation of the klystron. Such evacuation is accomplished through a tubulation 111 secured in a transverse bore 112 in the body portion 80 that intersects the central bore 81, in a manner similar to that described hereinbefore with respect to the structure shown in Fig. 2. After the evacuation is completed, the tubulation 111 is pinched off, as shown, and the end thereof is covered by an insulating plate 113, as of plastic. The plate 113 is suitably apertured to receive the ends of the described wires 110, 101, 102 and 109 and enable connection thereto.

A transverse bore 114 is drilled from the other side of the body portion 80 to intersect the central bore 81, and is subsequently enlarged through a major part of its length to form part of a resonant cavity 115. This cavity 115 is external to the vacuum envelope, being separated from the internal cavity within the cavity struc-

ture 82 by a ceramic window 116. Ceramic is again employed, as in the Fig. 2 structure to enhance the degree of coupling between the two cavities. To further optimize the coupling, a small threaded post 117 adjustably extends through upper wall of the external cavity 115 to terminate at a point adjacent the ceramic window 116. The remainder of the external cavity 115 is formed by a milled opening in a metal block or flange 118 secured to the side of the body portion 80 so as to register with the milled opening therein. A tuning screw 119 projects the desired, adjusted amount into the cavity 115 from a threaded bore formed adjacent one edge of the described flange 118 and a smaller coupling screw 120 extends from a bore adjacent the other edge of the flange 118 to project into the central aperture in a plate 121 that defines the end of the external cavity. This latter screw 120 provides for optimization of coupling between the external cavity 115 and an attached waveguide section (not shown). To provide for attachment of such wave guide section, four threaded holes 122 are machined at properly spaced points adjacent the corners of the flange 118, as shown in Fig. 3.

It is believed apparent from the foregoing that the structure shown in Figs. 3 and 4 embodies much the same features as the first embodiment disclosed in Figs. 1 and 2, but merely constitutes somewhat of a stripped down version for a slightly variant application.

A further variance in application is contemplated with respect to the third embodiment of the invention, as shown in Figs. 5 and 6. As best shown in Fig. 5, the electron gun 130, cavity structure 131 and reflector 132 are substantially identical to the corresponding portions of the device shown in Fig. 4 so that they will not be described in detail. These portions are mounted in body portion 133 that is generally similar to that shown in Fig. 2, with a slight rearrangement so that a variable resistor 134 can be mounted within the cubical outline of the block or body portion 133.

An external cavity 135 is formed in a central partition 136 formed between two bores 137, 138 at the opposite ends of the body portion 133 and is coupled to the internal cavity formed within the cavity structure 131 through a ceramic window 139. A tubulation 140 enabling evacuation of the klystron is disposed at right angles to the described external cavity 135 to thus allow the mentioned variable resistor 134 to be mounted in an enlarged opening 141 milled at a point diametrically opposite the external cavity. As shown, the resistor 134 is mounted on one of several plastic covers 142 arranged to close the various machined openings in the body portion 133 to provide a finished cubical outline therefor.

In accordance with a feature of this invention, the resistor 134 is electrically connected to the reflector 132 and is arranged to vary the voltage applied thereto upon a variance of the operating frequency of the klystron. It is, of course, well known that when the operating frequency of a reflex klystron is changed, a change in the reflector voltage will properly adjust the phase of the reflected electrons so that the optimum output of the klystron will be achieved.

As shown, the klystron is tuned by means of an elongated bar 143 which is conventionally threaded adjacent its lower end that projects through a threaded bore into the external cavity 135. Thus the amount of projection and the operating frequency of the klystron can be varied by turning of the bar 143. To enable such turning, longitudinally-extending teeth 144 are formed on the upper end of the bar 143 where it projects through a suitable opening in the top plastic cover 142 so as to mesh with a large gear 145. The gear 145 is rotatably supported on a centrally-disposed shaft 146 mounted on the plastic cover 142, such shaft also supporting a bevelled gear 147 immediately under the first gear 145. This bevelled gear 147 meshes, in turn, with a bevelled gear 148 supported on a control shaft 149 for the mentioned variable resistor 134, a small slot 150 being provided in the plastic cover 142 to permit projection of a small portion of the gear 148 therethrough.

When the centrally mounted shaft 146 is turned by an operator who may grip a knurled nut 151 secured to the top thereof, both gears 145 and 147 are simultaneously rotated. The rotation of gear 145 is transmitted to the tuning bar 143 which is accordingly shifted axially to project a greater or lesser amount into the external cavity 135. At the same time, the rotation of the bevelled gear 147 is transmitted through the meshing gear 148 to the control shaft 149 for the variable resistor 134 to accordingly vary its resistance value. Voltage supplied to the resistor 134 through a wire 152 is reduced a predetermined amount and then applied to the reflector 132 through connecting wire 153. The gear ratios are such that whatever the operating frequency of the klystron, the optimum voltage is always supplied to the reflector 132 so that the electrons will be reflected and returned through the cavity structure 131 in the proper phase relationship.

An indication of the operating frequency is provided by a pointer 154 disposed on the upper plastic cover 142 adjacent an inverted cup or dome 155 secured to the central shaft 146 for rotation therewith and having suitable indicia on the side thereof. This dome 155 also serves as a protective cover for the gears 145 and 147.

The operation of the klystron as shown in Figs. 5 and 6 is the same as that shown in Figs. 1 and 2 except for the automatic variation in the reflector voltage, so that a description of such operation is not warranted. It can be pointed out, however, that in view of the automatic adjustment of the reflector voltage, the klystron as shown in Figs. 5 and 6 after connection to suitable voltage sources, can by a mere turning of the knurled nut 151 be caused to produce a desired output frequency at the maximum power level. Thus, this klystron can be applied readily for use as a low-level signal generator for microwave experimentation.

Many further alterations and modifications can obviously be made without departing from the spirit of the present invention. For example, it is believed obvious that the central bore of the body portion, as described for each of the disclosed embodiments, might be lengthened so that more than one of the described cavity structures might be inserted therein, and a positively charged collector could be substituted for the negatively charged reflector to thus provide the basis for a multicavity klystron amplifier. Furthermore, it will be appreciated by those skilled in the art that the novel electron gun structure herein disclosed is applicable not only to klystrons but to other electron discharge devices such as, for example, a traveling wave tube. Accordingly, the foregoing description of three embodiments of the invention is to be considered as purely exemplary and not in a limiting sense, the scope of the invention being indicated by the appended claims.

I claim:

1. A klystron comprising a unitary metallic body portion of generally cubical outline having a small central bore therethrough, means forming a counterbore defining an annular seat on said body portion adjacent the end of said small bore and coaxial therewith, a cavity structure supported within said small central bore and defining a cavity having a capacitive gap, and means including an electron gun having a tubular member secured on said annular seat for producing and directing a beam of electrons through said capacitive gap, said electron gun being within the cubical outline of said body portion.

2. A reflex klystron comprising a unitary metallic body portion of generally cubical outline having a small central bore therethrough, means forming counterbores adjacent opposite ends of said small central bore to define

annular seats on said body portion coaxial with said small bore, a cavity structure supported within said small bore defining a cavity having a capacitive gap, an electron gun having a tubular member secured on said annular seat on said body portion to produce and direct a beam of electrons through said capacitive gap, and a reflector secured on the annular seat on said body portion at the opposite end of said small bore for reflecting electrons from said gun back through said capacitive gap, said electron gun and said reflector being within the cubical outline of said body portion.

3. A reflex klystron comprising a unitary metallic body portion of generally cubical outline having a small central bore therethrough, means forming counterbores at opposite ends of said small central bore to define annular seats on said body portion coaxial with said small bore, a cavity structure supported within said small central bore and defining a first cavity having a capacitive gap adapted to be traversed by a beam of electrons directed axially through said bore, said cavity structure having an iris opening in the side thereof, an electron gun having a tubular member secured on said annular seat at one end of said small bore arranged to produce and direct a beam of electrons through said capacitive gap, a reflector secured on said annular seat at the opposite end of said small bore for reflecting electrons from said gun back through said capacitive gap, said electron gun and said reflector being within the cubical outline of said body portion, means forming a second cavity in said body portion coupled through said iris opening to said first cavity, covers secured to said body portion over said reflector and said gun, and a tuning screw projecting through one of said covers and into said second cavity.

4. A reflex klystron comprising a unitary metallic body portion of generally cubical outline having a small central bore therethrough, means forming counterbores at opposite ends of said small central bore to define annular seats coaxial with said small bore, a cavity structure supported within said small central bore and defining a first cavity having a capacitive gap adapted to be traversed by a beam of electrons directed axially through said bore, said cavity structure having an iris opening in the side thereof, an electron gun having a tubular member secured on said annular seat at one end of said small bore adapted to produce and direct a beam of electrons through said capacitive gap, a reflector secured on the annular seat at the opposite end of said small bore so as to reflect, upon application of a negative voltage thereto, electrons from said gun back through said capacitive gap, means including a variable resistor connected to said reflector to provide a variable negative voltage to said reflector, said electron gun, said reflector, and said variable resistor being within the cubical outline of said body portion, means forming a second cavity in said body portion coupled through said iris opening to said first cavity, covers secured to said body portion over said reflector and said electron gun, a manually adjustable tuning screw projecting through one of said covers and into said second cavity, and means connecting said tuning screw to said variable resistor whereby manual adjustment of said tuning screw simultaneously varies the resistance of said variable resistor.

5. In a reflex klystron having a cavity external to the vacuum envelope thereof and a reflector, a manually adjustable tuning screw projecting into the external cavity to enable variance of its resonant frequency, a variable resistor electrically connected to the reflector to enable variance of voltage adapted to be supplied thereto, and means connecting said tuning screw and said variable resistor whereby the resonant frequency of the external cavity and the voltage supplied to the reflector are varied simultaneously and in predetermined proportion to provide substantially maximum output at every operating frequency.

6. A klystron comprising a metallic body portion having a central bore therethrough, a cavity structure supported within said bore and defining a cavity, said cavity structure including a cup-shaped metal element arranged to fit within said bore and having a central re-entrant tube formed integrally therewith and having an iris opening in the side thereof, a grid secured within said re-entrant tube adjacent its inner end, and a plate having an integral central grid secured to the lip of said cup-shaped element so that said grids are disposed in spaced aligned relation to form a capacitive gap therebetween, and means including an electron gun secured adjacent one end of said bore for producing and directing a beam of electrons through said capacitive gap.

7. A klystron according to claim 6 comprising means forming a second cavity in said body portion coupled through said iris opening to the cavity defined by said cavity structure.

8. A cavity structure for a klystron comprising a cup-shaped metal element having a central re-entrant tube formed integrally therewith and having an iris opening in the side thereof, a first grid secured within said re-entrant tube adjacent the inner end thereof, and a plate having a second grid integral therewith secured to the lip of said cup-shaped element whereby said grids are disposed in spaced, aligned relation to form a capacitive gap therebetween.

9. A klystron comprising a unitary metallic body portion having a central bore therethrough, means forming a counter-bore defining an annular seat on said body portion adjacent the end of said bore and coaxial therewith, a cavity structure supported within said bore and defining a cavity having a capacitive gap, and an electron gun adapted to produce and direct a beam of electrons, said electron gun including a tubular metal member arranged to be secured on said annular seat whereby the beam of electrons will be directed through said capacitive gap.

10. A klystron comprising a metallic body portion having a central bore therethrough, means forming an annular seat on said body portion adjacent the end of said bore and coaxial therewith, a cavity structure supported within said bore and defining a cavity having a capacitive gap, a metal tube secured endwise on said annular seat, a glass seal closing the end of said tube remote from said annular seat, a metal stem having the configuration of a thin, elongated cup mounted on said seal, and means including a cathode button supported from said stem in spaced, aligned relation with respect to said cavity structure for producing and directing a beam of electrons through said capacitive gap.

11. A reflex klystron comprising a metallic body portion having a central bore therethrough, means forming annular seats on said body portion adjacent the opposite ends of said bore, a cavity structure supported within said bore and defining a cavity having a capacitive gap, metal tubes secured endwise on said annular seats, a glass seal closing the end of each of said tubes remote from the respective one of said annular seats, metal stems sealingly encompassed and supported by said glass seals to extend toward said cavity structure, means including a cathode button supported from one of said stems for producing and directing a beam of electrons through said capacitive gap, and means including a reflector button supported from the other of said stems for reflecting electrons from said cathode button back through said capacitive gap.

12. An electron gun for klystrons or the like comprising a metal tube, a glass seal closing one end of said tube, a metal stem having the configuration of a thin, elongated cup sealingly encompassed and supported by said glass seal so that its open end projects coaxially within said metal tube, means forming openings in the side of said cup-shaped stem, a pair of eccentrically disposed metal pins sealingly encompassed and supported by said glass seal adjacent said stem, a tubular heat shield

secured in telescoping relation to the open end of said cup-shaped stem, a cathode button secured to the end of said heat shield remote from said stem, and a heater disposed within said heat shield and having ends projecting laterally through the openings in said stem for supporting connection to said pins.

13. An electron gun according to claim 12 comprising a hollow metal cylinder disposed concentrically around said tubular heat shield and having one end bent inwardly and secured to said heat shield where the latter telescopes into said stem so that the other end of said cylinder surrounds said cathode button.

14. An electron gun according to claim 13 wherein said

stem, said tubular heat shield and said hollow metal cylinder are secured together by a single braze.

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