Sept. 24, 1963 R. J. BRODERICK 3,105,167

INSULATED ELECTRON TUBE TUNING DEVICE

Filed July 26, 1960

Fig. 1.

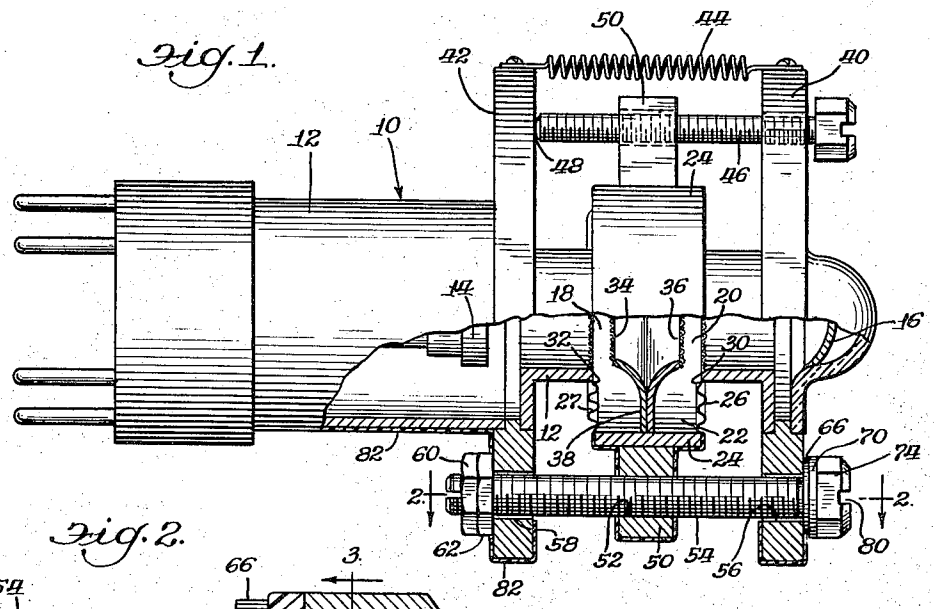


Fig. 2.

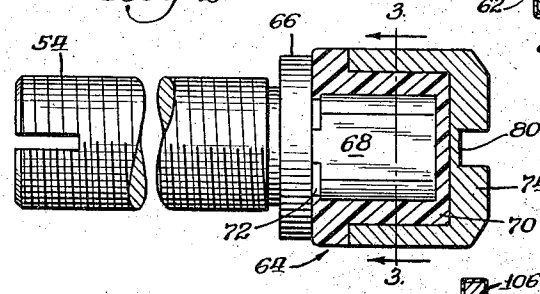


Fig. 3.

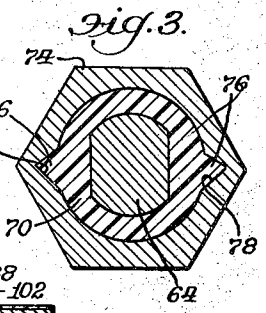
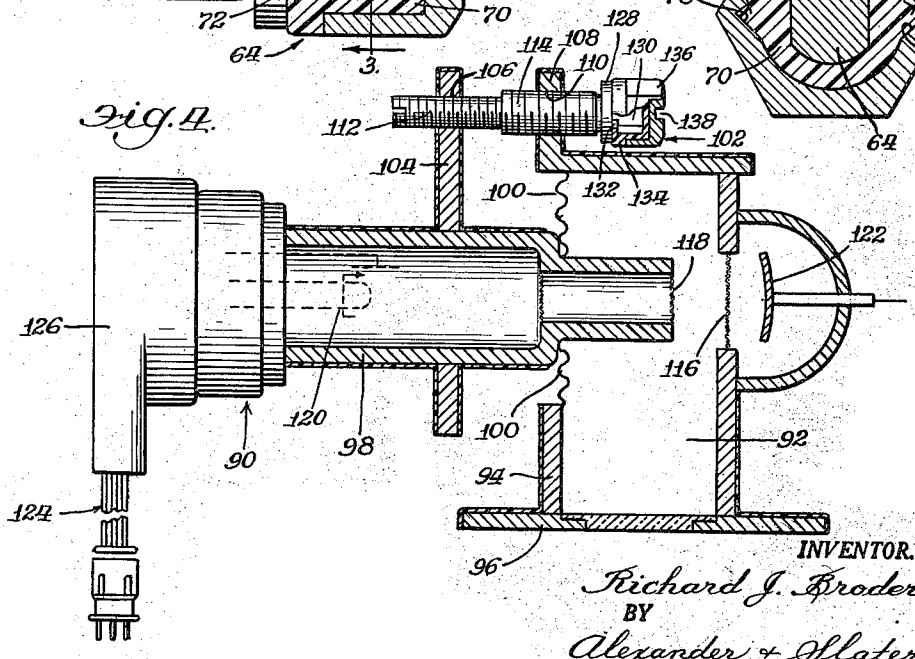


Fig. 4.



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INSULATED ELECTRON TUBE TUNING DEVICE

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This invention relates to electron tubes, more particularly to electron tubes having movable electrodes and tunable resonate cavities; such tubes are commonly termed klystrons.

Certain electron vacuum tubes which operate on the velocity modulation or electron bunching principle require adjustment of the position of electrodes and the relative position of resonate cavity structures in order to tune them. These tubes, commonly termed klystrons, are often encased in an evacuated metal envelope which during operation of the tube is charged to a high voltage above ground potential, +300 volts and even higher voltages being common. The mechanical mechanisms required to make the very fine vibration free position adjustments of the electrodes and the cavity resonator walls are made of metal, are in direct electrical contact with the tube envelope and consequently are operated at a high voltage above ground potential. These high voltages on exposed conducting surfaces, some of which require adjustment by operating personnel in order to tune the equipment, comprise a serious hazard both to the operating personnel and to the equipment. An accidental shorting of the tube to ground is a painful and even dangerous experience for operating personnel and such an accidental short may damage the tube and other sensitive electrical components associated with it.

Klystrons are a necessary component in radar and other microwave frequency devices. Such equipment is often operated on board aircraft, in rocket powered missiles, on board ships, and in other installations where considerable vibration and even mechanical shock is encountered. In order to remain operational in all of these environments, the adjustable parts of the tubes must be so constructed as to not move in response to vibration or shock. The tuning mechanisms of these tubes are finely machined and fitted to work smoothly with friction or spring loads which hold all movable parts rigidly in position between adjustments by the operator. Because of the friction and spring loaded designs of the adjusting mechanisms, most of the adjustments must be made with a tool to provide sufficient torque to overcome the anti-vibration loading on the movable parts. Insulated handle tools such as a screwdriver or wrench are commonly provided to make the tuning adjustments on the klystron. However, by reason of inadvertence or human error, an operator not infrequently touches the klystron tuning mechanism or the conducting klystron envelope with a non-insulated tool or with his hand while making contact with ground potential and receives a painful shock as well as risking damage to some of the equipment.

A need for an insulated klystron, and particularly an electrically insulated tuning mechanism has long been indicated. Despite the obvious hazards from the high voltage charge that they carry during operation, klystrons have not heretofore been designed to protect operating personnel from the high voltage on their surfaces and particularly that carried on their tuning mechanisms. Earlier efforts to insulate the high voltage members of klystron tubes were unsuccessful because of the relatively large mechanical loads that must be transmitted through the tuning mechanism free of backlash or play between the parts. Coupling the metal parts of the tube to suitable insulating materials, particularly in the sensitive

tuning mechanisms, has not heretofore been accomplished in a practical manner.

Tunable klystrons are utilized on board equipment and in ground installations where very high intensity audio and supersonic energy is radiated from jet and rocket engines. In very high intensity sound fields the various parts of a klystron are set into vibration which create noise in the electrical circuits associated with them, and, even interfere with the proper operation of the tube in extreme circumstances. Various external shields have been suggested to protect high intensity, noise sensitive tubes, but they are bulky, add undesirable weight to the structure and have not been universally practical. There is, therefore, need to damp high intensity sound field energy prior to its impinging on the parts of a klystron tube.

One object of my invention is to provide a novel tunable klystron tube which is adapted to operation in high intensity sound fields, is electrically insulated from inadvertent shorting by an operator, and may be tuned with electrically insulated positive mechanical control of the electrode positions.

Another object of my invention is to provide novel means to be utilized in combination with presently known klystron tubes to protect them from the hazards of high intensity sound fields and accidental external electrical shorting.

Still another object of my invention is to provide an improved safe means for tuning variable electrode electron tubes.

Yet another object of my invention is to provide novel improved means to protect tunable klystron tubes from the effects of high energy sound fields.

These and other objects and advantages of my invention will be evident from the following drawings, descriptions, specifications and claims.

My invention, broadly speaking is a combination of cooperating insulating means adapted to isolate the electrically conducting evacuated envelope of a movable electrode vacuum tube from impinging high energy sound fields and from the accidental electrical shorting of the envelope directly to ground or through the tuning mechanism.

My invention is further illustrated by the drawings of specific embodiments in the figures wherein:

FIGURE 1 is a side view partly cut away showing a preferred embodiment of my invention in combination with a klystron tube;

FIGURE 2 is a cross sectional view of the insulated lead screw illustrated in the embodiment of FIGURE 1;

FIGURE 3 is a cross sectional view taken through the lead screw shown in FIGURE 2 on line 3—3; and

FIGURE 4 is a partly cut away cross sectional view of an embodiment of my invention shown in combination with a different klystron tube.

Referring now to the drawings, FIGURE 1 illustrates, in a partly cut away section a common design of a klystron tube **10** having an electrically conducting evacuated envelope **12**, the various portions of which are described below, a cathode or electron gun **14**, a plate **16** sometimes referred to as a catcher or reflector, buncher grids **18**, catcher grids **20** and cavity resonator **22**. The cavity resonator is comprised of side walls **24** in the form of a circular cylinder, and top and bottom **26** and **27** respectively made of flexible crimped metal which permits longitudinal movement of the cylindrical side walls **24**. The flexible top and bottom **26** and **27** of the cavity resonator are sealed to the envelope **12** at **30** and **32** respectively. Movable electrodes or grids **34** and **36** are mounted on a bracket **38** which is rigidly attached to the cavity walls and holds the grids **34** and **36** within the cavity resonator.

Two rigid cylindrical flanges 40 and 42 project radially from the envelope 12. The two flanges 40 and 42 are held in rigid spaced relationship with a plurality of springs 44 attached to their peripheries held in tension; and a plurality of adjustment screws 46 positioned between the flanges in threaded engagement with openings in the flange 40 and in contact with the inner surface 48 of the flange 42. By such an arrangement of the springs 44 and adjustment screws 46 the flanges 40 and 42 may be held in adjustable but rigid vibration proof spaced relationship.

A cylindrical flange 50 projecting radially exteriorly from the resonator wall is provided with a plurality of threaded openings 52 through which lead screws 54 are threadedly engaged. For purposes of this description reference will be made to only a single lead screw. The lead screw 54 is mounted through coaxially aligned openings 56 and 58 respectively in flanges 40 and 42. The lead screw 54 is held axially in position within the openings 56 and 58 by lock nuts 60 and 62. By such an arrangement, as is readily apparent from FIGURE 1, rotation of the lead screw 54 will cause the flange 50 mounted on the cavity resonator to move linearly along the axis of the tube. In this way the positions of the electrodes 34 and 36 may be adjusted with respect to the electrodes 18 and 20 and therewith "tune" the klystron.

The lead screw 54 is in electrical contact with the flanges 40, 42 and 50 and therefore is operated at a high voltage with respect to ground potential. The head 64 of the lead screw 54 is comprised of a collar 66, and a flat sided post 68 which extends beyond the collar. A cap 70 made of insulating material such as polystyrene, epoxy, acrylic rubber, silicone rubber or other mechanically strong polymers, many of which are marketed under trade names, a preferred material for use in my invention being "Stycast." The cap 70 fits tightly over the post 68, seats on the collar 66 and extends radially outward beyond the collar. The cap 70 is preferably attached to the post with an adhesive material or is molded onto the post. FIGURE 2 illustrates, in cross section, a specific example of a lead screw 54 machined of cold rolled steel and prepared for having the insulating cap 70 molded thereto. An undercut slot 72 at the base of the post provides a locking means between the molded cap 70 and the post 68. The locking means is important and preferably forms a positive mechanical interlock as shown. Such a positive interlock is necessary to hold the insulating cap 70 which, in general, possesses a smaller coefficient of thermal expansion than the steel post 68, during the thermal excursions the entire device experiences when in operation.

The cap 70 is recessed to receive a metal cap or crown 74 which fits over the insulating cap 70 and is securely attached with suitable metal to polymer adhesive. The joining of the polymer cap 70 and the metal crown 74 is best illustrated in FIGURE 3, which shows the lead screw head 64 in transverse cross section. The cap 70 is provided with a convex contour 76 which distorts the circular symmetry of the cap 70. The crown 74 is provided with a concave contour 78 which fits tightly about the convex shape of the cap 70, and provides for applying tangential force between the crown 74 and the cap 70 without placing large shear forces on the metal to polymer adhesive which cements the two pieces together. By this arrangement the hexagonal crown may be gripped by a wrench or may be engaged by a screwdriver in the slot 80 whereupon substantial positive mechanical torque may be applied to the lead screw 54 without making electrical contact with the highly charged klystron body.

The adjustment screw 46, in the embodiment illustrated, may be fitted with an insulated head such as is shown in FIGURES 2 and 3. However, the tuning adjustments rarely require resetting the adjustment screw or screws during operation of the tube.

The exterior conducting surfaces of the envelope 12, the flanges 40, 42 and 50, the resonator walls 24 and other exposed parts of the klystron which carry a high voltage charge during operation are coated with a temperature resistant coating 82 such as, for example, "Stycast," polyethylene, epoxy, polyurethane, rubber, or silicone rubber.

By means of the combination of the insulated tuning mechanism and the insulated surfaces of the klystron it may be tuned without risk of shorting inadvertently by accidental contact between charged portions of the klystron and ground with a tool or with the operator's hand.

The insulating coating serves further to dampen high intensity sonic energy impinging upon the tube surfaces. In one specific example not illustrated in the drawings silicone rubber coating was applied on the exterior tube surfaces in a coating approximately $\frac{1}{32}$ inch in thickness. This coating permitted adjustment of the mechanical parts of the tube which underwent a small geometrical change during tuning without rupturing the insulating and sound deadening coating.

A second embodiment of my invention is illustrated in FIGURE 4, which shows a cross sectional view of a klystron 90 which is widely used; it is convenient because it mounts directly onto waveguide and requires only one adjustment to tune.

Referring now to FIGURE 4, a cavity resonator 92, comprised of a resonator wall 94, having a wave guide connection 96 is joined to a gas tight tube envelope 98 by means of a flexible metal diaphragm 100 and a differential lead screw 102. A rigid flange 104 projects radially from the envelope 98 and is provided with a threaded opening 106; a section of a flange 108 projects radially outwardly from the resonator wall 94 and it too is provided with a threaded opening 110. The threaded opening 106 is of smaller diameter and has a faster thread than does the opening 110; these openings are adapted to receive the differential lead screw 102 which has a smaller diameter section 112 and a larger diameter section 114. By this arrangement, which is clearly shown in FIGURE 4, rotation of the lead differential screw 102 will alter the spacing between the flange 104 and 108 and therewith "tune" the klystron by adjusting the spacing between the electrodes or grids 116 and 118. Electrons emitted by the cathode 120 are velocity modulated by passing through the grids 116 and 118 where a considerable portion of their energy is transferred to the cavity 92 as electromagnetic waves, which are conducted out of the cavity through the wave guide coupling. A plate 122 is mounted at the end of the electron trajectory. Power leads 124 for cathode and plate are connected through the tube base 126.

The exposed exterior surfaces of the enevelope 98 and resonator walls 94 are coated with an electrical insulating and sound deadening polymer, such as described above in connection with the embodiment of FIGURE 1. In order to complete the insulation of the klystron the tuning controls must also be electrically insulated from the high voltage charge carried by the klystron envelope and cavity walls. This is accomplished by utilizing a head 128 on the differential lead screw identical to that shown in cross section in FIGURES 2 and 3. The threaded shanks 112 and 114 terminate in a collar 128 and a flat sided post 130, all machined from cold rolled steel. The post 130 is undercut slightly at 132 to receive and interlock with a molded polymer insulating cap 134. The insulating cap 134 has a convex contour not shown in FIGURE 4, but identical to that illustrated in FIGURE 3, and a machined cold rolled steel metal crown 136 which fits securely over the cap 134 and engages the cap 134 for the transfer of torque through the cap 134 without creating large shear forces between the crown 136 and the cap 134. The metal crown is hexagon shaped about its perimeter and adapted to receive a wrench, as well as being provided with a slot 138 adapted to receive a screwdriver.

Rotation of the differential lead screw 102 is accom-

plished by applying torque to the crown by application of a tool. The threaded portions of the tuning mechanism are finely finished and fit without appreciable play so that the lead screw turns only by application of considerable force. Such a tight fit prevents detuning from vibration and mechanical shock of the klystron. By utilizing the combination of an insulating coating on the exposed exterior surfaces of the envelope and resonator of the klystron and my novel electrically insulated differential lead screw, the klystron may be tuned without risk of electrical shock to the operator or risk of damage to the apparatus.

The foregoing illustrations and specifications of specific embodiments of my invention are intended as merely descriptive, the scope of my invention being limited only by the following claims.

My invention is hereby claimed as follows:

1. An improved safe device for tuning adjustable cavity resonator electron discharge tubes comprising the combination of an electron tube having an electrically conducting evacuated envelope, moveable electrodes positioned in spaced relationship within the envelope, and threaded means for positioning the electrodes in combination with a lead screw having a head end, the lead screw being mechanically coupled to the threaded means, the head end being capped with an electrical insulating material and provided with a contour adapted to receive a hand tool for imparting torque to the lead screw, and a temperature resistant electrical insulating coating on the exterior of the envelope whereby the electrodes may be repositioned by adjusting the lead screw with a hand tool without risk of electrical contact with the electrical conducting tube envelope.

2. An improved electron discharge device comprising a tube body, movable electrode contained within the body in spaced relationship to form cavity resonators therein, a cathode and anode mounted within the tube body, threaded means for determining the positions of the electrodes in combination with a threaded lead screw having a head end, the lead screw mechanically coupled through the threads to the means, an electrically insulating spacer cap securely mounted over the lead screw head, and a metal cap securely mounted over the spacer cap whereby the electrode positions may be adjusted to effect tuning of the device by rotating the lead screw by applying torque to the metal cap without making an electrical connection with the tube body.

3. The improved combination of claim 2 wherein the exterior surfaces of the tube body are enclosed within a heat resistant electrically insulating coating.

4. An improved safe device for tuning adjustable cavity resonator electron tubes comprising the combination of a cavity resonator electron tube having movable electrodes in spaced relationship, threaded means for determining the positions of the electrodes in combination with a threaded lead screw having a head end, the lead screw mechanically coupled through the threads to the means, an electrically insulating spacer cap securely mounted over the lead screw head, and a hollow metal cap securely mounted over the spacer cap whereby the electrode positions may be adjusted to effect tuning of the device by rotating the lead screw without making an electrical connection with the tube body.

5. The device claimed in claim 4 wherein the lead screw head is provided with an undercut at its base and is non-circular in transverse cross section, the insulating spacer cap is securely mounted over the lead screw head and interlocks with the undercut, and the insulating spacer cap is provided with non-circular convex contours which interlock with the interior surfaces of the hollow metal cap.

6. An improved safe cavity resonator electron tube comprising an evacuated envelope having exposed exterior surfaces, a cathode, a plate, a cavity resonator through which electrons traverse between the cathode and the plate, electrodes positioned within the cavity in spaced relationship to the cathode, the cavity, cathode, plate and electrodes being positioned within the evacuated envelope, threaded means for adjusting the position of the electrodes, and means for conducting electrical and RF energy respectively into and from the tube in combination with a threaded lead screw having a head end mechanically coupled to the threaded means, and electrically insulating spacer cap securely mounted over the lead screw head, and a metal cap securely mounted over the spacer cap, the metal cap being provided with a slot for receiving a hand tool, and a temperature resistant electrically insulating coating over the exterior surfaces of the envelope whereby the electrode positions may be adjusted by applying a torque by means of a hand tool inserted into the slot which causes the lead screw to rotate and therewith through the threaded means causes the movement of the electrodes without risk of electrical contact between the hand tool and the electron tube.

7. The improved combination of claim 5 wherein the spacer cap and the insulating coating are polystyrene.

8. The improved combination of claim 5 wherein the spacer cap and the insulating coating are epoxy resin.

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