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W. K. BARLOW ETAL

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DAMPING MEANS FOR SHAFTS

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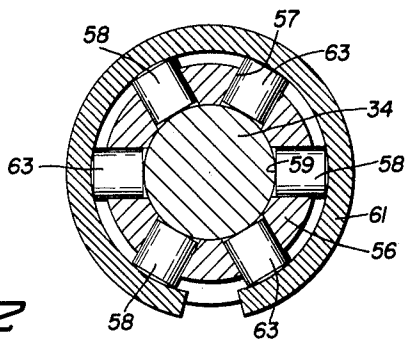


Fig. 2

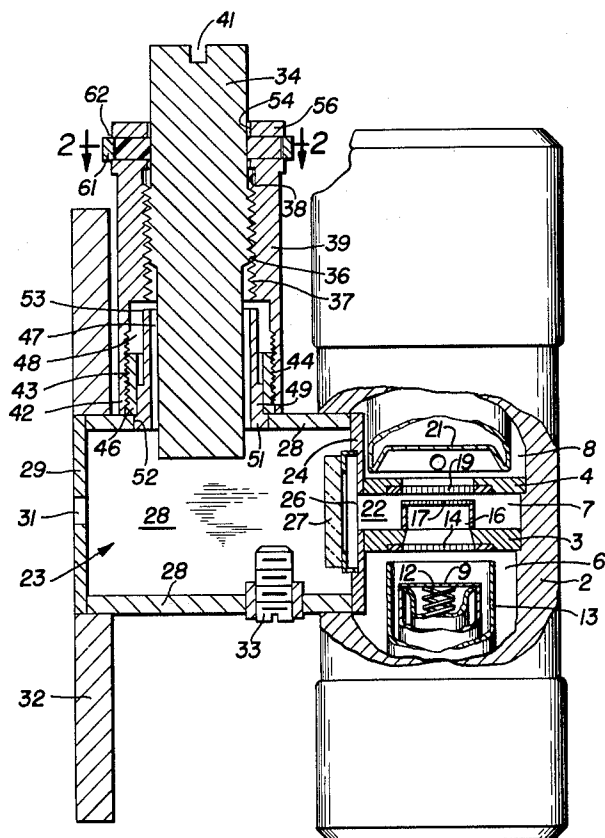


Fig. 1

INVENTORS
WAYNE K. BARLOW
JOHN F. MIDDLEAUGH

BY

Robert H. Diltz
ATTORNEY

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DAMPING MEANS FOR SHAFTS

Wayne K. Barlow, San Mateo, and John F. Middaugh, San Jose, Calif., assignor to Eitel-McCullough, Inc., San Carlos, Calif., a corporation of California
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6 Claims. (Cl. 333-83)

This invention relates to the control of undesired motion between two relatively movable mechanical members, and more particularly to vibration damping and torque control means for rotary shafts or threaded spindles.

It is the broad object of the present invention to provide a vibration damping and torque control mechanism in which vibration is eliminated and the torque required to turn a shaft is maintained within a predetermined range over a predetermined number of cycles of operation regardless of variations in temperature of the parts within specified limits.

For purposes of illustration and description, the invention is disclosed as applied to an electron tube tuner mechanism. Reflex klystrons, for instance, because of their small size and light weight, are often used in applications that require a maximum amount of reliability. These tubes also incorporate tuner mechanisms utilizing a rotary screw shaft for advancing and retracting a tuning member into a resonant cavity, and specific limitations are placed on the range of torque required to rotate the shaft. It will readily be understood that in a tuner mechanism which is designed to be cycled approximately 2,500 times, and heat cycled through temperatures ranging between -45°C. to 125°C. , it is extremely difficult to eliminate vibration and control the range of applied torque by which the tuner mechanism is operated. Therefore, as applied to an electron tube, another important object is the provision of a tuner mechanism employing a rotary shaft in which the torque required to turn the shaft is maintained within the range of 5 to 40 inch ounces over 2,500 cycles of operation through variations in temperature ranging between -45°C. to 125°C.

Another stringent requirement placed on electron tubes is that the noise level, both AM and FM, be minimal or be eliminated entirely. In reflex klystrons, AM and FM noise may arise from the distortion of electrical and magnetic fields within the resonant cavity, and from impedance changes along the threaded portion of the tuner shaft in tubes using screw shaft tuning mechanisms. It has been found that when vibration causes minute movements of the tuner shaft relative to its supporting shell and the cavity, both the electrical and magnetic fields within the cavity are distorted and the impedance along the threaded portion of the tuning shaft varies, thus giving rise to such noise. It is therefore another important object of the invention to provide a screw shaft tuner mechanism for an electron tube in which "tuner generated" noise is minimized.

Another criterion for reflex klystron tuners is that there be a minimum of "jitter" in the tuner mechanism. Jitter is a phenomenon which occurs as the tuner is operated. Like noise, it is caused by changes in impedance along the threaded portion of the tuner shaft, and results from the presence of backlash in the tuning mechanism or other irregularities in the mechanism, such as metallic chips, which tend to produce a jerky movement of the tuning shaft. Jitter is manifested by instantaneous displacements in the modulated mode pattern as the tuner is operated. It is desirable that jitter be eliminated entirely in a reflex klystron tuner mechanism, and it is therefore another important object of the present invention to provide a tuner screw mechanism for an electron tube which eliminates jitter entirely.

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It is not especially difficult to design electron tube tuner mechanisms which solve any one of the problems discussed above. It is difficult, however, to provide a structure in which all of the requirements respecting torque, elimination of electrical noise under vibration, and elimination of electrical jitter are satisfied. It is therefore another important object of this invention to provide an electron tube incorporating a new tuner mechanism for application in extreme environmental conditions and capable of extended tuner life, reliable torque control, jitter-free tuning, and minimized noise under vibration, all in one mechanism.

Broadly considered, the invention as embodied in an electron tube of the 2-cavity reflex klystron type comprises a generally cylindrical electron tube body portion having therewithin a cathode-heater assembly operatively aligned with a plurality of grids defining an interaction gap within the klystron for interaction with an electron beam projected from the cathode to the repeller. The gap defined by the grids forms a part of a primary resonant cavity, and the cavity is connected by a radio frequency window with an auxiliary or tuning cavity adapted to be interposed between the tube body and a waveguide. A flange on the auxiliary cavity provides means for securing the tube structure to the waveguide. A rotatable screw shaft mechanism and tuning member are provided to adjust the operating frequency of the resonant cavity. The tuning mechanism incorporates means for minimizing mechanical vibration and eliminating jitter, and for maintaining within predetermined limits the torque required to rotate the screw shaft.

Referring to the drawings:

FIGURE 1 is a plan view partly in section illustrating the relationship between the tuner mechanism and the tube.

FIGURE 2 is a sectional view taken in the plane indicated by the line 2-2 of FIGURE 1.

In terms of greater detail, the reflex klystron and tuner mechanism embodying the invention comprises a hollow metallic cylindrical tube body 2 symmetrical about a longitudinally extending axis, and having a pair of transversely extending apertured plates 3 and 4 therewithin and axially spaced apart to define a cathode chamber 6, a primary resonant cavity 7 and a repeller chamber 8. Within the cathode chamber is supported a cathode 9 appropriately heated by means of a heater coil 12, to generate a beam of electrons which is appropriately focused by focus electrode 13. The electrons of the beam are accelerated by an anode accelerating grid 14 supported on plate 3, and are permitted to drift through a drift tube 16, from which they pass through gap entrance grid 17, interaction gap 18, and exit grid 19. In passing through gap 18 the electron beam is velocity modulated to produce bunches of electrons which are then repelled by repeller electrode 21 in repeller chamber 8. The bunches of electrons repelled by the repeller electrode pass back through the gap and excite the resonant cavity 22 defined by the tube body and plates 3 and 4 into resonance at the operating frequency of the tube. Cavity 22 comprises a primary resonant cavity in the tube, and is coupled to a secondary cavity 23 having one wall 24 thereof forming a part of the tube body and having an aperture 26 therein hermetically closed by radio frequency window 27.

The secondary or auxiliary cavity 23 is provided with side wall members 28 integrally and hermetically united to end wall 24 and defining the configuration of cavity 23. The side walls 28 are closed on the ends thereof remote from wall 24 by wall 29 having aperture 31 therein for coupling electromagnetic energy into an adjoining or associated waveguide (not shown) adapted to be attached to the mounting flange 32.

As shown best in FIGURE 1, the auxiliary cavity 23 extends perpendicularly to the longitudinal axis of the tube, and is provided with adjustable plug 33 to optimize the coupling between the primary and auxiliary cavities.

In order to tune the output frequency of the tube, a tuner mechanism is provided adjustably mounted on the auxiliary cavity 23. As shown best in FIGURE 1, the tuner mechanism is preferably of the screw type having a longitudinal axis parallel to the axis of the tube, and incorporates a tuning shaft 34 having threads 36 intermediate its ends adapted to work in threads 37 formed on the inside periphery 38 of a hollow tuner support shell or housing 39. The outer end of the tuner shaft is provided with a screw driver slot 41 to facilitate adjustment. The tuner support shell 39 is provided with a cylindrical bore and is detachably connected at one end 42 to the auxiliary cavity wall 28. This connection is effectively made by means of threads 43 internally formed in the support shell 39 and adapted to engage threads 44 formed on integral cavity extension 46.

As shown best in FIGURE 1, the end of the tuner support shell adjacent the auxiliary cavity is enlarged in internal diameter over the diameter of the shell where threads 37 occur. This increase in diameter of the shell adjacent the auxiliary cavity wall provides an annular space between the inner end of tuner shaft 34 and the end of the shell. Centrally mounted within this space, to provide an annular space 47 immediately surrounding the tuner shaft and a second concentric annular space 48 immediately adjacent the tuner support shell is a cylindrical metallic sleeve 49 having one end 51 thereof integrally united, within aperture 52, to wall 28 of the auxiliary cavity. The cylindrical sleeve 49 extends away from wall 28 and terminates in a free end 53 axially spaced from the smaller diameter internally threaded portion of the tuner support shell. This construction results in the annular chambers 47 and 48 being connected at their upper ends in order to provide a folded passageway constituting a one-half wavelength choke section at the operating frequency of the tube.

In tuner mechanisms utilizing screws shafts where torque is achieved through thread interference, it has been found that repeated rotation of the screw shaft results in wear on threads 36 and 37, with resultant increase in the amount of space between shaft and shell. It has been found that such wear results in the capability of undesired movement of the shaft within the housing, thus contributing to undesired movement of the inner end of the shaft and consequent distortion of the electrical and magnetic fields within the cavity. Additionally, such wear allows impedance changes along the threaded portion of the tuner shaft when vibration causes minute movements of the tuner shaft relative to the cavity and the shell, thus giving rise to "tuner generated" noise. Such changes in impedance along the threaded portion of the tuner shaft also alter the smoothness with which the screw may be operated within the shell, and therefore give rise to the previously described phenomenon known as electrical jitter. Jitter is manifested by instantaneous displacements in the modulated mode pattern as the tuner is operated, and is therefore an undesirable effect best eliminated.

To eliminate electrical jitter and vibration of the tuner shaft, and to maintain within predetermined limits the torque required to rotate the screw shaft, the outer free end of the tuner support shell is provided with a bore 54 closely encircling a portion of the outer cylindrical peripheral surface of the screw shaft but radially spaced therefrom a small amount. Formed in the upper portion 56 of the tuner support shell are a plurality of radially extending circumferentially equally spaced bores 57, preferably six in number spaced 60° apart. Movably supported in alternate bores 57 are a plurality of metallic friction members or plugs 58 having their inner ends 59 frictionally engaging the smooth outer peripheral surface

of the adjacent tuner shaft. The friction members are retained in their respective bores by a split spring ring 61 circumscribing the outer ends of the friction members and riding in groove 62 formed in the exterior surface of the shell portion 56. The split spring ring 61 exerts a continuous uniform pressure on the outer ends of the friction members or plugs and causes the plugs to impinge with uniform force and friction on the surface of the tuner shaft, thus maintaining the frictional resistance to movement of the shaft constant. It has been found that friction members formed from "Cupron," an alloy of nickel, magnesium, silicon, iron and copper, and sold by the Wilbur B. Driver Company, perform satisfactorily in this environment.

In order to prevent excessive wear of either the screw shaft or the "Cupron" friction members, it is preferable that alternate bores 57 in the tuner support shell be provided with lubricating members or plugs 63. These are conveniently formed from a non-metallic synthetic resinous material sold under the trade name "Teflon." The lubricating plugs are movably interposed between the outer peripheral surface of the tuner shaft and the inner peripheral surface of the split spring ring 61, and are therefore also resiliently urged inwardly against the shaft as are the friction members 58. The inner ends of the lubricating plugs ride on the surface of the tuner shaft, and with rotation of the shaft lubricate the surface of the screw shaft defined by the track of the friction members to control the frictional resistance between the friction members and the tuner shaft. To prevent galling and/or seizing between the "Cupron" friction plugs and the screw shaft, the surface of the shaft is preferably plated with a metal which will provide a hard surface. Satisfactory results have been obtained with a hard nickel plate. Friction plugs and lubricating plugs thus have an effective chucking action on the shaft at a point axially spaced from the threaded portion of the shaft to maintain the shaft axially aligned within the shell.

From the foregoing it will be apparent to those skilled in the art that torque on the screw shaft may be closely controlled, that jitter is completely eliminated and vibration minimized. In an electron tube embodying a tuning mechanism constructed according to the teaching of this invention, the amount of torque on the tuner shaft was maintained at between 15 to 21 inch ounces over a cycling period extending through 2,500 cycles. The same structure was then temperature cycled commencing at 20° C. and increasing to a temperature of 140° C. During this increase in temperature the torque remained constant at 22 inch ounces, with no jitter present. The structure was then reduced in temperature to -60° C. from its elevated temperature of 140° C. and the torque increased gradually from 22 inch ounces to only 29 inch ounces, thus increasing over a torque range of only 7 inch ounces between 140° C. and -60° C. We know of no conventional tuner structure capable of this close control.

We claim:

1. In an electron tube including a resonant cavity, a tuning mechanism for tuning the cavity to a desired operating frequency and comprising a hollow support shell extending from said tube, a tuning shaft movably supported in the hollow support shell for movement upon application of a force thereto falling within a predetermined range, said shaft having a smooth surface portion within said shell, and means on said hollow support shell to damp vibration of said tuning shaft and maintain within said predetermined range the force required to move said shaft, said means comprising at least one friction member movably supported on said hollow support shell and impinging against said smooth portion of said shaft, and at least one lubricating member movably supported on said hollow support shell to lubricate the track of said friction member on the shaft upon relative movement therebetween.

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2. The combination according to claim 1, in which there are a plurality of friction members and a plurality of lubricating members, and the lubricating members are supported on the hollow support shell between adjacent friction members.

3. In an electron tube including a resonant cavity, a tuning mechanism for tuning the cavity to a desired operating frequency and comprising a hollow support shell mounted on the tube, a screw threaded shaft having its screw threads frictionally engaging matching threads in the hollow support shell and adapted to be selectively advanced or retracted in relation to the shell upon application of torque to the shaft within a predetermined range, and means on said hollow support shell to damp vibration of said screw shaft and maintain within the limits of said predetermined range the torque required to rotate said shaft, said means comprising radially extending circumferentially spaced bores in said shell, friction plugs movably supported in said bores and frictionally impinging against said smooth portion of the shaft, and resilient means urging said plugs radially inwardly.

4. The combination according to claim 3, in which at least one additional bore is provided in the shell and a lubricating member is movably supported in the additional bore to lubricate the track of said friction plugs on the shaft upon rotation of the shaft.

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5. The combination according to claim 4, in which there are a plurality of lubricating members, and said friction plugs and lubricating members are alternately circumferentially spaced about the shell, and said resilient means interconnects adjacent friction plugs and lubricating members to effect with substantially equal force the resilient impingement of each plug and member against the shaft.

6. The combination according to claim 5, in which each friction plug comprises a metallic body, each lubricating member comprises a non-metallic body, and said means interconnecting said friction plugs and lubricating members comprises a split spring ring.

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HERMAN KARL SAALBACH, *Primary Examiner.*
 JOHN W. HUCKERT, GEORGE N. WESTBY,
Examiners.