Dec. 23, 1958 J. E. McCANN 2,866,123

MECHANICALLY TUNED KLYSTRONS

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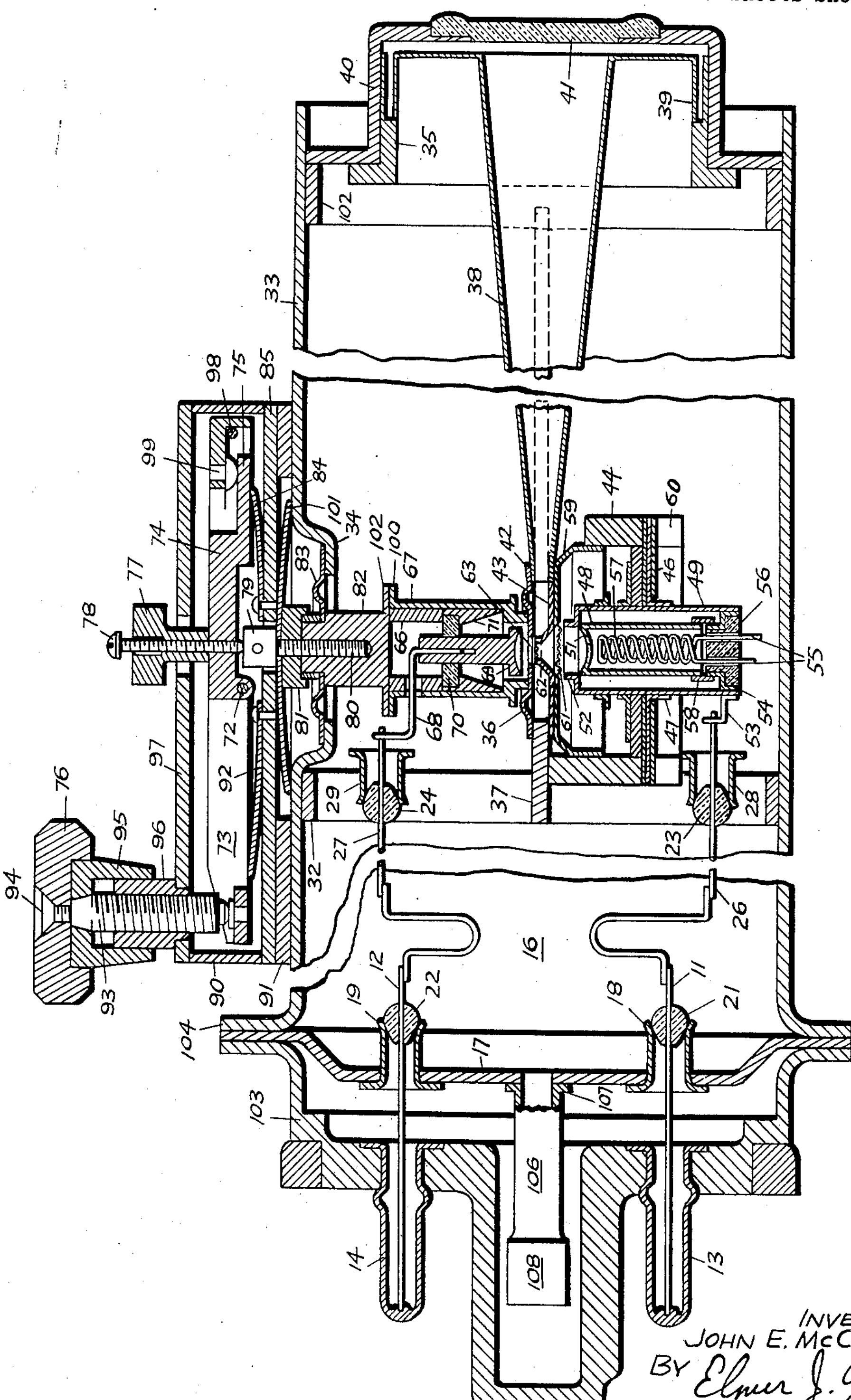

FIG. 1

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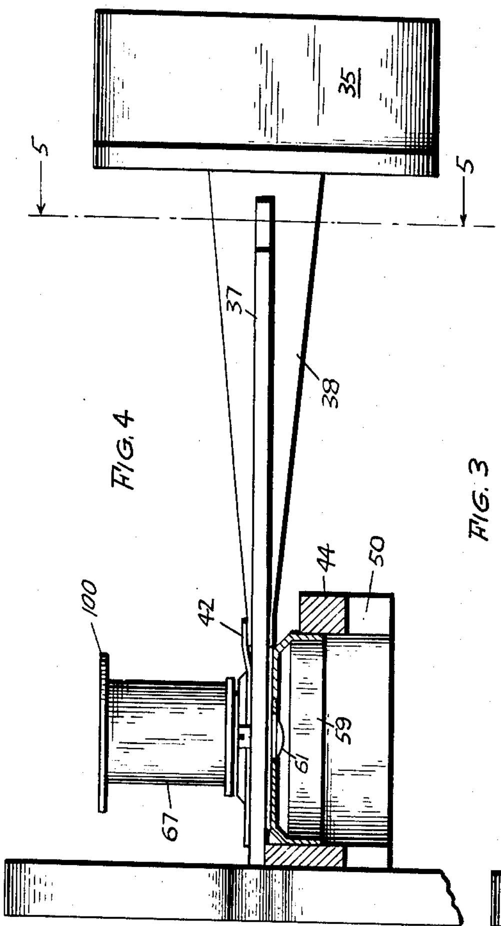

FIG. 4

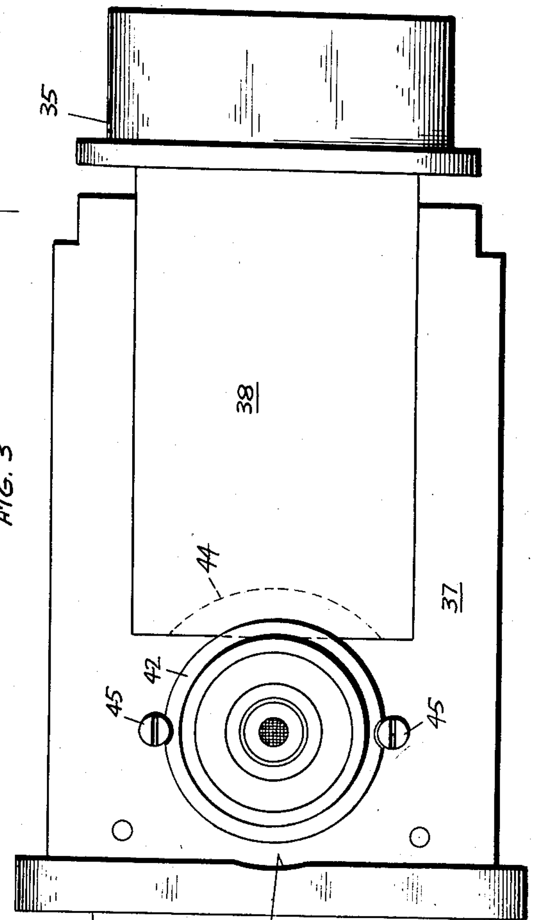

FIG. 3

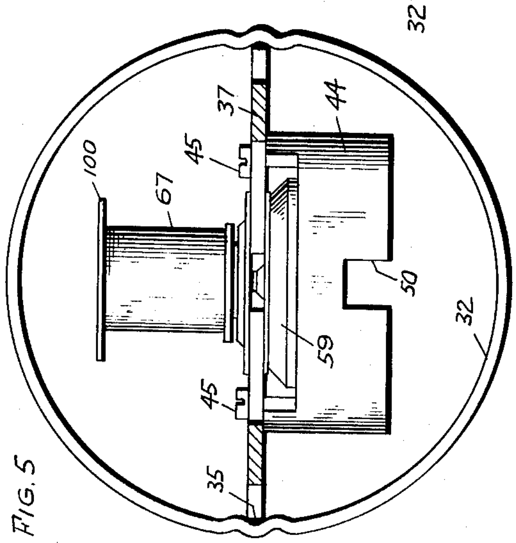

FIG. 5

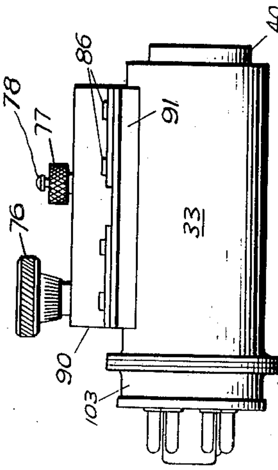

FIG. 2

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MECHANICALLY TUNED KLYSTRONS

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4 Claims. (Cl. 315—5.22)

This invention relates to velocity modulation of directed electron flow, and particularly to microwave oscillation generating systems employing electron discharge devices of the klystron type.

The invention resides in providing a klystron tube differing from prior tubes in the manner in which its beam control components may be assembled, and in the manner of tuning to the correct frequency factor for the service to which it is applied.

The successful operation of a klystron tube, as is well known, requires maintenance of precise dimensional relationships in the R. F. gap and resonant cavity controlling the energy output to an adjacent wave guide component of the associated system. As it is extremely difficult, with ordinary manufacturing methods, to achieve uniformity in the R. F. gap and resonant cavity dimensions, as between successively assembled tubes or groups of tubes, it is desirable to provide means for individually adjusting these dimensions as part of the integral structure of the device.

The present invention provides improved mechanical means for adjusting and maintaining the R. F. gap and resonant cavity dimensions of a klystron or equivalent velocity modulating tube, so that temperature changes produce no distortion or drift; also, improvements in the structure, mode of operation, interrelationship, and a method of combining and assembling the various components affecting the efficiency and performance of a tube of this general classification.

The improvements herein disclosed include the provision of a balanced, pre-adjusted and securely locked assembly, symmetrical about the longitudinal axis of the tube, and operative to exert a constant gap and volume maintaining pressure along the transverse center line of a centrally located resonant cavity of regular contour and balanced proportions, the rectilinear rigidity of the control being brought about by reason of structural interrelationships affecting both the electron beam focusing and electron beam repelling components of the tube, which components are in turn in rectilinear alignment along said transverse center line.

The complementary structures for beam control, just referred to, are in turn controlled by superimposed means for manually setting the R. F. gap between the focusing and repelling elements of the beam circuit, and concurrently establishing the corresponding volumetric dimensions of the resonant cavity. In this connection, a feature of the arrangement is the combining of coarse and fine adjustment elements in such manner as to establish an interlocking relationship affording greater positiveness in the maintenance of the parts in their adjusted setting.

Other characteristics of the invention will present themselves upon reference to the following description of one embodiment thereof as illustrated in the accompanying drawings wherein:

Fig. 1 is an enlarged scale broken longitudinal sectional view of a klystron tube embodying the invention;

Fig. 2 is an exterior view of the tube of Fig. 1, on a scale greatly reduced from that of Fig. 1;

Fig. 3 is a plan view of a partial assembly of certain components of the tube constituting a basic sub-assembly to which related sub-assemblies are successively attached;

Fig. 4 is in part a sectional and in part a side elevation view of the partial assembly of Fig. 3; and

Fig. 5 is a sectional view along line **5—5** of Fig. 4, with certain parts removed.

Referring first to Fig. 1, the illustrated tube has an electron gun circuit including a pair of circuit elements **11** and **12** extending from the tips of pins **13** and **14**, respectively, to points well within the evacuated compartment **16** of the tube, these circuit elements being supported on the transversely disposed metallic header **17** through the agency of the metallic eyelets **18** and **19**, adapted to have sealed therein the pear-shaped glass beads **21** and **22**, respectively, secured to the circuit elements at the appropriate locations to effect such mounting. Similar beads **23** and **24** are affixed to electrode extensions **26** and **27**, respectively, and are sealed correspondingly in metallic eyelets **28** and **29** carried by a circular hoop or ring **32** fitting snugly within and adapted to be united, mechanically or thermally, to the inner cylindrical surface of the main metallic housing section **33** of the tube. The beam focusing and beam reflecting assemblies are disposed in alignment transversely of housing section **33**, with their common axis passing through the center of a resonant cavity **36** formed by punching a hole through the centrally disposed U-shaped metallic frame or block **37** whose left-hand end is supported rigidly upon transversely disposed ring **32**, as by thermal union therewith, and whose right-hand (yoke) portion is united with the vertical sides of the tapered wave guide **38**, the latter terminating in the usual choke joint **39** supported, as by collar **35**, on a cup-shaped element **40** carrying the wave guide window **41** and constituting the end closure element of the tube.

The formation of cavity **36** is completed by the elements **42** and **43**, the former being a flexible corrugated sheet disposed over the punched hole in the block **37**, and the latter being an integrated extension of the lower side of the wave guide **38**, closing the hole along the plane of the lower surface of block **37**, as viewed in Fig. 1. Elements **42** and **43** are essential parts of the beam repelling and beam directing assemblies, respectively, now to be described.

The beam directing (electron gun) assembly is illustrated in Fig. 1 as including a supporting cylindrical bracket or collar **44** fastened by screws **45** (see Figs. 3 and 5) or equivalently secured at its upper edge surface to the under surface of frame **37** having a diametrically slotted base **50** to which are secured the tabs **60** at the outer ends of laminated bridging holders **46**. These bridges **46** have additional tabs or flanges **47** soldered to the outer one of a pair of concentric sleeves or ferrules **48** and **49** constituting the cathode carrier and cathode shield, respectively, and whose upper ends constitute the electron emitting cathode **51** and beam focusing ring **52**, respectively. The cathode lead **26** is connected to the inner cathode sleeve **48** by way of the interposed terminal **53** and connector ring **54** surrounding the base plug **56**. The electrical connection between **53** and **54**, as shown, is constituted by shield **49**, but it may be independent of the shield and insulated therefrom, if potential differences so require. The plug **56** of insulating material is apertured to permit sliding it over the leads **55** supplying heating current to helically coiled filament **57**, it being understood that the heating coil is first inserted within the inner ferrule **48**, with its coil ends extending therefrom, and the base ring **54** carrying plug **56** is then slipped over the coil leads and secured to the ferrule **48** through the agency of peripheral connector tabs **58**. An inverted cup-shaped element 59 is suitably secured to the inner cylindrical surface of mounting collar 44 and serves as a supporting member for the cavity floor 43 previously described. Element 59 has a depressed and perforated central area 61 serving as an accelerator grid for the electron stream emitted from element 51, and operates to bring the electrons to focus, in beam form, below the R. F. gap constituted by frusto-conical grid 62 and flat grid 63, formed integrally with cavity floor 43 and cavity ceiling 42, respectively, the upper grid 63 being an integrated part of the beam repelling assembly, now to be described.

The beam repelling, or beam reflecting assembly is illustrated in Fig. 1 as including a pair of nested cylindrical elements 66 and 67 laterally apertured to permit insertion of a lead 68 connecting the external line 12—27 with the concave reflector electrode 69, the latter carrying a non-conducting mounting ring 70 to facilitate its suspension upon a circular ledge formed on the lower cylinder 71, the element 66 being in turn supported upon the upper end surface of said lower cylinder 71. This mounting insures that reflector 69 will be axially aligned with the R. F. gap elements 62 and 63. The transversely aligned upper annular edge surfaces of parts 66 and 67 are united by soldering, or equivalent treatment, and serve as a junction area 100 for attachment of the novel gap-setting, or tuning, assembly now to be described.

The tuning assembly of the present invention is shown as including a system of inter-engaged levers 73 and 74 constructed and combined in such a way as to make it possible to control the dimension of the R. F. gap with extreme precision, the motion reduction capacity of the tuning linkage being such that a fractional turn of the manually operable fine adjustment knob 76 produces a gap increment or decrement of micro-inch proportions, so that accurate tuning to any frequency along the tube's operating range may be accomplished quickly and smoothly. To accelerate the tuning procedure, there is also provided a coarse adjustment screw 78, whose lower end presses upon the head 79 of a screw 80 threaded into a pair of aligned nuts 81 and 82 disposed on opposite sides of a flexible metallic diaphragm 83 sealing the opening in the depressed housing section 34 through which the tuning assembly operates. Screw 78 is provided with a knurled lock-nut 77, and exerts pressure along the axis of the beam reflector assembly by reason of the reaction of its threads upon a correspondingly threaded hole provided in the lever 74, the lever 74 being resiliently held against deflection about its pivot-bearing pin 72 during such operation by the resisting thrust exerted upwardly thereon at its outer toe 75, due to the upward bias of a leaf spring 84 whose outer end engages said lever and whose inner end is riveted to a rigid plate 85 constituting part of the rectangular box-like housing 90 whose side walls support the ends of the two parallel pivot-bearing pins 72 and 98 of the tuning assembly and secured to the main tube housing section 33 by screws 86 passing through mating flanges on housing elements 85 and 91, respectively.

A longer leaf spring 92 has its inner end riveted to plate 85, and its outer end biased into contact with the extreme end portion of the under surface of lever 73, approximately in line with the axis of a screw 93 forming part of the fine adjustment assembly constituted by the knob 76, the upper screw 94, the scale-carrying sleeve 95, and the lower screw 93. Screw 93 moves downwardly to exert deflecting thrust upon lever 73 as it is rotated within the correspondingly threaded sleeve 96 rigidly held upon the cover element 97 of the tuner housing, the lever 73 being pivotally mounted at the opposite end of the housing on the bearing pin 98, and equipped with a rivet 99 whose downwardly directed head bears upon the upper surface of shorter lever 74, at the toe portion 75 of the latter, to exchange thrust reactions therewith. It will be understood that lever 73 is slotted through most of its length to permit the nesting of the shorter lever 74 within the parallel sides of the longer lever 73. A third leaf spring 101 is interposed between the screw head 79 and the spacer 81, and has its ends bearing upon the tube housing element 33 to yieldably oppose downward deflection of the tuner assembly, and to damp vibrational tendencies. Nut 82 preferably has a flange 102 of the same diameter as the flanged upper surface 100 of the beam reflecting assembly heretofore described.

In assembling the components, the first step is to secure the cavity defining block 37, the wave guide assembly 38, 39, the cavity defining "ceiling" and "floor" elements 42 and 43, and the mounting ring 32 in assembled relationship, the peripheral edge surface of frame 37 being brazed to diametrically opposed crimped sections of the ring 32 along the inner surface of the latter, as indicated at 35 in Fig. 5. Prior to such assembly, the metallic eyelets 28 and 29 are also brazed or soldered to the ring 32. The parts just described constitute what may be termed sub-assembly No. 1.

Sub-assembly No. 2 consists of the beam directing components, including mounting collar 44, holder 46, concentric ferrules 48 and 49, and the accelerator grid-carrying element 59. Terminal connector 53 also is a part of this sub-assembly.

Sub-assembly No. 3 consists of the beam reflecting components, including the nested elements 66 and 67, the terminal connector 68, and the repeller electrode 69.

Sub-assembly No. 4 consists of the tuning components carried within rectangular box 90, and including the two nuts 81 and 82, the interposed diaphragm 83, and the flange 102 matching the flanged area 100 of sub-assembly No. 3.

When sub-assemblies 2, 3, and 4 are completed, sub-assemblies 2 and 3 are butt-welded or brazed to the floor and ceiling elements 43 and 42 of the resonant cavity, and the partial assembly consisting of sub-assemblies 1, 2 and 3 is then telescopically inserted into housing element 33, by way of the left-hand end thereof, the inner structure being moved inwardly until ring 32 makes contact with the shoulder formed on housing element 33 by the step of inwardly deflecting the diaphragm receiving section 34 of said housing element. The said ring 32 is then brazed, or otherwise secured to the housing, at the angularly centered position determined by causing dimple 105 (Fig. 3) to register with housing depression 34. The final major sub-assembling step of inserting the tuner assembly may now be performed. This final major step involves bringing sub-assembly No. 4 into position, such that the mating flat surfaces 102 and 100 abut and coincide, whereupon they are united by application of solder, or an equivalent fusing treatment, for which purpose the soldering or other fusing tools are inserted through one of the open ends of the cylindrical housing element 33. The remaining steps are to secure diaphragm 83 to the housing wall 34, base 91 to the housing element 33, cover 97 to box 90, knob assemblies 76 and 77, end cup 40 into registry with positioning ring 102 on the inner surface of the housing element 33, circuit elements 26 and 27, and associated parts, to the terminal connectors 53 and 68, respectively, and transverse partition 17 and terminal cap 103 to the flange 104 of housing element 33, the parts 17 and 103 having peripheral edges matching those of said flange 104. However, prior to applying the terminal cap 103, the compartment 16 is exhausted of air, to the customary degree, by application of suitable exhausting tubulation to the open end of metallic exhaust tube 106 whose flange 107 is welded to the apertured central surface of partition 17. After such evacuating operation, the open end 108 of tube 106 is closed in a conventional manner. The cap 103 is then applied, and serves to protect the tube 106 against damage.

It will be understood that in addition to the terminal pins 13 and 14, there are other pins mounted in the cap 103 to serve as terminals for leads (not shown) connecting with the two ends **55** of the cathode heater filament. These filament leads may be supported upon header **17** and ring **32** by the use of eyelets disposed in angularly spaced relationship to eyelets **18, 19** (for header **17**) and eyelets **28, 29** (for ring **32**), and similar thereto in structure. These additional parts do not appear in Fig. 1, as they are outside the plane of section represented in Fig. 1; moreover, such eyelet and pin supports conform to well-known techniques of the art, needing no specific illustration.

This invention is not limited to the particular details of construction, materials and processes described, as many equivalents will suggest themselves to those skilled in the art. It is, accordingly, desired that the appended claims be given a broad interpretation commensurate with the scope of the invention within the art.

What is claimed is:

1. In an electron discharge device, a cavity resonator assembly including a fixed portion and a movable portion, said cavity resonator assembly having an axis disposed substantially perpendicular to said fixed and movable portions, coarse adjusting means including an adjusting screw aligned with said axis of said assembly and directly engaging said movable portion of said assembly for effecting movement of said movable portion during rotation of said crew, and fine adjustment means including a first lever, a second lever embracing said screw, and means for controllably actuating said first lever, the position of said second lever being independent of rotation of said screw, said first lever bearing against said second lever and responsive to actuation of said first lever to impart longitudinally directed thrust to said screw.

2. In an electron discharge device, a cavity resonator assembly including a fixed portion and a movable portion, said cavity resonator assembly having an axis disposed substantially perpendicular to said fixed and movable portions, coarse adjusting means including an adjusting screw aligned with said axis of said assembly and directly engaging said movable portion of said assembly for effecting movement of said movable portion during rotation of said screw, fine adjustment means including a first lever, a second lever embracing said screw, and means for controllably actuating said first lever, the position of said second lever being independent of rotation of said screw, said first lever bearing against said second lever and responsive to actuation of said first lever to impart longitudinally directed thrust to said screw, and means contacting said first lever and said second lever for yieldably applying a given force to said screw.

3. In an electron discharge device, a cavity resonator including a fixed portion and a movable portion, said cavity resonator assembly having an axis disposed substantially perpendicular to said fixed and movable portions, first means for effecting coarse adjustment of said resonator, second means for effecting fine adjustment

of said resonator, said first means comprising a first adjusting screw aligned with said axis of said resonator and directly engaging the movable portion of said resonator for effecting movement of said movable portion during rotation of said first screw, said second means for adjusting including said first screw, a first lever, a first spring bearing against said first lever for applying a continuous force against said first lever, a second adjusting screw laterally offset from said first screw bearing against said first lever, a second lever mechanically engaging said first lever to impart longitudinally directed thrust to said first screw in accordance with the motion imparted to said second screw, the position of said second lever being independent of rotation of said first screw, and a second spring bearing against said second lever for applying a continuous force against said second lever.

4. In an electron discharge device, a cavity resonator including a fixed portion and a movable portion, said cavity resonator assembly having an axis disposed substantially perpendicular to said fixed and movable portions, first means for effecting coarse adjustment of said resonator, second means for effecting fine adjustment of said resonator, said first means comprising a first adjusting screw aligned with said axis of said resonator and directly engaging the movable portion of said resonator for effecting movement of said movable portion during rotation of said first screw, said second means for adjusting including said first screw, a first lever, a first spring bearing against said first lever for applying a continuous force against said first lever, a second adjusting screw laterally offset from said first screw bearing against said first lever, a second lever mechanically engaging said first lever to impart longitudinally directed thrust to said first screw in accordance with the motion imparted to said second screw, the position of said second lever being independent of rotation of said first screw, a second spring bearing against said second lever for applying a continuous force against said second lever, and a third spring engaging said resonator for yieldably opposing movement of said resonator.

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