April 20, 1948. W. W. RIGROD 2,439,908

TUNING MEANS FOR ELECTRON DISCHARGE DEVICES

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Fig. 1.

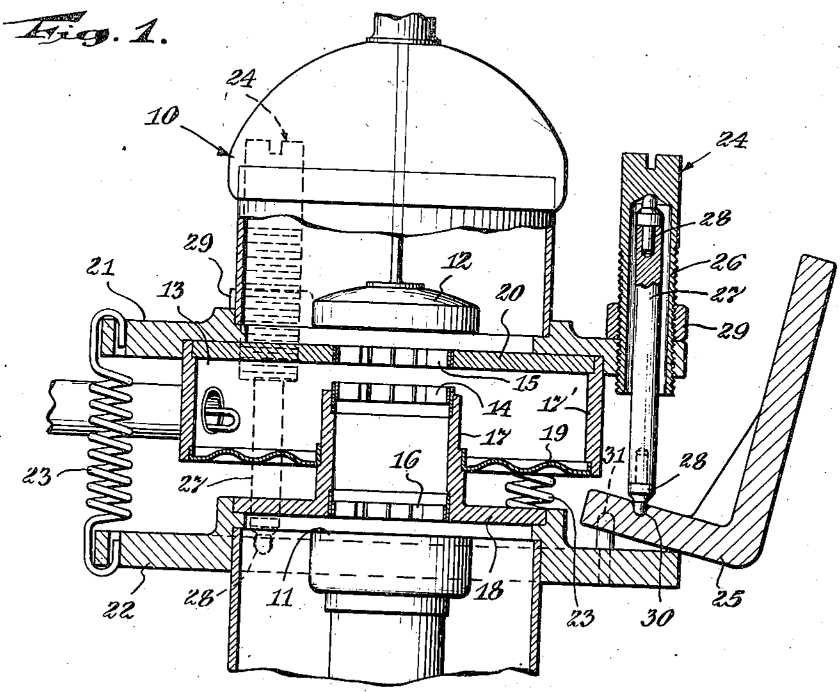
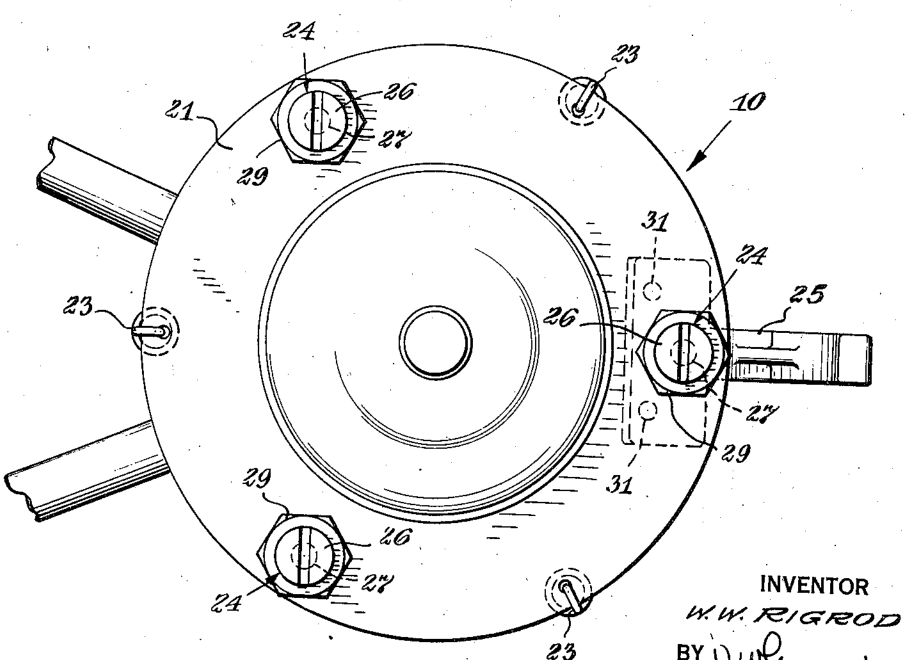


Fig. 2.



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TUNING MEANS FOR ELECTRON DISCHARGE DEVICES

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3 Claims. (Cl. 315—5)

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This invention relates to electron discharge devices and is exemplified in the present disclosure as embodied in a device available in the market under the trade name of "Klystron" which is one form of ultra high frequency device utilizing a beam of electrons and with a resonant cavity for producing the high frequency oscillation.

Due to the wide range of ambient temperatures (−35° C. to +60° C.) under which a "Klystron" must operate, for instance as a local U. H. F. oscillator, its copper parts undergo pronounced thermal contractions and expansions which cause the operating frequency to vary considerably. A typical test showed a frequency shift of 19 megacycles per second. A "Klystron" utilizes a hollow body resonator having a constricted gap between the hollow thereof and the passageway for the electron beam. This gap spacing is highly critical in determining the resonant frequency of the device, as the spacing determines most of the distributed equivalent capacitance of the cavity. In fact, advantage is taken of this critical spacing by varying it slightly for tuning purposes. Experiment and use have shown that the constriction varies in size or spacing as the result of variation in ambient temperature. Increase in ambient temperature leads to expansion of parts which control the gap opening of the constriction decreasing the gap opening with a corresponding increase in the equivalent capacitance of the cavity and hence a decrease in the operating frequency of the "Klystron." In its most general aspects, therefore, the invention seeks to overcome the detrimental effects of ambient temperature in a device of the character indicated.

Likewise broadly considered, an object of the invention is to provide compensating means for de-tuning effects of external temperature changes in a beam-type electron discharge device.

More specifically, an object of the invention is to maintain the gap opening of the constriction of a beam-type electron discharge device substantially constant under external or ambient temperature variations of a considerable range.

Another object of the invention is to provide a compensating means for de-tuning effects of temperature changes in a beam-type electron discharge device which is applicable to such devices as heretofore manufactured.

A further object of the invention is to provide a temperature compensating strut.

A still further object of the invention is to provide a strut which may be readily substituted in place of a present-day non-compensating strut.

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Other objects of the invention will appear as the description progresses, both by direct recitation thereof and by implication from the context.

Referring to the accompanying drawing in which like numerals of reference indicate the same parts in both views:

Figure 1 is a side elevation of an electron discharge device of the character indicated showing the invention incorporated therein; and

Figure 2 is a plan of the same.

In the specific embodiment of the invention illustrated in said drawing, the reference numeral **10** designates an electron discharge device of the beam type, and more specifically a "Klystron" and shown as constructed in general as a body of revolution about an axis. The usual structural features of such a device comprise a cathode **11**, in a plane normal to the axis, at a distance from which is disposed a reflector **12** also transverse to the axis, said axis passing through the centers of both the cathode and reflector. In the region intervening between the cathode and reflector is a hollow resonant chamber **13** the opposite walls of which transverse to and around the axis are perforate for passing the electron beam therethrough from the cathode to the reflector and back again into the resonator. The perforate parts of the walls, for want of a better term, have been identified in the art as grids, and accordingly in the order of nearness to the cathode will be here identified as the near grid **14** and far grid **15** of the resonator. Between the cathode and said near grid **14** of the resonator is a focusing grid **16**, it being situated as close as electrically and mechanically feasible to the cathode. This focusing grid **16** and said near grid **14** are mounted in opposite ends of a tube or collar **17** the end of which at the focusing grid having an outwardly directed flange **18** therearound. Said collar is usually of copper the coefficient of expansion of which is 17×10^{-6} inches per inch per degree centigrade. On the outside of said collar and shown approximately midway of the length thereof, is secured, vacuum tight, a flexible diaphragm **19** which constitutes a flexible end wall for the resonant chamber for tuning purposes. The lower end of the collar below said flexible diaphragm is exposed to effects of exterior temperatures. The opposite end wall **20** of the resonant chamber is shown as rigid and fixed, within the resonant chamber and in the plane of the far grid 15. The fixed end wall is secured within a central hollow in a circular plate or ring 21. Collar 17 to which the flexible wall of the resonator is attached has its flange 18 seated in a central socket in another circular plate or ring 22. A cylindric copper wall 17' extends between the rim of the fixed end wall 20 and outer periphery of the flexible diaphragm 19 completing the resonator enclosure. Said plates or rings 21 and 22 are substantially parallel and equal in size. Tension springs 23 have their opposite ends hooked into the two plates next their peripheries thereby tending to draw said plates toward each other, and interposed midway between the springs parallel thereto and perpendicular to the plates are struts 24 for holding the plates apart. According to the present showing, three struts are provided all of which are of like construction except that two seat directly in sockets in the movable plate 22 whereas the third one seats in a socket in tuning lever 25 carried by said plate. Description of one strut will accordingly suffice for all.

Construction of strut 24 represents an essential feature of the present invention. As shown, said strut comprises essentially two members of which one, called for convenience the adjusting member or spacer 26, is deeply recessed longitudinally to loosely receive the other member, for convenience referred to herein as prop 27. The body portion of said prop is elongated and has its opposite ends recessed to each receive the stem portion of a shouldered pin 28 the outer end of which has a rounded tip with the shoulder situated between the stem and tip and extending laterally so as to ride rotatably on the end of the body portion of the prop. At a given temperature the prop is of fixed length, but preferably has its body portion of a material highly responsive to heat changes and having considerable expansion with rising temperatures and a corresponding contraction with lowering temperatures. The overall length of said prop accordingly varies with the temperature. Several materials have been found satisfactory for use in the construction of this prop, namely, "Duralumin" identified by the maker as 17S–T, brass alloy "240" of the Revere Co. said to contain approximately 60% copper and 40% zinc, and Westinghouse alloy known in the trade as "Cupalloy." These several materials have coefficients of thermal expansion of substantially 24×10^{-6}, 21×10^{-6} and 18×10^{-6} respectively, and in any event greater than the coefficient of expansion of the collar 17.

The adjusting member 26 is preferably of a material having less expansion than prop 27 for a given rise of temperature. Satisfactory materials for this member have been found to be either of two materials, namely a material available in the market under the trade name "Kovar" having a coefficient of thermal expansion of substantially 4.7×10^{-6} and a material available in the market under the trade name "Nilvar" having a coefficient of thermal expansion of substantially 1×10^{-6}. These materials are alloys essentially of iron, nickel and cobalt. It is the purpose to use a satisfactory material for this spacer having as little expansion as possible.

By selecting for the adjusting member 26 a material as indicated of low thermal expansivity, and for the prop 27 a material of high thermal expansivity, the net effect of an increase in temperature is to increase the distance between the two mounting plates or rings 21 and 22. It is furthermore to be observed that the prop extends for approximately half its length above the fixed plate due to the deep recess in the adjusting member. This construction obtains desired length for obtaining requisite counter-acting expansion in the strut as a whole and obtains a stable support of the adjusting plate. The lesser expansion of the adjusting member subtracts from the greater expansion of the prop, and the parts are proportioned to have the net result of expansion and contraction due to temperature changes of the surrounding medium substantially equal to the lengthwise expansion or contraction of collar 17 due to external changes of temperature effective thereon. Thus, as collar 17 expands due to rise in temperature thereby tending to move the near grid 14 closer to far grid 15, the heat also effective upon the strut produces a substantially equal net expansion therein, thereby separating the plates 21, 22 a distance comparable to and compensating for expansion of the collar and thus automatically maintaining a substantially constant spacing of the grids.

The adjusting member is shown as finely screw threaded on its exterior at its end portion passing through the plate which is correspondingly threaded to receive and hold said member. The several adjusting members are brought to proper position during manufacture and locked thereat by a lock nut 29 on the said member next the plate. This setting ordinarily remains fixed after release of the device from the factory. The rounded tips of two of the props seat in hollows or sockets therefor in the movable plate. The rounded tip of the third prop seats in a like socket 30 in tuning lever 25 which is fulcrumed at 31. A micrometer screw (not shown) is employed in practice to swing this lever and thereby change the grid spacing for tuning purposes, but without disturbing the functioning of the prop for automatic compensation for heat expansion of collar 17.

While in the foregoing description certain materials and specific arrangement of parts have been recited, other materials having similar properties and other arrangements having equivalent utility may be employed. In this connection it may be pointed out that the prop material must possess, not merely high thermal expansivity to compensate for the collar expansion, but must furthermore have sufficient mechanical strength to resist buckling under combined compressive and shearing stresses to which it is subjected in use.

In order to prevent permanent deformation under stress or "creep" of the props, the pins in the ends thereof are preferably employed and these pins are of a hard material, such as stainless steel and have the rounded tips for permitting movement of the tip in the socket. The prop as a whole is preferably "aged" prior to installation by repeated heating and cooling over the entire temperature range of operation, this precaution having been found advantageous for preventing any permanent deformation, however slight, of the prop in use.

The mounting of the adjusting member or spacer by means of threaded engagement with the plate and securing by a lock nut is superior to a welded, brazed, soldered or other permanent or fixed assembly, because it permits convenient installation after the "Klystron" has been assembled, exhausted and sealed off; because it admits of factory tuning with the grids perfectly parallel; because of its simple and cheap construction; and because it permits the use of struts of various lengths for any desired grid spacing to be applied in manufacture interchangeably. The latter advantage is of great value in providing equally efficient temperature compensation at widely different operating frequencies, as well as permitting the use of struts of different materials and of different thermal expansivities.

The strut of the present invention is readily applied to "Klystrons" of prior art construction without material change of the "Klystron" parts other than the struts. These struts constitute broadly automatic temperature-compensated tuning means and have been found from test to maintain substantially constant or perfect frequency stability with ambient temperatures within the range encountered in use approximately from −40° C. to +60° C.

I claim:

1. An electron discharge device having a hollow body resonator with a fixed end wall, said resonator having a movable collar as a part thereof, said collar having an end thereof within the resonator spaced from and opposing a part of the fixed wall of said resonator and forming thereby a constriction, said collar having an end external of the resonator, plates respectively carrying said external end of the collar and said fixed part of the resonator, springs coupling and tending to draw said plates together and lessen the spacing between said fixed part of the resonator and the collar, and struts secured to one of said plates opposing the spring action and keeping said fixed part and collar spaced, said struts having greater coefficient of expansion than said collar and automatically compensating for expansion of the collar due to heat in use and thereby maintaining the said spacing between said fixed part and the collar substantially constant under varying heat conditions encountered in use of the device.

2. An electron discharge device having a hollow body resonator with a fixed end wall, said resonator having a movable collar as a part thereof, said collar having an end thereof within the resonator spaced from and opposing a part of the fixed wall of said resonator and forming thereby a constriction, said collar having an end external of the resonator, plates respectively carrying said external end of the collar and said fixed part of the resonator, springs coupling and tending to draw said plates together and lessen the spacing between said fixed part of the resonator and the collar, struts secured to one of said plates opposing the spring action and keeping said fixed part and collar spaced, said struts having greater coefficient of expansion than said collar and automatically compensating for expansion of the collar due to heat in use and thereby maintaining the said spacing between said fixed part and the collar substantially constant under varying heat conditions encountered in use of the device, and a tuning control under one of said struts for shifting said collar irrespective of the continued functioning of the strut as an automatic temperature compensation.

3. An electron discharge device having a hollow body resonator with a fixed end wall, said resonator having a movable collar as a part thereof, said collar having an end thereof within the resonator spaced from and opposing a part of the fixed wall of said resonator and forming thereby a constriction, said collar having an end external of the resonator, plates respectively carrying said external end of the collar and said fixed part of the resonator, springs coupling and tending to draw said plates together and lessen the spacing between said fixed part of the resonator and the collar, struts secured to one of said plates opposing the spring action and keeping said fixed part and collar spaced, said struts having greater coefficient of expansion than said collar and automatically compensating for expansion of the collar due to heat in use and thereby maintaining the said spacing between said fixed part and the collar substantially constant under varying heat conditions encountered in use of the device, and a tuning lever hinged to the said plate carrying said collar, said lever underlying an end of one strut for prying thereagainst and thereby shifting said collar irrespective of the continued functioning of the strut as an automatic temperature compensation.

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