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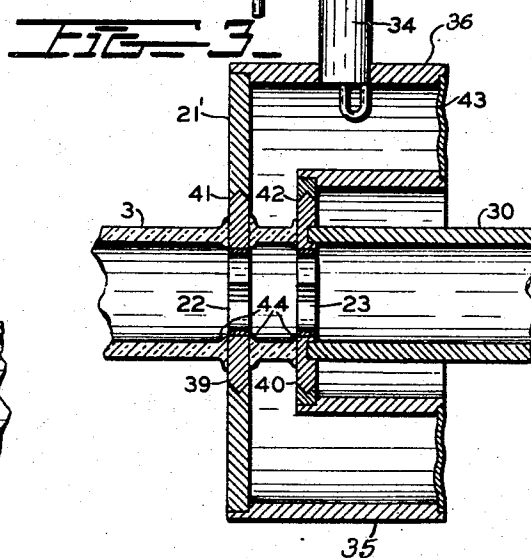
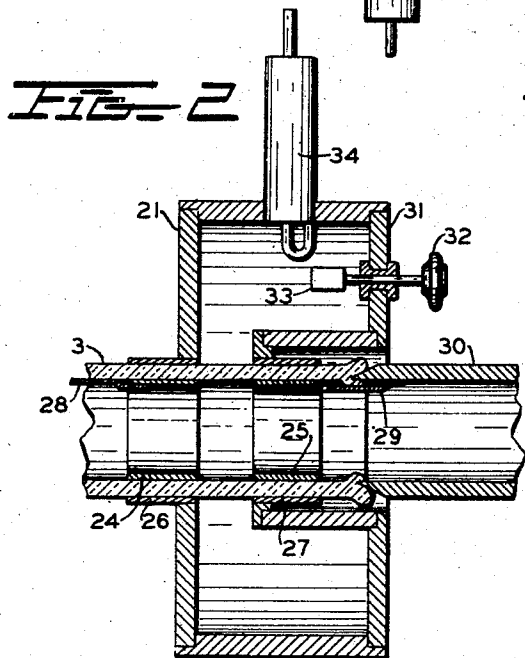
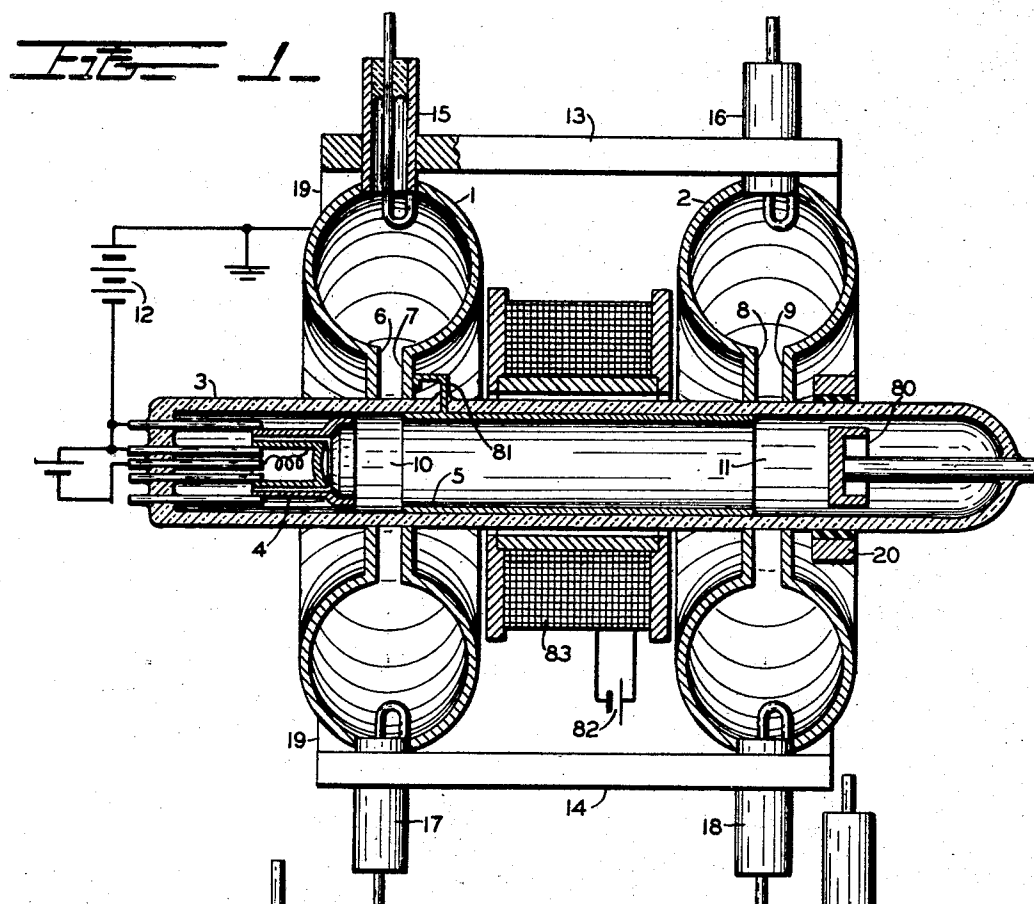
E. L. GINZTON ET AL

2,391,016

HIGH FREQUENCY TUBE STRUCTURE

Filed Oct. 31, 1941

3 Sheets-Sheet 1



INVENTORS
EDWARD L. GINZTON
WILLIAM W. HANSEN

BY
Herbert H. Thompson
ATTORNEY

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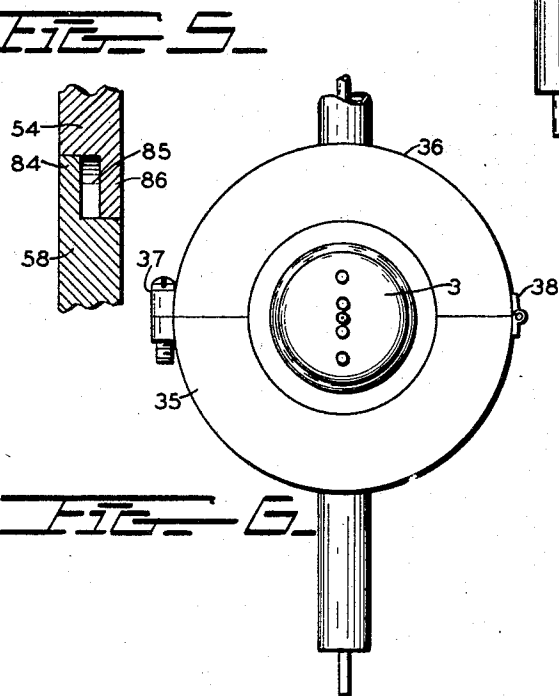
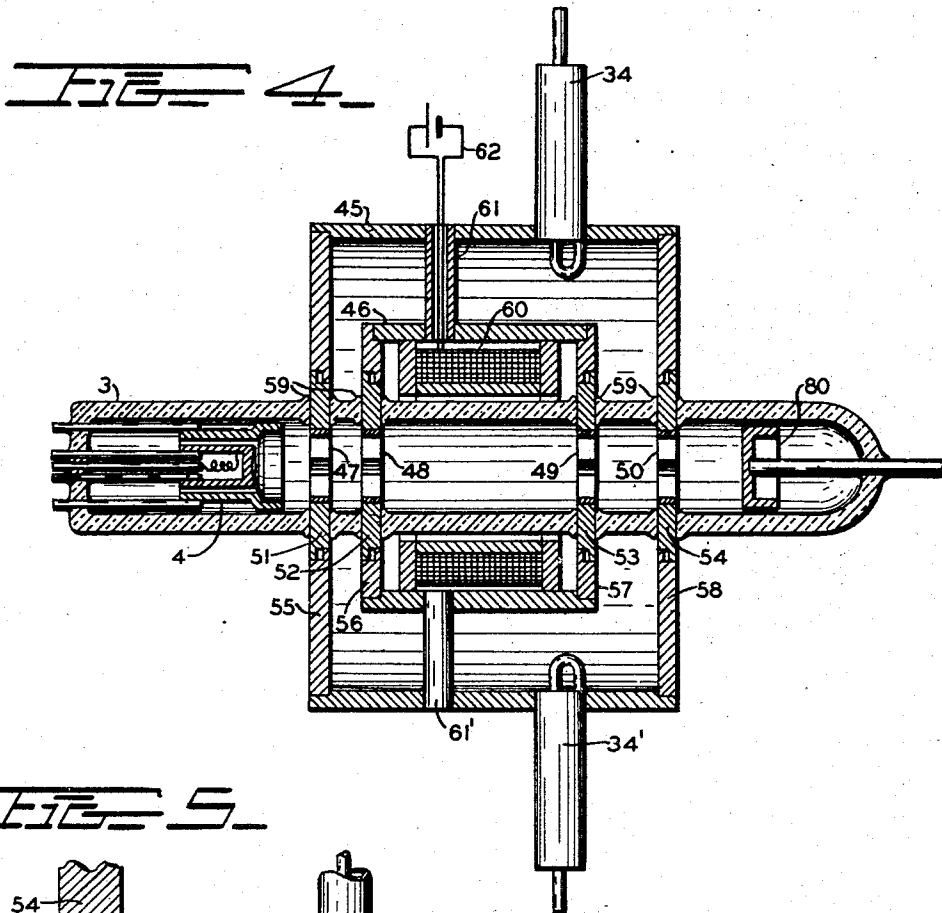
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EDWARD L. GINZTON
WILLIAM W. HANSEN

BY

Herbert H. Thompson
ATTORNEY

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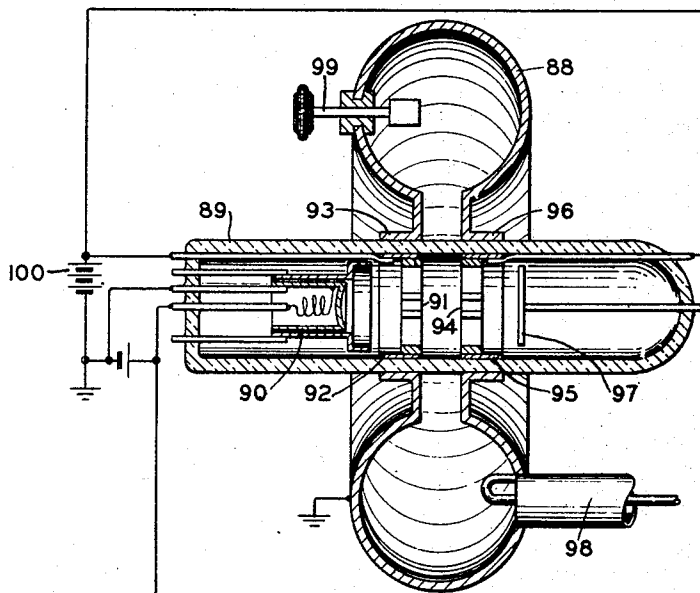
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3 Sheets-Sheet 3

FIG. 7



INVENTORS
EDWARD L. GINZTON
WILLIAM W. HANSEN

BY
Herbert H. Thompson
their ATTORNEY.

UNITED STATES PATENT OFFICE

2,391,016

HIGH-FREQUENCY TUBE STRUCTURE

Edward L. Ginzton, Rockville Centre, and William W. Hansen, Garden City, N. Y., assignors to Sperry Gyroscope Company, Inc., Brooklyn, N. Y., a corporation of New York

Application October 31, 1941, Serial No. 417,228

3 Claims. (Cl. 315-6)

This invention relates, generally, to high frequency tube structure having directly attached hollow resonators of the type disclosed in Patent No. 2,242,275, filed October 11, 1937, by Russell H. Varian, and copending applications Serial No. 201,898, filed April 14, 1938, by Russell H. Varian et al., now Patent No. 2,280,824, granted April 28, 1942, and the invention has reference, more specifically, to modifications wherein the evacuated portion of the tube is substantially confined to the electron beam path and wherein the frequency range over which such tube structures and similar resonators may operate is made flexible.

The principal object of the invention is the provision of novel practical embodiments of high frequency tube structures disclosed in the above mentioned patents and application, wherein the evacuated portion of the tube structure is substantially confined to the electron beam path and the resonators are made external to the tube and adapted to be removable.

Another object of the invention is to provide removable resonators for use with such tubes, said resonators being external to the vacuum chamber of the tube, thus providing a high frequency tube structure with a minimum amount of metal exposed to the vacuum itself, and so increasing the life of the vacuum by removing sources of gas.

Another object of the present invention is to provide a series of resonators which may replace any such externally attached removable resonator, thus increasing the frequency range over which such a resonator may operate very greatly beyond that provided by the tuning devices usually used with such resonators.

Still another object of this invention is to provide means of coupling such resonators electrically by capacitive means to the grids contained inside of the vacuum envelope used with such high frequency tubes, thereby linking the alternating electric field formed in the resonators to the grids.

A further object of the invention is to provide a resonator, one element of which is removable and replaceable by an element of different size.

Another object of the invention is to provide a resonator with one removable element so designed that tuning devices and coaxial energy removing or introducing lines may remain attached to the non-removable element, so that coaxial lines, and tuning devices do not have to be applied to each resonator, thus reducing the num-

ber of such devices required for a set of frequency ranges.

Other objects and advantages will become apparent from the specification, taken in connection with the accompanying drawings wherein the invention is embodied in concrete form.

In the drawings,

Fig. 1 is a plan view, partly in section, of one embodiment of our invention.

Fig. 2 is a cross-section view of an alternate form of our invention.

Fig. 3 is a cross-section view of a modification of Fig. 2.

Fig. 4 is a cross-section view of another modification of our invention.

Fig. 5 is an enlarged cross-section view of a fragment of Fig. 4.

Fig. 6 is an end view of the tube structures shown in Figs. 3 and 4.

Fig. 7 is a sectional view of a modified structure.

Similar characters of reference are used in all of the above figures to indicate corresponding parts.

Referring now to Fig. 1, one form of our present invention is shown comprising resonators 1 and 2 adaptable to be slid directly over a vacuum envelope chamber 3 containing no internal grid structures, the resonator shape and the resulting structure being similar to that of the high frequency tube disclosed in the aforementioned Patent No. 2,242,275. Resonators shown permanently attached, but outside of their associated vacuum envelope, have been disclosed in Patent No. 2,280,824, filed by Russell H. Varian and William W. Hansen, one of the present inventors. It is understood that our invention is adaptable to any related type of tube structure using directly attached hollow resonant members, singly or in plurality, Fig. 1 being shown with two resonators merely by way of illustration. The toroidal hollow resonant members 1 and 2 are removably fitted upon vacuum envelope 3, said vacuum envelope containing a focussing cathode structure 4 and a collector plate 80, as in previous disclosures. High frequency alternating voltages are built up on condenser members 6, 7 and 8, 9 attached directly to the resonators 1 and 2, respectively, as described in prior art. The vacuum chamber 3 is preferably made of a relatively low-loss dielectric material, such as of certain glasses or silica, so that the electrical lines of flux adjacent to the condenser portions 6, 7 and 8, 9 inside the vacuum chamber do not tend to concentrate on the chamber walls. A good

portion of the high frequency alternating voltage between condenser portions 6, 7, is thus available for active use inside the envelope 3 for velocity modulation of the beam emitted from cathode 4 in the region 10 between the condenser elements 6, 7. Similarly, the effect of the bunches of the modulated beam, in region 11 between the condenser elements 8, 9, is suitable to release a good portion of the energy available in these electron bunches for exciting oscillations in the toroidal resonator 2, in a manner described in Patent No. 2,242,249.

As disclosed in prior art, for a given cathode beam acceleration voltage, as supplied by a battery 12, it is desirable that cathode 4 and resonators 1 and 2 bear a fixed distance relation. Resonators 1 and 2 are shown spaced by clamp members 13, 14 having holes suitably spaced to slide over concentric line members or posts 15, 16, and 17, 18, respectively, clamp members 13 and 14 being positioned by a base 19. The cathode spacing relative to resonator 1 is determined by a clamp 20, which is attached to base 19 and which determines the axial displacement of vacuum envelope 3.

The lines of electric flux from the emitter surface of cathode 4 may, because of the geometry of the structure, have a slight radial component. A coil 83, energized by direct current from battery 82, is provided to give slight focusing to the beam to counteract this radial effect. Conducting tube 5, which may be a film of evaporated metal, is mounted coaxially inside of vacuum envelope 3 and grounded to resonator 1 as at 81, providing an electric field free space between the resonators 1 and 2 in which the electron bunches form.

It is obvious from the aforementioned disclosures, that many varied types of tuning of the resonant cavities 1 and 2 may be used to operate the resulting tube structure over a frequency range characteristic of particular resonator-tuner combination. The tuning device shown in application Serial No. 342,912, filed June 28, 1940, by William T. Cooke, Joe J. Caldwell and David G. Clifford, or other tuning devices as later discussed, may be so adapted. It is also evident that, in the case of the structure shown in Fig. 1, one may supply a set of pairs of interchangeable resonators of increasing frequency range, each range overlapping slightly the range of the previous pair of resonators, each pair of resonators being adapted to replace the resonator shown by sliding on and off the tube 3. In such manner, the frequency range of a klystron-like high frequency tube may be greatly increased, this being a feature also of modifications of our invention to be further described.

Fig. 2 shows an alternate construction for our removable resonator as applied to a resonator shape disclosed in copending application Serial No. 343,528, filed July 2, 1940, by William W. Hansen, Russell H. Varian and Sigurd F. Varian, now Patent No. 2,311,658, granted February 22, 1943. Mutually spaced conducting tubes 24 and 25 fit closely in the inner diameter of a vacuum envelope 3 and serve to concentrate a high frequency alternating electric field therebetween within the envelope. The tube 24 is held at a desired positive potential with respect to the cathode (not shown) and is also held in proper axial position by a conducting wire or wires 28 which may extend to the desired potential source; and, likewise, the tube 25 is similarly connected by wire or wires 29 leading to the metal drift tube

30 also connected to a source that is positive with respect to the cathode, in order to prevent the electron beam from building up charges on said conducting tubes. The resonator 21 is provided at its condenser portion with walled sleeves 26 and 27 which fit over the external diameter of the vacuum envelope 3, which extend in the same sense and are positioned opposite and which are the same length as sleeves 24 and 25, respectively. The concentric sleeves 24, 26 and 25, 27, form the plates of condensers, the dielectric of which is the material of the vacuum envelope 3, thus providing capacity coupling of the resonator 21 to the interior of envelope 3. The resonator 21 may be positioned exactly with respect to the sleeves 24 and 25 by means of any such clamping method as shown in Fig. 1. The coupling between the sleeves 24, 25 and the resonator 21 may be made large enough so that the high frequency voltage appearing across the condenser portions of resonator 21 will be practically all transferred to the sleeve members 24 and 25 by extending the length of the sleeve members.

Tuning of the resonator 21 may be accomplished by means of the rotatable paddle 33 in conjunction with the knob 32. The action of paddle 33, as explained in above mentioned Patent No. 2,280,824, depends upon the fact that it distorts the oscillating field in resonator 21 to a greater or less degree depending upon the relative orientation of the paddle. The resonator might also be tuned by replacing the rigid wall 31 by a flexible one and adapting the tuning mechanism of the aforementioned application Serial No. 342,912 to change the distance between the capacitive portions of the resonator 21, or by other means such as discussed in connection with Fig. 7. Concentric line 34, or a plurality of such concentric lines, may be provided for removal of energy from or introduction of energy into the resonator 21.

In place of providing resonators which are slidably removable from the vacuum envelope, a construction such as shown in Fig. 3 may be used. Resonator 21' may be divided into halves as shown at 35 and 36 in Fig. 6, being hinged at 38 and clamped together by screw 37, or may be divided into any convenient size and number of portions. Grid structures 22 and 23 are placed in male V-edged conducting disks 39 and 40 which are oriented coaxially to and are sealed to and form partitions in the vacuum envelope 3, the V-edges of the disks projecting out of the wall of the vacuum envelope. The structure of Fig. 2 may also employ grids attached to sleeves 24 and 25, if desired. The halves of the resonator 21' have their condenser portions slotted with female V-edges of a diameter exactly matching the V edges of the disks, as at 41, 42. One wall 43 of the resonator 21' is made thin and flexible, so that no lateral or other strains are exerted on the glass to metal seals 44. The hinged halves 35, 36 of resonator 21' are then folded around the disks 39, 40 and are clamped in position by the screw 37. Tuning of the resonator 21' may be effected by any of the methods preferably not requiring distortion of the resonator walls; i. e., by a tuner such as the paddle 33 of Fig. 2. This form of our invention affords direct metallic contact for the high frequency current carrying surfaces, and so introduces no losses of energy such as dielectric loss.

The features of our invention can also be applied to modifications of klystron-like tubes as illustrated in Fig. 4, which shows a variation of

the structure shown in Fig. 3 of copending application Serial No. 268,898, filed April 20, 1939 by William W. Hansen, Russell H. Varian and John R. Woodyard, now Patent No. 2,259,690, granted October 21, 1941, wherein velocity grouping tubes of single resonant circuit type are disclosed. In such a tube, a hollow external cylindrical case 45 is arranged to contain an oscillating high frequency electric field, and to also contain, placed coaxially to member 45, a second smaller hollow cylinder 46. As described in the aforementioned application Serial No. 268,898, members 45 and 46 have aligned grid structures 47, 48, 49, and 50, through which an electron beam from focusing cathode 4 may be projected. Cylindrical members 45 and 46 are so laterally spaced that grids 47, 48 are closer together than grids 49, 50, affording a relatively low intensity high frequency field between the "buncher" grids 47, 48, wherein the electron beam is velocity grouped, and a relatively high intensity alternating field between the "catcher" grids 49, 50, wherein energy absorption is effected, the electric field being substantially zero in the region in which supporting struts 61 and 61' are placed.

As shown in Fig. 6, the resonator 45 may be split in halves, hinged, and clamped around the vacuum envelope 3. The grids 47, 48, 49, 50 are mounted in alignment in conducting disks 51, 52, 53, 54, respectively, and are sealed in envelope 3. These disks are supported in the envelope 3 in an exactly similar manner as the disks 39, 40 of the structure shown in Fig. 3. The disks' peripheries, in place of being V-shaped, have a novel fitting which effects removal of lateral and other strain from the glass to metal seals of the tube. The joints between the disks and the resonator walls are substantially as shown in Fig. 5. Here portion 54 of one of the disks is shown to have a peripheral flange 86 extending past the body of the disk. Likewise, the walls 55, 56, 57, 58 of cylindrical members 45 and 46, as shown by wall portion 58, have an inwardly extending flange 84. The sum of the widths of flanges 84 and 89 is made somewhat less than the total width of the disk, the disk portion 54 and the wall portion 58 being shown as having equal widths.

Resonator 45 may be held in proper lateral position with reference to vacuum envelope 3 by means of clamping devices such as shown in Fig. 1, or by other appropriate means. Then by means of the structure shown in Fig. 5, any strains due to inaccuracy of construction of the resonator 45 or of positioning of the disks 51, 52, 53, 54 in the glass to metal sealing process, or any strains due to relative thermal expansions are not transmitted to the metal to glass seals.

The tube is shown provided with a focusing cathode 4 and focusing coil 60 energized by battery 62 through leads in hollow strut 61, although such focusing may not necessarily be a feature of our invention.

Fig. 7 illustrates a structure that is quite similar to that shown in Fig. 2 wherein a resonator 88 is slidable on or off the evacuated electron beam confining tube 89. Within the tube 89 there is provided the emitting cathode 90 that is maintained at a direct current potential difference with respect to an accelerating grid member 91 as by means of a battery 100. The grid member 91 underlies one wall of the resonator 88 and is capacity coupled thereto by the tube projec-

tions 92 and 93 formed on the grid structure 91 and resonator 88, respectively. A second grid structure 94 is also contained within tube 89 in opposed cooperative relation with grid structure 91. Grid structure 94 also has a tube projection 95 capacity coupled to a tube projection 96 also formed on the resonator 88. Thus, in use the standing electromagnetic field within resonator 88 establishes an alternating electric component between grid structures 91 and 94. This tube is shown as of the reflex type and has a reflector plate 97 held near cathode potential for reflecting electrons back into the space between grid structures 91 and 94 whereby resonator 88 is not only caused to serve as the "buncher" but also serves as the "catcher" resonator in that a portion of the energy of the electron groups is supplied to this resonator for driving the same. Energy may be removed by means of the terminal post 98 and tuning may be accomplished by the tuning means 99.

As many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

Having described our invention, what we claim and desire to secure by Letters Patent is:

1. High frequency electron discharge apparatus, comprising a tubular insulating envelope, a pair of tubular members coaxially mounted within said envelope, an electron-permeable grid supported in each of the adjacent ends of said members providing a narrow gap therebetween, a cathode adjacent one of said grids, a reflector electrode adjacent the other of said grids, a pair of conductive members substantially coplanar respectively with said grids and surrounding said envelope, conductive means connected to said members and defining therewith a toroidal cavity resonator, and a pair of tubular elements connected respectively to said coplanar members at the inner edges thereof and extending outwardly from said resonator and concentrically with respect to said first tubular members defining a capacitance between each of said last tubular elements and its corresponding tubular member.

2. High frequency electron discharge apparatus comprising a tubular insulating evacuated envelope, a pair of tubular members coaxially mounted within said envelope and having adjacent ends, a grid mounted in each of said ends and forming a narrow gap therebetween, a cathode adjacent one of said grids, a reflector electrode adjacent the other of said grids, means defining a cavity resonator removably surrounding said envelope adjacent said grids, and a pair of tubular elements connected at the inner edges of said resonator and extending outward therefrom concentrically with respect to said first tubular members and forming a large capacitance between each of said tubular elements and a corresponding tubular member.

3. Apparatus as in claim 2, further including means within said resonator and external to said envelope for varying the tuning of said resonator.

EDWARD L. GINZTON.
WILLIAM W. HANSEN.