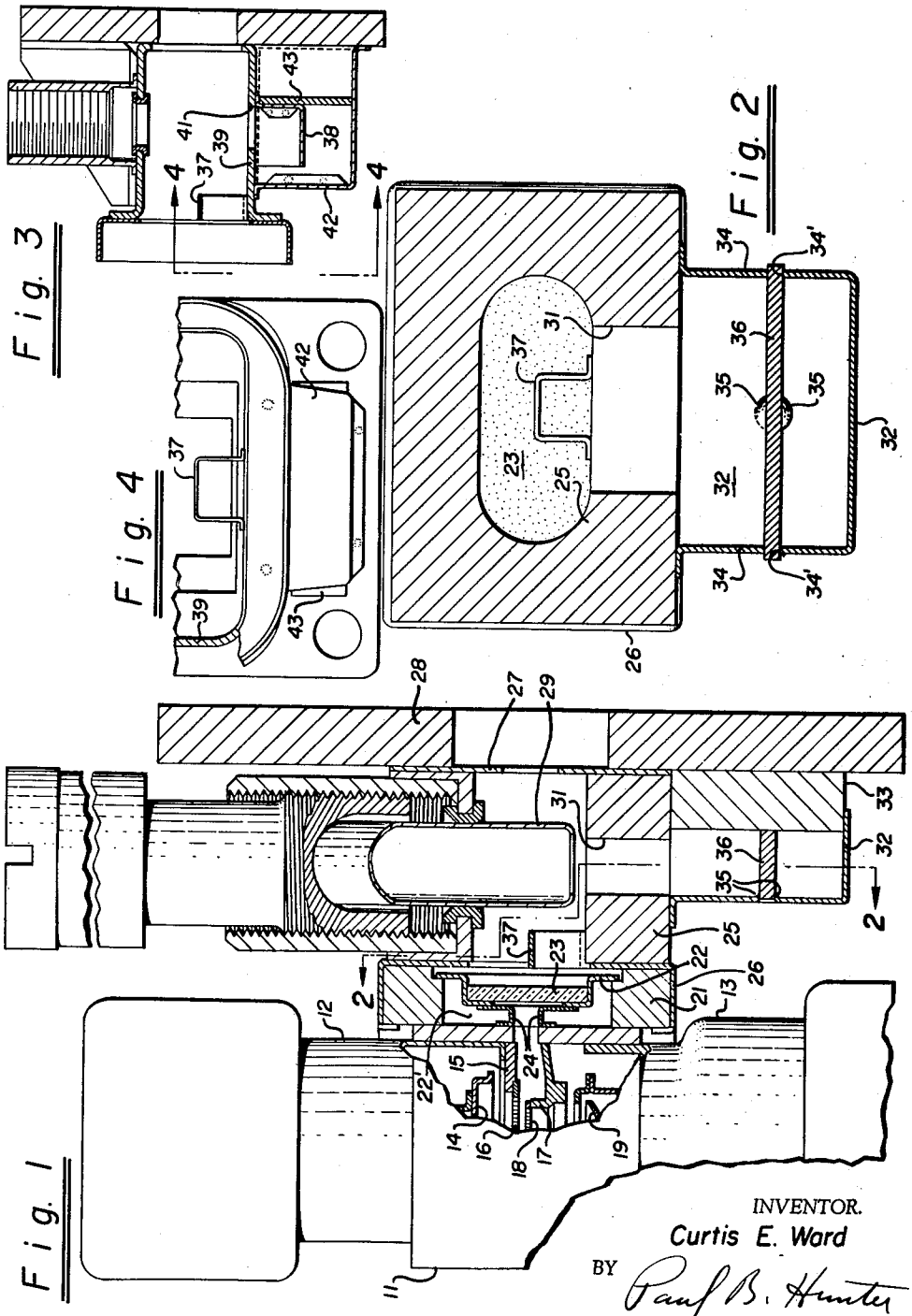
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ELECTRON DISCHARGE DEVICE

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ELECTRON DISCHARGE DEVICE

Curtis E. Ward, Los Altos, Calif., assignor to Varian Associates, Palo Alto, Calif., a corporation of California

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11 Claims. (Cl. 315—5.21)

This invention relates in general to high frequency devices and more particularly to a novel improved velocity modulation device of the tunable external cavity resonator type.

The particular type of klystron to which the present invention relates is an internal-external cavity resonator type klystron in which the kylstron frequency is tuned by means of a tuning mechanism in a cavity resonator outside the vacuum envelope of the device, this external cavity resonator being heavily coupled through an iris coupling and a wave energy permeable vacuum seal or window to an internal cavity resonator within the evacuated portion of the klystron. Heretofore lossy members such as screws have been inserted into the external cavity resonator at desired points to eliminate undesired modes of operation of the klystron. The present invention has for its object the provision of a novel internal-external cavity resonator type klystron having an improved window coupling structure and an improved mode suppressor arrangement incorporated in the external cavity resonator portion of the klystron.

One feature of the present invention is the provision of a klystron device of the internal-external cavity resonator type having an improved window coupling structure.

Another feature of the present invention is the provision of a klystron of the internal-external cavity resonator type which incorporates a novel waveguide mode suppressor trap in the external cavity resonator for suppressing undesired modes.

Another feature of the present invention is the provision of a novel klystron of the above featured type wherein the operation of the mode suppressor waveguide trap is enhanced by means of a coupling member or "mode handle" which also serves as an iris or window loading member for the klystron.

These and other features and advantages of the present invention will become more apparent upon a perusal of the following specification taken in connection with the drawings, wherein,

Fig. 1 is an elevation view partly cutaway and partly in longitudinal section of a reflex klystron device which embodies the novel mode suppressor mechanism in the external cavity,

Fig. 2 is a cross section view of the klystron of Fig. 1 taken along section lines 2—2,

Fig. 3 is a longitudinal cross section view of an external cavity resonator portion of a reflex klystron which incorporates a second embodiment of the present invention, and

Fig. 4 is a cross section view of the structure shown in Fig. 3 taken along the section line 4—4 therein.

Referring now to Figs. 1 and 2 there is shown a reflex klystron in which the present invention is incorporated for purposes of illustration, the reflex klystron comprising a metallic main body block 11, as of steel, having a cylindrical bore therein in which a metallic reflector bulb 12 and cathode bulb 13 as of, for example, steel are brazed. A reflector button 14 as of nickel is mounted on and extends within the reflector bulb 12. A steel reflector header

15 is brazed on the inner end of the reflector bulb 12 and a copper resonator grid 16 is brazed on the header 15. A copper anode header 17 is brazed within the main body 11 and carries a second copper resonator grid 18 which cooperates with grid 16 to form an interaction gap in the internal cavity resonator of the klystron. A cathode button 19 and associated focusing member 21 are mounted within the cathode bulb 13.

A window plate 21, as of steel, is brazed to the main body 11, the window plate having an oval-shaped flexible window frame 22, as of Kovar, vacuum sealed therein. An oval shaped wave permeable ceramic window 23 is vacuum sealed in the frame. The window frame 22 is coupled to the main body 11 by means of thin metallic conducting straps 24, as of nickel, which serve as window shorts as described below. An external cavity resonator member 25 is secured to a metallic cavity cup 26 which in turn is secured as by brazing on the window plate 21, the rim of the cavity cup 26 being pressed down over the back of the window plate 21. An iris plate 27, which has a circular opening therein, and a waveguide flange 28 are fixed to the outer end of the external cavity resonator member 25. A capacitive tuning post 29 is mounted on the external cavity resonator and adapted to be screwed therein for selectively tuning the frequency of this reflex klystron. A tuning member of this type is shown and described in U.S. patent application Serial No. 675,491, filed July 31, 1957, by B. C. Gardner et al.

In operation, electrons emitted from the cathode 19 are focused into a beam by the focusing electrode 21 and accelerated through the klystron by high positive potential on the accelerator electrode 17. In accordance with well-known reflex klystron action, electrons pass through the resonator gap between grids 18 and 16 where they interact with the R.F. electric field across the gap, the R.F. field velocity-modulating the beam. Electrons pass into the space adjacent the reflector electrode 14 which carries a negative potential adapted to repel the electrons in the beam. The electrons are turned about and again passed through the resonator gap between grids 16 and 18 in bunches due to the velocity modulation effect which took place in the electron beam. The bunched electrons deliver energy to the field across the resonator gap, the R.F. energy being removed from the cavity resonator through the window 23 into the external cavity resonator. The klystron may be tuned over its operating frequency range by means of the tuner rod 29 in the external cavity resonator. The radio frequency energy passes from the external cavity resonator through the opening in iris plate 27 to the external load circuits.

The window 23 is mounted in the thin flexible oval frame 22 which in turn is mounted on its outer flange in the window plate 21 for the purpose of allowing a definite amount of flexibility to the vacuum sealed window of this klystron. This flexibility is needed due to the mechanical stresses and strains of mounting, vibration, etc. to which the window is subjected during use of the klystron and also because of the expansion and contractions due to temperature variations and the like. Without the flexibiltiy provided by this window frame 22, the vacuum sealed window has a tendency to crack or open at its seal with the result that the klystron loses its vaccum. The window is preferably oval shaped because of the better tuning range obtained in the external cavity resonator with the movable tuner post 29. The result of the oval shape to the window frame and the particular mounting arrangement of the flexible window frame in the window plate 21 is that a series inductive element or choke is formed in the space 22' between the main body 11, the window frame 22, and window plate 21. It has been found that the effects due to this series inductive element or choke formed between the window and the body may be eliminated by means of

flexible metallic strips 24 brazed between the body 11 and the window frame 22. Thus the advantages of a flexibly mounted window as shown may be obtained without the resultant deleterious effect of a choke being evident. It has been found that one strip across each of the top and bottom sides of the window as shown in Fig. 1, works very well. A total of four strips in one embodiment resulted in a slight improvement over two strips.

A mode suppressor of novel construction is incorporated in the tunable external cavity resonator for suppressing undesired modes of operation of the reflex klystron. For example, in one embodiment of this invention the 3/2 mode is suppressed, the klystron operating in the full wave mode. This mode suppressor includes a wave trap cup 32 coupled to the external cavity resonator through an opening 31 in the lower wall of the external cavity resonator. This wave trap cup is formed from a sheet of metal such as nickel folded into a box-like cup which is secured as by spot-welding to the external cavity resonator 25 and to a block 33 which has been brazed to the waveguide flange 28. The sides 34 of this wave trap have slots 34' therein and, in addition, small indented lips 35 are located in the longer side of the wave trap which accommodate a lossy resistive card 36. This card is fixedly secured within the wave trap by tightly closing the edges of the slots 34 on the ends of the card 36 during spot welding of the cup 32 to the klystron. The opening 31 through the external resonator wall is approximately $\frac{1}{4}\lambda$ long and the distance between the resistor card 36 and the end of the cup is also approximately $\frac{1}{4}\lambda$. A U-shaped "mode handle" 37 as of nickel is secured within the external cavity resonator and serves a dual purpose. It serves as a window loading member for optimizing the coupling through window 23 between the internal and external cavity resonators and, in addition, it serves to give a wider frequency separation between the desired mode of operation of this klystron and the undesired mode which the mode suppressor 32 is arranged to suppress, thereby enhancing the suppression of the undesired mode. For example, in one klystron made in accordance with this invention the frequency separation was improved by about 50% due to utilization of the mode handle of proper width, i.e. horizontal length as viewed in Fig. 1. The optimum width of the mode handle is determined mainly on a trial and error basis to accomplish the optimum frequency separation. The U-shaped configuration of the mode handle permits slight vertical displacement of this mode handle by means of a bending tool inserted through the opening in iris plate 27, thus allowing for slight adjustments of the window loading and the mode suppressing characteristics of the mode handle.

Another form of the mode suppressor wherein two cup-like members are utilized is shown in Figs. 3 and 4 which depicts only the external cavity resonator portion of a klystron with the tuning screw removed. The internal cup 38 is spot-welded to the external cavity resonator 39 over the coupling opening 41. The horizontal length of this cup is $\frac{1}{4}\lambda$. The external cup 42 is also spot-welded to the external cavity resonator and the waveguide flange, a resistor card 43 being securely held within this cup, approximately $\frac{1}{4}\lambda$ from the waveguide flange, by squeezing the sides of the cup on the card during spot-welding. The two cups form a sinuous wave energy path of the desired wave length between the external cavity resonator and the resistor card.

Since 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.

What is claimed is:

1. A reflex klystron of the internal-external cavity resonator type comprising a main body portion having an evacuated resonator type comprising a main body portion having an evacuated cavity resonator formed therein, another body portion having an unevacuated external cavity resonator formed therein, a wave energy permeable window vacuum sealed between the internal cavity resonator and the external cavity resonator, the external cavity resonator being heavily coupled electrically to said internal cavity resonator through said window, a tuner mechanism in said external cavity resonator over its operating frequency range for tuning said reflex klystron, means for suppressing undesired modes of operation of said reflex klystron comprising a wave trap coupled to said external cavity resonator through an opening in the wall of said external cavity resonator, said wave trap comprising a waveguide and having a wave energy absorbing member therein for absorbing the energy of said undesired mode, the electrical length of said wave trap being of sufficient dimension to suppress the undesired mode, and a metallic conducting member in said external cavity resonator adjacent said wave permeable window for producing optimum wave energy coupling between said internal and said external cavity resonator and positioned in said external cavity resonator for also optimizing the frequency separation between the undesired mode to be suppressed and the desired mode of operation of the reflex klystron.

2. A reflex klystron device as claimed in claim 1 wherein the wall of said external cavity resonator in which the coupling opening leading to the wave trap is located is at least one-quarter wave length thick.

3. A reflex klystron device as claimed in claim 1 wherein said wave energy absorbing member comprises a resistive card and wherein said wave trap comprises a sheet of metal folded on at least three sides to form a box-like structure, two of the sides having slots therein adapted to accommodate and grip the ends of the resistive card to thereby hold the card within the wave trap.

4. A reflex klystron device as claimed in claim 1 wherein said conducting member utilized for enhancing the coupling between the internal cavity resonator and the external cavity resonator and for separating the modes of operation of the reflex klystron comprises a U-shaped conducting member mounted at its ends in the external cavity resonator and extending adjacent the vacuum seal window between the internal and external cavity resonators.

5. A reflex klystron as claimed in claim 1 wherein said wave trap comprises two sheets of metal folded to form a pair of box-like structures, one of said structures being mounted on said klystron over the opening in the wall of said external cavity resonator and the second of said structures being mounted over said one structure whereby a sinuous wave energy path is produced through said two wave trap structures, said wave energy absorbing member being positioned in said second structure.

6. A reflex klystron as claimed in claim 5 wherein said wave energy absorbing member comprises a resistive card.

7. A reflex klystron as claimed in claim 6 wherein said resistive card is received in slots in the sides of said second structure.

8. A reflex klystron of the internal-external cavity resonator type comprising a main body portion in which the internal cavity resonator is formed, a window plate portion integral with said body portion having a substantially oval-shaped opening therein, a flexible oval-shaped window frame having an oval-shaped wave energy permeable material vacuum sealed therein, the window frame being vacuum sealed in the opening in the window plate whereby a series inductive element or choke space is formed between the flexible window frame and said body and window plate portions, and plurality of conductive flexible strips secured between said flexible window frame and the main body portion to serve as choke shorts.

9. A reflex klystron of the internal-external cavity resonator type comprising a main body portion having an evacuated cavity resonator formed therein, a window plate portion integral with said body portion having a substantially oval-shaped opening therein, a flexible oval-shaped window frame having an oval-shaped wave energy permeable material vacuum sealed therein, the window frame being vacuum sealed in the opening in the window plate whereby a series inductive element or choke space is formed between the flexible window frame and said body and window plate portions, a plurality of conductive flexible strips secured between said flexible window frame and the main body portion to serve as choke shorts, another body portion having an external cavity resonator formed therein and mounted over said window, a tuner mechanism in said external cavity resonator for tuning said reflex klystron, means for suppressing undesired modes of operation of said reflex klystron comprising a wave trap coupled to said external cavity resonator through an opening in the wall of said external cavity resonator, said wave trap having a wave energy absorbing member therein for absorbing the energy of said undesired mode, the electrical length of said wave trap being of sufficient dimension to suppress the undesired mode, and a metallic conducting member in said external cavity resonator adjacent said wave permeable window for producing optimum wave energy coupling between said internal and said external cavity resonator and positioned in said external cavity resonator for also optimizing the frequency separation between the undesired mode to be suppressed and the desired mode of operation of the reflex klystron.

10. A reflex klystron comprising a main body in which an evacuated cavity resonator is formed, said main body having a substantially oval-shaped opening therein leading to the cavity resonator, a flexible oval-shaped window frame having an oval-shaped wave energy permeable material vacuum sealed therein, the window frame being vacuum sealed in the opening in said body whereby a series inductive element or choke space is formed between the flexible window frame and said body, and a

plurality of conductive flexible strips secured between said flexible window frame and the main body to serve as choke shorts.

11. A reflex klystron of the internal-external cavity resonator type comprising a main body portion having an evacuated cavity resonator formed therein, a window plate portion integral with said body portion having a substantially oval-shaped opening therein, a flexible oval-shaped window frame having an oval-shaped wave energy permeable material vacuum sealed therein, the window frame being vacuum sealed in the opening in the window plate whereby a series inductive element or choke space is formed between the flexible window frame and said body and window plate portions, a plurality of conductive flexible strips secured between said flexible window frame and the main body portion to serve as choke shorts, another body portion having an external cavity resonator formed therein and mounted over said window, a tuner mechanism in said external cavity resonator for tuning said reflex klystron, and means for suppressing undesired modes of operation of said reflex klystron comprising a wave trap coupled to said external cavity resonator through an opening in the wall of said external cavity resonator, said wave trap having a wave energy absorbing member therein for absorbing the energy of said undesired mode, the electrical length of said wave trap being of sufficient dimension to suppress the undesired mode of operation of the reflex klystron.

References Cited in the file of this patent

UNITED STATES PATENTS

2,591,696	Hansen	Apr. 8, 1952
2,644,889	Finke et al.	July 7, 1953
2,678,404	Sorg	May 11, 1954
2,806,977	Carter	Sept. 17, 1957
2,815,467	Gardner	Dec. 3, 1957
2,824,258	Snow et al.	Feb. 18, 1958

FOREIGN PATENTS

1,108,985	France	Sept. 14, 1955

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,955,228

October 4, 1960

Curtis E. Ward

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 21, for "kylstron" read -- klystron --; column 2, line 59, for "flexibiltiy" read -- flexibility --; column 4, lines 2 and 3, strike out "resonator type comprising a main body portion having an evacuated".

Signed and sealed this 11th day of April 1961.

(SEAL)
Attest:

ERNEST W. SWIDER

Attesting Officer

ARTHUR W. CROCKER
Acting Commissioner of Patents