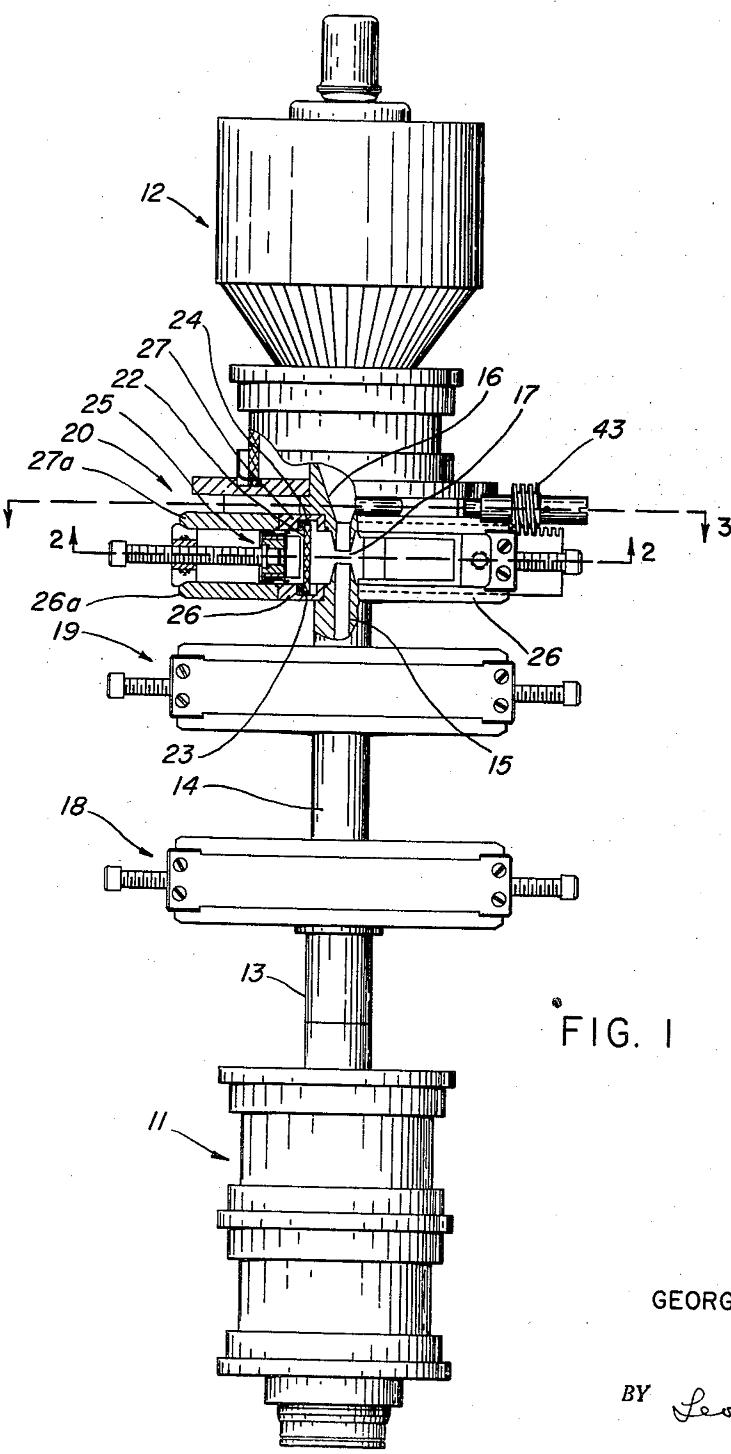

FIG. 1

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Aug. 16, 1960 G. K. MERDINIAN 2,949,559

KLYSTRON TUBE

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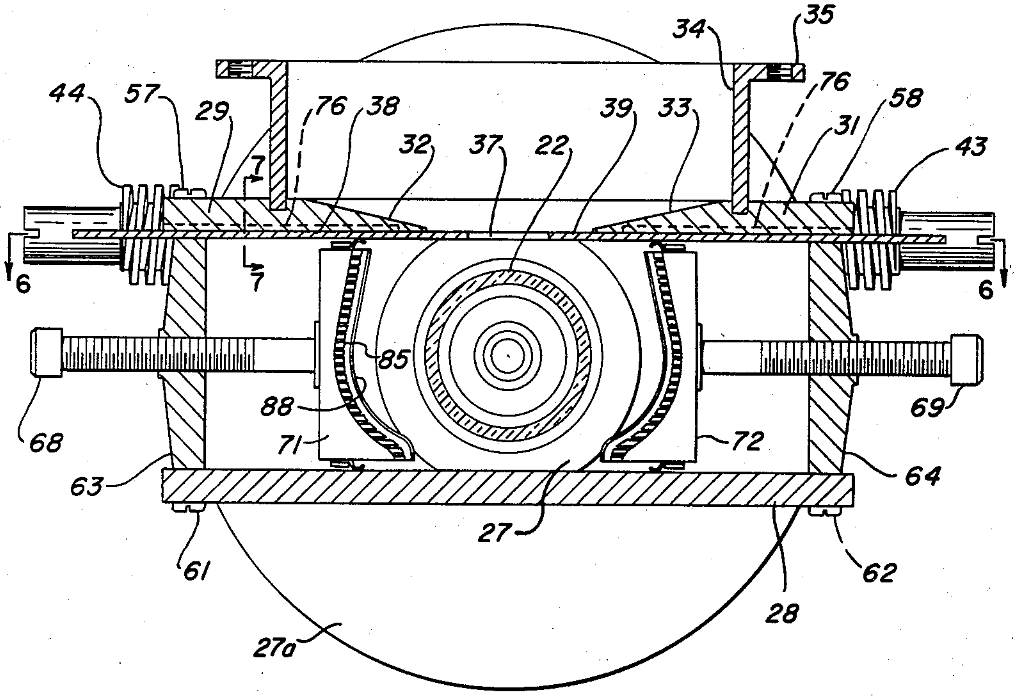

FIG. 2

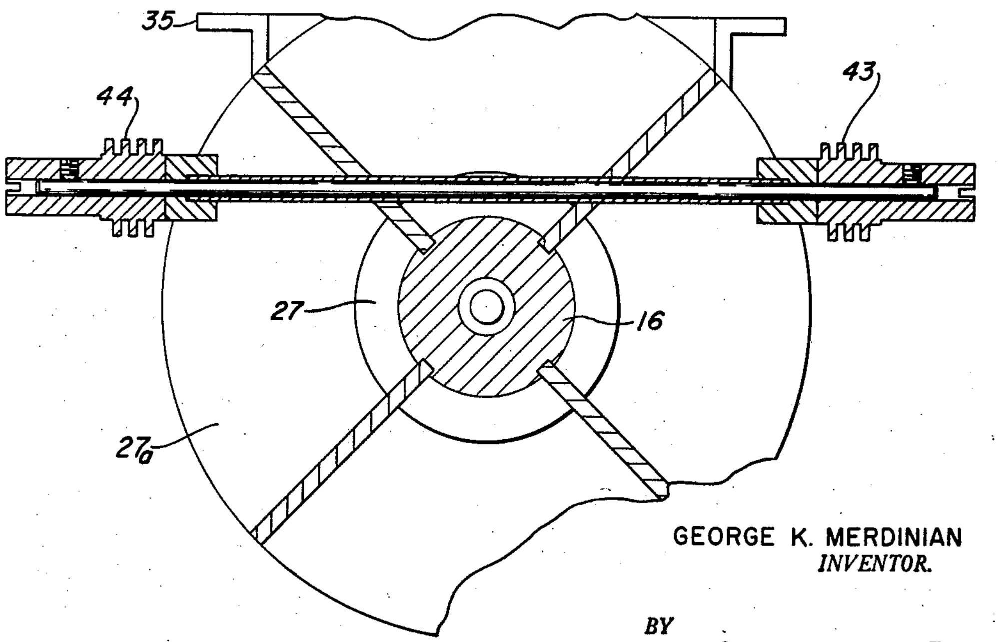

FIG. 3

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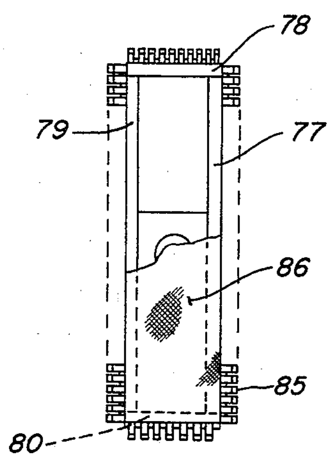

FIG. 4

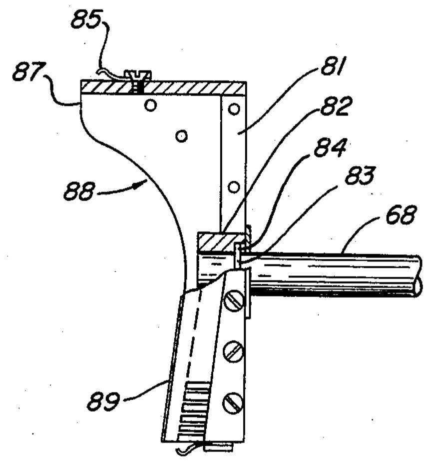

FIG. 5

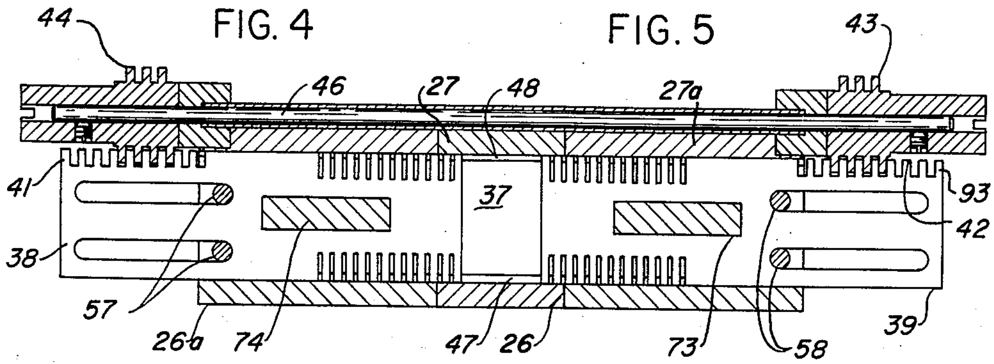

FIG. 6

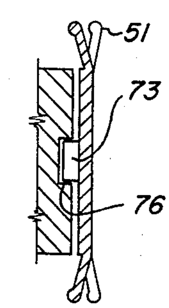

FIG. 7

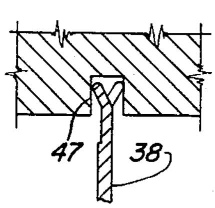

FIG. 8

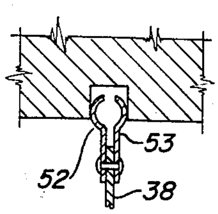

FIG. 9

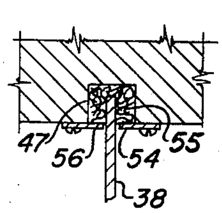

FIG. 10

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United States Patent Office 2,949,559
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2,949,559

KLYSTRON TUBE

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Filed Jan. 31, 1958, Ser. No. 712,354
10 Claims. (Cl. 315—5.46)

This invention relates generally to a klystron tube and more particularly to a klystron tube having an improved output cavity resonator, and improved means for coupling to a waveguide output circuit.

One of the problems encountered in klystron tubes is that of efficiently coupling energy from the output cavity. When operating at a particular power output and a relatively narrow band of frequencies, it is possible to design a coupling means which optimizes the degree of coupling between thte cavity and associated output circuit. However, when it is desired to operate a klystron tube over a relatively wide range of frequencies with variable power outputs, a fixed coupling of the above character is unsatisfactory.

Waveguide transmission circuits are capable of handling more power and introduce less power loss per unit length than are coaxial transmission circuits. Thus, in many applications it is desirable to connect waveguide transmission circuits directly to a cavity resonator, for example, the output cavity resonator of a klystron tube.

One type of klystron tube includes resonant cavities having two parts: a part which forms a portion of the evacuated envelope, and another part which carries the tuning means. The two parts are coupled together through a dielectric window. It is necessary to operate this type of tube in such a manner that the window does not overheat or it may crack, destroying the vacuum. When the energy in the cavity is not properly coupled out, the window may reach dangerously high temperatures.

It is a general object of the present invention to provide a klystron tube with improved waveguide coupling.

It is another object of the present invention to provide a cavity resonator for a klystron tube with waveguide transmission line input and/or output.

It is a further object of the present invention to provide improved coupling between a cavity resonator and a waveguide transmission circuit.

It is another object of the present invention to provide an output cavity resonator having an adjustable degree of coupling to associated apparatus.

It is another object of the present invention to provide an adjustable iris diaphragm coupling between a cavity resonator and associated apparatus.

It is another object of the present invention to provide a cavity resonator which is tunable over a relatively broad range of frequencies.

It is another object of the present invention to provide a tunable cavity resonator which may be air cooled thereby operating the coupling window at lower temperatures.

It is a still further object of this invention to provide a variable wave guide circuit element.

These and other objects of the invention will become more clearly apparent from the following description when taken in conjunction with the accompanying drawings.

Referring to the drawing:

Figure 1 is an elevational view, partly in section, of a three-cavity klystron tube;

Figure 2 is a sectional view taken along the lines 2—2 of Figure 1 and showing the tuning plungers and improved coupling;

Figure 3 is a sectional view taken along the lines 3—3 of Figure 1;

Figure 4 is an end view of a suitable tuning plunger;

Figure 5 is a side elevational view, partly in section, of the tuning plunger of Figure 4;

Figure 6 is a sectional view taken along the line 6—6 of Figure 2 showing the adjustable iris diaphragm in elevation;

Figure 7 is a sectional view taken along the line 7—7 of Figure 2 showing one of the iris diaphragm plates; and

Figures 8–10 show various means for making electrical contacts between the iris diaphragm plates and the cavity resonator walls.

Referring to Figure 1 of the drawing, a klystron tube with tuning chambers and coupling means according to the subject invention is illustrated. The tube comprises an elongated generally cylindrical envelope having an electron gun 11 at one end and a collector electrode 12 at its other end. The electron beam is projected from the electron gun to the collector and passes through a drift tube made up of metallic sections 13, 14, 15 and 16 which extend axially of the tube and have three gaps, of which 17 is shown. Such gaps are bridged by tuning chamber structures. Three chambers 18, 19 and 20 are shown associated with the gaps.

The tuning chambers are made up of two parts; an inner portion which is structurally integral with the envelope and forms a portion of the evacuated envelope, and an outer portion which is external to the evacuated envelope. Dielectric windows 22, one of which is shown, form portions of the envelope and provide means for coupling energy from the internal evacuated portions of the resonant cavities to the portions which are external of the vacuum envelope. The windows surround the associated gaps and have their ends 23 and 24 sealed to adjacent plates 26 and 27 which form a part of the evacuated envelope and which may also form a part of the resonant cavity. Tuning means 25 are carried in the external portions of the tuning chambers.

The above described elements of the tube function in a manner well known for klystron tubes of this type, namely, an electron beam from the gun 11 is accelerated by a positive potential on its anode (not shown) and passes through the drift tube past the interaction spaces provided by the gaps, and finally terminating on the collector 12. The associated tuning chambers 18, 19 and 20 serve as the frequency determining elements of the device. As previously described, the tuning chambers contain movable tuning means which serve to tune the cavity over a particular frequency range. The tube illustrated may function as an amplifier with the input signal for modulating the electron beam fed into the resonant cavity 18 and the amplified radio frequency output taken from the resonator 20 in accordance with the usual practice in a three-cavity type klystron.

The resonant cavities are formed by the plates 26 and 27, extension plates 26*a* and 27*a* being suitably secured thereto. As shown in Figure 2, the output cavity 20 comprises a side wall 28 suitably secured to the spaced end walls, and wall portions 29 and 31 which extend towards one another. The adjacent ends of the wall portions 29 and 31 are tapered and spaced from one another to provide a fixed opening through which the microwave energy within the cavity resonator may be coupled to associated apparatus. It is observed that the klystron and cavity resonator described are formed as a unitary structure.

However, it will be apparent from the description which follows that the invention is not to be limited in this respect. The external portion of the cavity may be formed as a separate assembly which is suitably clamped to the klystron for operation therewith. Klystrons of this type are well known in the art.

The output cavity is adapted to be coupled to a waveguide transmission circuit. Thus, a section of waveguide 34 provided with connecting flanges 35 is suitably secured to the adjacent wall portions 29 and 31 and the end walls 26 and 27. A waveguide may then be suitably attached to the flanges 35.

Energy is coupled to associated apparatus through the adjustable iris opening 37. The iris illustrated is an inductive iris; however, it will become apparent that a capacitive iris may be employed if desired. The area of the opening 37 may be controlled by moving the adjustable diaphragms 38 and 39. In Figure 6, the diaphragms 38 and 39 are shown in elevation. An edge of each of the diaphragms is provided with teeth 41, 42 which engage an adjacent threaded worm-screw 43, 44, respectively. The screws 43 and 44 are threaded in an opposite sense whereby rotation of the shaft 46 which is coupled to the screws 43 and 44 urges the diaphragms 38 and 39 in opposite directions. Thus, by rotating the shaft 46, the diaphragms 38 and 39 are moved symmetrically towards or away from one another to thereby control the width of the iris opening 37.

The diaphragms 38 and 39 are guided in the grooves 47 and 48 formed in the plates 26 and 27. The side edges of the diaphragms 38 and 39 are provided with suitable means for making electrical contact in the grooves. For example, the side portions may be serrated and bent to form a series of fingers 51 which engage opposite sides of the grooves as indicated in Figures 7 and 8. The diaphragms 38 and 39 may be provided with finger contacts 52 and 53 as indicated in Figure 9, which frictionally engage the sides of the groove to provide an electrical contact and guide the diaphragm. Alternatively, the side edges of the diaphragms may extend into the slot 47 which is filled with metallic material 55 which makes electrical contact therewith as shown in Figure 10. A pair of adjustable plates 54 and 56 is secured to the wall and guides the diaphragm. It is apparent that other means may be employed for guiding the diaphragms 38 and 39 and providing electrical contact.

The diaphragm 38 is guided between the plates 26 and 27 by means of the pins 57 which extend inwardly from the wall 29 while the diaphragm 39 is guided by the pins 58 which extend inwardly from the wall 31. These pins may be the screws 57 and 58 (Figure 2) which engage one end of the web members 63 and 64. The screws 61 and 62 extend inwardly and engage the other end of the web members 63 and 64. The web members 63 and 64 receive the adjusting screws 68 and 69 associated with the tuning plungers 71 and 72, to be presently described. The open construction of the web members makes it possible to blow air through the resonant cavity past the dielectric window to thereby cool the same.

The diaphragms 38 and 39 are also guided by the guides 73 and 74 which are carried on one face thereof and which are adapted to ride within accommodating slots 76 formed in the adjacent side wall portions 29 or 31.

Each of the tuning plungers is of box-like construction (as viewed from the end) comprising four walls; the side walls 77, 78, 79 and 80. The walls are carried by a frame 81. A strap 82 extends across the frame and receives the end of the associated tuning screw 68 or 69. The end of the tuning screw is rotatably received by the associated strap 82. For example, the arrangement might comprise a collar 83 carried on the screw 68 which collar is seated within an annular groove 84. Thus, rotative movement of the screw 68 moves the tuning plunger.

The tuning plunger is provided with a plurality of contact fingers 85 which are suitably secured to side walls

of the plunger and which frictionally engage the adjacent wall portions of the resonant cavity. Referring particularly to Figures 1 and 2, the contact fingers fritctionally engage the walls 26 and 27, and the side wall 28, and the diaphragms 38 and 39. Thus, electrical contact is made between the tuning plunger and the adjacent wall portions. The walls 77 and 79 have an end configuration which has a straight portion 87 which extends substantially at right angles to the side, a curved portion 88, and a relatively straight portion 89 which forms a continuation of the curved portion. The curved portion has the configuration of the window whereby when a pair of plungers is moved inwardly, they surround the window to form a relatively small resonant volume. If, on the other hand, the plungers had a straight end, the volume of the cavity could not be reduced to as small a volume and, therefore, the upper resonant frequency would be much lower. Because of the curved configuration, the tuning cavity may be tuned over a relatively wide range. The straight portion 89 lies adjacent the iris opening 37 whereby when the tuning plungers are moved towards one another they will not block the iris opening 37.

The exact configuration of the ends of the walls 77 and 79 may be arrived at by trial and error to achieve the smallest cavity volume and best coupling techniques, if desired. In general, as previously described, this can be achieved by walls having straight portions 87, a curved portion 88 which is adapted to fit around the window, and a straight portion 89 which forms a smooth continuation of the curved portion.

A screen mesh 86 is suitably secured to the forward end of the walls 77, 78, 79 and 80 to form the end wall. The open box-like configuration of the plungers and the screen mesh provide a means for circulating air through the cavity to cool the window.

The degree of coupling between the resonant cavity and the associated waveguide or to any other microwave transmission line or device is approximately proportional to the width of the iris. The required degree of coupling is, in general, dependent upon the amount of energy stored in the resonant cavity which is available for a load. It is often desirable to be able to adjust this coupling for optimum power output. This depends both upon the power output and the frequency of operation and, therefore, by providing an adjustable iris opening the greatest efficiency over the widest range of power outputs and frequencies may be obtained.

A suitable dial indicator may be coupled to the screws 43 and 44. A calibration for various outputs and frequencies may be obtained whereby the screws may be turned so that when the indicator dial is set to a predetermined value the most efficient coupling is obtained.

It is observed that the iris opening is symmetrical with respect to the axis of the tube, and the tuning means are formed symmetrical also. This provides a symmetrical field within the cavity and means symmetrically coupling thereto to give improved frequency characteristics to the cavity.

Thus, it is seen that there is provided a cavity resonator which can be tuned over a relatively broad band of frequencies with a novel adjustable waveguide coupling means therefor. The novel coupling means makes it possible to efficiently couple energy out of the resonator into a waveguide transmission system over a relatively broad band of frequencies and range of powers. There is also provided a klystron tube with improved waveguide coupling.

The novel coupling means according to this invention may also be adapted for use as a variable wave guide circuit element independently of a resonant cavity or of a klystron tube. For example, it may be desirable to provide inductive or capacitive diaphragms according to this invention in a wave guide circuit interconnecting microwave apparatus so that such apparatus may be matched to each other by introducing the proper amount of lumped inductance or capacitance into the interconnecting wave guide, the amount of reactance introduced into the wave guide being varied by varying the degree of insertion of the diaphragms into the wave guide.

I claim:

1. In combination, an electron tube and a cavity resonator, said cavity resonator including means for connecting a waveguide transmission system thereto, an opening formed in said resonator adapted to communicate with the associated waveguide transmission system, a pair of movable diaphragms serving to control the size of the opening, and means for moving said diaphragms simultaneously towards and away from one another, said movable diaphragms forming an adjustable iris for coupling the resonator to the associated waveguide transmission system.

2. A klystron tube comprising an electron gun serving to project an electron beam, a collector spaced from said gun and disposed to receive said beam, an input cavity resonator coupled to said beam and serving to bunch the same, an output cavity resonator coupled to said beam and adapted to be excited thereby, means for coupling said output cavity resonator to an associated waveguide circuit, said means including an adjustable iris having a pair of movable diaphragms, and means for moving said diaphragms simultaneously towards and away from one another to thereby control the size of the iris opening.

3. A klystron tube comprising an electron gun serving to project an electron beam, a collector spaced from said gun and adapted to intercept said beam, a drift tube including a plurality of sections forming at least first and second gaps, an input cavity resonator associated with said first gap serving to bunch the beam, an output cavity resonator associated with said second gap and adapted to be excited by the electron beam, means for connecting a waveguide transmission system to said output cavity resonator, an opening formed in said output cavity resonator adapted to communicate with the associated waveguide system, a pair of movable diaphragms serving to control the width of the opening, and means for moving said diaphragms simultaneously towards and away from one another, said movable diaphragms forming an adjustable iris for coupling the resonator to the associated waveguide transmission system.

4. A klystron tube of the type which includes an evacuated envelope portion and external resonator portions comprising an electron gun serving to project an electron beam, a collector spaced from said gun and adapted to intercept said beam, a drift tube including a plurality of sections forming at least first and second gaps, a plurality of windows each surrounding one of said gaps and forming a part of the evacuated envelope, an input cavity resonator serving to excite the beam at said first gap, an output cavity resonator adapted to be excited by the beam at said second gap, means for connecting said output cavity resonator to an associated waveguide circuit, an adjustable iris having a pair of movable diaphragms between said output cavity resonator and said waveguide circuit, and means for moving said diaphragms simultaneously towards and away from one another to control the width of the iris opening to thereby control the coupling between the resonant cavity and associated waveguide transmission circuit.

5. A klystron tube of the type which includes an evacuated envelope portion and external resonator portions comprising an electron gun serving to project a beam of electrons, a collector spaced from said gun and adapted to intercept said beam, a drift tube including a plurality of sections forming a plurality of gaps, one of said gaps serving as an output gap, a pair of spaced parallel plates disposed on either side of said output gap, a window surrounding said gap and forming a vacuum seal with said plates, means cooperating with said plates and forming a tunable resonant cavity, means for connecting said resonant cavity to an associated waveguide circuit, and an adjustable iris opening between said tunable resonant cavity and said waveguide serving to couple energy from the cavity to the associated waveguide circuit.

6. A klystron tube of the type which includes an evacuated envelope portion and external resonator portions comprising an electron gun serving to project a beam of electrons, a collector spaced from said gun and adapted to intercept said beam, a drift tube including a plurality of sections forming a plurality of gaps, one of said gaps serving as an output gap, a pair of spaced parallel plates disposed on either side of said gap, a window surrounding said gap and forming a vacuum seal with said plates, means cooperating with said plates and forming a tunable resonant cavity, means for connecting said resonant cavity to an associated waveguide circuit, an opening formed in said resonant cavity adapted to communicate with said associated waveguide circuit, a pair of movable diaphragms serving to control the width of the opening, and means for moving said diaphragms simultaneously and symmetrically towards and away from one another, said movable diaphragms forming an adjustable iris adapted to couple the resonant cavity to the associated waveguide circuit.

7. In combination, an electron tube and a rectangular cavity resonator, said rectangular cavity resonator including means for connecting a waveguide transmission system thereto, an opening formed in one wall of said resonator adapted to communicate with an associated waveguide transmission system, a pair of movable diaphragms serving to control the width of the opening, means for moving said diaphragms simultaneously toward and away from one another, said movable diaphragms forming an adjustable iris for coupling the resonator to the associated waveguide transmission system, a pair of tuning plungers making sliding contact with the walls of said cavity resonator, each of said plungers having cooperating opposed surfaces, said surfaces having a first straight portion, a curved portion, and a second straight portion forming a continuation of said curved portion, said last named straight portion extending to the wall of the cavity including said opening whereby said plungers do not interfere with the adjustable iris opening.

8. A klystron tube comprising an electron gun serving to project an electron beam, a collector spaced from said gun and disposed to receive said beam, an input cavity resonator coupled to said beam and serving to bunch the same, a rectangular output cavity resonator coupled to said beam and adapted to be excited thereby, means for coupling said output cavity resonator to an associated waveguide circuit, said means including an adjustable iris having a pair of movable diaphragms between said output cavity resonator and said waveguide circuit, and means for moving said diaphragms simultaneously and symmetrically toward and away from one another to thereby control the width of the iris opening, and a pair of tuning plungers making sliding contact with the walls of said cavity, each of said plungers having opposed cooperating surfaces including a first straight portion, a curved portion and a second straight portion forming a continuation of said curved portion and extending toward the iris opening.

9. A klystron tube of the type which includes an evacuated envelope portion and external resonator portions comprising an electron gun serving to project an electron beam, a collector spaced from said gun and adapted to intercept said beam, a drift tube including a plurality of sections forming at least first and second gaps, a plurality of windows each surrounding one of said gaps and forming a part of the evacuated envelope, an input cavity resonator serving to excite the beam at the first gap, an output cavity resonator adapted to be excited by the beam at the second gap, means for connecting said output resonant cavity to an associated waveguide circuit, an adjustable iris opening having a pair of movable

diaphragms between said output cavity resonator and said waveguide circuit, means for moving said diaphragms simultaneously toward and away from one another to control the width of the iris opening to thereby control the coupling between the resonant cavity and associated waveguide transmission circuit, and a pair of tuning plungers making sliding contact with the walls of said output resonant cavity, each of said plungers having co-operating surfaces, said surfaces having a first straight portion, a curved portion adapted to surround said window and a second straight portion forming a continuation of the curved portion and extending toward the iris opening.

10. A klystron tube comprising an electron gun serving to project an electron beam, a collector spaced from said gun and adapted to intercept said beam, a drift tube including a plurality of sections forming at least first and second gaps, said second gap forming the output gap, a pair of spaced parallel plates disposed on each side of said output gap, a window surrounding said gap and forming a vacuum seal with said plates, side walls connected to said plates, a pair of tuning plungers making sliding

contact with said plates and side walls, each of said plungers having opposed cooperating surfaces, said surfaces having a first straight portion, a curved portion adapted to surround said window, and a second straight portion forming a continuation of said curved portion, and adjustable iris coupling means adapted to couple energy form the cavity formed by said plates and said sidewalls to an associated waveguide circuit.

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