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ADJUSTABLE COUPLER FOR ELECTRON TUBES; ADJUSTMENT
MADE OUTSIDE THE VACUUM AND THROUGH
A DIELECTRIC VACUUM SEAL

3,305,799

Filed June 12, 1963

2 Sheets-Sheet 1

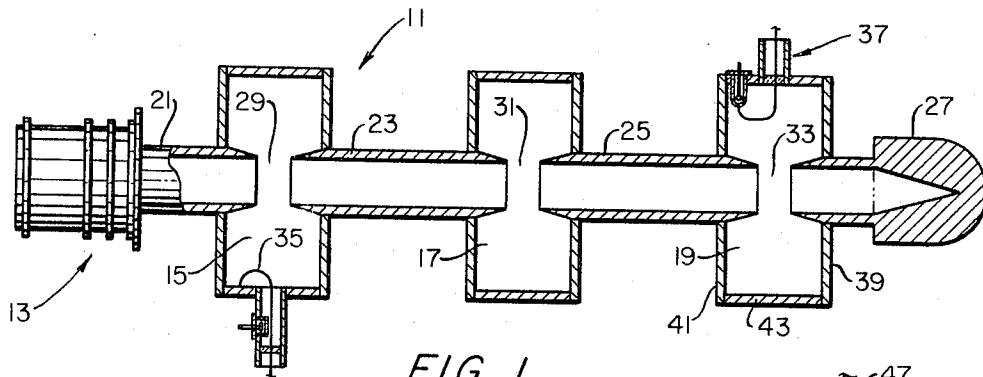


FIG. 1

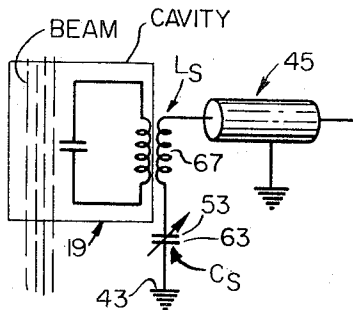


FIG. 3

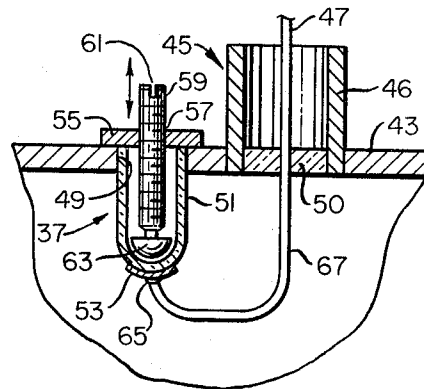


FIG. 2

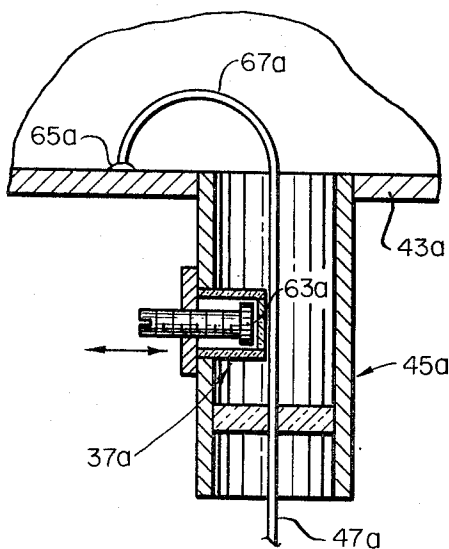


FIG. 4

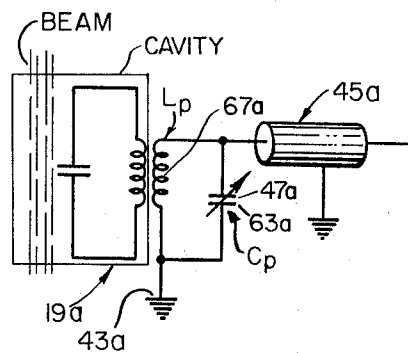


FIG. 5

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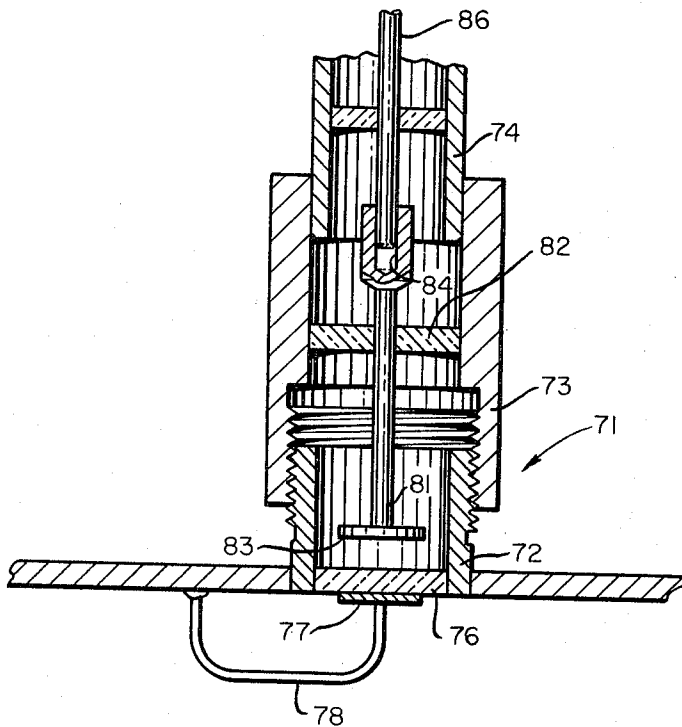


FIG. 6

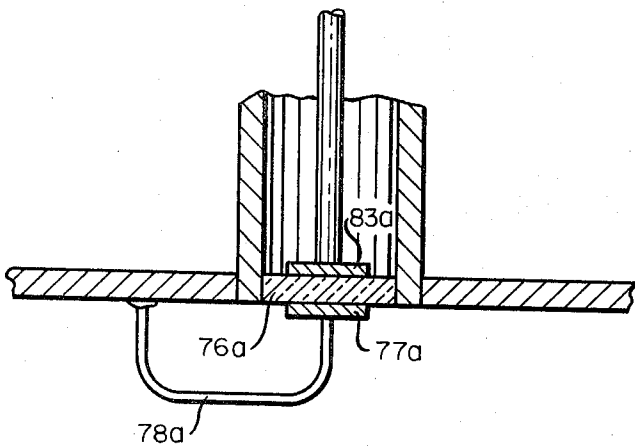


FIG. 7

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3,305,799

**ADJUSTABLE COUPLER FOR ELECTRON TUBES;
ADJUSTMENT MADE OUTSIDE THE VACUUM
AND THROUGH A DIELECTRIC VACUUM SEAL**
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2 Claims. (Cl. 333-24)

This invention relates generally to electron tubes and more particularly to couplers for transferring energy between one electromagnetic circuit, such as a resonant cavity of the type employed with an electron tube and associated circuits.

As is well known, energy is introduced into and extracted from resonant cavities and other electromagnetic energy circuits in a large number of ways. The energy may be extracted through an appropriately located opening formed in the wall of the circuit element or cavity. Alternatively, the energy can be extracted by an inductive loop coupler.

When the resonant cavity or circuit element forms a portion of an evacuated envelope, then there are added complications. If an opening is used to couple energy out of the cavity, a sealed window must be provided. The window must be made of suitable dielectric material and have suitable structure to minimize reflections of the electromagnetic energy passing therethrough; it must be able to withstand the heating effects to which it is subjected; and it must form a competent seal with the adjacent envelope portion.

Induction loops can be employed for coupling into a cavity or other circuit element. However, if adjustment is desired, then resort must be had to relatively complicated arrangements. Where the cavity forms part of the evacuated envelope, bellows, movable seals and the like are required for tuning or adjusting the inductive loop. Such arrangements are relatively cumbersome and increase the risk of leaks in the evacuated envelope.

It is, therefore, an object of this invention to provide an improved coupler for electromagnetic energy.

It is another object of the present invention to provide a coupler for resonant cavities.

It is a more particular object of this invention to provide an improved adjustable load coupler suitable for use with resonant cavities of the type which form a portion of an evacuated envelope.

It is another object of this invention to provide an adjustable load coupler of the aforementioned character which eliminates the requirement for moving parts within an evacuated envelope.

It is still another object of this invention to provide an adjustable coupler of the aforementioned character suitable for both input and output cavities and for loading intermediate cavities of an electron device, such as a klystron.

These and other objects and features of the invention will become more clearly apparent upon a review of the following description in conjunction with the accompanying drawings in which:

FIGURE 1 is a view partially in elevation and partially in cross-section of a klystron type of electron tube employing a coupler in accordance with this invention;

FIGURE 2 is an enlarged view of one coupler shown in FIGURE 1;

FIGURE 3 is an equivalent circuit of the coupler shown in FIGURE 2;

FIGURE 4 is a view somewhat similar to FIGURE 2 but showing a coupler providing parallel rather than series tuning;

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FIGURE 5 is an equivalent circuit of the coupler shown in FIGURE 4;

FIGURE 6 shows an adjustable inductive coupler having a single seal formed with the envelope; and

FIGURE 7 shows another embodiment of a coupler in accordance with FIGURE 6.

Referring to FIGURE 1, one type of electron device to which the invention is applicable is illustrated. The device is a klystron 11 including a gun 13, a plurality of cavities 15, 17 and 19 connected by drift tube sections 21, 23 and 25, and a collector electrode 27. The drift tube sections 21, 23 and 25 are separated by interaction gaps 29, 31 and 33 within each of the cavities 15, 17 and 19.

The gun 13 produces a focused beam of electrons which is directed axially through the drift tube sections toward the collector electrode. Electron flow is accomplished by maintaining the drift tube sections and the collector electrode at a positive electrical potential with respect to the cathode of the gun 13.

The input cavity 15 may be excited by means, for example, of a loop type inductor 35. The electromagnetic fields within the cavity produce voltage variations which appear across the interaction gap 29. The gap voltage interacts with the electrons and modulates their velocity as is well known in the klystron art. The velocity modulation of the electron beam causes bunching of the electrons. When the bunched beam passes the next gap 31, it excites the cavity 17 which excitation, in turn, produces additional modulation and further bunching of the electrons in the beam. As the bunched electrons cross the gap 33, the output cavity 19 is excited.

The amplified energy may be extracted from the output cavity by an adjustable load coupler 37 in accordance with the present invention. The input cavity may also employ an adjustable load coupler in accordance with the invention.

A coupling device in accordance with the invention is shown in more detail in FIGURE 2. A coaxial transmission line 45 including outer conductor wall 46 and center conductor 47 is shown mounted with the outer conductor to the cylindrical wall 43 of the cavity 19. The wall 46 of the coaxial line is, therefore, electrically connected to the cavity walls (plate wall sections 39, 41 and cylindrical wall sections 43 in FIGURE 1) to form a common ground plane. A dielectric disc-like member 50 forms and envelope portion and permits electrical energy to travel from within the cavity to the coaxial transmission line.

A window or opening 49 is formed in the cylindrical wall 43 and a closed tube 51 of dielectric material, such as ceramic, is secured to wall 43, in accordance with conventional vacuum sealing practice, with its open end in registry with the window. A metallic plate or member 53 is carried at the end of the tube 51. The plate may be formed, for example, by metallizing the end portion of the tube 51.

The open end of the tube may be open to the atmosphere. In the embodiment shown, however, the open end includes a metallic cover 55 provided with a threaded opening 57 which threadably receives metal stud 59. The outer end of the stud is formed to receive an adjusting tool, for example, it may be slotted as shown at 61 to accommodate a screwdriver. The inner end includes a metal member 63 which conforms generally in shape with the adjacent surface of metal plate 53. Stud 59 and plate 63, together, then form a plunger which is movable with respect to the metallic plate or member 53.

It is apparent that by screwing the stud 59 in an out of the cover 55, the capacitance between the metal plate 53 and member 63 is varied. Since the member 63, stud

59 and plate 55 are metal, the member 63 then is electrically connected to the cavity walls, the common ground. Plate 53, on the other hand, is connected at 65 to the inner conductor of the coaxial transmission line by the loop 67.

The equivalent circuit of FIGURE 3 represents the tuner shown in FIGURE 2. Operation of the adjustable load coupler is more clearly apparent from a review of FIGURE 3. The cavity is designated by a resonant circuit 19 including a capacitor, inductor and the electron beam, shown adjacent the capacitor, which represents the gap 33. The inductive loop 67 of FIGURE 2 is shown in FIGURE 3 as a coil L_S . The capacitor formed by the plates 53 and member 63 of FIGURE 2 is shown in FIGURE 3 as a variable capacitor C_S connected between the coil L_S and ground. The other side of the coil L_S is connected to the center conductor of the coaxial transmission line 45. The combination just described provides means for coupling energy from the beam into the coaxial transmission line. The cavity and coupling loop cooperate to provide, in effect, an impedance transformer whereby the impedance of the beam is transformed to a value which corresponds generally to the impedance of the coaxial line to maximize transfer of energy from the beam to the line. In general, the beam impedance is transformed to an impedance of the order of the coaxial transmission line impedance. However, the adjustable coupler of the present invention provides means for obtaining a more precise match of impedance to achieve maximum energy transfer.

Adjustment of the coupler can be made without having any moving parts within the evacuated cavity. The degree of adjustment for a given movement may be varied by altering the size of the member 63 and/or plate 53.

A tuned coupler of the type described is preferably employed in conjunction with the output cavity.

Referring now to FIGURES 4 and 5, a parallel tuned coupler rather than a series tuned coupler is shown. This type of coupler is preferably employed with the input cavity to apply the signal thereto or may be employed for loading intermediate cavities. In this instance, the tuning element 37a is similar to the element 37 of FIGURE 2 but is located in the circuit to provide a capacitance between ground and the center conductor 47a of the coaxial transmission line 45a. In the embodiment shown in FIGURE 4, the capacitive coupling is between the member 63a and the center conductor 47a of the coaxial transmission line. A metallic member similar to member 53 may be added to line 47a to increase the parallel capacitance if required.

Referring to FIGURE 5, an equivalent circuit of the coupler of FIGURE 4 is shown. The resonant cavity is shown as the resonant circuit 19a, and the loop 67a is shown as the inductance L_P . The capacitance C_P in parallel with the inductance L_P incorporates the member 63a and the line 47a. Both the inductor L_P and the capacitor C_P are connected to the center conductor of the coaxial line 45a. Again, by adjusting the position of the member 63a, the capacitance C_P is varied and, therefore, the impedance of the input coaxial line is matched to the impedance of the beam through the impedance transformation introduced by the combination of the input coupler and resonant cavity.

The adjustable coupler shown in FIGURE 6 is simpler in construction than the couplers described above because it employs a single vacuum seal. The coupler shown includes a coaxial transmission line 71. The transmission line includes an outer conductor including a first portion 72 which is sealed to the envelope, a second portion 73 which is threadably received by the first portion whereby the second portion can be moved axially with respect to the first portion, and a third portion 74 is the end of an associated coaxial line. The portion 74 is in sliding electrical contact with the movable portion 73.

A dielectric window 76, such as a ceramic disc, is suit-

ably sealed to the envelope by well known means to form with the associated envelope portions the evacuated envelope for the electron tube. A metal plate 77 is carried by the inner surface of the window. The plate may, for example, be formed by metallizing onto the surface of the window. A coupler loop 78 has one end attached to the metal plate and its other end suitably connected to the metal envelope of the electron tube.

The coaxial line 71 includes an inner conductor which is formed with a first portion 81 which is supported by a dielectric window 82 suitably carried by the movable outer conductor portion 73. The end of the inner conductor 81 is provided with a plate 83 which cooperates with the plate 77 to form a variable capacitor. It is seen that by rotation of the outer conductor portion 73, it is moved axially to thereby adjust the relative spacing of the plates 77 and 83 and, therefore, the capacitance in series with the center conductor of the transmission line.

The upper portion of the center conductor 81 includes an opening or recess 84 adapted to slidably receive the portion 86 of the associated coaxial line to provide electrical contact but permit axial movement of the inner conductor 81.

It is apparent that the mechanical means illustrated are merely suggestive of a possible means providing an axially adjustable inner conductor and that other mechanical configurations may be employed.

However, it is to be observed that only a single ceramic to metal seal is required to form the envelope and that the capacitive adjustment or impedance matching adjustment is external of the envelope.

In certain applications where the coupler need not be adjustable, for example, in instances where the coupler elements can be designed to give the desired impedance match, the concept of coupling through a dielectric window is still important. Referring to FIGURE 7, there is shown a coupler similar to that shown in FIGURE 6. Like reference numerals are used for like parts. The coupling between the electromagnetic circuit and the associated transmission line is achieved with the combination of the loop 78a having a metallic element 77a supported by the dielectric window 76a. A second metallic element 83a is secured to the other side of the window. The metallic elements and window form a capacitor which couples the energy from the first circuit 78a to the coaxial transmission line 71. It is apparent that the capacity can be designed to have the correct value by controlling the size of the metal plates, and the material and thickness of the dielectric window.

Thus, it is apparent that a new coupler has been provided. It solves the long standing problem of permitting adjustment of the coupling between a beam, cavity and associated transmission line in an electron device, such as an integral cavity klystron. Adjustment of the coupling is effected without use of moving parts within the cavity. The tuning may be of the series or parallel type. The adjustment provides means for matching the coaxial line and beam impedances. A minimum number of seals is required whereby the danger of leaks in an evacuated envelope is substantially reduced.

I claim:

1. An adjustable coupler for extracting energy from an electromagnetic circuit of the type having a conductive wall defining an electromagnetic energy confining circuit comprising a loop insulated from said wall and disposed in said circuit in coupled relationship to the fields of the electromagnetic energy, and connected directly to the center conductor of a coaxial output transmission line, a cylindrical dielectric member having an open end mounted on said wall and a closed end extending into said circuit, a 1st conductive member disposed within said cylindrical dielectric member and mounted directly on said conductive wall for axial movement with respect to said dielectric member, and a 2nd conductive member

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affixed to said dielectric member and to one end of said loop, said 2nd conductive member being capacitively coupled through the dielectric member to said 1st conductive member whereby the capacitance between said 1st and 2nd conductive member is variable and placed in series with said loop. 5

2. In an electron tube of the type employing at least one resonant cavity a load coupler for coupling energy between said resonant cavity and an associated circuit comprising a loop disposed within and insulated from said cavity and coupled to the electromagnetic fields in the cavity, said loop connected directly to the center conductor of a coaxial output transmission line, a cylindrical dielectric member having an open end mounted on the cavity wall and a closed end within the cavity, a 1st conductive member disposed within said cylindrical dielectric member electrically and mechanically connected directly to the walls of said cavity for axial movement with respect to said dielectric member, and a 2nd conductive 10

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member affixed within the cavity to said dielectric member and to one end of said loop, said 2nd conductive member being capacitively coupled through the dielectric member to said 1st conductive member.

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