June 17, 1947. M. D. FISKE 2,422,190

ULTRA HIGH FREQUENCY COUPLING DEVICE AND SYSTEM

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Fig. 1.

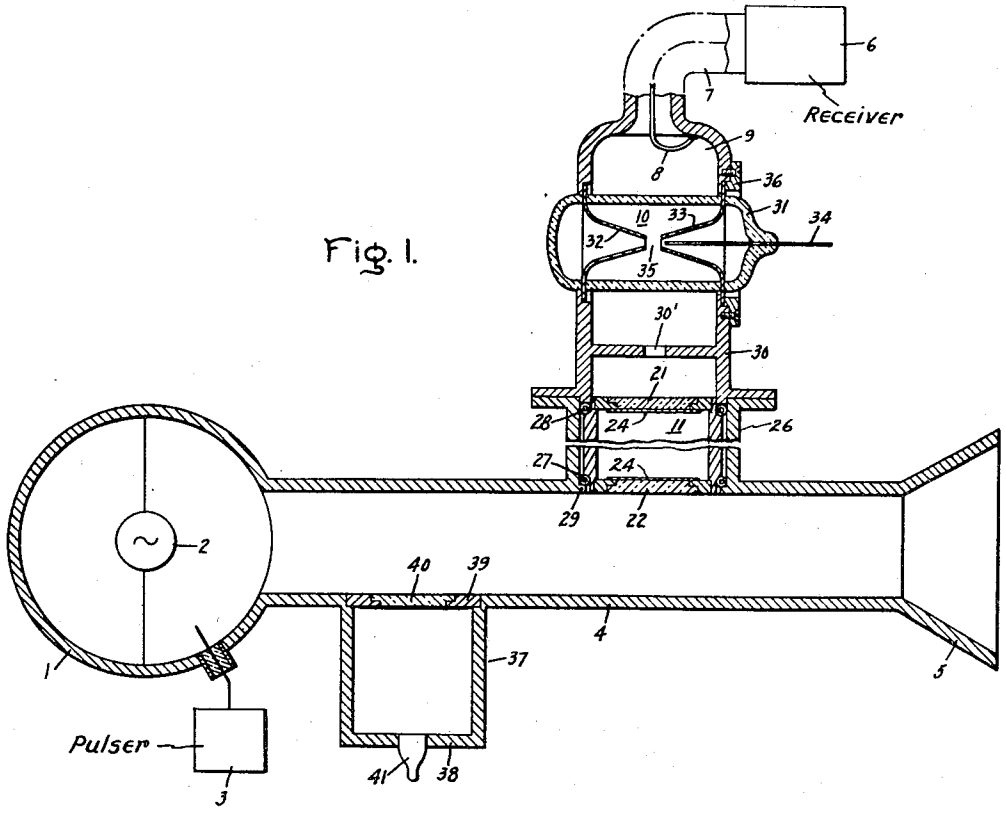
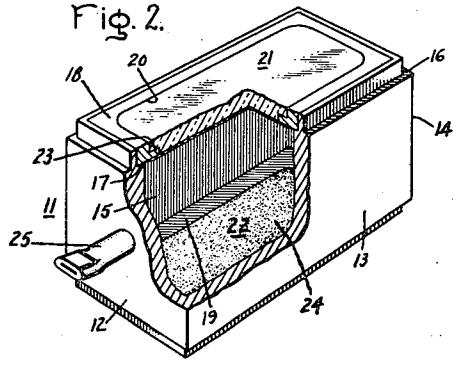



Fig. 2.




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2,422,190

## ULTRA HIGH FREQUENCY COUPLING DEVICE AND SYSTEM

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7 Claims. (Cl. 250—13)

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My invention relates to apparatus for coupling ultra high frequency systems and has for its object to provide a new and improved broad band coupling device for ultra high frequency circuits of the type employing wave guides of the hollow pipe type.

In ultra high frequency systems which employ transmitting and receiving apparatus connected to the same antenna system, the antenna radiating high intensity signals from the transmitter and receiving relatively weak signals reflected from an object upon which the radiated signals impinge, it has long been a problem to decouple the receiving apparatus from the transmitting circuits during transmission periods in order to protect the relatively sensitive apparatus and circuits of the receiver. The necessity for such protection is particularly great in the case of such high frequency systems which use a magnetron as a source of high frequency waves, the magnetron being repeatedly pulsed by a spark gap. Heretofore, in such systems, gas switches have been used to protect the receiver during transmitting periods. However, it has been found that a pulsed magnetron of this type produces waves of frequencies other than that to which the conventional highly selective gas switches are tuned. As a result delicate apparatus in receivers, such as crystal detectors, are injured by signals of unwanted frequency produced by the pulse magnetron.

It is an object of the present invention to provide a new and improved broad band decoupling device for effectively isolating receiving apparatus from an ultra high frequency system of this type during transmission periods.

It is another object of my invention to provide a new and improved coupling device or transmission cell having a characteristic such that it provides substantially reflectionless transmission of ultra high frequency energy below a predetermined energy level, but provides sufficient attenuation for energy above that level that it substantially completely blocks transmission of energy therethrough.

It is a still further object of my invention to provide a new and improved coupling device for ultra high frequency systems which is operative over a broad frequency range.

One of the features of my invention consists in the use, in an ultra high frequency system, of a decoupling device or transmission cell having a broad band characteristic which, in conjunction with a conventional gas switch having a control electrode, isolates receiving apparatus

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from interconnected transmitting apparatus during transmission periods for not only desired frequencies, but also for parasitic or unwanted frequencies. The transmission cell is so constructed that it effectively short-circuits the wave guide of the system and is so located with respect to the circuits of the receiving equipment that it isolates the receiving equipment during transmitting periods and yet assures efficient transmission of all incoming power during receiving periods. The transmission cell employs a gas-filled section of metallic wave guide connected to a principal wave guide system through a pair of space resonant slots sealed by glazed windows, these slots breaking down in the presence of waves of high energy level.

For a better understanding of my invention, reference may be had to the following description taken in connection with the accompanying drawing and its scope will be pointed out in the appended claims. Fig. 1 illustrates an ultra high frequency system employing the coupling device of my invention and Fig. 2 is a perspective view, partly in section, of the coupling device employed in the system of Fig. 1.

Referring now to the accompanying drawing, Fig. 1 illustrates an ultra high frequency system which may be used, for example, for radio detection and direction purposes. In this figure, the transmitter 1 includes an ultra high frequency generator 2 which may be, for example, a magnetron and which is repeatedly and periodically pulsed by pulsing apparatus 3 which may include, for example, a spark gap. The transmitter 1 is connected to a dielectric wave guide 4 which is terminated at its other end in a flared horn which forms a radiative element or antenna 5. A receiver 6 is likewise connected to wave guide 4 through a branch transmission circuit connected to wave guide 4. The transmission circuit comprises a coaxial transmission line 7 which terminates in coupling loop 8 which extends into one side of a cavity resonator 9. The resonator 9 includes a conventional gas switching tube 10 centrally disposed in the resonator. The input of the resonator is coupled to the wave guide 4 through my improved coupling device 11.

The coupling device or transmission cell 11 is shown in enlarged perspective view, partly in cross-section, in Fig. 2 and comprises an approximate quarter wave length of metallic wave guide having metallic side walls 12—15 which are provided with inner and outer shoulders 16, 17 at each end. Supported on the shoulders 17 and united thereto as by soldering or welding are a

pair of transverse metallic walls 18, 19, the wall 18 being supported on the upper shoulder 17 and the wall 19 extending across the lower end of the wave guide section. The transverse walls 18, 19 are provided with apertures 20 having an appreciable dimension transverse to the direction of propagation of electromagnetic waves through the wave guide. Where the wave guide is excited by electromagnetic waves of the $TE_{01}$ type, for example, the aperture or slot 20 affords a principal dimension transverse to the electric component of the electromagnetic field and effects a concentration of the potential due to the wave across the edges of the slot parallel with the walls 13, 15. This accentuation or concentration of the potential due to the wave is effected in part by virtue of the fact that the slot is tuned to the frequency of the exciting waves, i. e., causes little reflection of electromagnetic waves of this frequency and in part by decreasing the distance over which the potential is effective; i. e. the slot has a smaller dimension parallel to the electric vector than does the wave guide alone. As shown in Fig. 2, the resonant aperture is rectangular in shape, although other configurations of resonant slots may be used where desired. A resonant slot of this type is described in greater detail and claimed in my copending application, Serial No. 458,422, filed September 15, 1942, and assigned to the assignee of the present invention.

The openings 20 at the opposite ends of the device 11 are sealed by means of dielectric windows 21, 22 constructed of a suitable vitreous material, such as a boro-silicate glass. The practical window design must provide a metal frame or transverse wall 18 sufficiently rigid to prevent fracture of the dielectric window 21 during handling operations, must permit soldering or welding of the frame to the wave guide, and must allow for tuning of the window in cases where manufacturing tolerances cannot insure that the window as built will be resonant at the desired frequency. The frame or transverse wall 18 may be made of a suitable alloy, such as an iron-nickel-cobalt alloy which is machined with an aperture having a lip 23 of a width roughly equal to the thickness of the metal. The glass window 21 is sealed across the opening 20 and the composite structure is ground for tuning, if necessary, and chemically deoxidized and soldered in position.

In order to improve the uniformity of the bond between the window 21 and the frame member 18, there is provided a coating of powdered glass which is fired to produce a glaze 24 which extends over the portions of the wall members 18, 19 adjacent respectively the windows 21, 22. The glaze 24 is provided only on the sides of the windows 21, 22 within the device 11 in order to reduce or eliminate sputtering on the glass window produced by the electrodeless discharge which is formed on this particular side of the window. This electrodeless discharge is a discharge which takes place by virtue of the electric field strength being sufficient to produce ionization without the presence of any electrodes and occurs across the windows 21, 22 on their sides of lower pressure, the glaze or layer of glass 24 having minimum thickness and extending a substantial distance over the inner surfaces of the walls 18, 19, respectively, toward the walls 12—15 of the wave guide.

Means are provided for evacuating the device 11 and comprise a tubulation 25 connected to the wall 12. The tubulation 25 likewise serves as means to admit a suitable readily ionizable gas, such as argon or hydrogen for example, and for thereafter sealing the device or cell 11.



Referring again to Fig. 1, the coupling device 11 is placed within a surrounding metallic wall 26, conductive connection being made thereto by means of a pair of garter springs 27, 28. The garter springs rest upon the shoulders 16, spring 27 engaging a lip 29 formed at the junction of the wall 26 and wave guide 4 and garter spring 28 abutting a coupling section 30 of wave guide at the opposite end of the device 11 and which is coupled to resonator 9 by means of a small aperture 30'. The device 11 is so arranged in the metallic wall 26 that the lower face of the window 22 is flush with the inner surface of the upper wall of wave guide 4.

The gas switch 10 comprises a cylindrical dielectric vitreous member 31 in which are supported two cone-shaped metallic members 32, 33 extending in opposite directions and having their apices in opposed relation. The members 32, 33 are hollow and a control electrode 34 extends along the axis of the member 33 to a point adjacent the gap 35 between the members 32, 33. The control electrode 34 is biased negatively with respect to the cone 33 so that a small discharge is maintained in the gas-filled enclosure 31 between members 33, 34. The cone-shaped members 32, 33 extend through the vitreous member 31 to engage the walls of the resonator 9 and to form a portion of the boundary of the cavity resonator. The switch 10 is held in position in the generally toroidal shaped resonator 9 by means of a ring 36 which engages the external part of member 33, clamping that member to the associated wall of the resonator 9.

In the operation of the portion of the ultra high frequency signalling system of Fig. 1 thus far described, the transmitter 1 propagates a high intensity electromagnetic wave along the wave guide 4 to be radiated by the antenna 5. Lower intensity signals received from space, after reflection from an object upon which the signals impinge, are transmitted by the radiating element or horn 5 to the receiver 6 through the coupling device 11, the branch wave guide 30, the cavity resonator 9, and the coaxial transmission line 7. The opposed members 32, 33 of switch 10 effect a concentration of the field intensity of potential incident to the electromagnetic field within the resonator 9 and cause a breakdown of the gap 35 in the presence of high intensity waves, destroying the resonance condition of member 9 and preventing transmission of energy of the resonanace frequency to receiver 6. The control electrode 34 provides a continuous source of ions in the vicinity of this gap of the gas switch 10. The gas switch 10 within the resonator 9 is thus normally effective to prevent transmission to the receiver 6 of any large amounts of energy at the resonance frequency of the resonator 9. As has been previously stated, however, when the magentron tube is pulsed by a system which employs a spark gap, energy of undesired frequencies and of frequencies other than the resonance frequency of the resonator 9 is produced and may affect deleteriously the sensitive apparatus of the receiver 6. A receiver of this type normally includes delicate crystals or other rectifying means which may be seriously injured by any large amounts of energy which pass through the resonator 9.

The windows 21, 22 preferably have a phase extension of less than, say, a twentieth wave length along the guide across which they are

placed and are spaced apart by a distance equal to a quarter wave length. This type of structure effects a break down across the wave guide system in the presence of large amounts of power, varying over a wide frequency range. The voltage or potential difference appearing between the edges of the aperture 20 adjacent the walls 13, 15 effects a concentration of electric field across the aperture 20 and across the window 22. As this potential difference increases, an electrode-less discharge occurs across the window 22 on the side within the device 11. In operation, it has been found that such a device is effective to handle powers of the order of 1000 kilowatts, where the repetition rate is less than 10,000 per second. The window 22 breaks down in approximately .01 microsecond and prevents any substantial flow of energy through the device 11 thereafter. It has been found that all spurious and undesired frequencies are reflected from the window 22 and that none reach the crystal of the receiver 6 so that ample protection is provided. In the absence of large amounts of energy, the window 22 deionizes rather completely within a few microseconds and the device 11 appears simply as a quarter wave length section of guide to signals of low level energy.

In order to prevent dissipation of relatively low intensity incoming signals in the high Q circuits of the magnetron 2, an anti-resonant element 37 is connected across the wave guide 4. The element 37, which hinders dissipation of the incoming energy in the high Q circuits of the transmitter, is connected across the wave guide 4 between the point of connection of device 11 and transmitter 1 at a point spaced from device 11 by a distance equal to a quarter wave length at the mid band frequency of the system. The element 37 comprises a section of wave guide having a length approximately equal to a quarter wave length at the mid frequency of the band of frequencies of operation of the system. This section of wave guide is short-circuited at its end remote from the wave guide by a transverse metallic wall 38 and is sealed at its point of connection to wave guide 4 by means of a transverse metallic wall 39 having a resonant slot therein across which is sealed a glass window 40. The construction of the wall 39 and the window 40 is the same as that of the previously described wall 18 of the window 21. The anti-resonant element 37 may be evacuated through a tubulation 41 and, subsequently, filled with a suitable gas to proper pressure. This portion of the circuit of Fig. 1 is described in detail and claimed in my copending application, Serial No. 545,314, filed July 17, 1944.

In the operation of this portion of the circuit of Fig. 1, since the opening in wall 39 sealed by window 40 is in the form of a resonant slot, the voltage or potential difference appearing between the edges of this opening is affected by the resonant character of the slot and the magnitude of this voltage difference increases as the magnitude of the electromagnetic waves passing along the wave guide 4 increases. The dielectric window 40 breaks down when the magnitude of these waves reaches a predetermined value, the voltage difference being sufficient to cause ionization of the gas on the interior surface of the window 20 and an electric discharge takes place across this window. As a result, when high intensity waves from transmitter 1 are being transmitted over the wave guide 4, very small reflection of the electromagnetic waves is caused by the element 37. However, when low intensity waves are being transmitted over the wave guide 4, such as incoming signals, there is no discharge across the resonant slot and the short-circuit constituted by the transverse wall 38, since it is located a half wave length away from the point of connection of device 11 across wave guide 4, appears as an electrical short-circuit across the wave guide 4 at this point and matches all the incoming power to the receiver 6 over the wave guide 30 and the resonator 9.



While I have shown and described my invention as applied to one particular embodiment thereof, it will be obvious to those skilled in the art that changes and modifications may be made without departing from my invention and I, therefore, aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In combination, a metallic wave guide of the hollow pipe type for transmitting an ultra high frequency wave therethrough, a transmission cell disposed within said wave guide comprising a pair of transverse metallic walls, said walls being provided with apertures having an appreciable dimension perpendicular to the electric component of the field incident to the propagation of waves to said guide, and vitreous means sealed across said apertures and substantially coplanar with said walls, said apertures and said vitreous means being tuned to the frequency of said wave and having substantially zero phase extension along said guide.

2. A coupling device for an ultra high frequency wave guide of the hollow metallic pipe type comprising a section of wave guide, a pair of transverse metallic walls defining end walls for said section, each of said transverse walls being provided with an aperture having an appreciable dimension perpendicular to the electric component of field incident to the propagation of waves through said section, and vitreous means sealed across said apertures and substantially coplanar with said transverse walls, the region between said transverse walls being filled with gas at a low pressure and said apertures and said vitreous means being tuned to the desired operating frequency of said wave guide.

3. In combination, with a principal hollow pipe type wave guide for transmitting electromagnetic waves, dielectric means for transmitting high intensity waves over said guide, receiving means connected to said guide through a branch wave transmission system, and means for preventing transmission of high intensity waves to said receiver comprising a section of metallic wave guide interposed between said principal guide and said branch system, said section comprising a pair of transverse metallic walls spaced apart by a distance equal to a quarter wave length at the frequency of said transmitted wave, each of said walls being provided with an aperture having an appreciable dimension perpendicular to the electric component of field incident to the propagation of waves through said section, and vitreous means sealed across said aperture and substantially coplanar with said transverse wall.

4. In a system for transmitting and receiving ultra high frequency electromagnetic waves comprising a transmitter and receiver connected by a common wave guide system of the hollow pipe type, means for preventing transmission of waves from said transmitter to said receiver directly comprising a pair of transverse metallic walls

connected across said common wave guide, each of said walls being provided with an aperture, vitreous means sealed across said respective apertures and substantially coplanar with a respective one of said walls, said respective apertures and vitreous means being tuned to the frequency of said transmitter, and said transverse walls being spaced apart by a distance substantially equal to a quarter wave length at said frequency.

5. In combination, a metallic wave guide of the hollow pipe type, a transmitter connected to said guide at one of its ends, an antenna connected to said guide at its other end, receiving means connected to said guide at a point intermediate said ends, means connected between said receiving means and said point for preventing waves from said transmitter from reaching said receiver comprising a section of wave guide having a pair of transverse metallic walls spaced apart by a distance equal to a quarter wave length at the frequency of said transmitter, each of said transverse walls having an aperture therein, vitreous means sealed across the respective ones of said apertures, said apertures and said vitreous means being tuned to the frequency of said transmitter.

6. In combination, a metallic wave guide of the hollow pipe type, a transmitter connected to said guide at one of its ends, an antenna connected to said guide at its other end, receiving means connected to said guide at a point intermediate said ends, means connected between said receiving means and said point for preventing waves from said transmitter from reaching said receiver comprising a section of wave guide having a pair of transverse metallic walls spaced apart by a distance equal to a quarter wave length at the frequency of said transmitter, each



of said transverse walls having an aperture therein, vitreous means sealed across the respective ones of said apertures, said apertures and said vitreous means being tuned to the frequency of said transmitter, and means connected between said point and said transmitter for transmitting high intensity waves over said guide and for reflecting low intensity waves.

7. In combination, a metallic wave guide of the hollow pipe type, a transmitter connected to said guide at one of its ends, an antenna connected to said guide at its other end, receiving means connected to said guide at a point intermediate said ends, means connected between said receiving means and said point for preventing waves from said transmitter from reaching said receiver comprising a section of wave guide having a pair of transverse metallic walls spaced apart by a distance equal to a quarter wave length at the frequency of said transmitter, each of said transverse walls having an aperture therein, vitreous means sealed across the respective ones of said apertures, said apertures and said vitreous means being tuned to the frequency of said transmitter, and means connected between said point and said transmitter for transmitting high intensity waves over said guide and for reflecting low intensity waves, said last means comprising a stub section of wave guide connected to said first line through an aperture tuned to the frequency of said transmitter, said stub section having a length equal approximately to an odd multiple of a quarter wave length at said frequency, and said stub section being short-circuited at its end remote from said aperture.

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