

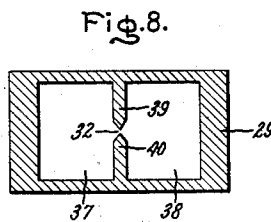
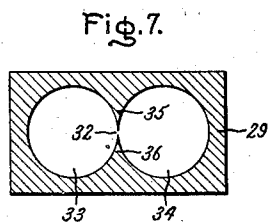
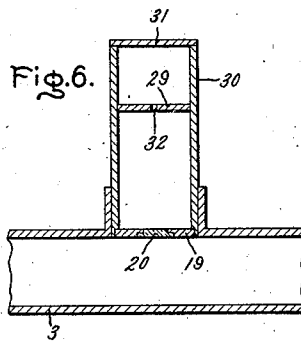
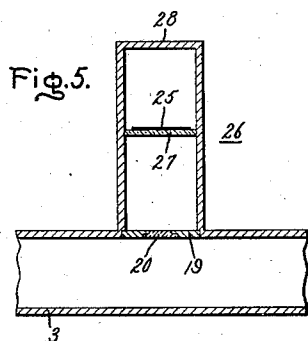
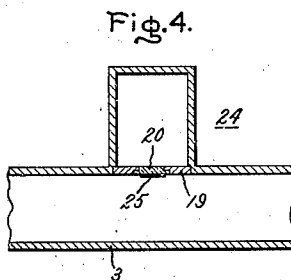
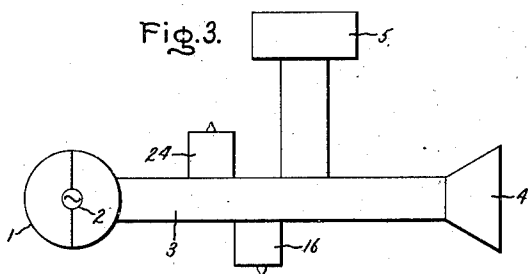
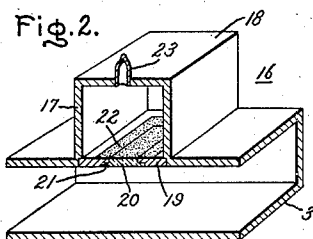
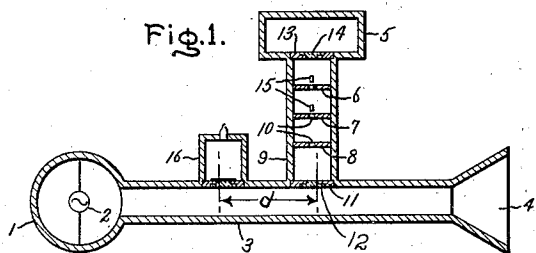
Sept. 24, 1946.

M. D. FISKE

2,408,055

ULTRA HIGH FREQUENCY COUPLING DEVICE AND SYSTEM

Filed July 17, 1944



Inventor:
Milan D. Fiske,
by *Harry E. Dunham*
His Attorney.

UNITED STATES PATENT OFFICE

2,408,055

ULTRA HIGH FREQUENCY COUPLING
DEVICE AND SYSTEMMilan D. Fiske, Schenectady, N. Y., assignor to
General Electric Company, a corporation of
New York

Application July 17, 1944, Serial No. 545,314

14 Claims. (Cl. 178-44)

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My invention relates to apparatus and methods for coupling ultra high frequency systems and it has for its object to provide a new and improved broad band coupling device for ultra high frequency circuits of the type employing dielectric wave guides of the hollow pipe type, concentric or coaxial transmission lines, or interconnecting wave guides and coaxial transmission lines.

In ultra high frequency systems which employ transmitting apparatus 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 high frequency signal generating apparatus from the interconnecting circuits to prevent dissipation of the relatively weak incoming signals in the circuits of such apparatus or reflection of the signals to the antenna to be reradiated thereby. Accordingly, it is another object of my invention to provide a new and improved device for decoupling ultra high frequency generating equipment in such a system from receiving circuits during periods when incoming signals are being received by the antenna.

It is another object of my invention to provide new and improved devices for isolating undesired parts from a desired transmission path for low level signals substantially without attenuation.

It is a further object of my invention to provide new and improved coupling devices for ultra high frequency apparatus having an impedance characteristic responsive to the energy of the signals incident thereon.

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.

Briefly stated, in accordance with a general aspect of my invention, I provide new and improved apparatus and methods for coupling elements or parts of high frequency systems, such as systems designed for the utilization of ultra high frequency electromagnetic waves or microwaves. An anti-resonant element, which is connected across a wave guide used for transmitting ultra high frequency waves, breaks down under relatively high energy waves transmitted from the system, but is not broken down for received waves of considerably lower energy level. The element is so constructed that it effectively short-circuits the wave guide and it is so located with respect to the circuits of the receiving equipment that it assures efficient transmission of all

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incoming power into these receiving circuits. The anti-resonant element employs a gas-filled section of dielectric wave guide connected to a principal wave guide system through a resonant slot sealed by a glazed window, the slot breaking down in the presence of waves of high energy level.

In another aspect, the invention includes the use of additional anti-resonant elements serially connected between the generating equipment of the system and the ultra high frequency circuits of the receiving equipment to insert a resistance in series with the circuits of the generating equipment to prevent dissipation of the energy of received signals.

In still another aspect of this system, the serially connected element may comprise a breakdown element which effectively short-circuits the anti-resonant element in the presence of high energy signals and provides high reflection of low level signals.

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 embodying the coupling device of my invention; Fig. 2 is an enlarged sectional view of the coupling device employed in the system of Fig. 1; Fig. 3 diagrammatically illustrates a modification of the invention as embodied in an ultra high frequency signalling system; Figs. 4 and 5 illustrate alternative forms of resistance elements which may be employed in the system of Fig. 3; Fig. 6 illustrates a broad band coupling device particularly adapted for high frequency signalling systems operating at low power levels; and Figs. 7 and 8 illustrate different forms of breakdown elements which may be employed in the system of Fig. 6.

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, which includes an ultra high frequency generator 2 which may be for example a magnetron, is connected to a dielectric wave guide 3 which is terminated at its other end in a flared horn or radiative element 4. A receiver 5 is likewise connected to wave guide 3 through a coupling unit which comprises a plurality of transverse metallic walls 6-8 connected across a branch wave guide 9. The transverse walls 6-8 are provided with resonant or tuned apertures 10, such as slots which may be of rectangu-

lar form having their principal dimension parallel to the principal dimension of the guide 9. Across the guide 9 at its point of connection to the wave guide 3, there is connected a transverse wall 11 having a resonant tuned aperture therein sealed by means of a glass window 12. The opposite end of the branch wave guide 9 is likewise closed by a transverse wall 13 having a resonant or tuned aperture therein sealed by a glass window 14. The region within the wave guide 9 is filled with gas and the resonant slot structures 10 of transverse walls 6 and 7 may employ electrodes 15 for maintaining a discharge across the associated slots 10. The discharge maintained across the slots 10 by the electrodes is sufficiently small that it does not interfere with the transmission of low level signals through the slots. Because of its presence, however, the slot breaks down more readily when high level signals reach the slot. Each of the electrodes 15 lies in a plane parallel with the slot 10 and its associated wall and is spaced from the slot by a distance great enough that the tuning of the slot is not disturbed. The inner edges of the electrodes 15 are bent inwardly toward the slot to localize the discharge in the center of the slots 10. Certain features of the system shown in Fig. 1 are disclosed and claimed in my copending application, Serial No. 538,483, filed June 2, 1944, and assigned to the assignee of the present invention; while the construction and operation of the glass window 12 is disclosed and claimed in my copending application, Serial No. 519,267, filed January 22, 1944.

The rectangular guides 3 and 9 may comprise metallic enclosing walls constructed of a conductive material, such as copper or brass. The depth and height of the guide, the dielectric constant of the medium within the guide, and the wave pattern determine principally the critical or cut-off frequency of the guide. The dielectric medium through which the electromagnetic energy is transmitted may be considered as being air or gas. Of course, the waves may also be satisfactorily transmitted through an evacuated space. The gaseous medium within the sealed guide 9 may be, for example, hydrogen under a pressure of about ten millimeters. The transverse walls 11 and 13 preferably are formed of an iron-nickel-cobalt alloy sealed to the walls of the guide 9 and the windows 12, 14 sealed across the resonant apertures in these transverse walls preferably are formed of a boro silicate glass.

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 3 to be radiated by antenna 4. Lower intensity signals, received from space after reflection from an object upon which the signals impinge, are transmitted by the radiating element or horn 4 to the receiver 5 over the wave guides 3 and 9. The slots 10 affect a concentration of the field intensity or potential incident to the electromagnetic field across the horizontal edges of the slot. The slots 10 of the transverse walls 6-8 and the slots of the transverse walls 11 and 13 are tuned to the frequency of the electromagnetic waves propagated along the wave guide so that they cause little reflection of the electromagnetic waves transmitted along the guide. Because of the resonant character of the slots in the transverse walls 6-8, 11 and 13, the low intensity signals such as those received by the

antenna 4 provide substantially reflectionless transmission over a relatively broad band of frequencies. During periods when high intensity signals are being transmitted from the transmitter 1, a unidirectional potential from any suitable source (not shown) and connected between electrodes 15 and the walls 6, 7 maintains a discharge across the resonant gaps in transverse walls 6 and 7 to cause the gaps to break down more readily. At the same time, the resonant gaps in walls 11 and 13 break down because the magnitude of the high intensity waves is sufficient to cause ionization of the gas on the interior surface of the window 12 and across the gap 10 in transverse wall 8. An electric discharge, therefore, takes place across all of the resonant slots which prevents transmission of high intensity signals to the sensitive apparatus of the receiver 5.

It has been observed that, in a system of the type illustrated in Fig. 1, a considerable portion of the signals received by antenna 4 and translated to the receiver 5 is dissipated in the high Q circuits of the magnetron 2 used in the transmitter 1. In order to prevent such dissipation of relatively low intensity incoming signals, an anti-resonant element 16, that is, an element which hinders dissipation of the incoming energy in the high Q circuits of the transmitter, is connected across the wave guide 3 between the point of connection of branch guide 9 and transmitter 1 at a point spaced from wave guide 9 by a distance d equal to a quarter wave length at the mid-band frequency of the system. The construction of the element 16, which is shown in detail in an enlarged view in Fig. 2, comprises a section of wave guide 17, having a length approximately equal to a quarter wave length at the mid frequency of the band of frequencies of operation of the signalling system, connected to wave guide 3. The wave guide 17 is short-circuited at its end remote from wave guide 3 by a transverse metallic wall 18 and is sealed at its point of connection to wave guide 3 by means of a transverse metallic wall 19 having a resonant slot therein across which is sealed a glass window 20. The transverse metallic wall 19 is constituted preferably of an iron-nickel-cobalt alloy and is provided with a recessed shoulder 21 across which is hermetically sealed the window 20 formed of boro silicate glass. A glaze or thin layer of glass 22, connected to the glass window 20 and extending over a portion of the metal wall 19 adjacent the resonant slot therein, is provided to reduce or eliminate sputtering onto the glass 20 produced by an electrodeless discharge which occurs across the window 20 on its side of lower pressure. The wave guide section 17 is closed, exhausted, and filled with gas to the proper pressure through a tubulation 23. The wall 18 and the glass window 20 are made sufficiently thin that they have very small phase extension along the guide and, hence, can be made reflectionless and of very low Q, the Q being determined by the height of the opening in the wall 19.

Since the opening in wall 19 sealed by the window 20 is in the form of a resonant slot, the voltage or potential difference appearing between the upper and lower 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 3 increases. The dielectric window 20 breaks down when the magnitude of these waves reaches a predeter-

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mined 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 the transmitter 1 are being transmitted over the wave guide 3, very small reflection of the electromagnetic waves is caused by the element 16. However, when low intensity waves are being transmitted over the wave guide 3, such as incoming signals, there is no discharge across the resonant slot and the short-circuit across the wave guide 17 constituted by the transverse wall 18, since it is located a half wave length away from the point of connection of wave guide 9 across wave guide 3, appears as an electrical short circuit across the wave guide 3 at this point and directs substantially all of the incoming power into the receiver 5 over the wave guide 9. It has been found that, at the mid band frequency of the system, the frequency to which the slot in wall 19 is tuned, substantially less than 10 per cent of incident power is transmitted past the element 16 when the energy of the electromagnetic waves in the guide 3 is insufficient to cause a breakdown in the resonant slot 16. Moreover, over a frequency interval of from five to ten per cent of the desired frequency, the energy transmitted past the element 16 in wave guide 3 remains less than thirty per cent of the total energy. It has been found that the decoupling element 16 itself causes virtually no dissipation of energy at the lower level of incoming signals, the dissipation in the element 16 being less than one-tenth of one per cent of the total received energy.

In the modification of the invention illustrated in Fig. 3, there is shown an ultra high frequency circuit which employs a second anti-resonant element or decoupling device 24 connected across the wave guide 3 between the first anti-resonant element 16 and the transmitter 1 and spaced from the element 16 by a distance equal to a quarter wave length at the mid band frequency of the system. It has been noted that, if the spacing between the element 16 and the highly reactive magnetron circuit of the transmitter 1 bears a certain relationship with the frequency of the wave transmitted over the wave guide 3, a resonance is built up between these units such that a large portion of incoming signals received by antenna 4 is lost because of the resonant circuit thus established and is not transmitted to receiver 5 but may be reradiated by antenna 4 and absorbed in the circuit element. This loss is of very small value for frequencies near that to which the resonant gap in the element 16 is tuned, but may be of considerable value at frequencies removed from the mid band frequency of the system. The addition of the second anti-resonant element 24 separated from the element 16 by a distance equal to a multiple of a quarter wave length at the mid band frequency not only substantially doubles the band width obtainable with a single anti-resonant element, but reduces the possibility of great loss of low level signals at frequencies near the edges of the pass band, especially if the element 24 is made to be moderately dissipative to low level signals. With such addition, the magnetron 2 of the transmitter 1, no matter how reactive its circuits may be, always has connected in series with it a resistance which precludes the building up of resonance of significant value.

Two arrangements which may be used for presenting a predetermined resistance to low level

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signals, but which have substantially little effect upon high level transmitter power, are shown in Figs. 4 and 5. In the arrangement of Fig. 4, the window 20 across the resonant gap in the transverse metallic wall 19 is covered with a dissipative element in the form of a resistance paint 25 which may be, for example, a graphite-impregnated silicone varnish or a tin oxide deposit. This paint is placed on the outside of the window 20, i. e., on the side facing the wave guide 3, away from the electric discharge which occurs across the inner surface of the window when high intensity waves in the wave guide 3 cause a breakdown of the resonant gap in the transverse wall 19.

In the alternative anti-resonant element 26 illustrated in Fig. 5, the resistive paint 25 is applied to the surface of a transverse wall 27, which may comprise a pane of glass and which is spaced from the short-circuited end wall 28 of the wave guide section by a distance equal to a quarter wave length at the mid band frequency. While the spacing of the glass plate 27 from the transverse wall 19 preferably is of the order of one-half wave length, it has been found that this spacing is not critical. If the resistance of element 25 is made equal to the characteristic resistance of the guide section, the spacing of wall 27 with respect to wall 19 may have any value. For higher resistance values of element 25, the spacing of wall 27 with respect to wall 19 approaches a half wave length. Wall 28 is spaced from wall 27 by a distance equal to a quarter wave length, regardless of the resistance of element 25. Hence, for high resistance values of the element 25, wall 28 is spaced from wall 19 by approximately three-quarters of a wave length.

The arrangement illustrated in Fig. 5 has the advantage that its frequency sensitivity is very low and it affords the desired protection against resonance conditions over the entire band of operation of the high frequency system. For the arrangement shown in Fig. 3, when using either of the dissipative arrangements illustrated in Figs. 4 and 5, a gain in band width over the arrangement of Fig. 1 of approximately fifty per cent is obtained. At the same time, since the dissipative paint element 25 is of much higher resistance than the discharge across the window 20 in the tuned aperture, the operation of the system for transmission of high energy waves from the transmitter 1 to the antenna 4 is unaffected by the addition of the dissipative paint element.

In the modification of the invention illustrated in Fig. 6, there is shown a coupling device particularly adapted for high frequency signals operating at low power levels. At such low power levels, of the order of a few hundred watts peak, the energy of the high frequency waves propagated along the wave guide 3 from the transmitter connected therewith is insufficient to cause breakdown of window 20 across the resonant gap of transverse metallic wall 19. In such installations, in order to provide an element which will break down at energy levels of this order, a transverse metallic wall 29 is placed across the stub wave guide 30 connected across the principal guide 3. The transverse metallic wall 29, which may be placed either directly behind wall 19 or may be spaced from wall 19 by a distance equal to an integral number of half wave lengths at the mid band frequency and from the end wall 31 by a distance equal to a quarter wave length at the mid band frequency, has therein a cen-

trally positioned resonant gap 32 constructed to break down and initiate an electric discharge thereacross at any power level desired. When such an electric discharge occurs, it functions as a short-circuit across the wave guide 30, which short-circuit is reproduced at the window 20 and the power in the main guide 3 passes the coupling device without reflection. The decoupling device constituted by the stub wave guide 29 is sealed by the transparent window 20 and filled with a desired gaseous medium in the manner pointed out in connection with the description of the structure of Fig. 2. The decoupling device of Fig. 6 is connected across the wave guide 3 at a point spaced a quarter wave length from the point of connection of the receiver circuit therewith and is located between the point of connection of the receiver circuit and a source of ultra high frequency waves in the same manner as is shown in the systems of Figs. 1 and 2. In the presence of signals of an energy level lower than that at which breakdown of the resonant gap 32 occurs, the short-circuit constituted by the end wall 31 and which is located an integral number of half wave lengths away from the point of connection of the receiver to the wave guide 3 is reproduced at this point of connection to provide required high reflection of signals of low energy level and assure their transmission to the receiver circuits.

Two forms of the resonant gap structure which may be employed in the coupling device of Fig. 6 are illustrated in Figs. 7 and 8. In Fig. 7, the metallic member 29 which is placed across a wave guide as a transverse wall contains two symmetrically placed circular apertures 33, 34. The metallic wall 29 forms a pair of opposed points 35, 36 which define the gap 32 connecting the openings 33, 34. The dimensions of the gap 32 are correlated with the total area of the wall 29 to form an aperture which is resonant at the mid band frequency of the electromagnetic waves propagated along the wave guide 3. In operation, the points 35, 36 form a gap which, when sealed in a gaseous medium as described previously, functions as means for effecting a conversion of the potential of the electromagnetic wave propagated therethrough and breaks down upon the incidence of electromagnetic waves of the relatively low energy level to produce current flow across the resonant aperture and the metallic wall 29.

In the modification of the transverse wall 29 shown in Fig. 8, the openings 37, 38 are rectangular in form and a central portion of the wall 29 forms a pair of opposed points 39, 40 which define the gap 32 connecting the openings 37, 38. In other respects the structure of Fig. 8 operates similar to that explained in connection with the description of Fig. 7.

From the foregoing, it is seen that my invention provides a new and improved apparatus and method for coupling elements or parts of high frequency systems in which transmission of low level signals to receiver circuits of the system is assured by decoupling high reactance circuits of the transmitting equipment connected therewith during periods when such low level signals are being received. Furthermore, during transmitting periods, not only is the effect of the decoupling means employed removed from the system, but adequate protection for the receiver circuits is provided to prevent injury thereto.

While I have shown particular embodiments of my invention, it will of course be understood that I do not wish to be limited thereto since various:

modifications may be made, and I contemplate by the appended claims to cover any such 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 with a principal hollow pipe type wave guide for transmitting electromagnetic waves dielectrically, means for transmitting high intensity waves over said guide and for reflecting low intensity waves comprising a stub section of wave guide connected to said principal guide through an aperture tuned to the frequency of said waves, 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.

2. In combination with a principal hollow pipe type wave guide for transmitting electromagnetic waves dielectrically, means for transmitting high intensity waves over said guide and for reflecting low intensity waves comprising, a stub section of wave guide connected to said principal guide through an aperture tuned to the frequency of said waves, said stub section having a length equal approximately to an odd multiple of a quarter wave length at said frequency and being short circuited at its end remote from said aperture, and dielectric means sealed across said aperture, said section being gas-filled to facilitate establishment of an electric discharge across said aperture in the presence of said high intensity waves.

3. In combination, a first hollow pipe type wave guide for transmitting electromagnetic waves dielectrically, a transmitter connected to said wave guide, a receiver connected to said wave guide through a branch transmission path, and means to decouple said transmitter from said guide to prevent dissipation therein of low intensity signals for said receiver comprising, a stub wave guide connected to said first guide at a point between said transmitter and said path and spaced from said path by a distance equal to a quarter wave length of said wave, said stub guide being connected to said first guide through an aperture tuned to the frequency of said waves, said stub guide being short circuited at its end remote from said aperture and having a length equal approximately to a quarter wave length at said frequency.

4. In combination, a first hollow pipe type wave guide for transmitting electromagnetic waves dielectrically, a transmitter connected to said wave guide, a receiver connected to said wave guide through a branch transmission path, and means to decouple said transmitter from said guide to prevent dissipation therein of low intensity signals for said receiver comprising, a stub wave guide connected to said first guide at a point between said transmitter and said path and spaced from said path by a distance equal to a quarter wave length of said waves, said stub guide being connected to said first guide through an aperture tuned to the frequency of said waves and being short circuited at its end remote from said aperture and having a length approximately equal to a quarter wave length at said frequency, and dielectric means sealed across said aperture, said section being gas-filled to facilitate establishment of an electric discharge across said aperture in the presence of said high intensity waves.

5. In a system for transmitting and receiving ultra high frequency electromagnetic waves comprising a transmitter and a receiver connected by a common wave guide system of the hollow pipe

type, a pair of stub wave guides connected across said common guide between the points of connection of said transmitter and receiver therewith, each of said stub guides being connected to said common guide through an aperture tuned to the frequency of said waves and being short circuited at a point spaced from said common guide by a distance approximately equal to a quarter wave length at said frequency, one of said stub guides being connected to said common guide at a point spaced from the point of connection of said receiver therewith by a distance equal to a quarter wave length at said frequency, the other of said stub guides being connected to said common guide between the points of connection of said one guide and said transmitter therewith, said other stub guide including a resistance element.

6. In a system for transmitting and receiving ultra high frequency electromagnetic waves comprising a transmitter and a receiver connected by a common wave guide system of the hollow pipe type, a pair of stub wave guides connected across said common guide between the points of connection of said transmitter and receiver therewith, each of said stub guides being connected to said common guide through an aperture tuned to the frequency of said waves and being short circuited at a point spaced from said common guide by a distance approximately equal to a quarter wave length at said frequency, dielectric means sealed across said apertures, said stub guides being gas-filled to facilitate establishment of an electric discharge across the apertures thereof in the presence of high intensity waves in said common guide.

7. A coupling device for selectively controlling the transmission of electromagnetic waves over a first wave guide of the hollow pipe type in accordance with the energy of said waves comprising, a stub wave guide connected across said first guide and having a length approximately equal to a quarter wave length at the frequency of said waves, said stub guide being short-circuited at its end remote from said first guide, and a transverse metallic wall connected across said stub guide at its point of connection with said first guide having an aperture therein tuned to the frequency of said wave.

8. A coupling device for selectively controlling the transmission of electromagnetic waves over a first wave guide of the hollow pipe type in accordance with the energy of said waves comprising, a stub wave guide connected across said first guide and having a length approximately equal to a quarter wave length at the frequency of said waves, said stub guide being short-circuited at its end remote from said first guide, a transverse metallic wall connected across said stub guide at its point of connection with said first guide having an aperture therein tuned to the frequency of said wave, and dielectric means sealed across said aperture, said stub guide being gas-filled to establish an electric discharge across said aperture in the presence of high energy waves in said first guide.

9. A coupling device for selectively controlling the transmission of electromagnetic waves over a first wave guide of the hollow pipe type in accordance with the energy of said waves comprising, a stub wave guide connected across said first guide and having a length approximately equal to a quarter wave length at the frequency of said waves, said stub guide being short-circuited at its end remote from said first guide, a transverse metallic wall connected across said stub guide

at its point of connection with said first guide having an aperture therein tuned to the frequency of said wave, a glass window sealed across said aperture, and a dissipative element connected across said window on its side facing said first guide.

10. In a system for transmitting and receiving ultra high frequency electromagnetic waves comprising a transmitter and a receiver connected by a common wave guide system of the hollow pipe type, a pair of stub wave guides connected across said common guide between the points of connection of said transmitter and receiver therewith, each of said stub guides being connected to said common guide through an aperture tuned to the frequency of said waves and being short-circuited at a point spaced from said common guide by a distance approximately equal to a multiple of said quarter wave length at said frequency, one of said stub guides being connected to said common guide at a point spaced from the point of connection of said receiver therewith by a distance equal to a quarter wave length at said frequency, the other of said stub guides being connected to said common guide between the points of connection of said one guide and said transmitter therewith, said other stub guide having a transverse wall therein, and a dissipative element supported on said transverse wall to prevent establishment of resonance in said transmitter and said common wave guide in the presence of low energy waves in said common guide.

11. In combination with a first wave guide of the hollow pipe type for transmitting electromagnetic waves dielectrically, means for permitting transmission of waves above a predetermined energy level through said guide and resisting transmission of waves below said energy level therethrough comprising, a stub wave guide connected across said first wave guide and having a length approximately equal to an odd multiple of the quarter wave length at the frequency of said waves, said stub wave guide being short-circuited at its end remote from said main guide and having a transverse metallic wall connected thereacross at its point of connection with said first guide, said metallic wall having an aperture therein tuned to the frequency of said waves, a dielectric window sealed across said aperture, and a resistance element attached to said window on its side facing said first guide.

12. In combination with a first wave guide of the hollow pipe type for transmitting electromagnetic waves dielectrically, means for permitting transmission of waves above a predetermined energy level through said guide and resisting transmission of waves below said energy level therethrough comprising, a stub wave guide connected across said first wave guide and having a length approximately equal to an odd multiple of the quarter wave length at the frequency of said waves, said stub wave guide being short-circuited at its end remote from said main guide and having a transverse metallic wall connected thereacross at its point of connection with said first guide, said metallic wall having an aperture therein tuned to the frequency of said waves, a dielectric window sealed across said aperture, and a resistance element attached to said window on its side facing said first guide, said stub guide being gas-filled to facilitate establishment of an electric discharge across said aperture in the presence of high intensity waves in said first guide.

13. In combination with a first wave guide of

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the hollow pipe type for transmitting electromagnetic waves dielectrically, means for permitting transmission of waves above a predetermined energy level through said guide and resisting transmission of waves below said energy level therethrough comprising, a stub wave guide connected across said first wave guide and having a length approximately equal to an odd multiple of the quarter wave length at the frequency of said waves, said stub wave guide being short-circuited at its end remote from said main guide and having a transverse metallic wall connected thereacross at its point of connection with said first guide, said metallic wall having an aperture therein tuned to the frequency of said waves, a dielectric window sealed across said aperture, a second transverse wall connected across said stub guide at a point spaced between said ends, and a resistance element supported on said last-mentioned transverse wall.

14. In combination with a first wave guide of

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the hollow pipe type for transmitting electromagnetic waves dielectrically, means for permitting transmission of waves above a predetermined energy level through said guide and resisting transmission of waves below said energy level therethrough comprising, a stub wave guide connected across said first wave guide and having a length approximately equal to an odd multiple of the quarter wave length at the frequency of said waves, said stub wave guide being short-circuited at its end remote from said main guide and having a transverse metallic wall connected thereacross at its point of connection with said first guide, said metallic wall having an aperture therein tuned to the frequency of said waves, a dielectric window sealed across said aperture, and a second transverse metallic wall connected across said stub guide, said second transverse wall having a resonant aperture therein tuned to said frequency.

MILAN D. FISKE.