Sept. 24, 1946. A. C. BECK 2,408,032

COUPLING ARRANGEMENT

Filed Feb. 3, 1942

FIG. 1

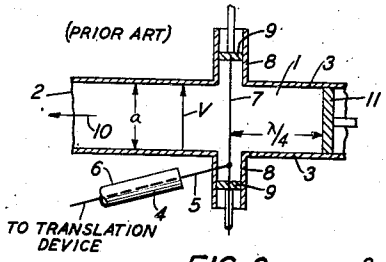


FIG. 2

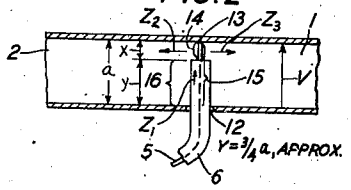


FIG. 3

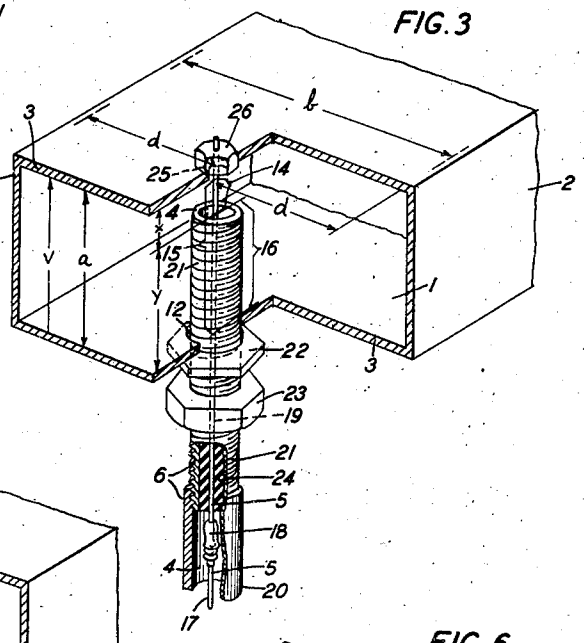


FIG. 4

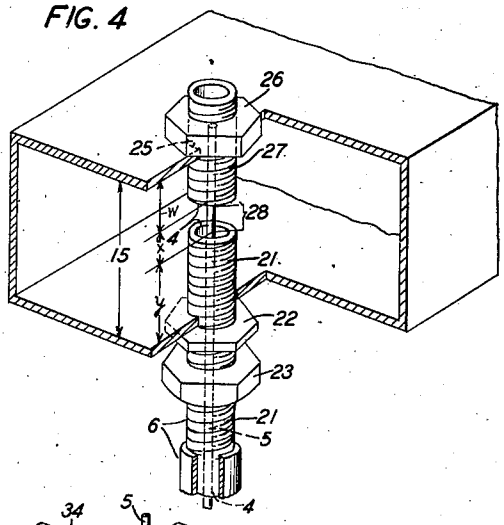


FIG. 5

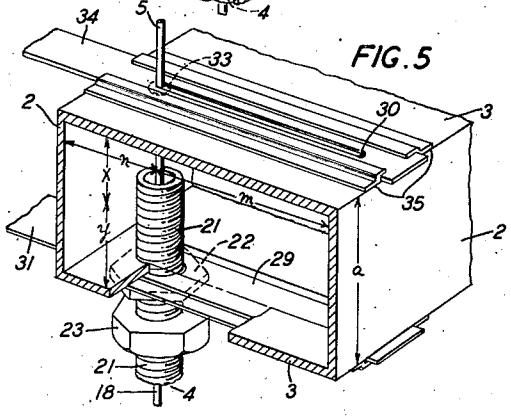
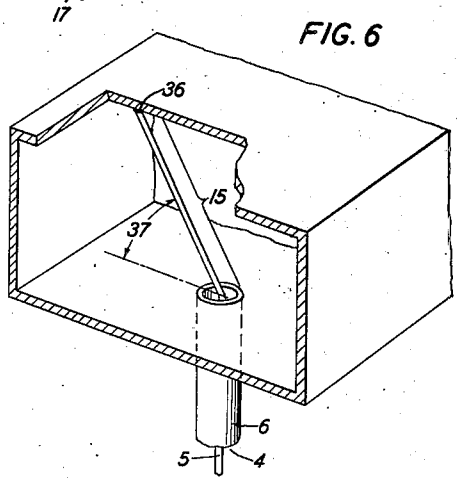


FIG. 6



INVENTOR
A.C. BECK
BY
A. J. Zerbarini
ATTORNEY

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COUPLING ARRANGEMENT

Alfred C. Beck, Red Bank, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

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9 Claims. (Cl. 178—44)

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This invention relates to transmission coupling structures and more particularly to multifrequency microwave transmission line-wave guide coupling arrangements.

As is known, the arrangements now employed in the microwave field for coupling a dielectric path or channel, such as a conventional wave guide to a conductor channel comprising a two-conductor balanced or unbalanced line, usually include one or more piston tuners for matching the characteristic impedances, which are ordinarily substantially different of the two channels. The tuners utilized in these arrangements are of the coaxial line or distributed impedance type and the tuning or impedance match is effected by moving the pistons to positions at which the linear exciter wire included in the guide has a resonant length as, for example, a half wavelength, at the single operating frequency. In addition, in these arrangements, the tuning or matching is facilitated by utilizing a third piston positioned at one end of the guide and adjusted so that its distance from the exciter wire is a quarter wave-length of the operating frequency. These arrangements are therefore limited to single frequency operation, at least the frequency-impedance matching characteristic is sharply peaked at the mean frequency corresponding to the aforementioned operating frequency. It now appears desirable to eliminate the above-mentioned peak in the frequency-impedance matching characteristic and to couple dielectric and conductor paths for non-reflective operation over a frequency band having a width of several hundred megacycles and including a large number of microwave channels.

It is one object of this invention to match the impedance of a wave guide and a coaxial line over a wide band of carrier frequencies.

It is another object of this invention to secure in a multifrequency microwave transmission system a fairly flat frequency-impedance matching characteristic.

It is still another object of this invention to obtain, for use in a single frequency transmission system, a wave guide coaxial line coupling structure which does not include the piston type tuners employed in the prior art coupling devices.

It is another object of this invention to transfer energy between a dielectric channel and a conventional two-conductor channel having substantially different characteristic impedances, at each frequency included in a band of operating carrier frequencies, and with minimum reflection loss.

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In accordance with one embodiment of the invention, both conductors of a coaxial line having a given impedance are inserted through an aperture in one of the wider side walls of a rectangular wave guide having a non-square cross section and an impedance differing from that of the line. The component of the wave in the dielectric guide utilized and considered herein is assumed to be the electric vector which has a polarization parallel to the narrow sides of the wave guide. The inner line conductor extends completely across the dielectric channel, in the plane of polarization of the linear wave component, and is prererably rigidly attached to the far side or opposite wall at a point facing the above-mentioned aperture, the aperture and point of attachment being equidistant from the opposing narrow wave guide walls. The outer line conductor included in the dielectric channel is preferably slidably associated with the inner conductor and its extension into the dielectric channel is adjusted so that an optimum or suitable portion of the inner conductor section included in the guide and contiguous with the far side wall is exposed or unshielded, the ratio of the shielded and the exposed portions of the aforementioned inner conductor section included in the guide being greater than one as, for example, approximately three. As viewed from the extremity of the outer conductor positioned in the guide, the wave guide impedance comprises two impedances connected in parallel. The exposed or exciter portion of the inner conductor, the impedance of which portion is a function of its length, may be regarded as an impedance transformer which functions to translate uniformly the wave guide impedance into the coaxial line impedance over the operating frequency band. Regardless of the theory underlying its operation, it has been found in practice that, in a receiving system utilizing the invention, the same output and thererore the same impedance match are obtained at the mean operating frequency, as are secured in a system utilizing the prior art piston arrangement. Moreover, primarily by reason of the elimination of the critical frequency tuners employed in the prior art arrangements, the frequency-matching characteristic is broadly peaked and relatively flat over the operating frequency band. It has also been found that the embodiment of the invention described above possesses distinct advantages over the prior art device when used in a system utilizing a single operating frequency,

since the adjustment mentioned above may be more quickly and more accurately made.

The invention will be more fully understood from a perusal of the following specification taken in conjunction with the drawing on which like reference characters denote elements of similar function, and on which:

Fig. 1 illustrates a single frequency coupling structure of the prior art shown here for the purpose of explaining applicant's invention;

Fig. 2 is an elevation view of one embodiment of the invention in which the inner and outer conductors are immovable relative to each other;

Fig. 3 is a perspective view of another embodiment of the invention in which the outer coaxial conductor is slidably related to the inner conductor and the entire line may be moved along one transverse dimension or axis of the rectangular guide;

Fig. 4 illustrates an embodiment in which the central portion of the inner conductor is exposed;

Fig. 5 illustrates an embodiment including structure for moving the entire line along different transverse quadrature axes of the guide; and

Fig. 6 illustrates an embodiment in which the length of the enclosed inner conductor is adjusted in a manner differing from that utilized in the structures of the preceding figures.

Referring to Fig. 1, the prior art device illustrated therein is similar to those disclosed in Patent 2,142,159, A. P. King et al., January 3, 1939; Patent 2,232,179, A. P. King, February 18, 1941, Fig. 7; and the copending application of G. C. Southworth, Serial No. 359,643, filed October 4, 1940. The single frequency coupling device of Fig. 1 comprises the rectangular wave guide or dielectric channel 1 having adjacent side walls of different width, the narrow side walls 2 having width a and the wider side walls 3 having width b. Reference character v denotes the instantaneous polarity of the electric vector of the particular type of microwave, H_{11}, in connection with which the invention will be explained. The term "microwave" as used herein denotes a wave having a wave-length less than a meter and as short as a centimeter or a millimeter. Numeral 4 designates a coaxial line having an inner conductor 5 and an outer conductor 6 and connected to a translation device (not shown) such as a transmitter or receiver. The inner conductor is joined to the exciter wire 7 which is positioned within the guide and is, in effect, an extension of inner conductor 5. The exposed length of the exciter wire 7 may be adjusted for half wave or quarter wave resonance at a particular frequency by means of the tuners 8 comprising adjustable pistons 9, for the purpose of matching the line and the wave guide impedances. The impedance match is facilitated and improved, and unilateral propagation in the direction 10 is obtained, by adjusting the reflecting or end piston 11 so that the spacing between exciter wire 7 and piston 11 is a quarter wavelength. Assuming line 4 is connected to a transmitter, the function of piston 11 is the same as that of a reflector used in short wave antenna systems, the waves reflected by piston 11 in the direction 10 being in phase, at wire 7, with the waves emanating from wire 7. As is obvious, the coupling structure is extremely frequency selective and while a match between the dissimilar wave guide and coaxial line impedances is obtained at the operating frequency by reason of the tuning of exciter 7, considerable reflection loss and mismatching occurs at frequencies slightly removed from the critical operating frequency.

Referring to the embodiment of applicant's invention illustrated by Fig. 2, both conductors 5 and 6 of the coaxial line 4 extend through an aperture 12 in one of the wide guide walls 3 and project into the dielectric channel 1, the extremity of the inner conductor 5 being attached to the opposite or far side wall 3 at a point 13 facing the aperture 12. As shown by dimensions d in Fig. 3, the coaxial line conductors 5 and 6 are positioned equally distant from the narrow side walls 2. The outer conductor extends through the channel 1 a distance equal approximately to three-fourths of dimension a, a portion 14 of the inner conductor section 15 included in the guide 1 being left exposed and the greater portion 16 of the aforementioned section 15, having a length y, being shielded by the outer conductor 6. The ratio y/x is chosen such that a satisfactory impedance match over a band of frequencies is obtained between the coaxial line impedance z_1 and the total wave guide impedance comprising the parallel impedances z_2 and z_3. The ratio is critical in the sense that it should be greater than one. In effect the unshielded portion 14 of line section 15 functions to transform the combined parallel impedances z_2 and z_3 into the line impedance z_1.

Referring to Fig. 3, the coaxial line 4 is connected to, and projects into, the wave guide 1 through means for moving within the guide the outer conductor 6 relative to and along the inner conductor 5, so that the length x of the exposed portion 14 of the inner conductor section 15 may be varied or adjusted to an optimum value. The inner conductor 5 comprises a conducting element 17, plug and jack assembly 18, conducting element 19 and section 15; and the outer conductor 6 comprises sheath element 20 which is removably connected to the threaded coaxial sleeve or shield 21 extending through an aperture 12 in one of the walls 3. The sleeve 21 is provided with a lock-nut assembly comprising the nuts 22 and 23. Numeral 24 designates a rubber insulator included between the inner conductor and the portion of the outer conductor comprising sleeve 21. The rubber insulation 23 is employed to compensate for the decrease in spacing between the inner and outer conductors in the sleeve section relative to the spacing in the air-insulated portion of the line, whereby the characteristic impedance of the line 4 is maintained uniform. Preferably, the inner conductor 5 extends through an aperture 25 in the other or far side wall 3 and is rigidly secured to the guide by nut 26. Apertures 12 and 25 are each equally spaced, as indicated by the dimension d, from the adjacent narrow walls 2. Thus, in accordance with this embodiment, the distance x may be varied by adjusting the position of sleeve 21 on the transverse axis a. In practice the distance x is varied to obtain an impedance match between guide 1 and line 4 over a band of microwave carrier frequencies and after the optimum position is determined, nuts 22 and 23 are tightened to hold sleeve 21 in place. In an actual comparison test, the structure of Fig. 3 produced the same impedance match at the mean frequency as was obtained with the prior art tuned exciter and piston arrangement. The frequency-match characteristic of the embodiment of Fig. 3 is, as compared to that of the prior art device, relatively flat. When the embodiment shown in Fig. 3 is used in a single

frequency system the adjustment required for optimum results may, as compared to that required in the case of the piston type coupler, be more easily made. If desired, the air-insulated portion of line 4 comprising conductors 17 and 20 may be disconnected from the rubber-insulated line portion comprising conductor 19 and sleeve 21 and another air-insulated line may be substituted in place of the disconnected line.

The coupling arrangement of Fig. 4 differs from that illustrated by Fig. 3 primarily in the provision of an additional coaxial sleeve 27 which, together with inner conductor 5, extends through an aperture 25 in the far side wave guide wall 3 and is preferably fastened thereto by the nut 26. In this arrangement the sleeves 21 and 27 may be moved relative to each other so that an intermediate, and substantially central, portion 28 of the inner conductor section 15 is exposed within the guide. More particularly, the lengths y and w of the portions of sleeves 21 and 27, respectively, projecting into guide 1 are adjusted so that length x of the exposed inner conductor has a value suitable for securing an impedance match over an operating frequency band of several hundred megacycles.

Fig. 5 illustrates a coupling arrangement which is substantially the same as that illustrated by Fig. 3 except that slots 29 and 30 are provided in the opposite wide guide walls in place of the fixed apertures 12 and 25 employed in the structure of Fig. 3. Both conductors 18 and 21 of line 4 extend through an aperture in flat plate 31 which is slidably associated with retaining members attached to one wide wall 3. The inner conductor 5 protrudes through an opening 33 in the flat member 34 which is slidably associated with retaining members 35 mounted on the other side wall 3. Thus, sliding members 31 and 34 and the coaxial line section 15 included in the guide may be simultaneously moved in a direction parallel to the longer transverse dimension or axis b of the guide. The lengths of the members 31 and 34 are such that at all positions of the coaxial line the slots 29 and 30 remain covered. In practice, in order to obtain an optimum or satisfactory match between the line 4 and the guide 1, the ratio y/x is preferably first adjusted and, if desirable and necessary, the ratio m/n, where m and n are the distances between the line 4 and the narrow wave guide walls 2, is then slightly altered to improve the match. In general, it has been found that as the line 4 is moved toward one narrow side wall 2, the sleeve 21 should be inserted farther into the dielectric channel 1, that is, as n decreases and m increases or vice versa, the ratio y/x should be increased for optimum results.

Fig. 6 illustrates an arrangement designed for use in certain transmission systems and in which, in effect, the length of the exposed inner line conductor section 15, and hence its distributed impedance and transforming characteristic, are controlled and determined by positioning the aforementioned conductor section within the guide at an adjustable angle relative to the wide guide walls 3. In this respect, the embodiment differs from those illustrated in the structures of the preceding figures wherein the exposed inner conductor length is varied by changing the projection into the guide 1 of the outer line conductor or shield. As shown in Fig. 6, the outer conductor 6 does not project into the dielectric channel but terminates in the lower or near side wide guide wall 3. The inner conductor section 15

terminates at a point 36 in the far side wall 3. By changing the position of this point and simultaneously moving inner conductor 5 relative to outer conductor 6, the angle 37 and the position and length of inner conductor section 15 may be adjusted to secure the desired match. While the structure of Fig. 6 is satisfactory for certain purposes, the structures of the preceding figures, particularly the embodiment of Fig. 3, are ordinarily preferred for the reason among others that in the structures of the preceding figures the inner conductor length may be more readily adjusted to the optimum value. In this connection it should be understood that the refinements and the modifications included in the embodiments illustrated by Figs. 4 and 5, and omitted in the structure of Fig. 3, are not absolutely essential and that in practice the structure of Fig. 3 not only performs satisfactorily but is the embodiment preferred.

Although the invention has been explained in connection with certain embodiments thereof, it should be understood that it is not to be limited to these structural arrangements, inasmuch as other apparatus may be employed in successfully practicing the invention. More particularly, the portion of line 4 external to the guide may be of a type other than coaxial as, for example, a shielded or unshielded balanced line. Also, while the invention has been explained in connection with a particular type of microwave component, the invention is applicable to other types of guided wave components and may be utilized in connection with the transmission of waves having wavelengths considerably greater than a meter.

What is claimed is:

1. In combination, a dielectric radio wave channel, a conductive radio wave channel comprising two metallic conductors projecting into said dielectric channel along a transverse dimension thereof unequally and for a distance at least as great as one-half of said dimension, whereby energy is conveyed from one channel to the other with minimum reflection loss at a plurality of frequencies included in a microwave frequency band.

2. In combination, a wave guide, a line conductor projecting into and completely across said guide, and a shield enclosing the greater portion of the conductor section positioned within said guide.

3. In combination, a wave guide, a coaxial line comprising a pair of conductors projecting transversely into the interior of said guide unequally and for a distance greater than one-half of a transverse dimension of said guide.

4. In combination, a rectangular wave guide, a coaxial line comprising an inner conductor and an outer conductor, said conductors extending through the wave guide wall and across at least a half of the dielectric channel of said guide, and said inner conductor extending a distance beyond said outer conductor.

5. In combination, a rectangular wave guide, a coaxial line comprising inner and outer conductors extending through an aperture in one wall of said guide, the inner conductor being connected to the opposite wall, and means for adjusting the length of the outer conductor section included within said guide.

6. In combination, a rectangular wave guide having adjacent walls of different width, a coaxial line comprising inner and outer conductors and extending through an aperture in one of the wider guide walls, the inner conductor being connected to the opposite wall at a point facing the

aforementioned aperture and the outer conductor enclosing approximately three-fourths of the inner conductor section included within said guide.

7. In combination, a rectangular wave guide, a coaxial line having its inner conductor extending through apertures in one pair of opposite walls and its outer conductor extending through only one of said apertures, said outer conductor enclosing a section of the inner conductor positioned within said guide, and means attached to said opposite walls for simultaneously moving said apertures and line conductors along a transverse dimension of said guide.

8. A combination in accordance with claim 7, and means for adjusting the length of the portion of said inner conductor exposed within said guide,

said length being adjusted an amount related to the position within the guide of said line conductors.

9. In combination, a rectangular wave guide, a coaxial line, said guide and line having different characteristic impedances, and means for coupling said guide and line and matching their impedances over a several hundred million cycle band of micro-wave carrier frequencies, said means comprising an end section of the inner line conductor extending through an aperture in the wave guide wall and completely across the dielectric wave guide path and an end section of the outer conductor extending through said aperture and enclosing the greater portion of the said inner conductor section.

ALFRED C. BECK.