

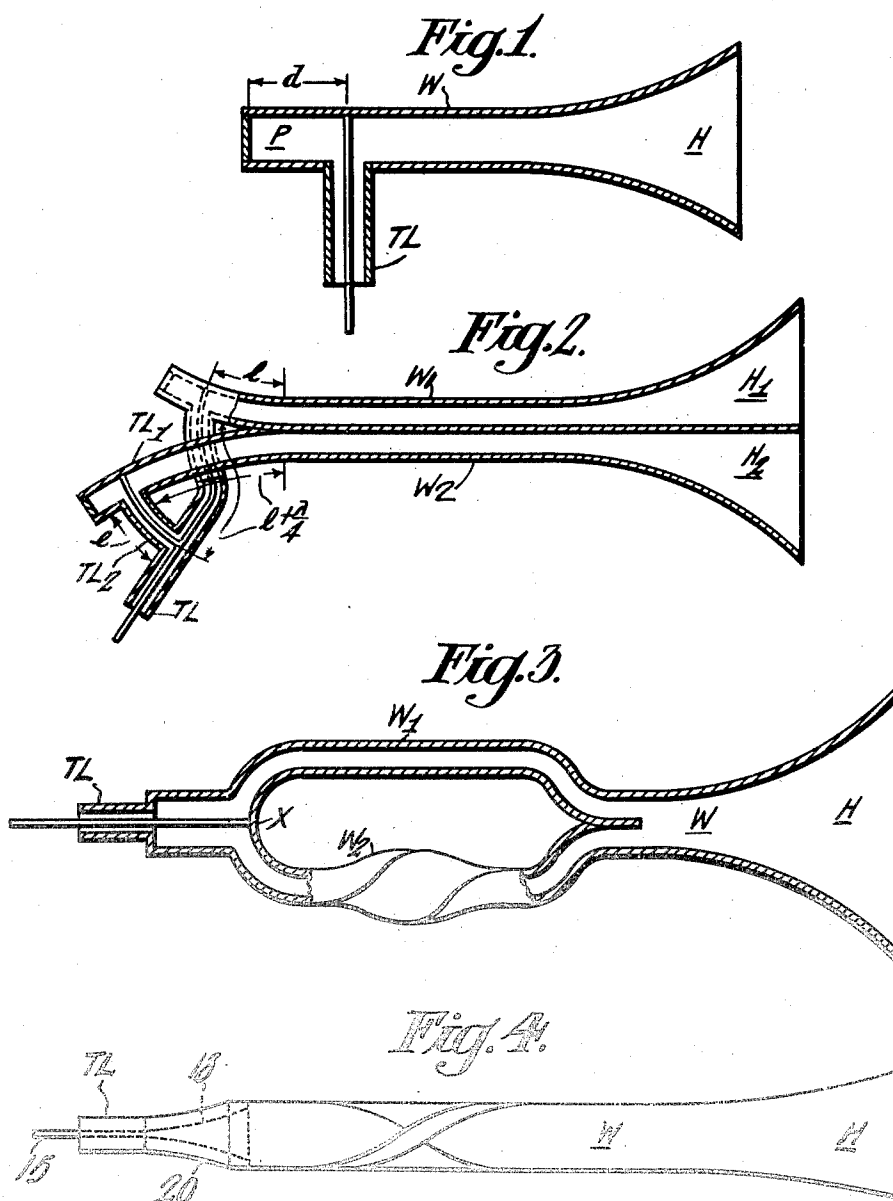
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HIGH-FREQUENCY APPARATUS

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2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 5.

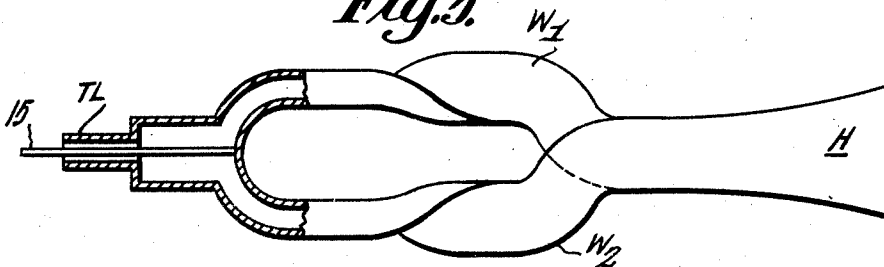


Fig. 6.

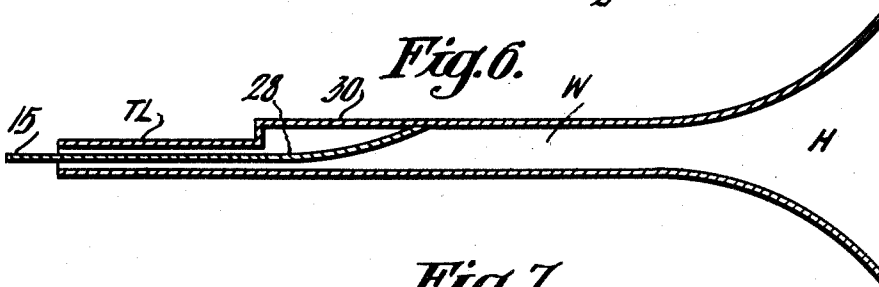


Fig. 7.

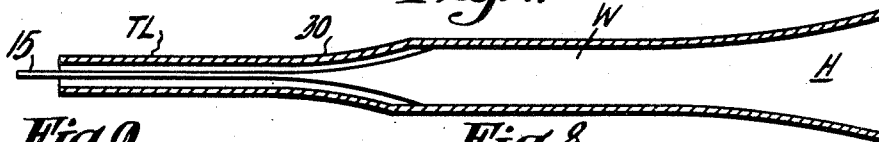


Fig. 9.

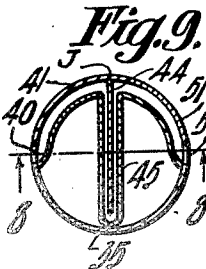


Fig. 8.

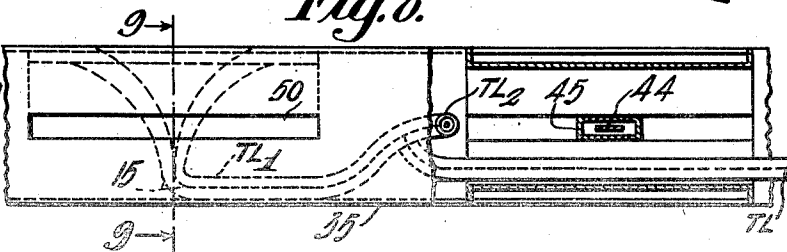
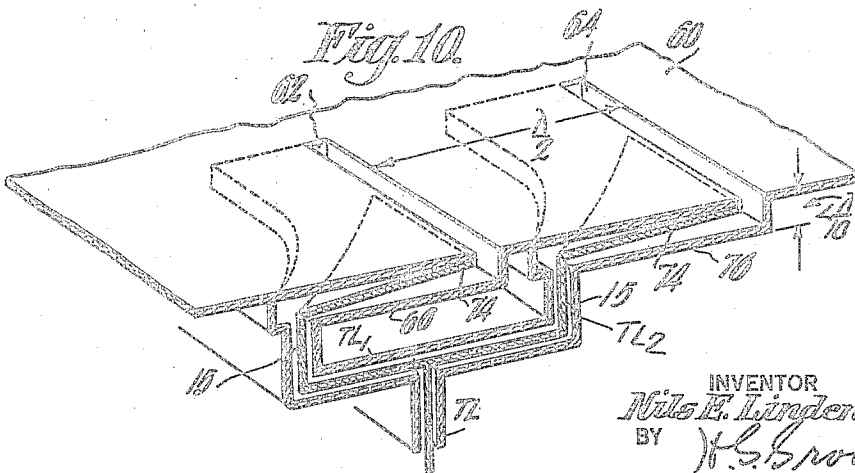


Fig. 10.



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HIGH-FREQUENCY APPARATUS

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9 Claims. (Cl. 250—33.63)

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The present invention relates to ultra high frequency transmission systems and more particularly to a means for coupling a two-conductor transmission line to a wave guide.

An object of the present invention is to facilitate the transfer of high frequency energy from a two-conductor transmission line to a wave guide without introducing discontinuities in the junction impedance with a variation in the frequency of the energy supplied to the system.

Another object of the present invention is the elimination of the difficulties of transferring high frequency energy between a two-conductor transmission line and a wave guide.

Another object of the present invention is to improve the width of the operable frequency band over which coupling systems as aforesaid may be used.

A further object of the present invention is the provision of a simplified system for coupling between a two-conductor transmission line and wave guide which is readily understood and handled by technicians who have not had the benefit of special training in such structures.

A further object of the present invention is to provide a broad band coupling system in which the frequency characteristics do not go through abrupt changes at the ends of the operating band.

Still another object of the present invention is the provision of a junction as aforesaid which does not depend upon artificial compensating means for broadening the frequency band.

The foregoing objects and others which may appear from the following detailed description are attained by providing a gradual transition between the two-conductor transmission line and a wave guide, the conductors of the transmission line being so tapered as to avoid impedance discontinuities.

A further aspect of the present invention contemplates coupling the transmission line to the wave guide in two senses at points so separated along the guide that the energy from the two directions of coupling is additive in its phase relationship where the energies finally combine.

The present invention will be more fully understood by reference to the following detailed description which is accompanied by a drawing wherein:

Figures 1 and 2 illustrate in transverse cross section systems for coupling a two-conductor transmission line to a wave guide and which are chiefly useful in understanding the operation of the present invention;

Figure 3 illustrates an embodiment of the pres-

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ent invention in horizontal cross section, while Figure 4 is an elevational view of the embodiment shown in Figure 3;

Figure 5 illustrates partly in section a modified embodiment of the form of the invention shown in Figure 3;

Figures 6 and 7 are cross sectional views in plan and elevation of a modified form of the invention;

Figure 8 is a view partly in section of another modification of the present invention, while

Figure 9 is a transverse section taken along 9, 9 of Figure 8, and

Figure 10 is a further modification of the present invention.

The problems solved by the present invention may be best understood by referring to the illustration in Figure 1 wherein a wave guide W, terminated at one end by horn H, is coupled to transmission line TL by having the inner conductor thereof extending transversely through a portion of the wave guide W. A pocket P back of the point of extension of the inner conductor of transmission line TL is provided to prevent the rear closure of the guide from acting as a short circuit across the wave guide at the junction of the transmission line TL and wave guide W. The depth of the pocket distance d may be so chosen as to aid in impedance matching between the transmission line TL and the wave guide W or it may often be simply made a quarter wave long in order to provide a maximum impedance across the guide at the point of entrance of the inner conductor of transmission line TL. In this way pocket P has a minimum influence on the junction impedance. However, this condition only obtains for frequencies at which the pocket depth distance d is a quarter of the operating wavelength or an odd multiple thereof.

The width of the operable frequency band may be improved by resorting to phase quadrature feed as shown in Figure 2. Here the horn H is divided into a pair of parallel horns H₁ and H₂ which are fed by a pair of parallel arranged wave guides W₁ and W₂. Near the end of the wave guides remote from the point of connection to horns H₁ and H₂ the wave guides separate and are terminated in pockets similar to those shown in Figure 1. The differential length of the separated portions of the wave guides is an odd multiple of a quarter of the operating wavelength. The transmission lines TL₁ and TL₂ from their points of common junction with transmission line TL and from their points of entrance into

wave guides W_1 and W_2 respectively likewise have a differential length equal to an odd multiple of a quarter wavelength. Thus energy supplied to the pockets at the ends of the wave guides W_1 and W_2 in phase quadrature relationship, due to the differential quarter wave difference in length of wave guides W_1 and W_2 , emerges from horns H_1 and H_2 in an in-phase relationship. The phase quadrature feed to the two pockets results in any reactance introduced at one pocket due to a departure from the operating frequency being compensated for by a similar reactance introduced by the other pocket. Due to the well known inversion of sign of the impedance when passing through a quarter wavelength line the reactances neutralize each other at the junction of transmission lines TL_1 and TL_2 with transmission line TL .

The structure shown in Figure 2 may prove sufficient for a reasonable operating band width but it is somewhat complicated and difficult to be understood and handled by those who have not had the benefit of special training. Furthermore, the frequency characteristics of such systems go through very abrupt changes at the end of the operating band. This is often very undesirable since a slight change in the system may call for operation very slightly outside the limits which have originally been set. Such operation is practically impossible with the form of compensation shown in Figure 2.

However, the natural type of junction shown in Figure 3 does not depend upon compensation means for neutralizing introduced reactance and as a consequence exhibits much slower and more gradual deviations as the frequency is varied. Here the main wave guide W leading to the radiator horn H is divided into a pair of wave guide elements W_1 and W_2 connected in a parallel relationship to the wave guide W and connected in an end-to-end relationship at point X . Thus in effect it has been converted to two series connected wave guides. In order to feed these branches in parallel through transmission line TL at junction X and wave guide W , one of the wave guides W_2 is twisted 180° . Thus energy introduced from transmission line TL into wave guides W_1 and W_2 in an effectively phase opposing relationship is brought together in an in-phase relationship at wave guide W .

Preferably as shown by the dotted lines the inner conductor 15 of transmission line TL is expanded as a flat tapering wedge 18 within a transition section 20. Thus, a gradual transfer of the characteristic impedance of transmission line TL to the characteristic impedance of the wave guides W_1 and W_2 is obtained.

If desired, instead of putting one twist in wave guide W_2 each guide may be twisted 90° as shown in Figure 5. The same reference characters are applied to Figure 5 as to Figures 3 and 4. Also, if desired one of the parallel wave guide branches may be merely made 180 electrical degrees longer than the other.

In Figures 6 and 7 a further modification of the present invention has been shown. The inner conductor 15 of the transmission line TL is expanded into a flat wedge shaped tongue 28 within the transitional section 30. At the junction of the transitional section 30 and the wave guide W the tongue 28 is bent over and electrically connected to one of the walls of wave guide W . Thus, the center conductor of the coaxial line expands as a wedge and eventually joins up with walls of the pocket cavity formed by the tran-

sitional section 30. The modification shown in Figure 6 is not a preferred embodiment of the invention since one wedge shaped cavity between tapered tongue 28 and the wall of transitional section 30 becomes less effective as the transmission line expands. The partial pocket formed may have large circulating currents therein. However, in spite of this electrical imperfection due to geometrical requirements of the transitional section, very good results have been experimentally obtained.

In Figure 8 and in cross section in Figure 9 I have illustrated an application of the present invention to vertical tubular antenna having diametric half wave resonance which is particularly useful for broadcast use since the radiation pattern in a plane normal to the axis of the antenna is substantially circular. The embodiment shown in these figures utilizes a pair of vertically stacked cylindrical radiators though, of course, any desired number may be used. Each cylindrical radiation portion includes a pair of opposing slots 40 and 50, diametrically opposed about conductive cylinder 35. The slot 40 is energized from a wave guide section 41 while slot 50 is energized from a wave guide section 51. The wave guide sections 41 and 51 join at junction point J where the base portion of a somewhat triangular transitional conductor 44 is connected. The transitional conductor 44 tapers by some mathematical or experimentally found function such as a triangular function or exponential elliptic function from its point of attachment to the walls of guide sections 41, 51 down to a point where it may be directly connected to the inner conductor 15 of transmission line TL . The tapered transitional conductor section 44 is surrounded by a similarly tapering outer shell 45. The wave guides 41 and 51 and the slots to which they are connected may have a longitudinal dimension parallel to the axis of cylinder 35 of as much as a full wavelength while the minimum dimension must be not less than a half wave. The transmission lines TL_1 and TL_2 from a pair of adjacent radiating elements preferably have a differential length equal to an odd multiple of a quarter of the operating wavelength between their points of connection to the transitional sections 44 and the main transmission line TL whereby any impedance irregularities introduced in one section tend to be compensated for by the other. In order to insure that the energy from adjacent sections is radiated in an in-phase relationship, successive sections are oriented at mutual angles of 90° .

In some cases it may not be necessary to obtain uniform horizontal radiation pattern or it may even be desirable to obtain some directive effect. In such cases a modification shown in Figure 10 may be used. Here I have illustrated a flat conductive ground sheet 60 which may, for example, be the side wall of an airplane fuselage or the under or upper surface of a wing of an airplane. Slots 62 and 64 spaced a half wave apart are cut in the conductive sheet 60. These slots may have any length between the upper limit of a full wavelength and a minimum limit somewhat in excess of a half wavelength. The slots 62 and 64 are fed through transitional pockets 66 and 76 covering the rear side of the slots. The pockets 66 and 76 each contain therein a tapered tongue 74 connected at the base edge along one edge of the radiating slot and connected at the apex to inner conductor 15 of transmission line branches TL_1 and TL_2 . Transmission lines TL_1 and TL_2 are

fed in an in-phase relationship from main transmission line TL.

While in the foregoing description the entire operation has been predicated on the assumption that the antennas are being used as radiators of high frequency energy, it should be clearly understood that the antennas may likewise be used to receive high frequency energy radiated from some other transmitting equipment, the antennas being coupled by transmission line TL to appropriate receiving apparatus.

While I have illustrated a particular embodiment of the present invention, it should be clearly understood that it is not limited thereto since many modifications may be made in the several elements employed and in their arrangement and it is therefore contemplated by the appended claims to cover any such modifications as fall within the spirit and scope of the invention.

What is claimed is:

1. A high frequency system including a coaxial transmission line having an inner conductor and an outer shell, a hollow wave guide section, a tapered transitional section including a tapered outer shell connecting the outer shell of said transmission line and said wave guide section at a point intermediate the wave guide section ends and a flat tapered tongue having its apex connected to said inner conductor and its base connected to a side wall of said wave guide section.

2. The system claimed in claim 1, further comprising radiator means connected to the opposite ends of said wave guide section and means for causing energy reaching the ends of said wave guide section from the connection of said transmission line thereto and radiated from said radiating means to be radiated in an in-phase relationship.

3. The system claimed in claim 1, said wave guide section being bent in a U formation and means for bringing the bent ends of said U together into a single wave guide.

4. The system claimed in claim 1, said wave guide section being bent in a U formation and means for bringing the bent ends of said U together into a single wave guide, at least one leg of said wave guide section being twisted and the electrical lengths of said legs being the same whereby energy fed from said transitional section through the legs of said wave guide section combines in an in-phase relationship in said single wave guide.

5. The system claimed in claim 1, said wave guide section being bent in a U formation and means for bringing the bent ends of said U together into a single wave guide, said wave guide section having a 180 degree twist in one of the legs of said U, whereby energy fed from said transition section through the legs of said U combines in an in-phase relationship in said single wave guide.

6. The system claimed in claim 1, said wave guide section being bent in a U formation and

means for bringing the bent ends of said U together into a single wave guide, said wave guide section having a 90 degree twist along each of the legs of said U, whereby energy fed from said transmission line through the legs of said U combines in an in-phase relationship in said single wave guide.

7. The system claimed in claim 1, further comprising a broadcast antenna including a vertical conductive cylinder having a pair of diametrically opposed slots along the cylinder length, said wave guide section being thin and flat and being disposed within and following the circumference of said cylinder and connecting said slots to feed energy from the respective legs of said wave guide section to each of said slots, said tapered transitional section being thin and flat.

8. The system claimed in claim 7, said cylinder having a diameter of the order of a half of the free space operating wavelength, each of said slots having a length between one half and one said wavelength.

9. The combination comprising a plurality of systems as claimed in claim 1, and a broadcast antenna including a vertical conductive cylinder having a like plurality of pairs of diametrically opposed slots along the cylinder length as said plurality of systems, said cylinder having a diameter of the order of a half of the free space operating wavelength, each of said slots having a length between one half and one said wavelength, each of said wave guide sections being thin and flat and being disposed within and following the circumference of said cylinder and each respectively connecting a pair of slots to feed energy from the respective legs of each said wave guide sections respectively to one slot, said tapered transitional sections each being thin and flat, said coaxial transmission lines being connected together in a parallel relationship to another transmission line, the lengths of said coaxial transmission lines differing by an odd multiple including unity of a quarter of said wavelength, adjacent pairs of opposed slots in said antenna being oriented at 90 degrees with respect to each other.

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