Dec. 31, 1940. A. ALFORD 2,226,688

WAVE TRANSMISSION SYSTEM

Filed May 19, 1939

FIG. 1.

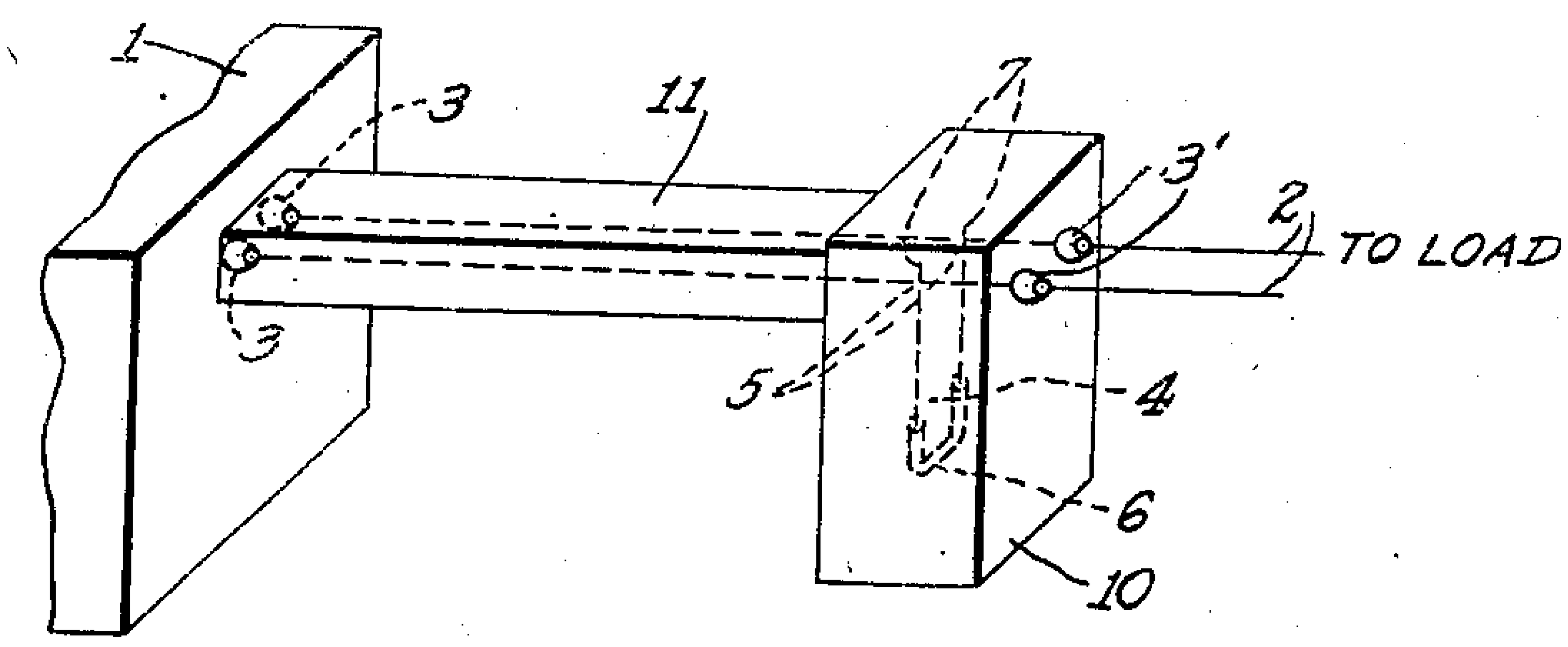


FIG. 2.

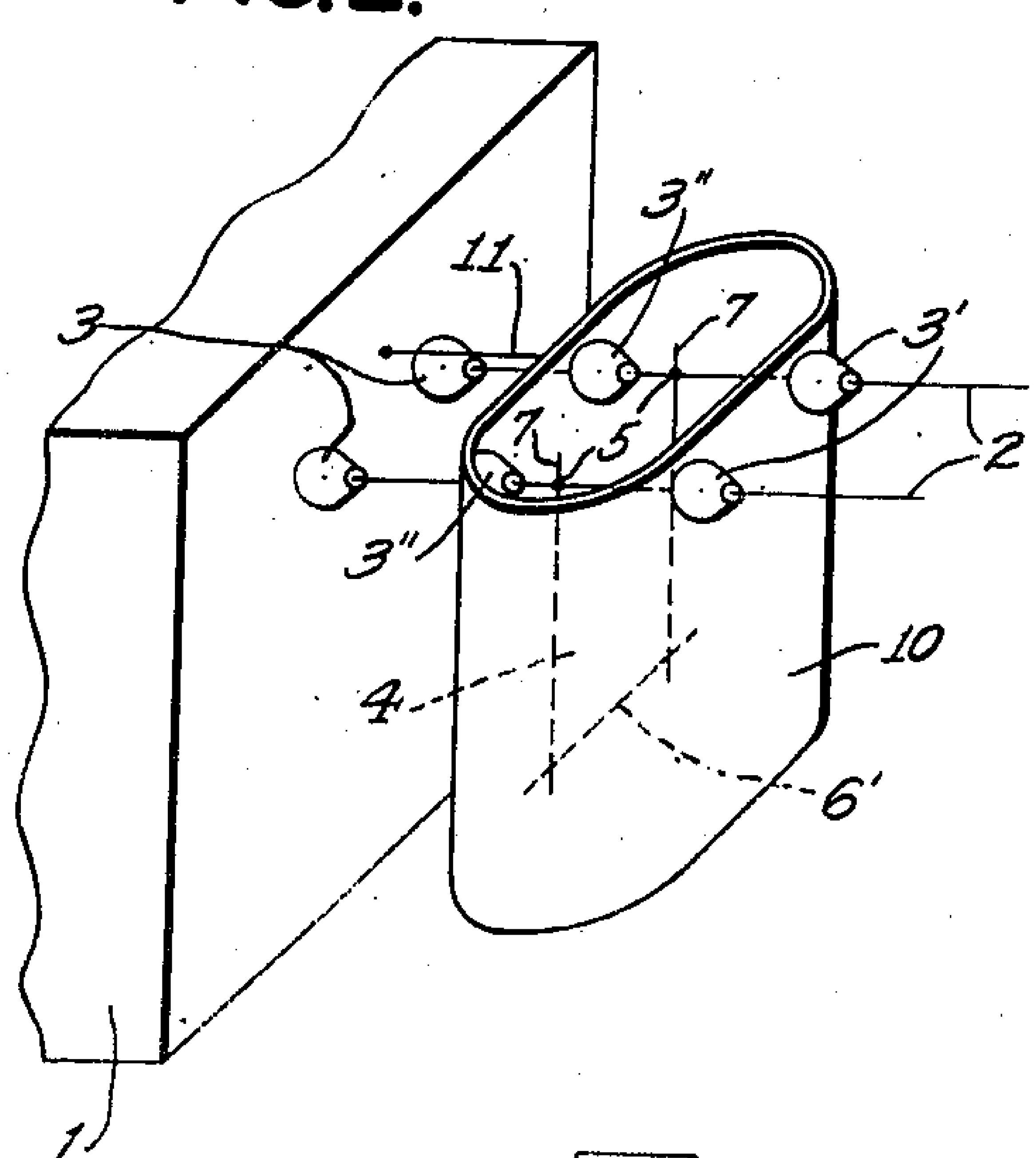
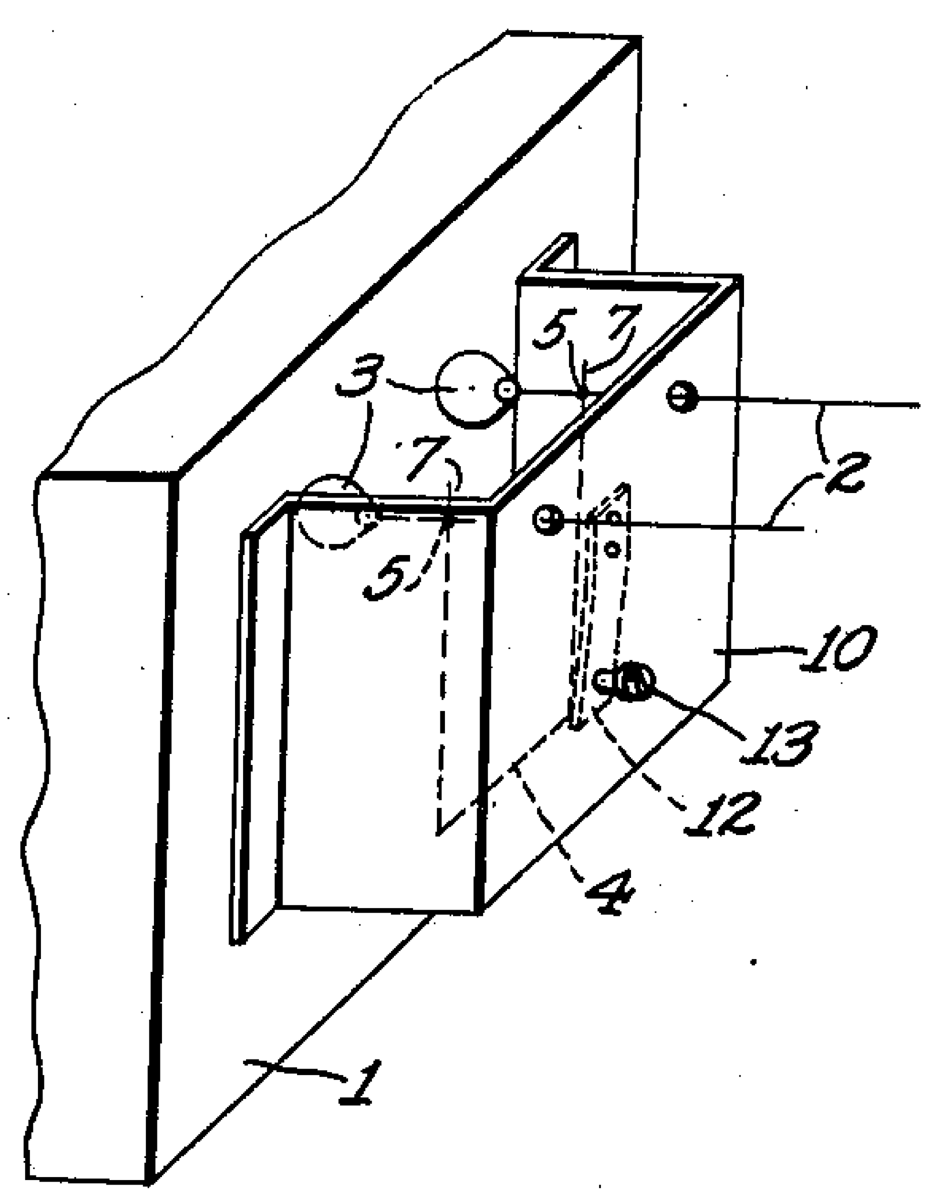


FIG. 3.



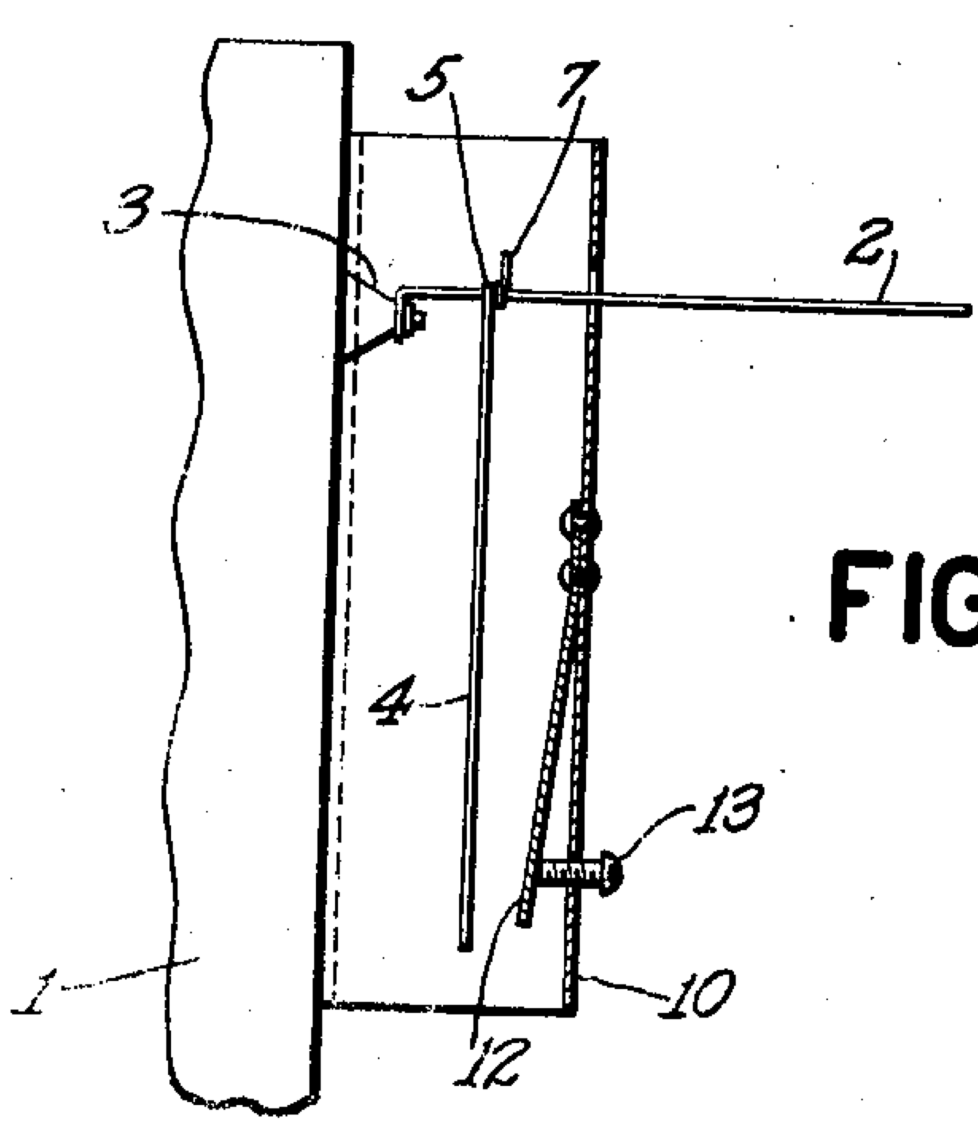


FIG. 4.

INVENTOR
ANDREW ALFORD
BY E. D. Phinney
ATTORNEY

Patented Dec. 31, 1940 2,226,688

UNITED STATES PATENT OFFICE

2,226,688

WAVE TRANSMISSION SYSTEM

Andrew Alford, New York, N. Y., assignor to Mackay Radio and Telegraph Company, New York, N. Y., a corporation of Delaware

Application May 19, 1939, Serial No. 274,498

6 Claims. (Cl. 178—44)

The present invention relates to wave transmission systems and more particularly to an arrangement for blocking the flow of parallel currents or so-called "longitudinal" waves flowing cophasally in the two conductors of a transmission line, while still permitting the passage of so-called "series" or "transverse" waves whose currents flow antiphasally in the two conductors of a transmission line.

It is an object of the present invention to provide an arrangement for blocking longitudinal waves while freely passing transverse waves which shall be simpler to construct and adjust than devices heretofore known. It is a further object to provide an arrangement for blocking longitudinal waves while freely passing transverse waves in a transmission line which shall be principally constructed of transmission line components similar to the components generally employed in constructing transmission lines as distinguished from lumped inductances, impedances, transformers, or similar lumped electrical components.

It is an especial object of my invention to provide an inexpensive, simple and readily adjustable arrangement for by-passing longitudinal currents while exerting substantially no influence upon transverse currents, which shall be particularly adapted for use with short wave transmitting systems comprising a short wave transmitter and a balanced transmission line extending therefrom to a suitable load. More particularly it is an object to provide such an arrangement especially suitable for use in such a short wave system wherein the short wave transmitter is wholly or partially enclosed within a grounded conductive housing, and wherein the said balanced transmission line extending from the transmitter to the load is of the ordinary two conductor, open wire type.

Briefly, my invention contemplates connecting to a balanced transmission line which extends from a transmitter to a load a branch line one-quarter wavelength long and short circuited at its free end, thus constituting effectively an infinite impedance connected across the transmission line and thus not influencing the flow of transverse wave power along such line. In accordance with my invention a shield is disposed adjacent such quarter wave line branch, preferably wholly or partially surrounding this branch, so that this shield and this quarter wave line together constitute a further transmission line effective for longitudinal currents whose currents flow in parallel in the two wires of the main transmission line. This further composite transmission line constituted by the quarter wave branch line and the shield surrounding it is effectively open circuited at its free end so as to constitute an effective short circuit with respect to longitudinal waves.

The exact nature of my invention may best be understood from the following description taken in conjunction with the attached drawing, in which

Fig. 1 is a perspective representation of one embodiment of my invention;

Figs. 2 and 3 are perspective representations of two alternative embodiments of my invention; and

Fig. 4 is a sectional elevation of the embodiment shown in perspective in Fig. 3.

Referring more particularly to Fig. 1, 1 represents a transmitter housing which is assumed to be of metal and which is grounded in conventional manner. A balanced two conductor transmission line 2 of the ordinary parallel open-wire type extends from a transmitter (not shown), being brought out through the metallic housing 1 of the transmitter by means of insulators 3 in conventional manner. In accordance with my invention a branch line 4 is connected to line 2 at junction point 5—5, this branch line 4 being substantially one-quarter wavelength long and being short circuited at its free end, as shown, by the adjustable U-shaped trombone slide 6. For a purpose more fully explained hereafter the conductors of branch line 4 extend beyond the junction 5—5 to form short open-ended stubs 7—7, as shown. Because of the fact that line 4 is substantially one-quarter wavelength long at the desired operating frequency and is short circuited at its free end, the impedance of this line as seen from terminal or junction point 5—5 is very high for transverse waves passing along line 2, and therefore does not appreciably attenuate such waves nor cause substantial reflections thereof.

Around branch line 4 and the adjacent portion of the main line 2 is disposed a shield 10 of conductive material, which is grounded through a hollow rectangular return conductor 11 as more particularly explained hereafter. For so-called longitudinal waves whose currents flow in parallel in both conductors of transmission line 2 and whose corresponding voltages represent cophasal voltages between the two conductors and ground, the branch line 4 on the one hand, and the surrounding shield 10 on the other hand, may be considered as together constituting a composite two conductor branch transmission line 10—4 which is substantially one-quarter wavelength long and open circuited at its free end. One side of this composite branch line 10—4 may be considered as constituted by the two conductors of branch line 4 in parallel and the other side of this composite branch line may be considered as constituted by the grounded shield 10. For the undesired longitudinal waves, therefore, this composite branch line 10—4 effectively forms an impedance to ground which is substantially zero since it has an electrical effective length of one-quarter wavelength and is open circuited at its far end. Thus such undesired longitudinal waves are by-passed to ground and cannot flow out over transmission line 2 to the load.

In the above discussion it has been generally stated without detailed explanation that both the effective electrical length of branch line 4 for transverse waves and the effective electrical length of the composite branch line for longitudinal waves, are equal to one-quarter wavelength at the desired operating frequency. In general, these two conditions will not simultaneously be met by one and the same length of branch line 4, except under very special conditions. To a first approximation, however, the length of branch line 4 which renders the composite line formed by this branch line and the shield 10 exactly one-quarter wavelength long for longitudinal waves will also render this branch line 4 nearly one-quarter wavelength long for transverse waves.

Ordinarily the length of branch line 4 when properly adjusted to give the quarter wavelength effective length for the total composite line with respect to longitudinal waves, will be slightly less than one-quarter length in effective electrical length with respect to transverse waves. The short stub sections of conductors 7—7 are provided to compensate for this deficiency in electrical length of branch line 4 by providing a capacitative admittance of suitable value to form an anti-resonant circuit with the small inductive admittance which will be provided by branch line 4.

As previously mentioned the grounding of shield 10 is effected through hollow conductor 11 which is connected to shield 10 and to the metallic housing 1 of the transmitter. In order to maintain the upper portion of shield 10 at ground potential the hollow conductor 11 should have an effective electrical length of one-half wavelength or an integral multiple of a half wavelength. This effective length should include the effective electrical length of the ground lead (not shown) which grounds the metallic housing 1 of the transmitter, as well as the effective electrical length of that portion of the housing 1 lying between such ground lead and the point of connection of the hollow conductor 11. The actual length of conductor 11 will therefore generally be slightly less than one-half wavelength. This exact length required for conductor 11 may either be found by trial or may be computed. For most purposes, however, it is sufficiently accurate to make the actual physical length of hollow conductor 11 one-half wavelength or an integral multiple of one-half wavelength long since any slight errors in this length can readily be compensated when adjusting the effective length of the composite line 10—4.

After the length of hollow conductor 11 has been determined with a sufficient degree of accuracy the U-shaped trombone slide 6 of branch line 4 is adjusted to give the desired effective length of one-quarter wavelength for the composite line 10—4, or in other words, to eliminate the passage of longitudinal waves out over the main transmission line 2 toward the load. Finally the short conductor stubs 7 are adjusted in length to cause the total joint impedance of branch line 4 and the stub conductors 7—7 to become substantially infinite for transverse waves. The adjustment of conductor stubs 7 may be made by constructing the stubs in telescopic fashion, but for most purposes it is unnecessary to adjust these conductor stubs 7 very accurately and therefore it is ordinarily sufficient merely to provide such conductors of greater length than necessary and then adjust them by cutting off successive small portions until approximately the desired adjustment is reached. A slight misadjustment of the length of stubs 7—7 merely results in producing a small percentage of standing waves in that portion of line 2 lying between branch line 4 and the transmitter. Since this portion of line 2 is ordinarily comparatively short the presence of this small percentage of standing waves on this portion of the transmission line is of little importance.

It will thus be seen that neither the length of hollow conductor 11 nor the length of stub conductors 7—7 need be critically adjusted. The only adjustment which need be carefully made is the adjustment of the effective electrical length of the composite line 10—4. This adjustment can readily be made by the U-shaped trombone slide 6.

Fig. 2 represents a simpler, less elaborate embodiment of my invention. This embodiment is essentially similar to that of Fig. 2, except that the return conductor 11 has been shortened to a negligible length, thus being approximately zero wavelength in length instead of one-half wavelength, or two half-wavelengths, or three half-wavelengths in length. Because of the shortening of this return conductor 11 the possibility of radiation is greatly reduced and therefore a simple wire 11 can be used for the return conductor in place of the hollow rectangular form shown in Fig. 1. It will be understood, however, that if desired conductor 11 of Fig. 2 may be of a hollow or channel-shaped or sheet-shaped form which wholly or partially surrounds transmission line 2 so as to still further reduce radiation.

Similarly in Fig. 1 or any of the other figures, a simple return wire such as shown in Fig. 2 may be used as the return conductor 11 in place of the hollow return conductor shown. Preferably, however, the hollow or at least channel-shaped or sheet-shaped return conductor is used in installations where the branch line 4 is at a considerable distance from the transmitter 1.

The adjusting member 6′ of Fig. 2 is also somewhat simpler than the corresponding U-shaped trombone slide 6 of Fig. 1, being merely a short circuiting bar clamped to the two conductors of branch line 4 and slidably adjustable along them. It will be clear that by adjusting short circuiting bar 6′ along the length of branch line 4 in Fig. 2, the effective length of the branch line 4 for transverse currents may be varied. It should also be noted that this adjustment of short circuiting bar 6′ likewise slightly varies the effective length of the composite line 10—4 for longitudinal waves since the distributed capacity between the short circuiting bar 6′ and the shield 10 becomes more or less effective according as the position of this bar varies nearer or farther from the voltage maximum point (for longitudinal waves) of the composite line 10—4.

If the length of branch line 4 is precomputed so as to be approximately correct the variations obtainable by moving the short-circuiting bar 6' will be sufficient to enable the composite line 10—4 to be adjusted to an effective electrical length one-quarter wavelength so as to impress longitudinal waves. Then stub lines 7—7 may be adjusted in length by cutting these to render the effective impedance across the junction points 5—5 substantially infinite for transverse waves. It should be noted that the adjustment of stub line sections 7—7 has no effect upon the apparent impedance to longitudinal waves since the composite line 10—4 is effectively a short-circuit for these longitudinal waves and therefore it is immaterial what further elements be connected across such short-circuit.

Figs. 3 and 4 represent a still simpler embodiment of the invention. In this embodiment the shield 10 not only has its top and bottom open as in Fig. 2, but also has one side omitted and is clamped directly against the conducting wall of the transmitter housing 1, as shown. The insulators 3' which are employed in Figs. 1 and 2 to insulate the conductors of line 2 from the shield where these lines pass through the shield, and which also serve to support the shield from the conductors of line 2 in the embodiment of Figs. 1 and 2, are omitted in the embodiment of Fig. 3 and in place thereof the wires are merely led out through suitable holes which are cut sufficiently large to prevent the possibility of arcing over. Since the back side of the shield 10 is constituted by the wall of the transmitter housing 1 the ordinary lead-in insulators 3 which carry the transmission line out through the wall of the transmitter housing serve to replace the insulators 3' of Fig. 2. The branch line 4 itself is constructed simply of a unitary loop of heavy wire which forms both conductors and the short circuiting end portion and which also extends upward to form the stub portion 7—7.

It will be noted that in the simple construction of Fig. 3 the length of the branch line 4 is not readily adjustable. The required length of this branch line may be computed with reasonable accuracy, making an appropriate allowance for end effects for the type of construction employed. If insulators are added to support the branch line 4 at or near its lower end a considerably larger end correction will exist for longitudinal waves in the composite line 10—4. Even in the absence of such insulators, however, the actual physical length of the branch line 4 should be somewhat less than one-quarter wavelength in order to yield an effective electrical length of one-quarter wavelength for the composite line 10—4. For any given type of construction the approximate value of the end effect can be reasonably accurately predicted so that the length of the branch line 4 can be designed and made approximately correct. To provide a final fine adjustment of the effective length of composite line 10—4, an adjustable member 12 is disposed inside of the shield 10 in proximity to the branch line 4 as most clearly shown in the section of Fig. 4, and a screw 13 is provided for readily adjusting the position of such capacity-forming member 12. By this means the effective capacity between the lower portion of branch line 4 and the shield 10 may be adjusted so as to give a very accurate adjustment of the effective length of the composite line 10—4.

To adjust the effective length of the branch line 4 for transverse currents, the stubs 7 are preferably provided as shown. These stubs may be adjusted to the desired length by constructing them slightly longer than required and then cutting them off, but in most cases even this is not necessary since the length of these stubs can be sufficiently accurately predicted for any given type of construction and since an accurate adjustment of these stub lengths is not essential.

If desired stub sections 7—7 may be omitted from any of the embodiments of my invention, and the corresponding correction for maximum impedance with respect to transverse waves may be effected by terminating line 4 in a small inductance. Or the correction may be disregarded since the admittance of line 4 for transverse waves will inherently be small in comparison with the reciprocal of the surge impedance of line 2.

Alternatively the length of branch line 4 may be adjusted to inherently give substantially infinite impedance for transverse waves. Then the length of screen 10 may be made shorter than the length of branch 4 so as to provide the desired effective electrical length for the composite line 10—4 with respect to longitudinal waves. For example, the shield 10 in Fig. 2 or 3 may be made shorter than branch line 4 and a telescopic extension or variable capacity means may be provided on such shield to accurately adjust the effective length of the composite line.

The embodiment of Figs. 3 and 4 may be still further simplified by omitting shield 10, thus employing, for the grounded conductor of the composite line, only the wall of transmitter housing 1, instead of this wall plus the U-shaped shield member 10. In such a skeletonized embodiment there will be somewhat more radiation of longitudinal waves from branch line 4 than in the more fully shielded arrangements above described. Also the end corrections of the composite line 10—4 and the branch line 4 differ more widely in this simplified arrangement, thus requiring a greater length for stubs 7—7. This skeletonized embodiment is, however, very satisfactory in many applications.

In the above description of my invention, only a few embodiments have been considered, these embodiments being chosen to illustrate different types of return connection between the shield 10 and ground, different means for adjusting the effective length of the composite line 10—4, and different constructions of the shield. It will be understood, however, that the features of any of these embodiments may be incorporated in any of the other embodiments. Also other known means may be substituted for adjusting means 6, 12—13, or 7—7. For example, a conventional type of variable condenser could be used to trim either the effective electrical length of composite line 10—4 or that of branch line 4, thus replacing either 12—13 or 7—7. It should further be noted that though I prefer to connect the extra capacitative admittance means such as 7—7 across the main transmission line at the same place where the line 4 is connected, it is also possible and sometimes desirable to connect 7—7 (or some other admittance means) across the main line at a different point. In such case the admittance will generally be modified in magnitude so that line 4 and the extra admittance means together result in no reflection nor substantial attenuation of transverse waves. U. S. Patent 2,147,807, issued February

21, 1939, sets forth the rules of proportioning applicable in such a case.

In the above description of my invention the invention has been discussed as a sort of filter for by-passing to ground all longitudinal waves so as to permit only the transverse waves to be transmitted along the line. It has been tacitly assumed that most of the energy applied to the line was in the form of transverse waves and that the longitudinal component was comparatively small and unintended. The apparatus of my invention can, however, be employed for converting longitudinal waves into transverse waves by merely applying the longitudinal energy to be converted to either one (but not both) of the wires of the input line (shown connected to insulators **3—3**). The unbalanced source used to supply such longitudinal wave energy must be suitably matched.

Inversely the invention may be used to convert balanced or transverse energy into unbalanced or longitudinal wave energy by applying the balanced energy to the two conductors of the input line as shown in the figures, but connecting the unbalanced load between ground and one only of the output wires. The unbalanced load must be matched.

Although I have shown and described certain embodiments of my invention for the purpose of illustration, it will be understood generally that adaptations, alterations and modifications thereof occurring to one skilled in the art may be made without departing from the scope of my invention as defined in the appended claims.

What I claim is:

1. A wave transmission arrangement comprising a main two conductor transmission line, a source of transverse and longitudinal waves connected to said line, impedance means for presenting a negligibly low admittance to said transverse waves including at least one section of transmission line connected in branch to said main transmission line, and conductive means connected to ground and disposed adjacent said section of transmission line to form with said section of line a composite line of effectively negligible impedance effectively connected between said main transmission line and ground, conductive means comprising a hollow conductive shield at least partially surrounding said section of transmission line, and conductor means at least partially extending along said main transmission line effectively connecting said shield to ground.

2. A wave transmission arrangement comprising a main two conductor transmission line, a source of transverse and longitudinal waves connected to said line, impedance means for presenting a negligibly low admittance to said transverse waves including at least one section of transmission line connected in branch to said main transmission line, conductive means connected to ground and disposed adjacent said section of transmission line to form with said section of line a composite line of effectively negligible impedance effectively connected between said main transmission line and ground, and means for adjusting the capacity between said section of transmission line and said conductive means.

3. A wave transmission arrangement comprising a source of transverse and longitudinal waves, a housing for said source having a conductive wall, a main transmission line extending from said source through said wall, a branch line extending from said main line substantially parallel to said wall to form with said wall a composite transmission line whose electrical length is substantially an odd number of quarter wavelengths of the frequency of said source.

4. An arrangement according to claim 3, wherein said branch line is terminated in a low impedance at its free end to present at its junction with said main line an admittance for transverse waves which is small compared with the reciprocal of the surge impedance of said main line.

5. An arrangement according to claim 3, wherein said branch line is terminated in a low impedance at its free end to present at its junction with said main line an admittance for transverse waves which is small compared with the reciprocal of the surge impedance of said main line, further comprising means for presenting to said main line another admittance for transverse waves to neutralize reflections resulting from said small admittance presented by said branch line.

6. An arrangement according to claim 3, further comprising shield means positioned against and connected to said wall and constituting with said wall a conducting housing around said branch line and forming part of said composite line, and means adjustable with said shield in position for varying the effective electrical length of said composite line.

ANDREW ALFORD.