

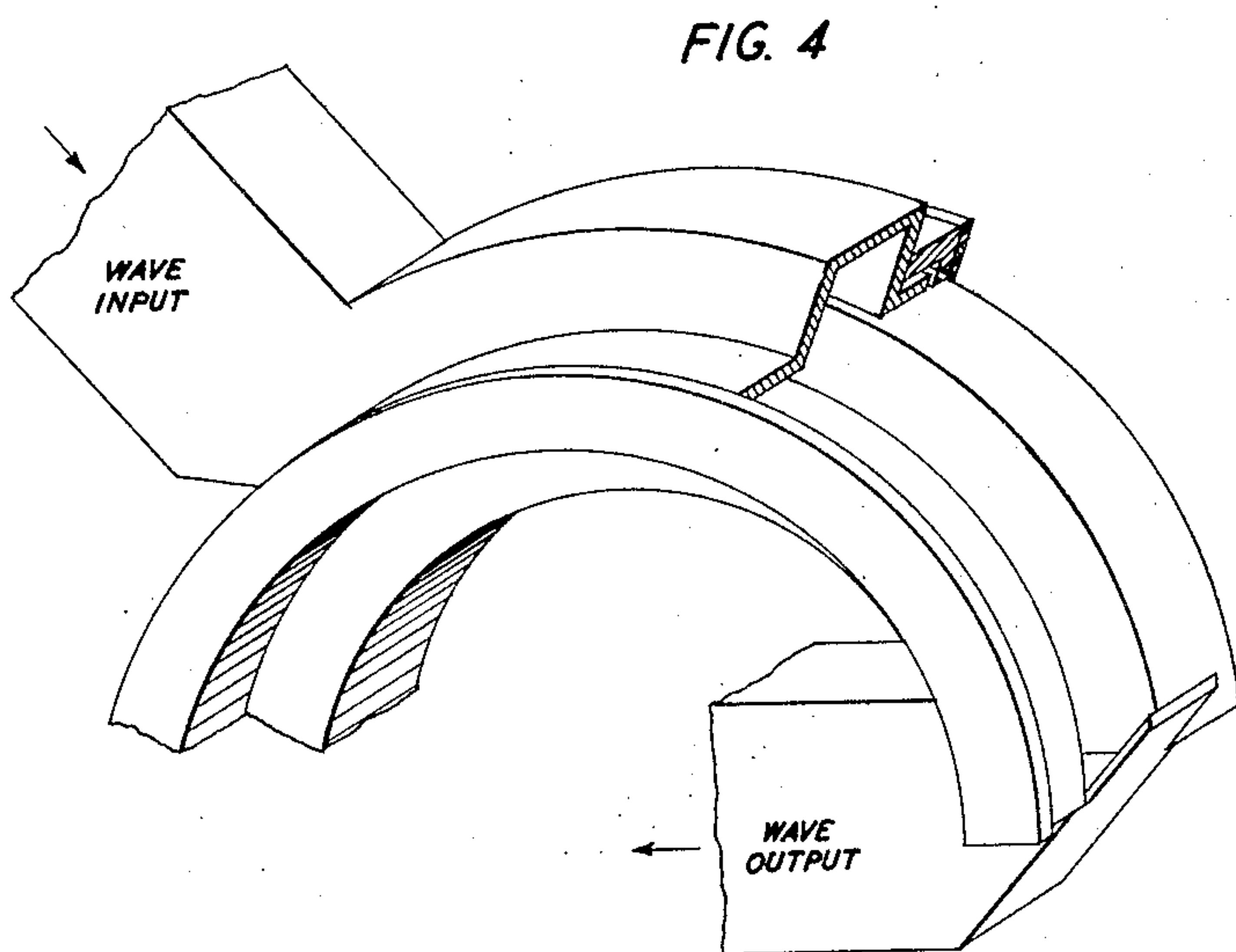
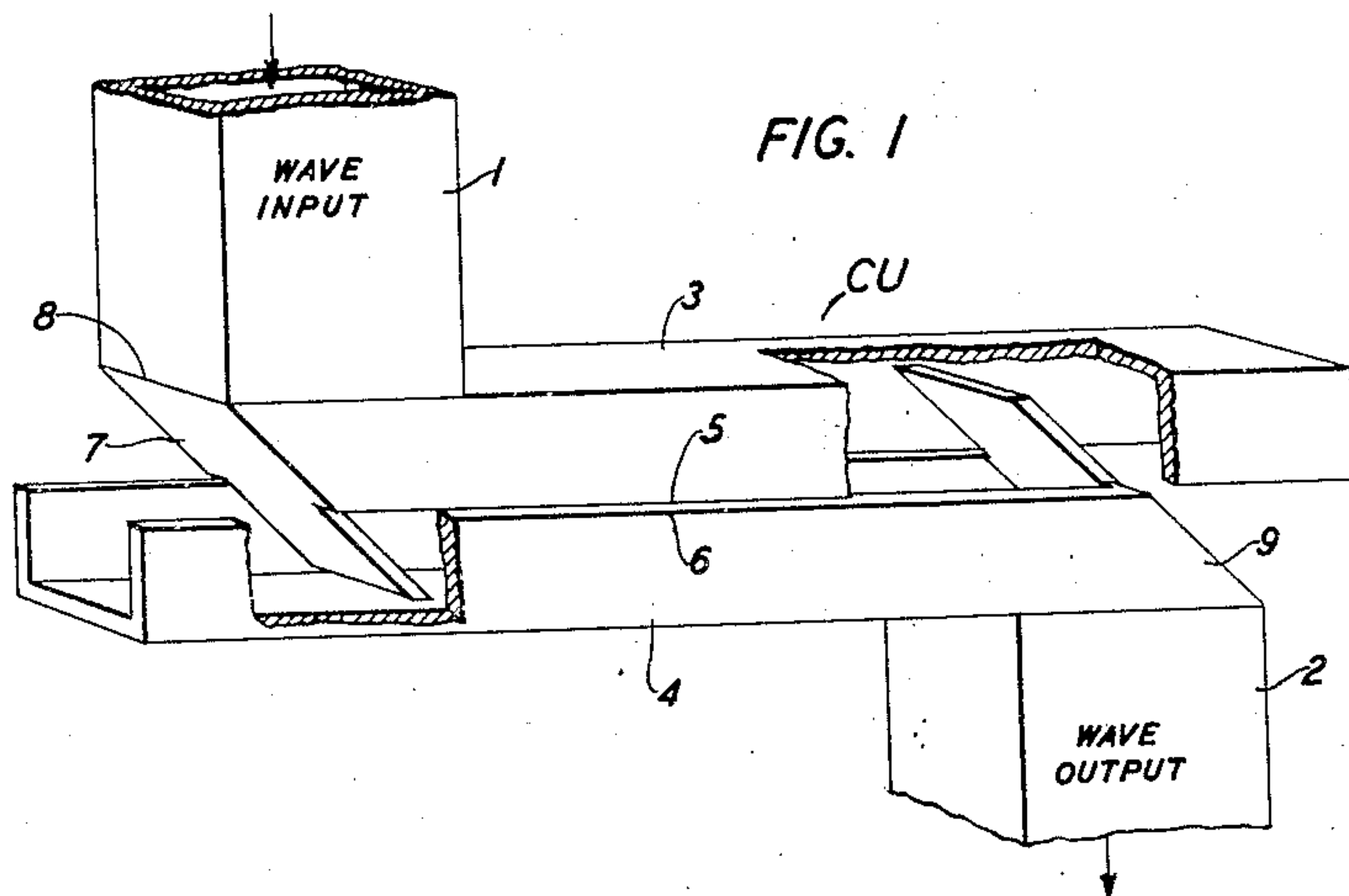
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W. J. ALBERSHEIM
WAVE TRANSMISSION SYSTEM

2,418,809

Filed Aug. 25, 1943

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

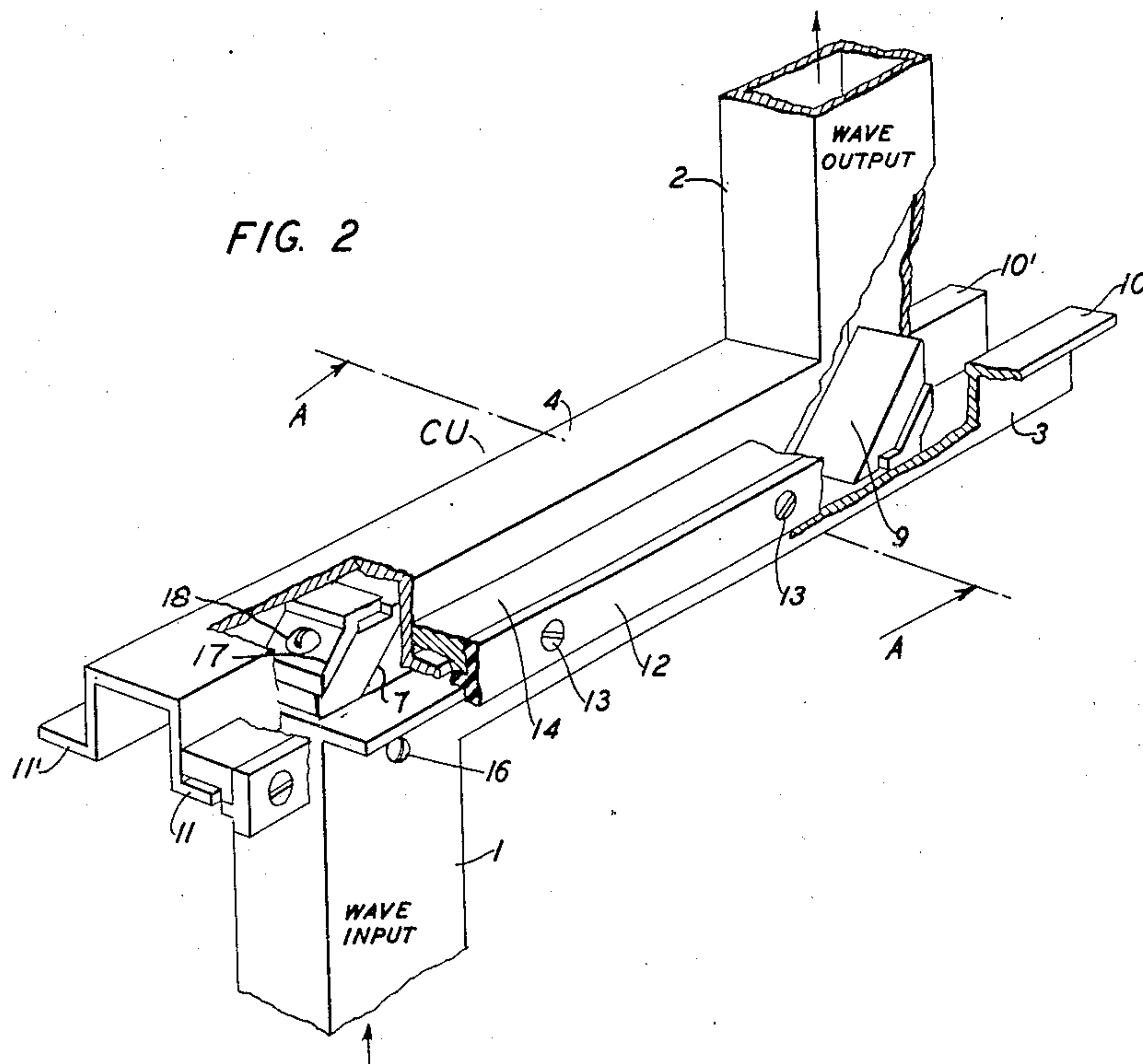
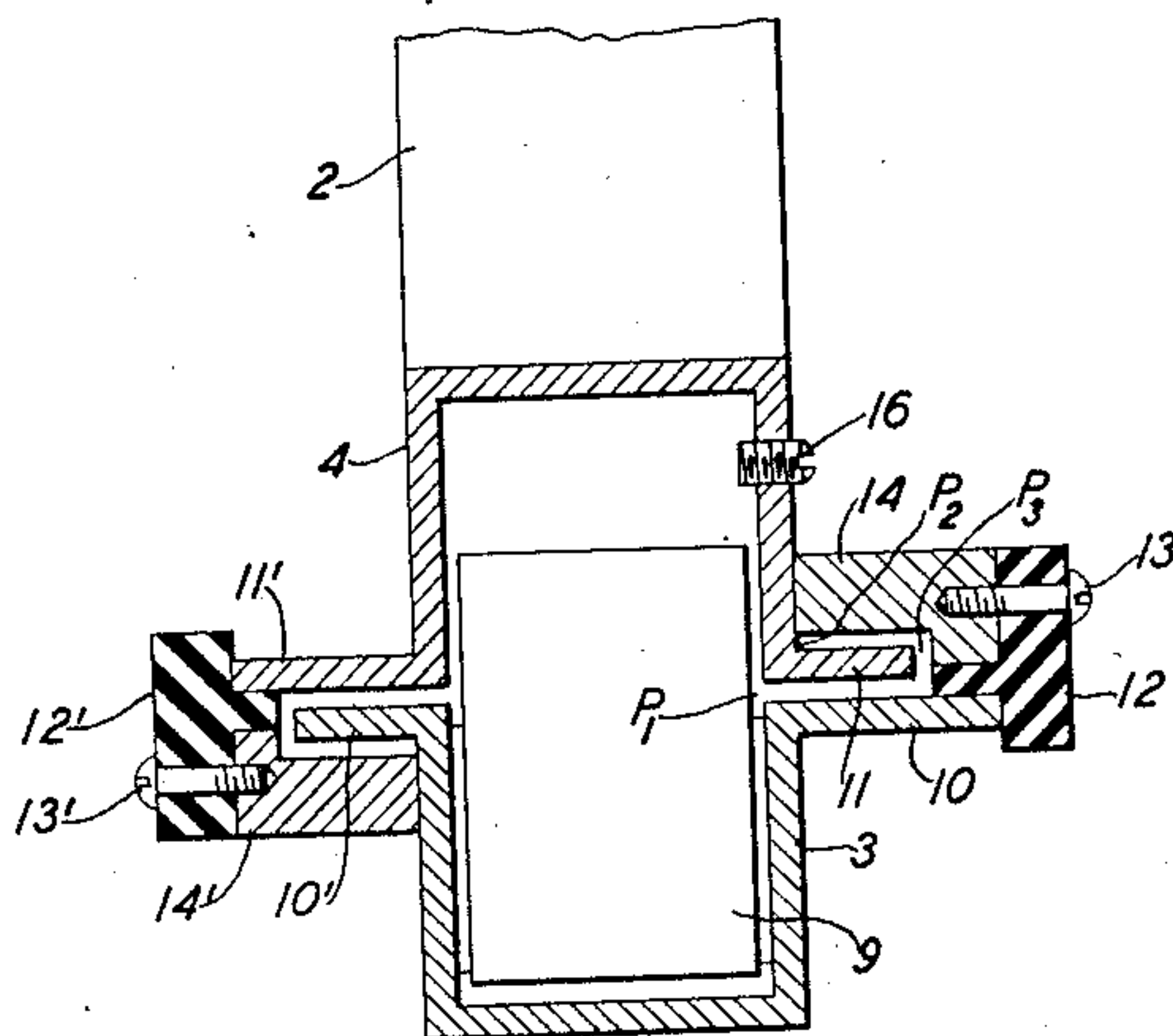


FIG. 3



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WAVE TRANSMISSION SYSTEM

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The invention relates to wave transmission systems and particularly to systems employing dielectric wave guides or similar line structures for transmitting high frequency electro-magnetic waves.

An object of the invention is to connect sections of dielectric wave guide or similar structure forming portions of a continuous transmission line in such a system, so as to enable the total effective line length to be varied at will.

Another object is to couple two sections of dielectric wave guide or similar line structure forming portions of a continuous transmission line in a wave transmission system, so as to provide an adjustable-length offset between them having relatively low transmission losses.

These objects are attained in accordance with the invention by simple and effective slide line joints. In one embodiment, a straight-line slide joint is employed for coupling together two parallel wave guides respectively forming an input and an output transmission portion of an ultra-high frequency electromagnetic wave transmission system, so that the total length of transmission line may be varied at will, or for providing an offset coupling between the input and output guides the length of which may be readily adjusted to a desired value. This straight-line slide joint may comprise another straight section of similar wave guide made in two parts equivalent to those which would be formed by splitting a straight section of wave guide along its longitudinal axis, so that the two coupling wave guide parts are slidable with respect to each other longitudinally. The two parts of the wave guide coupling are respectively affixed at opposite ends to the input and output wave guides, and two wave reflectors respectively affixed to the input and output wave guides are angularly disposed with respect to the complete cross-section of the wave guide coupling so as to reflect wave energy incoming over the input guide into the coupling guide and to reflect wave energy received over the coupling guide into the output guide. Thus, the longitudinal sliding movement of either part of the coupling wave guide on the other part in either direction will change the effective length of the coupling wave guide and thus the amount of offset and the combined length of the connected wave guide sections.

In another embodiment, the two parts of a similar wave guide coupling between two sections of wave guide line or similar line structure, which make sliding contact with each other or slide past each other, are bent along parallel arcs of circles

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so as to provide a reciprocating rotary slide joint. The various objects and features of the invention will be better understood from the following detailed description when read in conjunction with the accompanying drawings in which:

Fig. 1 shows a perspective diagrammatic view of a portion of an ultra-high frequency electromagnetic wave transmission system including one form of wave guide slide joint embodying the essential features of the invention;

Figs. 2 and 3 respectively show a perspective and a cross-sectional view of a practical embodiment of the form of wave guide slide joint diagrammatically illustrated in Fig. 1; and

Fig. 4 shows a perspective view of a portion of a similar wave transmission system including another form of wave guide slide joint in accordance with the invention.

In the system of Fig. 1, the parallel elements identified as 1 and 2 represent sections of dielectric wave guide, shown as consisting of equivalent straight pieces of hollow metal pipe of rectangular cross-section, which may be input and output line portions, respectively, of a continuous transmission line for transmitting ultra-high frequency electromagnetic wave energy. The input wave guide section 1 and the output wave guide section 2 are coupled by a straight-line wave guide slide joint CU consisting of a similar straight section of dielectric wave guide, which, as shown, may comprise a straight piece of hollow metal pipe of rectangular cross-section, made in two channel parts 3 and 4 equivalent to the two halves of a straight piece of dielectric wave guide split along its longitudinal axis, that is, along the line of zero current in the wave guide. With the wave guide slide joint or coupling unit CU so constructed, the contacting surfaces 5, 6 which slide past each other, indicated in Fig. 1 by double outlines with exaggerated clearances, of the upper channel part 3 and the lower channel part 4, respectively, of the coupling wave guide unit, are adapted for relative slidable movement longitudinally in either direction.

In any suitable manner, the lower end of the input wave guide 1 is permanently affixed to the left end of the upper channel part 3 of the coupling unit CU, and the upper end of the output wave guide 2 is permanently affixed to the right end of the lower channel part 4 of the coupling unit, so that the interior portions of the input wave guide 1 and the output wave guide 2 open into the interior portion of the wave guide coupling unit CU.

An angularly disposed reflector plate 7 (pref-

erably positioned at an angle of 45 degrees with respect to the longitudinal axis of the coupling wave guide unit CU) having about the same width as that of the coupling unit, is permanently affixed to the left end of the channel part 3 of the coupling unit, and to the far lower pipe edge 8 of the input wave guide 1. As shown through the broken-away side portion of the lower channel part 4 of the coupling unit, the reflector plate 7 extends within the interior portion of the latter channel part so that it provides a reflecting boundary for the connected interior portions of the input wave guide 1 and of the coupling unit CU. Similarly, the angularly disposed (45-degree) reflector plate 9, having about the same width as the coupling unit CU, is permanently affixed to the right end of the lower wave guide part 4 of the coupling unit and to the right upper pipe edge of the output wave guide 2, and, as shown through the broken-away side portion of the upper channel part 3 of the coupling unit CU, extends into the interior portion of the latter channel part of the coupling unit, so that it provides a reflecting boundary for the connected interior portions of the coupling unit CU and the output wave guide 2. Thus, for any relative positioning of the upper and lower wave guide parts 3 and 4 of the coupling unit CU, the reflector 7 serves to reflect the electromagnetic wave energy received over the input wave guide 1 into that coupling unit and the reflector 9 serves to reflect that electromagnetic wave energy received over the coupling unit into the output wave guide 2.

It will be apparent, then, that by longitudinal movement of either sliding wave guide part 3, 4 of the coupling unit CU, in one direction or the other, the offset distance between the parallel input wave guide 1 and output wave guide 2 may be increased or decreased by any desired amount within the sliding range of the wave guide parts 3, 4, and thus the effective length of the continuous transmission line including the input wave guide 1, the output wave guide 2 and the coupling unit CU may be varied within the same limits.

Fig. 2 shows a perspective view, and Fig. 3 a cross-sectional view of that perspective view, of a portion of an ultra-high frequency electromagnetic wave transmission system, including a straight-line wave guide slide joint similar to that illustrated diagrammatically in Fig. 1, corresponding elements in the two figures bearing the same identification characters.

In Fig. 2, the parallel input wave guide 1 and output wave guide 2 are shown as comprising straight hollow metal pipes with rectangular cross-sections, as in Fig. 1. The oppositely disposed identical channel parts 3 and 4 of the coupling unit CU in combination also form a straight hollow metal pipe wave guide with rectangular cross-section as in Fig. 1, but in Fig. 2 the longitudinally extending sides of the wave guide parts 3 and 4 of the coupling unit CU are shown as having adjacent outwardly flanging portions 10, 10' and 11, 11', respectively. To avoid sparking, resistance losses and standing waves in the two surfaces sliding past each other, with or without an air-gap, due to the high frequency current passing across the sliding surfaces, the so-called "labyrinth" construction is used, which does not necessitate the adjacent flanging portions of the coupling unit making direct contact with each other.

As shown more clearly in the cross-sectional view of Fig. 3, which is taken along the lines

A—A looking toward the output wave guide 2 in Fig. 2, the adjacent flanging portions 10, 10' and 11, 11' on opposite sides of the two channel parts 3, 4 of the coupling unit are separated along their lengths by a substantial air-gap in the form of straight, meandering grooves each a half wavelength deep, the ends of each groove being metal-lically closed at one end "P₂" as shown. From transmission line theory, it is known that at a distance of a half wave, that is, at the gap entrance point "P₁" (Fig. 3) there will be a voltage node so that no sparking potential can exist. Half-way along each groove, at the quarter wave point "P₃," there will be a current node and a voltage maximum. The latter points along each side of the coupling unit are used for the actual bearing sliding surfaces. At this voltage maximum, there is no voltage gradient across the slide surface, and, therefore, no current and no sparking. The flange surface 10 on one side of the channel portion 4 of the coupling unit is arranged to slide longitudinally at such voltage maxima points along suitable bearing surfaces, which may be formed from a commercial self-lubricating material, on the outer front rail piece 12 extending along the length of the coupling unit. The rail piece 12 is attached firmly by screws 13 to a spacer block 14 also extending along the length of the coupling unit, which in turn is affixed in any suitable manner to one side of the channel portion 3 of the coupling unit. Similarly, the flange portion 11' on the opposite side of the channel portion 4 of the coupling unit slides longitudinally along suitable bearing surfaces at the voltage maxima points, which bearing surfaces may be formed from a commercial self-lubricating material, on the back rail 12' extending along the length of the coupling unit. The rail piece 12' is attached firmly by screws 13' to a spacer block 14' also extending along the length of the coupling unit, which in turn is affixed in any suitable manner to the side of the channel portion 3 of the coupling unit.

As shown in Figs. 2 and 3 tuning screws 15 extend through the walls of the channel parts of the coupling unit CU at points near where the waves are reflected by the reflector plates 7 and 9, to provide small adjustments in tuning as they are screwed in or out of the interior portion of the coupling unit. The tuning screws will not be necessary if the 45-degree elbows, formed by the reflector plates 7 and 9, are cut out to exactly the right depth, but for avoidance of reflection losses and standing waves, it is convenient to provide tuning members which are adjustable in accordance with the desired frequency band. As shown through the broken-away portion of the front side of the channel part 4 of the coupling unit in Fig. 2, a screw 13 extending through a bearing plate 17 affixed to one pipe side of the channel part 3 of the coupling unit CU, and bearing against the reflector plate 7, provides means for adjusting the angular position of the reflector slightly. The angular position of the reflector plate 9 at the other end of the coupling unit may also be adjusted slightly by similar means (not shown). A specific application of the straight-line slide joint one form of which is illustrated in Figs. 1 to 3, might be to provide an arrangement for sliding the feed horn across a parabolic antenna in a radio echo type object location system in order to tilt the direction of the reflected beam.

Fig. 4 shows the application of the same design principle embodied in the straight-line wave

guide slide joint illustrated in Figs. 1 and 2, to reciprocating rotary motion. The arrangement shown differs essentially from that of Figs. 1 to 3 merely in that the two channel element parts 3 and 4 of the wave guide coupling which make sliding contact with each other or slide past each other, are in the system of Fig. 4 bent to form parallel circular arcs so as to provide a reciprocating rotary slide joint coupling the input wave guide 1 and the output wave guide 2, the angular position of the output wave guide with respect to the input wave guide being varied as the distance between the two wave guides along the arc of sliding movement is varied in one direction or the other. To prevent sparking, resistance losses and standing waves due to the high frequency current passing across the sliding surfaces, these surfaces can be protected by half wave grooves and the actual bearing surfaces located at quarter wave points like those illustrated in detail in the arrangement of Figs. 2 and 3, as indicated diagrammatically in Fig. 4. One practical application of the arrangement of Fig. 4 would be to serve as a feed connection to a rocking paraboloid antenna, where the location of a rotary joint at the rocking axis is mechanically impractical.

In the form of the invention shown in Figs. 1 and 2, the variable length section of wave guide providing the coupling unit is split along the line of zero current. A mechanically more compact form of this same type of wave joint may be obtained by turning the wave guide on edge so that it is divided across the center line of the short walls. This center line would have a high current density which might introduce sparking, resistance losses and standing waves, but these may be prevented if the gaps between the elements which slide past each other are bridged by quarter wave grooves in the manner described above. Other modifications of the circuits illustrated and described which are within the spirit and scope of the invention will occur to persons skilled in the art.

What is claimed is:

1. In an electromagnetic wave transmission system, two dielectric wave guides forming portions of a continuous wave transmission line and variable length wave coupling means between said two wave guides comprising a third dielectric wave guide divided longitudinally into two parts adapted for relative slidable movement longitudinally, one of said two wave guides being fixedly connected to one end of one of said parts and the other being fixedly connected to the opposite end of the other part of said third wave guide, so that the length of the wave transmission path between said two wave guides over said coupling means may be varied by said relative slidable movement of said two wave guide parts, and wave deflecting means respectively fixedly connected to a different one of said two wave guides, for diverting the wave energy received over one of said two wave guides into said third coupling wave guide and that energy from the latter wave guide into the other of said two wave guides.

2. The system of claim 1, in which the two-part third dielectric wave guide comprises a straight hollow metal tube split longitudinally along its center line to form a straight-line slide joint coupling between said two dielectric wave guides.

3. The system of claim 1, in which the two-part third dielectric wave guide comprises a hollow metal pipe of rectangular cross-section, curved

so that its longitudinal axis is in the arc of a circle, said metal pipe being split into two identical channel parts along said longitudinal axis, the reciprocating rotary slidable movement of said two wave guide parts relative to each other providing means for varying the coupling distance between said two wave guides along said longitudinal axis.

4. A variable-length coupling arrangement for use between two tubular wave conductors forming sections of a continuous transmission line for transmitting high frequency electromagnetic wave energy, comprising a third tubular conductor made in two parts such as would be formed by splitting a similar conductor along a plane parallel to its longitudinal axis, so as to permit relative slidable motion longitudinally between said two parts, each of the first two conductors being respectively connected to a different one of said two parts of said third tubular conductor at opposite ends thereof, so as to be movable longitudinally with that part and to be in wave-transmitting relation with said third tubular conductor, and wave transferring means respectively fixedly connected to a different of said two conductors and being disposed across the cross-sectional area of said third conductor so as to respectively direct the wave energy received over one of said two conductors into said third conductor and that wave energy transmitted over said third conductor into the other of said two conductors.

5. In a high frequency electromagnetic wave transmission system comprising several tubular wave conductors forming sections of a continuous wave transmission line, means for enabling the effective length of said continuous line to be varied within certain limits, comprising a third tubular wave conductor of a given length, having two separate parts equivalent to those which would be produced by splitting a similar wave conductor along a plane parallel to its longitudinal axis, so as to permit relative slidable movement longitudinally between said two parts, said third tubular conductor coupling two successive ones of said several tubular line conductors in wave-transmitting relation with each other, one of said two successive wave conductors being fixedly connected to one end of one of said two parts and the other of said two successive conductors being fixedly connected to the opposite end of the other of said two parts of said third conductor, so as to be respectively movable longitudinally with movement of the connected part, and reflector means respectively fixedly connected to one of said two successive conductors and angularly disposed across the cross-sectional area of said third tubular conductor at opposite ends thereof, said reflector means respectively serving to reflect wave energy received over one of said two successive tubular conductors into said third conductor and to reflect that wave energy transmitted through said third conductor into the other of said two successive tubular conductors.

6. The system of claim 5, in which said two successive tubular conductors are in parallel with each other and said third conductor provides means for obtaining an adjustable length offset coupling between them.

7. The coupling arrangement of claim 4 in which each of said two tubular wave conductors and said third tubular conductor comprises a hollow metal pipe forming a dielectric wave guide, the hollow metal pipe of said third tubular con-

ductor being split along its longitudinal axis to form two identical parts adapted for sliding past each other longitudinally in one direction or the other to adjust the effective length of the coupling between said two conductors, and said wave transferring means comprise two metal plates each having one edge fixedly connected to the far pipe edge of a different one of said first two conductors and extending angularly across the end of the pipe part of said third conductor connected thereto into the interior of the other pipe part of said third conductor, so as to be movable longitudinally therein with relative longitudinal movement of the two pipe parts.

8. The coupling arrangement of claim 4, in which said third conductor comprises a straight length of hollow pipe of rectangular cross-section, split into two parts in a plane along the longitudinal axis, the connection of the respective parts of said pipe to said two wave conductors being such that the interior portions of said pipe and those of said two tubular conductors open into each other.

9. In combination in a wave transmission system, a dielectric wave guide split longitudinally into two portions adapted for relative slidable movement longitudinally, an input wave guide and an output wave guide coupled in wave-transmitting relation with the first wave guide, said input wave guide being fixedly connected to one end of one of said wave guide portions and said output wave guide being fixedly connected to the opposite end of the other wave guide portion, so that the effective wave transmission distance between said input wave guide and said output wave guide may be varied by relative longitudinal movement between the two wave guide portions of the first wave guide and means for deflecting wave energy received over said input wave guide into said first wave guide and that wave energy transmitted over said first wave guide into said output wave guide.

10. The combination of claim 9 in which said first wave guide is split longitudinally along a straight line so that it provides a straight-line

slide joint coupling between said input and output wave guides.

11. The combination of claim 4, in which said third tubular conductor comprises a straight hollow metal pipe of rectangular cross-section split longitudinally into two identical parts along a horizontal plane midway between its short walls so as to enable straight-line slidable movement between the two parts in either direction to vary the effective length of the wave transmission path between said two tubular conductors through said straight hollow metal pipe, and means to prevent sparking and resistance losses in said coupling arrangement due to the high frequency current passing across the slide surfaces of said identical wave parts.

12. The system of claim 5, in which each of said tubular wave conductors comprises a straight piece of hollow metal pipe of rectangular cross-section, the straight hollow metal pipe forming said third tubular conductor being divided into two parts longitudinally along the line of zero current.

13. The system of claim 5 in which all of said tubular conductors comprise straight hollow metal pipes of rectangular cross-section, the hollow metal pipe forming said third tubular conductor being divided into two identical portions across the center line of the short walls, said two identical portions being spaced from each other along their length by an appreciable air-gap, and being adapted for relative slidable movement longitudinally to vary the wave transmission distance between the hollow metal pipes comprising said two successive conductors over the first hollow metal pipe.

14. The system of claim 9, in which said input and said output wave guides comprise straight pieces of hollow metal pipe, and said first dielectric wave guide comprises a hollow metal pipe bent so that its longitudinal axis is curved in the arc of a circle with the relative slidable movement of the two portions thereof being a rotary reciprocating one.

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