April 7, 1953 H. HONDA 2,634,331

WAVE ATTENUATOR

Filed May 19, 1950 3 Sheets-Sheet 1

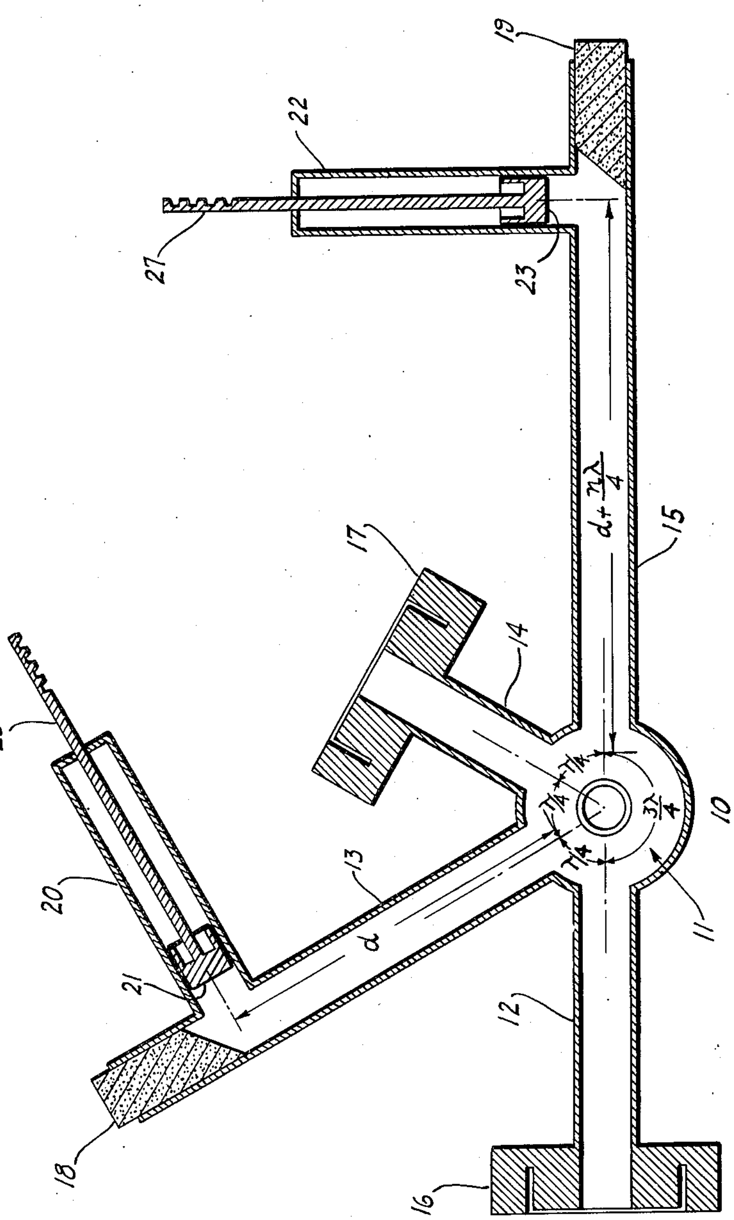

FIG. 1.

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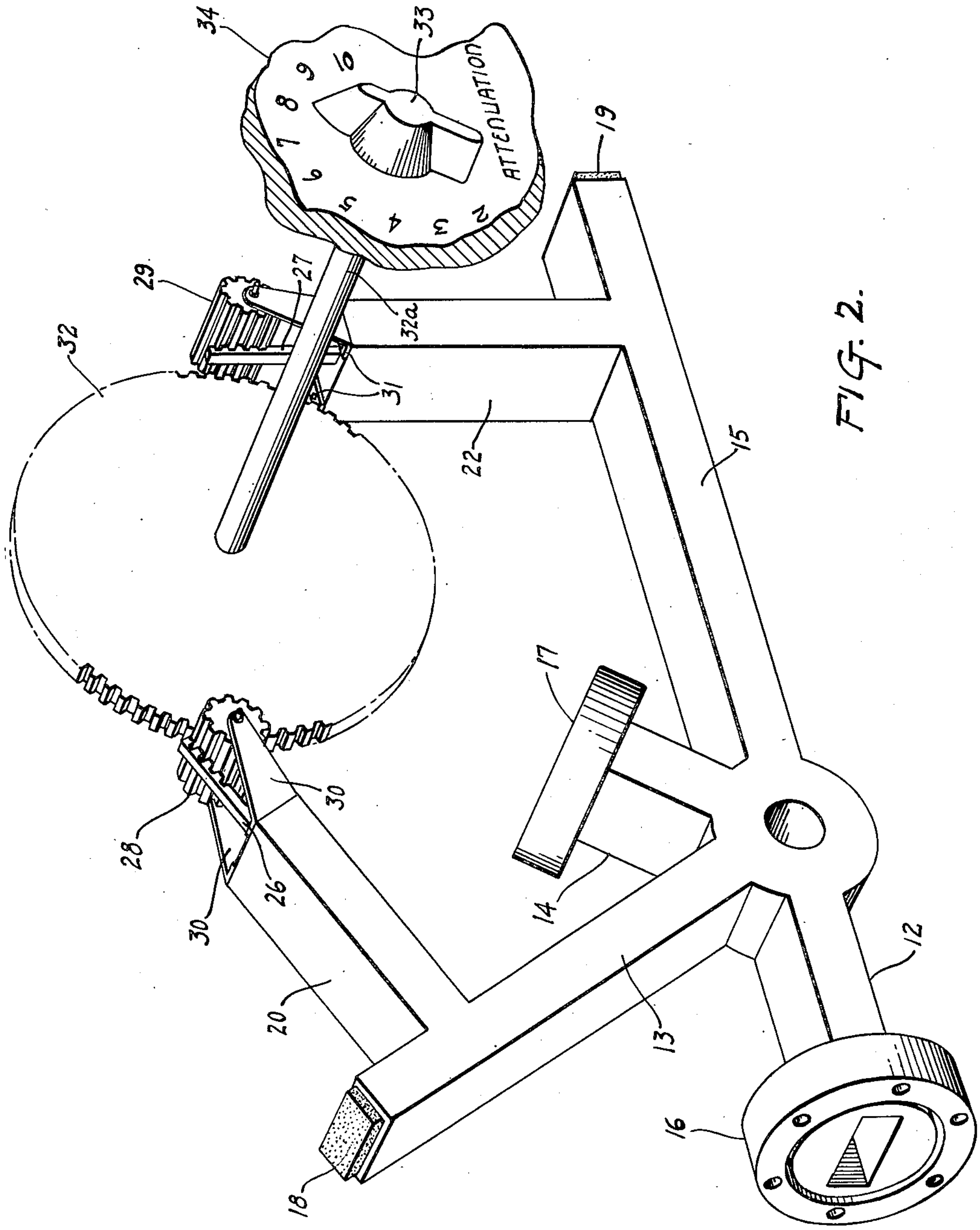

FIG. 2.

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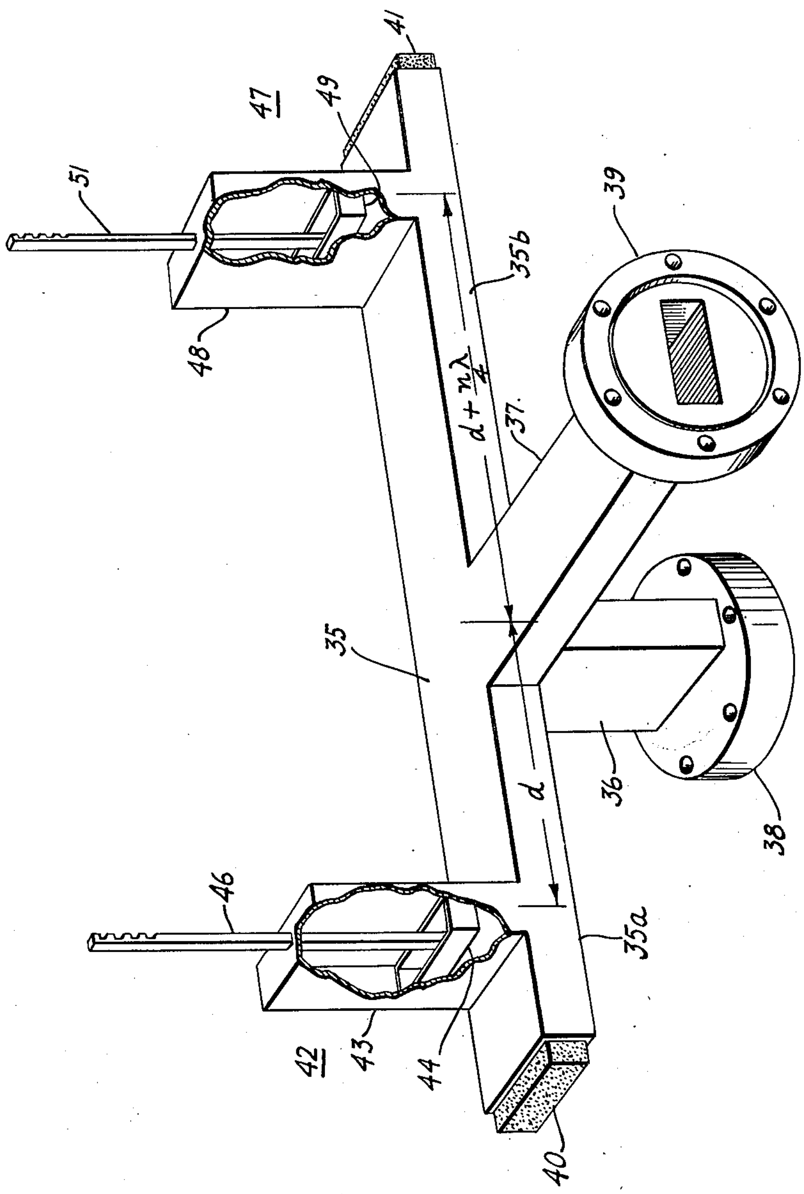
FIG. 3.



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Patented Apr. 7, 1953

2,634,331

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2,634,331

WAVE ATTENUATOR

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Application May 19, 1950, Serial No. 162,947

3 Claims. (Cl. 178—44)

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The present invention relates to variable attenuators and, more particularly, to apparatus for attenuating, to any desired degree, electromagnetic wave energy propagated through a waveguide.

Variable attenuators find wide application in the high frequency art, both in operational and in mensural capacities. For example, it is frequently desirable to vary the amount of power supplied from a high frequency generator, such as a magnetron, to a radiating antenna. While it is not feasible to vary directly the power output of a magnetron oscillator, the desired objective can be achieved by including a variable attenuator in the connection between the magnetron and the antenna. Although attenuators are known to the art which are partially satisfactory for this purpose, all of them suffer from certain defects. Certain of them, for example, are unsatisfactory in that they are reliably operative only over a very narrow frequency range. Thus, whenever such prior art attenuators were used in conjunction with a magnetron oscillator, they would provide the desired variation in the power derived from the magnetron only if its frequency of operation remained substantially fixed. Whenever that frequency changed slightly, by reason of aging of the magnetron or any one of numerous other unavoidable and unpredictable influences, the reliable operation of the attenuator was disturbed. This type of disturbance is, of course, extremely undesirable, since it renders calibration of the attenuator meaningless. The responsibility for this erratic behavior of prior art attenuators may be attributed, to a large extent, to the fact that these prior art attenuators had, for their principal structural components, a number of simple waveguide junctions which are inherently highly frequency sensitive or, to use a more common term, "narrow band."

Accordingly, it is a principal object of the invention to provide apparatus for variably attenuating high frequency energy supplied thereto.

It is another object of the invention to provide a variable high frequency attenuator whose attenuation characteristics are relatively independent of variations in signal frequency.

It is a still further object of the invention to provide apparatus adapted for connection between two adjoining portions of a section of waveguide, and which is operative to vary the amount of energy supplied through it from one of the portions to the other portion.

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It is a feature of apparatus constructed in accordance with my invention that the degree to which it attenuates high frequency energy transmitted therethrough is controllably and continuously variable to permit the transfer of any desired fraction of the energy supplied to it while absorbing the remainder. Furthermore, the adjustment required to effect a desired attenuation is unaffected by relatively wide variations in the frequency of the transmitted energy.

In practicing my invention, there may be utilized certain conventional four-branch waveguide junctions which are so constructed and arranged that signals injected into a first branch are transmitted substantially exclusively to second and third branches, said signals being transmitted to said second and third branches respectively in substantially equal magnitudes and in substantially a first predetermined phase relationship, and which are constructed and arranged so that signals injected into said second and third branches respectively in substantially equal magnitudes and substantially a second predetermined phase relationship are transmitted substantially exclusively to a fourth branch. Typical of such waveguide junctions are those known respectively as the "magic T" and the "hybrid ring," either of which may be utilized in embodiments of the invention.

Briefly, in accordance with the invention, there are coupled to the second and third branches respectively, of such a junction, means for reflecting substantially equal fractions of signals transmitted to said second and third branches respectively from said first branch. Also there are included, in at least one of said second and third branches, means for relatively shifting the phases of signals transmitted to said second and third branches by an amount such as to cause said reflected fractions of said signals to be reinjected into said second and third branches respectively in substantially said second predetermined phase relationship. Further, in accordance with the invention, there are disposed in said second and third branches respectively, means for absorbing fractions of signals transmitted to said branches which are not reflected by said reflecting means.

In such an arrangement, by virtue of the inherent properties of the four-branch junction, only the reflected fractions of signals, which are reinjected into the second and third branches, are supplied to the fourth branch. Thus, only a fraction of the energy injected into the first branch will be supplied to the fourth branch, the balance of the energy being absorbed by the absorbing means disposed respectively in the second and third branches. In further accordance with the invention, the means coupled to the second and third branches respectively for reflecting substantially equal fractions of signals transmitted to said branches from the first branch may be made controllable to vary the magnitudes of the fractions reflected, whereby the amount of energy transmitted from the first, or input, branch to the fourth, or output, branch may be varied.

It is a feature of apparatus constructed as hereinbefore outlined, that all the energy which is not supplied to the output branch of the junction is absorbed in the energy absorbing means disposed in the second and third branches, so that no reflection of energy into input branch takes place regardless of how the reflecting means may be adjusted. Thus there is prevented the formation, in the input branch, of standing waves, which might result in deleteriously altering the characteristics of the attenuator as well as of the system to which it is connected.

The detailed description of the construction and operation of apparatus in accordance with my invention to which I shall now proceed will be more readily understood with reference to the accompanying drawings, in which:

Figure 1 is a cross-sectional view of a variable attenuator constructed in accordance with my invention and incorporating a waveguide junction of the type commonly known as a hybrid ring;

Figure 2 is a view, in perspective, of the attenuator of the form illustrated in Figure 1 together with means for adjusting certain of its components to vary the attenuation which it produces; and

Figure 3 is a view of a variable attenuator, also constructed in accordance with my invention, and embodying the same basic principles as the attenuator illustrated in Figure 1, but incorporating a magic T waveguide junction.

With more particular reference now to Figure 1, there is illustrated therein, in section, a hybrid ring waveguide junction 10, comprising a closed annular loop of waveguide 11, whose mean length is equal to one and one-half wavelengths of signals to be transmitted therethrough. Four waveguide branches, respectively designated 12, 13, 14 and 15, extend radially outward from spaced points along the outer circumference of waveguide loop 11. As is usual in hybrid ring junctions, the connection between each branch guide and the annular guide takes the form of a conventional E-plane junction, in which the longitudinal axes of all of the branches lie in a common plane and each branch is oriented with respect to its longitudinal axis so that the electric field vectors of waves propagated therein are parallel to that plane. In the arrangement as thus described, all of the waveguide sections may be of rectangular cross-section and of the usual dimensions for the frequencies with which it is to be employed. The section plane, it will be noted, is taken parallel to the directions of the electric field vectors of waves propagated in the several sections.

As indicated by appropriate dimensional designations in the diagram, the spacing between branches 12 and 13, between branches 13 and 14, and between branches 14 and 15, measured along the annular waveguide 11 from junction to junction are each made equal to a quarter-wavelength at the operating frequency. The spacing between branches 12 and 15, on the other hand, is made equal to three-quarters of a wavelength, measured in either direction around the annular guide 11. The free end of branch guide 12 is provided with a conventional choke-type waveguide coupling 16 which adapts it for connection to a source of input signals (not shown). A similar coupling 17 is provided at the free end of branch guide 14 for connection to signal utilization means. A tapered plug 18, of energy absorbent material, is fitted into the free end of branch guide 13, and a similar plug 19 is fitted into the free end of branch guide 15. These two plugs function in accordance with principles well known in the prior art to provide substantially reflectionless terminations for their respective branch guides. At a convenient distance d from annular guide 11, there is joined, to branch guide 13, a waveguide section 20, containing a plunger 21 adapted for longitudinal movement therein. The junction between guide section 20 and branch guide 13 takes the form of an E-plane junction, as hereinbefore defined. A second waveguide section 22, containing a plunger 23 adapted for longitudinal adjustment therein, is joined to branch guide 15 by means of another E-plane junction at a distance from annular guide 11 which exceeds the aforementioned distance d by an odd integral number n of quarter-wavelengths of signals to be transmitted through the attenuator. It will be recognized that waveguide sections 20 and 22, together with their respective plungers 21 and 23, constitute tuning stubs, whereby the impedance presented by branch guides 13 and 15 to energy flow therein from annular guide 11 may be adjusted throughout a wide range of values, depending upon the degree of insertion of each plunger into its corresponding waveguide section. To insure efficient operation of the tuning stubs, their plungers should be made sufficiently long to prevent appreciably leakage of energy past them. The plungers are provided with driving rods 26 and 27, respectively, to facilitate adjusting their positions within their respective stub waveguide sections. In accordance with the invention, the plungers 21 and 23 are adjusted to corresponding positions in their respective tuning stubs. Means for moving the two plungers simultaneously and for maintaining such correspondence will be discussed hereinafter.

Considering now the operation of the structure as illustrated, in response to input signals of predetermined frequency injected into branch 12, it will be observed that these signals will be propagated in both directions around annular guide 11. By reason of the spacings of the various branch guides, as hereinbefore mentioned and as shown in the figure, the signals thus propagated will arrive at branch 13 having their respective electric fields in phase opposition. The same relationship will exist with respect to signals arriving from opposite directions at branch 15. Accordingly, and by reason of the existence of these phase relationships, the signals at these points will be caused to propagate into these branches respectively. It will be observed, however, that, owing to the one-half wavelength spacing between branches 13 and 15, the signals thus propagated into these branches, respectively, will differ mutually in phase by 180°. Further it will be observed that signals injected into branch 12 and propagated in opposite directions around the annular section will arrive at branch

14 with their electric fields in the same phase, so that none of these signals will be propagated into branch 14.

Signals propagated into branch guides 13 and 15 would eventually reach the absorbent plugs which terminate these branches and be absorbed thereby in their entirety, were it not for the presence of the tuning stubs 20 and 22 coupled to guides 13 and 15 respectively. As aforementioned, each of the tuning stubs may function to modify the effective impedance of the branch with which it is associated to an extent determined by the position of its plunger, and, depending upon the extent to which the impedance of each branch is thus modified, a certain fraction of signal energy entering the branch will be reflected and caused to return toward annular guide 11. Since, in accordance with the invention, the plungers of both tuning stubs are adjusted in the same manner, the impedances of both branches 13 and 15 will be modified to the same extent so as to cause equal fractions of signals injected into both branches to be reflected. Only the remaining unreflected fractions of the signals thus propagated through the branch guides are permitted to pass on to, and be dissipated in the terminating plugs 18 and 19. Since, as has been pointed out, the signals initially supplied to the variable attenuator through branch guide 12 are equally divided between branch guides 13 and 15 by virtue of their relative displacements from the input branch guide along annular guide 11, and since, furthermore, equal fractions of these divided signals are reflected by the tuning stubs into the respective branch guides, the absolute magnitudes of the signals which are thus reflected from each of branch guides 13 and 15 back into annular guide 11 are equal. Specifically, when the plunger surfaces which confront branch guides 13 and 15, respectively, are flush with the inner walls of these guides, none of the signals initially propagated into either of these guides will be reflected, so that the attenuator output will be zero, and its attenuation a maximum. Maximum reflection of signals in branch guides 13 and 15, and consequent minimum attenuation of signals supplied to the attenuator, takes place when the guide-confronting surface of each plunger is at a quarter-wavelength mean distance from the associated branch guide. Plunger adjustments between these limits, of course, produce intermediate attenuation values.

Next it will be observed that signals supplied to branch guide 13 from annular guide 11 and reflected by reason of the action of tuning stub 20, will undergo a phase displacement equal to the distance $2d$, measured in wavelengths, which they traverse, between their introduction into branch guide 13 and reissue therefrom. Signals reflected in branch guide 15 by reason of the action of tuning stub 22, on the other hand, will undergo a phase displacement of

$$2\left(d+\frac{n\lambda}{4}\right)$$

where n is an odd integer, between their application to and their reissue from branch guide 15. Thus signals traversing branch 15 will be subjected to a phase shift which exceeds that to which signals traversing branch 13 are subjected by an odd integral multiple of 180°. By reason of this, and by reason of the fact that the signals propagated into branches 13 and 15 respectively from annular guide 11 differ in phase by 180°, the reflected signals in both branches 13 and 15 will arrive at the junctions of those branches with the annular guide 11 in the same phase as well as in equal magnitudes.

Reflected signals derived from each of branch guides 13 and 15 will now also propagate in both directions around annular waveguide 11. By virtue of the spacing of guides 13 and 15 from the other two branch guides 12 and 14 joined to the annular guide 11, reflected signals derived from branch guide 13 will arrive at the junction of branch guide 12 and annular guide 11 in the same phase as reflected signals derived from branch guide 15, with the result that none of the reflected signals will be propagated into branch 12, thereby preventing any reflection of signals into the source from which the signals are originally supplied to the variable attenuator. On the other hand, reflected signals derived from each of branch guides 13 and 15 will arrive at the junction of branch guide 14 with annular guide 11 in phase opposition and will therefore be propagated into branch guide 14.

From the foregoing, it will be clear that, by appropriate adjustment of the two tuning plungers provided in my variable attenuator, any desired fraction of signals supplied to the attenuator through input branch guide 12 may be transmitted through the attenuator and will issue therefrom through output branch guide 14, the remaining fraction being dissipated in the energy absorbent plugs which terminate branch guides 13 and 15. Since, as has been shown, the electrical characteristics of my variable attenuator are such as to inhibit reflections of energy supplied thereto through branch guide 12 back into the same branch guide, one of the most vexing problems of prior art devices, namely the high input standing wave ratio, is solved.

While the embodiment of Fig. 1 has been described with reference to the case in which branch 12 operates as the input to the attenuator, and branch 14 as the output therefrom, it is to be noted that similar results will obtain if branch 14 is used as the input branch and branch 12 as the output branch. While it is not deemed necessary to discuss the mode of operation under such circumstances in detail, since it is essentially similar to that which obtains in the case described, it may be noted that signals injected into branch 14 will be propagated in opposite directions around annular guide 11. The oppositely propagated components will arrive out of phase at the junctions between branches 13 and 15 and annular guide 11 respectively and will therefore be propagated into those branches. In this instance, however, the signals propagated into branches 13 and 15 respectively will be in phase rather than out of phase. By reason of the difference in length of the two branches, however, the respective signals will be returned to the annular guide 11 in phase opposition. Because of this, the components, which they cause to be propagated in opposite directions in guide 11, will arrive at the junction between branch 12 and guide 11 in phase opposition so as to cause them to be propagated through branch 12; but will arrive at the junction between branch 14 and annular guide 11 in phase so as to prevent their entry into branch 14. Apparently, therefore, it is immaterial into which of branches 12 and 14 the signals to be attenuated are injected.

It is, of course, important to the achievement of the stated objects of my invention, that the signals reflected in each of branch guides 13 and 15, by the action of the tuning plungers, be as nearly equal as possible, for only such equality can insure complete cancellation of reflected signals at the junction of input branch guide 12 and annular guide 11, thereby guaranteeing reflectionless attenuation of signals supplied to the attenuator. Since the magnitude of the fraction of energy reflected in each of branches 13 and 15 is dependent upon the adjustment of the plunger of the tuning stub coupled to that section, it is accordingly essential that positioning of these two plungers within their respective stubs be as nearly the same as possible. One suitable mechanism for maintaining this relationship, while simultaneously varying the positions of the plungers in the respective tuning stubs, is illustrated in Fig. 2 in association with an attenuator of the form just described with reference to Fig. 1.

While Fig. 2 is a perspective view, rather than a sectional one like Fig. 1, it will be apparent that the attenuator shown in Fig. 2 is identical in form to that shown in Fig. 1. Accordingly no further discussion of the attenuator proper is deemed necessary, and corresponding reference numerals will be employed in referring to certain elements of the attenuator of Fig. 2 which are identical to those of Fig. 1. To effect simultaneous and equivalent adjustment of the plungers of tuning stubs 20 and 22, there are provided pinions 28 and 29 which, respectively, engage racks formed in the driving rods 26 and 27 affixed to the plungers of tuning stubs 20 and 22 respectively as shown in Fig. 1. Pinions 28 and 29 are mounted for rotation about their respective axes on brackets 30 and 31 suitably affixed to opposite sides of tuning stubs 20 and 22 respectively. Both pinions 28 and 29 are driven by a common spur gear 32 rigidly affixed to a shaft 32*a*. A knob 33 is affixed to the end of shaft 32*a* to provide for manual rotation thereof. It is noted that the relationship, between the racks on driving rods 26 and 27 and the pinions 28 and 29 respectively engaging said racks, is such that, when shaft 32*a* is rotated in a clockwise direction, the plungers of both tuning stubs 20 and 22 will be driven inward simultaneously toward the branch sections 13 and 15, while, if shaft 32*a* is rotated in a counter-clockwise direction, both plungers will move in the reverse direction. In either case both plungers will move the same distance if both racks and both pinions are identical. For convenience in adjusting the plungers to yield the desired value of attenuation, a suitable scale 34 may be provided for cooperation with the pointer on knob 33, which scale may be calibrated in terms of any desired units of attenuation.

It will be apparent that the adjusting mechanism just described with reference to Fig. 2 does not constitute an essential feature of the invention, and that many other mechanical arrangements for producing equivalent results may be employed, which will readily occur to those skilled in the art.

As hereinbefore indicated, the hybrid ring type of waveguide junction is not the only one adapted for use in embodiments of my invention, but other junctions possessing similar properties may be substituted therefor, such, for example, as the magic T. This is likewise a four-branch junction characterized in that signals injected into a first branch thereof are transmitted substantially exclusively to second and third branches, said signals being transmitted to said second and third branches respectively in substantially equal magnitudes and in substantially a first predetermined phase relationship, and also characterized in that signals injected into said second and third branches respectively in substantially equal magnitudes and in substantially a second predetermined phase relationship are transmitted substantially exclusively to the fourth branch. Figure 3 illustrates an alternative embodiment of my invention incorporating such a magic T junction.

Referring now to Fig. 3 the magic T junction comprises a section of rectangular waveguide 35 to which are joined two other sections of waveguide 36 and 37. The axes of the latter sections are disposed perpendicularly to the axes of the first section and perpendicularly to each other, the two sections being electrically coupled to the first section through openings in adjacent sides of the first section. The portions of waveguide section 35 on either side of the junction constitute separate branches of the four-branch junction and are designated 35*a* and 35*b* respectively. As is generally recognized, the resultant four-branch junction comprises the combination of an E-plane T-junction with an H-plane T-junction.

The free end of branch guide 36 is provided with a conventional choke-type waveguide coupling 38 which adapts it for connection to a source of input signals (not shown). A similar coupling, 39, is provided at the free end of branch guide 37 for connection to a signal utilization device. A pair of tapered plugs 40 and 41, of energy absorbent material, are fitted, respectively, into each of the free ends of branch guides 35*a* and 35*b*. These two plugs are similar in purpose to plugs 18 and 19 of Figure 1 and function, in accordance with principles well known in the prior art, to provide substantially reflectionless termination for energy propagating towards the free ends of branch guide 35*a* and 35*b*. At a convenient distance *d* measured along branch guide 35*a* from the junction of guides 35, 36 and 37, there is joined, to branch guide 35*a*, a tuning stub 42, comprising a waveguide section 43 and a plunger 44 provided with a driving rod 46, which is of the same form as those shown in Fig. 1. Similarly, at a distance measured along branch guide 35*b* from the junction of guides 35, 36 and 37 which exceeds the distance *d* by an odd integral number *n* of quarter-wavelengths, there is joined, to branch guide 35*b*, a tuning stub 47, comprising a waveguide section 48 containing a plunger 49 provided with a driving rod 1. As discussed at length in the description of the embodiment illustrated in Figures 1 and 2, movement of plungers 44 and 49 within their respective tuning stubs is effective to vary, throughout a wide range of values, the impedance presented by branch guides 35*a* and 35*b* to energy propagated therein outwardly from the junction of guides 35, 36, and 37.

Signals to be attenuated may be supplied to the arrangement through branch guide 36. By virtue of the characteristics of the magic T junction, which are well known, these signals divide equally between, and propagate respectively into branch guides 35*a* and 35*b*, while substantially none of the input signal is propagated into output branch guide 37. The signals thus propagated into branch guides 35*a* and 35*b* will be mutually out of phase. In the absence of tuning stubs 42 and 47, signals propagated through these branch guides toward the free ends thereof would eventually reach wave absorbent terminal plugs 40 and 41 and would be absorbed thereby in their entirety. The same effect is achieved by positioning both plungers 44 and 49 in such a manner that their branch guide-confronting faces are flush with the inner wall surfaces of these branch guides. When these tuning plungers are thus adjusted to permit unimpeded passage of signals through the waveguide branches with which they are associated and towards their signal absorbent terminal plugs, the attenuator as a whole is in its maximum-attenuation condition, all of the signals supplied thereto being dissipated therein, and no portion thereof being supplied either to the output of the attenuator, or reflector into the input branch of the attenuator. Adjustment of tuning plungers 44 and 49 to different positions within their respective waveguide sections causes the impedance presented to signals propagating through branch guides 35*a* and 35*b* to vary, with the result that varying fractions of the signals propagating therethrough in the direction of the respective terminal plugs will be reflected towards the principal waveguide junction, instead of being permitted to proceed to the terminal plugs where they would be absorbed. Signals reflected in branch guide 35*b* will undergo, between introduction into and issuance from branch guide 35*b*, a phase shift which exceeds the phase shift undergone by signals similarly reflected in branch guide 35*a* by an odd number of one-half wavelengths owing to the different positioning of stub 47 with respect to branch guide 35*b*, and since the signals propagated into branch guides 35*a* and 35*b* were initially out of phase, as hereinbefore stated, their reflected fractions will be in phase upon reissuing therefrom and will, consequently, combine and propagate into output branch guide 37, while substantially none of these reflected fractions of energy will be able to reenter input guide 36, where they might produce deleterious standing waves. This inability of reflected fractions of signals from branch guides 35*a* and 35*b* to propagate into input guide 36 is due to the inherent operation of the magic T waveguide junction and is predicated upon the substantial equality in amplitude as well as in phase of the reflected fractions of signals, which issue from branch guides 35*a* and 35*b*. In order to insure this amplitude equality of reflected fractions of energy, it is necessary that both tuning plungers be adjusted simultaneously so that both plungers will, at all times, be at the same mean distances from the waveguide branches associated with their respective tuning stubs. As in the embodiment of Figures 1 and 2, this identity of plunger positioning may be achieved in any desired manner, as, for example, by an adjusting mechanism of the sort illustrated in, and described in detail with reference to Figure 2 of the drawings. Again as in the embodiment of Figures 1 and 2, the plunger position for which all of the signal propagating through branch guides 35*a* and 35*b* are reflected, and for which the overall attenuation of the attenuator is substantially zero, is that at which the branch guide-confronting surface of each plunger is at a mean distance of one-quarter wavelength from its corresponding branch guide.

As in the embodiment of Fig. 1, the signal input and the signal output connections may be interchanged without in any way affecting the operation of the device in accordance with the invention.

It will be understood that various other structures may be devised without departing from the scope of the invention as defined by the appended claims.

I claim:

1. An electromagnetic wave attenuator comprising: a waveguide junction having first, second, third and fourth branches, said junction being constructed and arranged so that signals injected into said first branch are transmitted substantially exclusively to said second and third branches, said signals being transmitted to said second and third branches respectively in substantially equal magnitudes and in substantially a first predetermined phase relationship, and said junction being constructed and arranged so that signals injected into said second and third branches respectively in equal magnitudes and in substantially a second predetermined phase relationship are transmitted substantially exclusively to said fourth branch; a pair of tuning stubs respectively coupled to said second and third branches and arranged to reflect substantially equal fractions of signals transmitted to said second and third branches respectively from said first branch, said tuning stubs being coupled to their respective branches at points whose effective electrical distances from said first branch differ by an amount such as to cause said reflected fractions of said signals to be substantially in said second predetermined phase relationship, and said tuning stubs being provided with means for varying their respective electrical lengths simultaneously to vary the magnitudes of said reflected fractions of signals transmitted to said second and third branches respectively from said first branch while maintaining the magnitudes of said fractions substantially equal; and means disposed in said second and third branches respectively for absorbing fractions of signals transmitted by said branches which are not reflected by said tuning stubs.

2. An electromagnetic wave attenuator comprising: a hybrid ring waveguide junction including a closed waveguide loop and first, second, third and fourth branches coupled to said loop at points so spaced along said loop that signals injected into said first branch are transmitted substantially exclusively to said second and third branches in substantially equal magnitudes and in substantially opposite phase relationship, and that signals injected into said second and third branches respectively in substantially equal magnitudes and in such phase relationship as to arrive at said loop waveguide in substantially equal phase relationship are transmitted substantially exclusively to said fourth branch; a pair of tuning stubs respectively coupled to said second and third branches and arranged to reflect substantially equal fractions of signals transmitted to said second and third branches respectively, said tuning stubs being coupled to their respective branches at points whose effective electrical distances from said loop waveguide differ by substantially a quarter wavelength at said operating frequency, and said tuning stubs being provided with means for varying their respective electrical lengths simultaneously to vary the magnitudes of said reflected fractions of signals while maintaining the magnitudes of said fractions substantially equal; and means disposed in said second and

third branches for absorbing fractions of signals transmitted by said branches which are not reflected by said tuning stubs.

3. An electromagnetic wave attenuator according to claim 1 in which each said tuning stub is comprised of a waveguide section, joined to the respective branch by an E-plane junction, and containing a conductive plunger whose spacing from said respective branch is mechanically adjustable to vary the said fraction of signals reflected by each said tuning stub.

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