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[54] **WATER LOAD**
10 Claims, 1 Drawing Fig.

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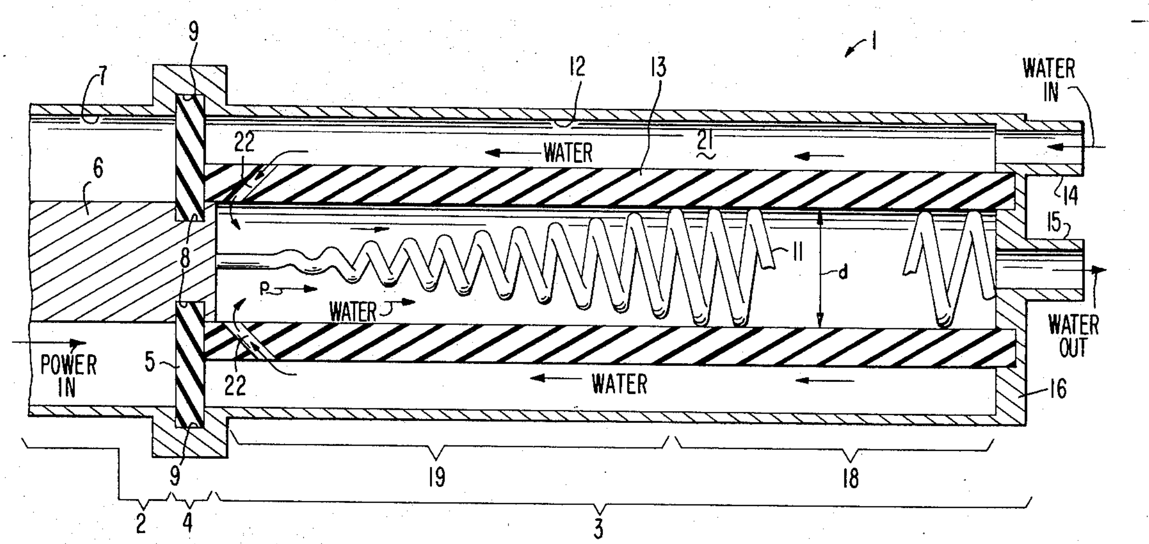
ABSTRACT: A radio frequency water load is disclosed having a loss section of transmission line. The loss section of transmission line includes a delay line portion for slowing the group velocity of wave energy traveling in the loss section. Conduits are arranged for directing a stream of wave-attenuative liquid through the loss section in wave-energy-exchanging relation with wave energy on the delay line for attenuating the wave energy, whereby the physical length of the loss section is reduced for a given amount of attenuation. In a preferred embodiment, the loss section is a section of coaxial line and the inner conductor is a helical delay line.



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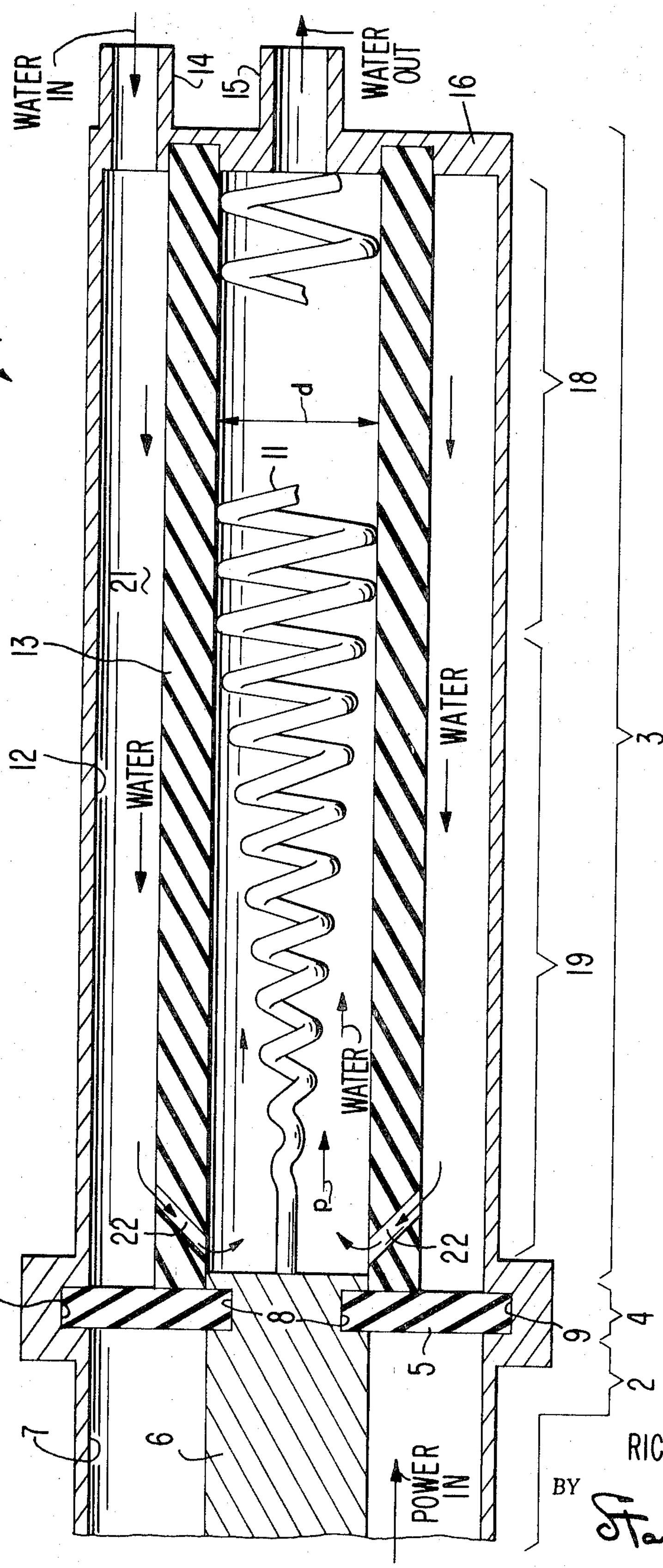

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WATER LOAD

DESCRIPTION OF THE PRIOR ART

Heretofore, coaxial water loads have been constructed wherein a conically shaped teflon partitioning wall was provided interconnecting the inner and outer conductors of the coaxial load to form a transition from air-filled coaxial line to water filled coaxial line, such water-filled section of coaxial line providing dielectric loss in the water.

One of the problems with this prior art coaxial water load was that the teflon was relatively difficult to seal and to machine. In addition, the coaxial load was excessively long due to the long taper for the cone needed to get the wave energy into the water without reflection and to accommodate the long path length in water to absorb the energy. It would be desirable to provide an improved water load having reduced length and employing a disc-shaped water barrier to prevent having to seal and machine the teflon cone.

SUMMARY OF THE PRESENT INVENTION

The principal object of the present invention is the provision of an improved water load.

One feature of the present invention is the provision of a water load having a loss section of transmission line including a delay line portion for slowing the group velocity of the wave energy to be attenuated and including means for directing a stream of wave energy attenuative liquid through the loss section in wave-energy-exchanging relation with the wave energy on the delay line.

Another feature of the present invention is the same as the preceding feature wherein the loss section of transmission line is a section of coaxial line and the delay line portion of the transmission line is formed by the inner conductor.

Another feature of the present invention is the same as the immediately preceding feature wherein the delay line inner conductor is a helix or topological equivalent of a helix, whereby a broad band load is obtained.

Another feature of the present invention is the same as any one or more of the preceding features including the provision of a dielectric structure disposed within the delay line portion of the loss section for displacing some of the wave energy attenuative liquid for reducing the dielectric loading of the loss section of transmission line.

Another feature of the present invention is the same as any one or more of the preceding features including the provision of a transition section at the input end of the loss section for gradually decreasing the axial group velocity of wave energy traveling in the direction of power flow on the delay line for reducing wave reflection from the delay line.

Another feature of the present invention is the provision of an abrupt impedance matching transition at the partitioning wall between the attenuative liquid filled loss section and the transmission line input to the loss section.

Other features and advantages of the present invention will become apparent upon a perusal of the following specification taken in connection with the accompanying DRAWING wherein:

BRIEF DESCRIPTION OF THE DRAWING

The DRAWING is a longitudinal sectional view of a coaxial water load incorporating features of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the DRAWING, there is shown a coaxial water load 1 incorporating features of the present invention. The water load 1 includes an input section of air-filled coaxial line 2 connected to a loss section of coaxial line 3 via the intermediary of an abrupt impedance-matching transition section 4 formed by a wave-permeable water-impervious dielectric disc 5, as of teflon, sealed between the inner conductor 6 and the outer conductor 7 of the input section 2 of air-filled coaxial line. The characteristic impedance of the abrupt transition section 4 is made substantially equal to the characteristic impedance of the 50-ohm coaxial line section 2 by undercutting the center conductor 6 at 8 and by enlarging the inside diameter of the outer conductor 7 at 9 to compensate for the increased dielectric constant of the teflon-filled transition section 4 of the coaxial line. By an abrupt transition it is meant that the wave-permeable partition 5 has an axial length substantially less than one-quarter wavelength at the center frequency of the operating band of the load 1.

The loss section of coaxial line 3 includes an inner conductor 11 coaxially surrounded by a hollow cylindrical outer conductor 12. A hollow cylindrical dielectric sleeve structure 13, as of teflon, coaxially surrounds the inner conductor 11 and is interposed in the space between the inner conductor 11 and the outer conductor 12 for reducing the dielectric loading of the loss section of coaxial line 3.

The loss section 3 includes an input conduit 14 and an output conduit 15 communicating through a conductive end closing wall 16 which closes off the terminal end of the load 1 and provides a wave-reflective discontinuity at the terminal end for reflecting wave energy back into the loss section 3 for further attenuation. A stream of wave energy attenuative liquid, as of water, is conducted through the coaxial loss section 3 in wave-energy-exchanging relation with wave energy traveling therein for attenuating wave energy. In the case where water is utilized as the wave energy attenuative liquid, the dielectric constant of the water dielectric fill is approximately 81 such that the impedance of the water-filled loss section 3 would ordinarily be decreased by approximately a factor of 9 as compared to a similar air-filled section. Therefore, the teflon sleeve 13 is provided to reduce the dielectric loading of the loss section of coaxial line 3 by displacing some of the water between the inner and outer conductor 11 and 12, respectively. In this manner, the diameter of the inner conductor 11 can be maintained at a reasonable diameter consistent with the power-handling requirements of the inner conductor 11 while maintaining a 50Ω characteristic impedance to match the impedance of the transition 4 and the input line 2. In addition, the inner conductor 11 is preferably made of a material which retains its strength at relatively high temperatures, such as stainless steel or Monel.

The loss section of coaxial line 3 also includes a delay-line section 18 and a delay-line transition section 19. In the delay-line section 18 the inner conductor 11 is wound into a helix to form a helical delay-line, thereby substantially reducing the group velocity for wave energy traveling on the helix in the TEM mode.

In the delay line transition section 19, the inner conductor 11 has an initial straight portion having a length sufficiently long to extend beyond the local electromagnetic fields of the discontinuity produced by the abrupt transition section 4. The straight portion of the inner conductor 11 is followed, taken in the direction of power flow, indicated by the arrow p, by a helix having a conically tapered diameter d, which increases in the direction of power flow. The diameter of the helix increases throughout the transition section 19 until it reaches the diameter of the helix in the delay section 18. The transition section 19 performs two functions, first, it forms a velocity transformation for transforming the group velocity of wave energy on the coaxial line from the velocity of light to a substantially slower group velocity in the delay line section 18, as of one-tenth the velocity of light. Secondly, transition section 19 provides an impedance transition section for transforming the impedance from the 50Ω characteristic impedance at the power input end of the loss section 3 to a relatively low characteristic impedance of approximately 11Ω for the helix as immersed in water in the delay-line section 18.

The wave energy attenuative liquid passes into the loss section 3 via input conduit 14 and is passed through the annular chamber 21 between the teflon sleeve 13 and the outer conductor 12 to the power input end of the loss section 3 at which point the attenuative liquid flows to the center of the sleeve 13 via a plurality of inclined bores 22 passing through the wall of the sleeve **13**. The attenuative liquid within the center of the sleeve **13** immerses the helical delay-line and transition section in the wave energy attenuative liquid, thereby greatly attenuating the wave energy on the helical portion of the center conductor **11**.

In the typical example of a coaxial water load **1**, for use in the UHF band from 450 MHz. to 900 MHz., the inner conductor **11** has a diameter of three-sixteenths of an inch which tapers over a 6-inch length to a helix of an outside diameter of 1 inch with a pitch of five-sixteenths of an inch. The attenuation for wave energy within the delay line section **18** is approximately 0.94 db. per inch. Thus, a section 5.3 inches long yields 5 db. for wave energy traveling in one direction. The teflon sleeve has an outer diameter of 2.0 inches and an inside diameter of 1.285 inches and the outer conductor **12** has an inside diameter of 3 inches.

In an alternative embodiment, not shown, the inside diameter of the teflon sleeve **13** is bored to a larger diameter in the delay line section **18** since the dielectric sleeve structure **13** is not required in this region for impedance matching purposes. The diameter of the helix in the loss section would then be increased to the inside diameter of the bored teflon sleeve to further decrease the group velocity for wave energy traveling in the delay-line section **18**. If the helix is increased to 1.75 inches in diameter the axial length of the delay line section **18** can be reduced to 3 inches for 5 db. of attenuation for energy traveling in one direction.

Although the helix delay-line has been shown for the inner conductor **11**, it is to be understood that other types of delay lines may be employed such as topological equivalents of the helix or helix derived circuits, namely, crosswound helices, bifilar helices, ring and bar, and double ring and bar slow-wave circuits. It is also to be understood that other types of periodic loading for the center conductor may be employed such as a disc-loaded center conductor. Also, other types of delay-lines may be employed for the center conductor such as a meander line. As an alternative, the outer conductor **12** of the loss section **3** may include periodic loading members for decreasing the group velocity of wave energy traveling in the loss section **3**.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. In a load for dissipating electromagnetic energy in a transmission line into a liquid coolant, a loss section of coaxial transmission line having a portion of the inner conductor thereof comprising a delay-line portion, and means for directing a stream of wave attenuative liquid through said loss section of line in wave-energy-exchanging relation with the wave energy on said delay-line for attenuating the wave energy, whereby the physical length of said loss section is reduced for a given amount of attenuation, and further including a dielectric structure interposed in said delay-line between said inner conductor and said outer conductor, said dielectric structure having a dielectric constant substantially less than the dielectric constant of the wave-attenuative liquid to be passed through said loss section of coaxial line for reducing the dielectric loading of the loss section of the coaxial line.

2. The apparatus of claim **1** wherein said delay-line inner conductor is a helix or topologically equivalent helix.

3. The apparatus of claim **1** including a conductive end closing wall disposed at the terminal end of said loss section and interconnecting said inner delay-line and said outer conductor to provide a wave reflective termination for said loss section.

4. The apparatus of claim **1** wherein said delay-line has a portion with tapered dimensions in the direction of power flow within said loss section for gradually decreasing the axial group velocity of wave energy traveling on said inner delay-line in a direction of power flow therealong.

5. The apparatus of claim **4** wherein said inner delay-line is a helix and wherein the tapered dimension of said helix is the diameter, such diameter increasing in the direction of power flow on said helix.

6. The apparatus of claim **1** wherein said dielectric structure comprises a dielectric sleeve disposed coaxially of and surrounding said delay-line.

7. The apparatus of claim **1** wherein said means for directing a stream of wave attenuative liquid through said loss section includes means for immersing said delay-line in the stream of wave attenuative liquid.

8. The apparatus of claim **1** including a liquid-impervious dielectric wave-permeable structure sealed across said loss section of coaxial line between said inner conductor and said outer conductor at the wave energy input end of said loss section for partitioning an attenuative liquid-filled portion of said loss section from an input coaxial-line section to be connected to the input end of said loss section.

9. The apparatus of claim **8** wherein said dielectric partitioning structure is a disc, and including inductive reactive means disposed at said disc for impedance-matching said disc to said liquid-filled loss section.

10. The apparatus of claim **1** wherein said liquid-filled loss section of coaxial line proximate said partitioning wave-permeable structure is dimensioned to have a characteristic impedance when filled with attenuative liquid which is substantially equal to the characteristic impedance of said coaxial line proximate the side of said partitioning wave-permeable structure opposite to said liquid-filled side to provide a broadband substantially wave-reflectionless transmission line transition to said liquid-filled loss section.

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