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KUNIHIRO SUETAKE ET AL  
TERMINATION FOR ULTRA-HIGH-FREQUENCY  
AND MICROWAVE TRANSMISSION LINES

3,560,889

Filed Aug. 25, 1969

3 Sheets-Sheet 1

*Fig. 1*

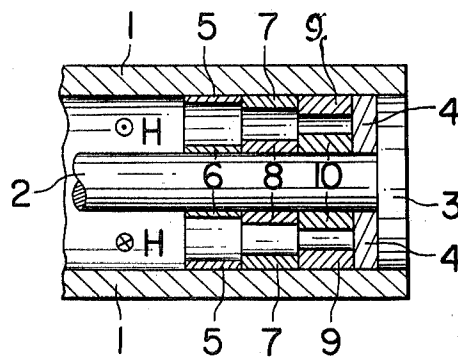
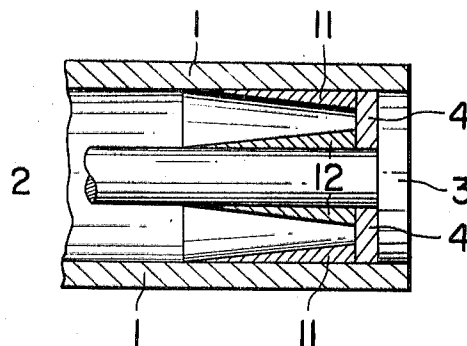


*Fig. 2*



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**Fig. 3**

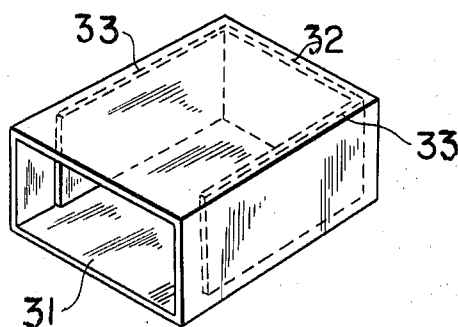
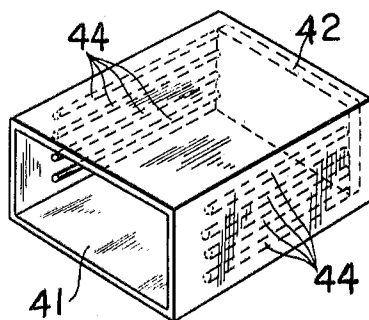


**Fig. 4**



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**Fig. 5**

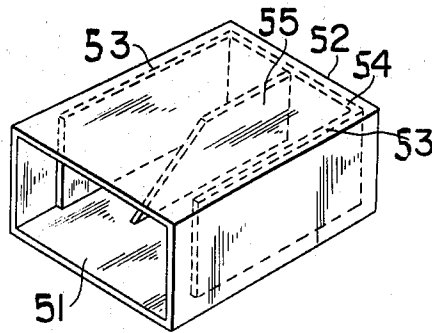


**Fig. 6**

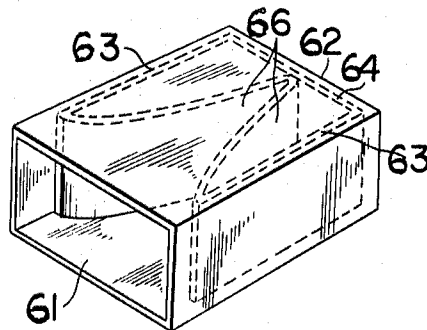
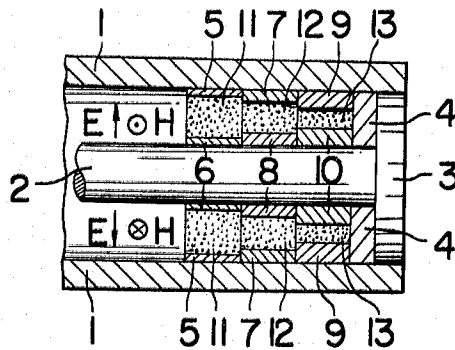


**Fig. 7**



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## TERMINATION FOR ULTRA-HIGH-FREQUENCY AND MICROWAVE TRANSMISSION LINES

Kunihiro Suetake, 11 10-ban, Minami 3-chome, Meguro-ku, Tokyo, Japan, and Yasutaka Shimizu, 2969 Oaza, Iiyama-shi, Nagano-ken, Japan

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7 Claims

### ABSTRACT OF THE DISCLOSURE

A termination for ultra-high-frequency and microwave transmission lines comprising magnetic material. For coaxial transmission lines, the termination comprises a toroidal magnetic member adjacent the shunt end-plate and cylindrical magnetic members disposed between the inner and outer conductors. For waveguides, magnetic material is disposed adjacent to both the walls of the waveguide and terminating end-plate. The termination for waveguides may also include a tapered resistive film or a V-shaped resistive film.

### BACKGROUND OF THE INVENTION

The invention relates generally to terminations for ultra-high-frequency and microwave transmission lines and, more particularly, to a termination for a transmission line such that the reflective wave is minimal over a wide band of frequencies and said termination is impedance-matched to the transmission line.

In the prior art, a resistive element is primarily used for attenuation in the termination of microwave circuits, but such elements have several undesirable defects. For instance, in the case of using resistive films, surface impedance of one side depends on the impedance of the other side. Therefore, the effect of the impedance of the back side cannot be neglected. The size of the termination, to achieve proper impedance-matching, has to be rather long. An undesirably long length of termination is required if one wishes to attain a good frequency characteristic with total attenuation and wave reflection at a bare minimum. The terminations of the prior art are of unsatisfactorily narrow band width. Finally, the characteristics of the entire transmission line are degraded by heating in high power transmission.

### SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide an impedance-matched termination for ultra-high-frequency and microwave transmission lines that is capable of being used in a high power transmission system without appreciable heating.

It is another object of the present invention to provide an impedance-matched termination for ultra-high-frequency and microwave transmission lines of short length.

It is a further object of the present invention to provide an impedance-matched termination effective over a wide band of frequencies.

Briefly stated, the present invention comprises a termination for ultra-high-frequency and microwave transmission lines, said termination including magnetic material adjacent both an end-plate of said transmission line and at least a portion of the side walls of said transmission line.

### BRIEF DESCRIPTION OF THE DRAWINGS

While the specification concludes with claims particularly pointing out and distinctly claiming the subject mat-

ter which is regarded as the invention, a preferred embodiment is disclosed in the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a side elevation view, partially in cross section, of a first embodiment of the present invention as applied to a coaxial transmission line;

FIG. 2 is a side elevation view, partially in cross section, of a second embodiment of the present invention as applied to a coaxial transmission line;

FIGS. 3, 4, 5 and 6 are isometric projections of four embodiments of the present invention as applied to waveguides;

FIG. 7 is a side elevation, partially in cross section, of a third embodiment of the present invention as applied to coaxial transmission lines.

### DETAILED DESCRIPTION OF THE INVENTION

With reference to the drawings, FIG. 1 shows the cross-sectional termination's view for a coaxial transmission line embodying the principles of this invention. Said termination comprises an outer conductor 1 of the coaxial transmission line, an inner conductor 2 thereof, a shunt end-plate 3, a toroidal member 4 of magnetic material adjacent to said shunt end-plate 3, cylindrical magnetic members 5, 7 and 9 adjacent to said outer conductor 1 and cylindrical magnetic members 6, 8 and 10 adjacent to said inner conductor 2.

The electromagnetic waves are attenuated by magnetic members 5 through 10 since the electromagnetic field within the coaxial transmission line includes a ringlike magnetic field, as shown in FIG. 1. Furthermore, if the shape of the magnetic members is rather thin in the front of the load and thicker toward the back, the electromagnetic field of the wave is attenuated more and more until it is substantially absorbed by the toroidal magnetic member 4. Therefore, the band width of matched frequency is very wide in this case.

FIG. 2 illustrates an embodiment of the present invention slightly modified over that shown in FIG. 1; however, the same reference numerals denote the same member parts as in FIG. 1.

In this embodiment, coaxial termination includes tapered cylindrical magnetic members 11 and 12, so that the termination is effected over a wider band of frequencies.

While in the embodiments shown in FIGS. 1 and 2, magnetic members are arranged adjacent to both inner and outer conductors, matched termination can be attained even though one of said members is omitted. In particular, when the magnetic member is arranged only in the outer conductor 1, cooling is easily carried out from outside and so it may be used in high power transmission lines.

Above described embodiments relate only to coaxial transmission lines, but wide band matched terminations can be obtained by disposing thin layers of magnetic material on the wall surface of the waveguides, such as rectangular and circular waveguides strip lines.

For instance, the matched termination of a rectangular waveguide is formed by disposing the thin layers 32 and 33 of magnetic material in said waveguide, as shown in FIG. 3.

FIG. 4 shows still another embodiment of this invention, wherein magnetic rods are substituted for the thin layer 33 of FIG. 3, on the basis of the principle that the attenuation is achieved by the magnetic members disposed parallel to the magnetic field.

As clearly illustrated in above description, a termination for a wide band of frequencies is obtained by a simple structure. The magnetic members are closely adjacent to the wall of the waveguide, so that water or air

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cooling is easily carried out from outside and its characteristics are not deteriorated, even if used in high power transmission.

FIG. 5 shows another embodiment of this invention, wherein rectangular waveguide 51 includes a shunt plate 52, a magnetic member 53 adjacent to wall of the waveguide 51, a magnetic member 54 adjacent to said shunt plate 52 and a tapered resistive film 55.

It is well known that an excellent matched termination is obtained by arranging a tapered resistive film parallel to the electric field in the center of a rectangular waveguide. However, it is recognized that use of such a film exclusively requires a termination of undesirable length. If, in accordance with the present invention, magnetic members are disposed adjacent to the walls of the waveguide and the shunt plate, as shown in FIG. 5, attenuation is achieved by both the resistive film and the magnetic members. Therefore, matching characteristics become better and the length of the waveguide can be appreciably shortened.

FIG. 6 shows still another embodiment of the present invention, wherein a resistive film is also used. In FIG. 6, reference numerals 61 through 64 denote the same parts as numerals 51 through 54 in FIG. 5, except that a V-shaped resistive film 66 is used instead of the tapered resistive film 55 of FIG. 5.

The magnetic members 54, 64 adjacent to the shunt end-plate in FIGS. 5 and 6 may be omitted, and the matched termination without the members 54, 64, respectively, is shorter and better than the conventional matched termination which has a resistive film in a waveguide.

FIG. 7 shows still another embodiment of this invention as applied to a coaxial line, wherein the termination is comprised of magnetic members and a dielectric attenuation member. In FIG. 7, a coaxial line includes an outer conductor 1, an inner conductor 2, a shunt end-plate 3, a toroidal magnetic member 4 adjacent to said shunt plate 3, cylindrical magnetic members 5, 7 and 9 adjacent to said outer conductor 1, cylindrical magnetic members 6, 8 and 10 adjacent to said inner conductor 2, and dielectric attenuative members 11, 12 and 13.

When an electromagnetic field, as shown in FIG. 7, is applied to this coaxial line, the magnetic attenuation members 4 through 10 are effective for the magnetic field H, and the dielectric attenuation members 11 through 13, for the electric field E. The matched termination has the multistep structure, as shown in FIG. 7, so that attenuation becomes gradually larger as the wave travels forward into the termination. Therefore, the frequency characteristic of this termination is much improved over the known termination structures.

While the embodiment of FIG. 7 relates to a coaxial line, it is clear that the principle can be applied to waveguides of other types. In the embodiment of FIG. 7, attenuation can be achieved by both electric and magnetic fields, so that the termination structure is much shorter and has wider variety of applications.

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Although particular embodiments of the present invention have been shown and described, it will be appreciated that numerous changes and modifications will occur to those skilled in the art. It is, therefore, intended in the appended claims to cover all such changes and modifications that fall within the true spirit and scope of this invention.

What is claimed is:

1. A termination for ultra-high-frequency and microwave transmission lines, said termination comprising an end-plate and side walls contiguous therewith and thin magnetic resistance sheets positioned adjacent said end-plate and at least a portion of said side walls parallel to the magnetic field.

2. A termination, as defined in claim 1, wherein said transmission line comprises a coaxial line having an inner conductor and a coaxial outer conductor in spaced relation, said termination including a toroidal magnetic member juxtaposed said end-plate, at least one cylindrical magnetic member coaxial with and next adjacent said inner conductor, and at least one cylindrical magnetic member next adjacent to and within said outer conductor.

3. A termination, as defined in claim 2, wherein dielectric material is positioned between said at least one cylindrical magnetic member contiguous with said inner conductor and said at least one cylindrical magnetic member contiguous with said outer conductor.

4. A termination, as defined in claim 1, wherein said transmission line comprises a waveguide, said termination including a layer of thin magnetic resistance sheets disposed adjacent said end-plate and magnetic material disposed adjacent at least a portion of said side walls parallel to the magnetic field.

5. A termination, as defined in claim 4, wherein the thin magnetic resistance sheets on the side walls comprise a plurality of individual strips parallel to and spaced apart from each other.

6. A termination, as defined in claim 4, wherein a tapered resistive film is positioned within said termination in spaced relation with said side walls.

7. A termination, as defined in claim 4, wherein a V-shaped resistive film is positioned within said termination in spaced relation with said side walls.

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HERMAN KARL SAALBACH, Primary Examiner

M. NUSSBAUM, Assistant Examiner

U.S. Cl. X.R.

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