Oct. 31, 1950 H. J. SCHLAFLY, JR 2,528,248

WIDE BAND FLEXIBLE SECTION FOR WAVE GUIDES

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Fig.1.

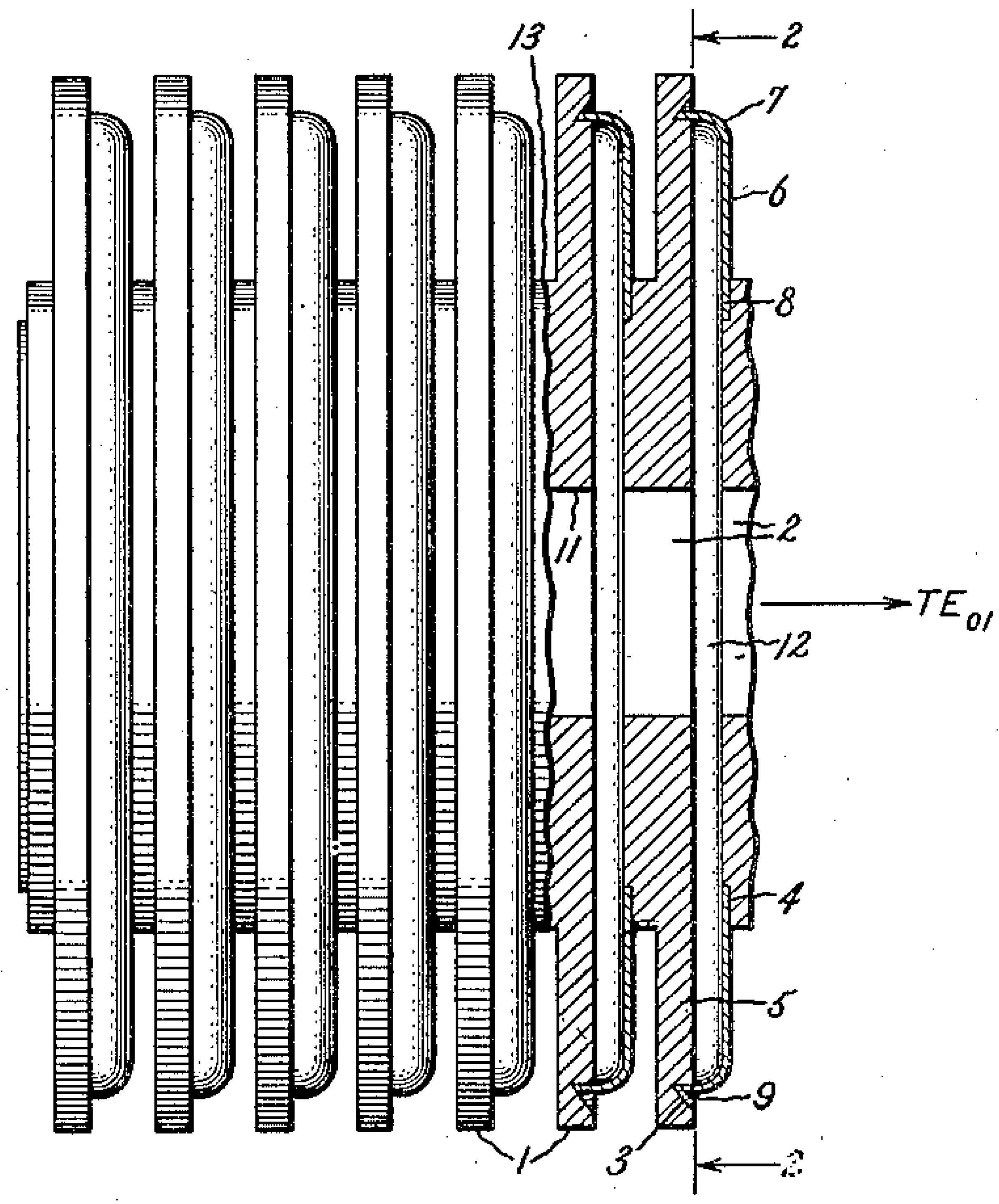
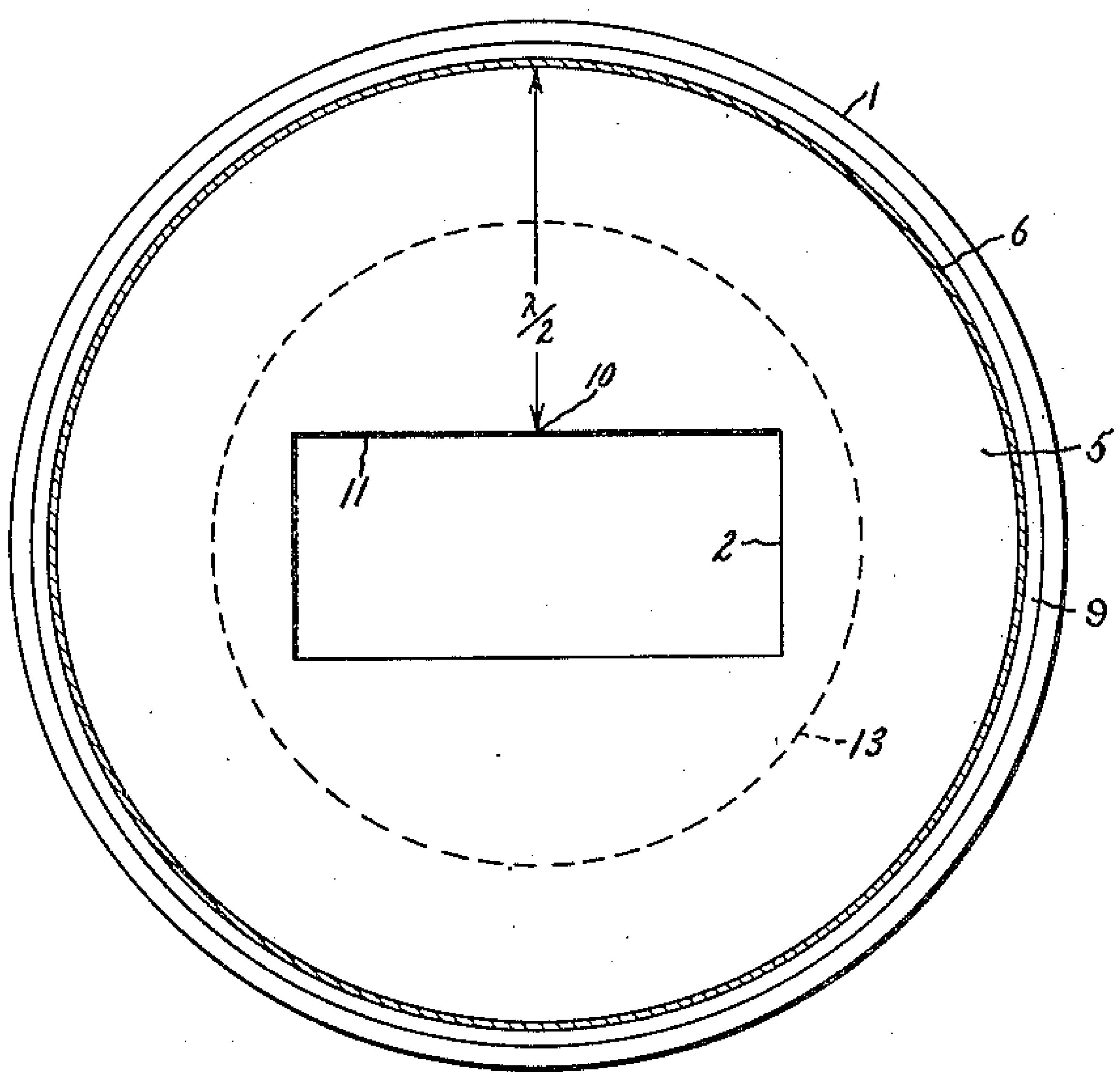


Fig.2.



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WIDE BAND FLEXIBLE SECTION FOR WAVE GUIDES

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6 Claims. (Cl. 178—44)

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My invention relates to dielectric wave guides of the hollow pipe type used for transmission of ultra high frequency energy and, particularly, to a flexible section for use in such guides.

It is known in dielectric wave guide systems used for the propagation of electromagnetic waves that, when adjacent sections of the guide are not axially aligned, reflections of the electromagnetic waves are set up which affect undesirably the transmission of power through the guide. It is desirable, therefore, especially in systems which employ wave guides for transmitting ultra high frequency waves from a transmitter to an oscillating or rotating antenna, to be able to use hollow pipes throughout without resorting to the expedient of converting to either a different mode or type of electromagnetic wave for propagation through the hollow pipe or of converting from the wave guide system to a coaxial or concentric transmission line system where each plane of freedom or rotation requires a separate set of conversions. Accordingly, it is an object of my invention to provide a new and improved flexible section for a wave guide of the hollow pipe type.

It is another object of my invention to provide a new and improved flexible section for a wave guide of the rectangular hollow pipe type.

It is a further object of my invention to provide a new and improved flexible section for a wave guide of the hollow pipe type in which large angular movement is permitted for a very short length of the wave guide.

It is a further object of my invention to provide a new and improved flexible section for a wave guide of the hollow pipe type which is operable over a wide range of ambient temperatures and in which leakage of ultra high frequency power is prevented.

It is a still further object of my invention to provide a new and improved construction for a flexible section for a wave guide of the hollow pipe type in which all critical dimensions can be accurately established and maintained under all conditions of flexing.

It is a still further object of my invention to provide a new and improved flexible section for a wave guide of the rectangular hollow pipe type which permits hermetic sealing and operation of the section over a wide range of pressures without distortion of the critical dimensions of the wave guide.

One of the features of my invention is the forming of a flexible section of a wave guide comprising a plurality of closely spaced metallic

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disks having aligned, centrally positioned, rectangular openings therethrough and the use of a flexible metallic collar positioned between adjacent ones of the disks and so connected to opposing faces of the adjacent disks at points spaced from the rectangular openings that the disks and the collar form a half wave length section of radial transmission line short-circuited at its end remote from the openings in the disks so that substantially no discontinuities in conductance are introduced along the inner edges of the disks.

For a better understanding of my invention, reference may be had to the following description taken in connection with the accompanying drawing and its scope will be pointed out in the appended claims. Fig. 1 diagrammatcially illustrates an embodiment of the invention as applied to a dielectric wave guide of the rectangular hollow pipe type in which a plurality of half wave chokes is employed; and Fig. 2 is a sectional view of the flexible section of Fig. 1 taken along the line 2—2.

Referring to Figs. 1 and 2 jointly, there is shown a flexible section for a dielectric wave guide of the rectangular hollow pipe type and through which electromagnetic waves, for example of the transverse electric type and shown in the drawing as TE_{01} waves, are propagated. The flexible section comprises a plurality of closely spaced transverse substantially rigid metallic disks 1, each of which is provided with a centrally positioned rectangular opening 2 suitable for transmission of transverse electric waves therethrough. The central rectangular holes of successive disks are so aligned that the first disk of the section is aligned with the last disk within one degree of variation. On one of its faces, each of the disks is provided with a circular notch or groove 3 and on its opposite face with a circular shoulder 4 and a portion of reduced thickness 5 near the outer edge thereof. A flexible circular metallic collar member 6, which is positioned between adjacent ones of the disks 1 and which is curved near its outer edge at the point 7, has its inner edge 8 fitting into the shoulder 4 of one of the adjacent disks and its outer edge 9 fitting into the natch 3 of the other of the adjacent disks. Preferably, the disks 1 are made of a good conductive material, such as brass, and the collar or metallic spinning 6 is made of a good conductive material which is likewise flexible, such as beryllium copper or phosphor bronze. The collar 6 is hermetically sealed to adjacent ones of the disks at its edges 8 and 9, as by brazing to the shoulder 4 and by soldering to the notch 3. The flexibility of the spring metal of which the collar 6 is formed permits a substantial angular displacement between adjacent ones of the disks 1. When a substantial number of these sections are joined together, as shown in Fig. 1, the total angle of bending will be the summation of angles between the individual sections and the resultant flexible section provides a large angular movement for a very short length of the wave guide.

In constructing a flexible section of the type described for use with a wave guide for transmitting an electromagnetic wave of a desired frequency, the mean length of the disk 1 between points on the notch 3 therein and the mid point 10 along a leg of the rectangular opening 2 is made equal to an effective half wave length in this radial cavity at this desired operating frequency. The connection of the collar 6 to the disk 1 in the groove 3 functions as a short-circuit at the end of the radial cavity or transmission line formed between the opposed surfaces of two adjacent disks 1 and the collar 6. This short circuit is effectively a half wave length from the inner edge 11 of the opening in the disk. According to well-known transmission line theory, the short-circuit at the point of connection of the edge 9 and the collar 6 in the groove 3 of disk 1 is reproduced across the gap 12 between the surfaces 11 of two adjacent disks so that substantially zero impedance is encountered across gap 12. The discontinuity in the wave guide structure caused by the gap 12, therefore, appears to be an electrical short-circuit and electromagnetic power propagated in the wave guide is not disturbed by the presence of the radial cavity formed between two adjacent disks.

The flexible wave guide section may be so constructed that the radial cavities between adjacent disks 1 occur at definite predetermined intervals along the wave guide, these intervals being so spaced that the reflection which occurs because of mismatching of conductances at any one cavity is wholly or partially compensated or cancelled by the mismatch of an adjacent cavity. In this manner, it is possible to reduce the effect of slight mismatching throughout the length of the section and the flexible section as a whole has an improved broad band pass characteristic. It is apparent, of course, that for all waves propagated therethrough the wave guide section provides a completely enclosed metallic construction which prevents leakage of any ultra high frequency power, as well as permits hermetic sealing in operation at pressures other than atmospheric pressure without substantial distortion of the flexible walls.

An important advantage of the flexible wave guide construction shown is that all the critical dimensions of the wave guide opening 2, as well as the distances between the walls of this opening and the groove 3, may be accurately machined. The solid construction of the metallic disk 1 maintains the critical dimensions of the cavity formed between the adjacent disks under all conditions of flexing of the collar member 6. The portion 5 of each disk between the outer edge thereof and the shoulder 13 facilitates flexing of the members 6. It is apparent, moreover, that, while the structure has been shown as applied to a flexible section for a wave guide of the rectangular hollow pipe type, wave guides of any other configuration may be used. Thus, the structure is particularly adapted for use with circular wave guides in which case the dimension

of the central opening in the disk member 1 may be spaced exactly a half wave length away from the short-circuit at the groove 3.

While the invention has been described by reference to a particular embodiment thereof, it will be understood that numerous modifications may be made by those skilled in the art without departing from the invention. I therefore aim in the appended claims to cover all such equivalent variations as come within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A flexible section for a wave guide of the rectangular hollow pipe type comprising a plurality of closely spaced metallic disks, each of said disks having substantially planar parallel faces extending outwardly from its axis, the opposed faces of adjacent disks being arranged in substantially parallel relation with a dielectric gap therebetween, flexible metallic members affixed to adjacent ones of said disks, said disks having centrally positioned rectangular apertures through which electromagnetic waves may be propagated, said adjacent ones of said disks and the flexible members affixed thereto forming a section of radial transmission line, and the length of said line being correlated with respect to the frequency of said waves to present a low impedance path for said waves across said gap.

2. A flexible section for a wave guide of the rectangular hollow pipe type comprising a plurality of substantially rigid metallic disks having aligned, centrally positioned, rectangular openings therein, flexible, circular metallic members having a central aperture larger than said rectangular opening, said members having inner and outer edges sealed respectively to opposing faces of adjacent ones of said disks to form a sealed enclosure therebetween, the radial distance between said outer edge and the longer leg of said rectangular opening at the mid point thereof being effectively equal to a half wave length of the electromagnetic wave propagated through said guide.

3. In a dielectric wave guide system of the rectangular hollow pipe type, a flexible section therefor comprising a plurality of closely spaced transverse metallic disks having aligned, centrally positioned, rectangular openings therethrough, a flexible metallic collar having a central aperture substantially larger than said openings positioned between adjacent ones of said disks, said collar having inner and outer edges connected respectively to the opposing faces of said adjacent disks, the radial distance along each of said disks between the edge of the opening therein and the point of connection of the outer edge of the collar associated therewith being of the order of a half wave length at the frequency of the wave propagated through said guide.

4. A flexible section for a wave guide of the hollow pipe type comprising a plurality of closely spaced transverse metallic disks having aligned, centrally positioned, openings therethrough, a flexible metallic collar positioned between adjacent ones of said disks, said collar having inner and outer edges connected respectively to the opposing faces of said adjacent disks, each of said disks being of reduced thickness between the outer edge thereof and the point of connection of said inner edge therewith to permit substantial angular movement between said adiacent disks.

5. A flexible section for a wave guide compris-

ing a pair of spaced rigid metallic disks and an interposed flexible metallic disk having a common axis, said flexible and rigid disks each comprising a pair of substantially planar parallel faces extending outwardly from said axis, the opposed faces of adjacent disks being arranged in substantially parallel relation with a dielectric gap therebetween, said flexible disk having an outer edge connected to one disk of said pair of disks and an inner edge connected to the other disk of said pair of disks, all of said disks having aligned central apertures of a configuration adapted to transmit an electromagnet wave supplied thereto.

6. A flexible section for a wave guide comprising a pair of spaced rigid metallic disks and an interposed flexible metallic disk having a common axis, said flexible and rigid disks each comprising a pair of substantially planar parallel faces extending outwardly from said axis, the opposed faces of adjacent disks being arranged in substantially parallel relation with a dielectric gap therebetween, said flexible disk having an outer edge connected to one disk of said pair of disks and an inner edge connected to the other disk of said pair of disks, all of said disks having aligned central apertures, the configuration of said apertures and the distance between said apertures and said outer edge being correlated to the frequency and mode of an electromagnetic wave supplied thereto to effect substantially reflectionless transmission of said wave.

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