Oct. 31, 1950 H. A. IAMS 2,528,367

RADIO WAVE CONDUCTING DEVICE

Filed March 9, 1946 2 Sheets-Sheet 1

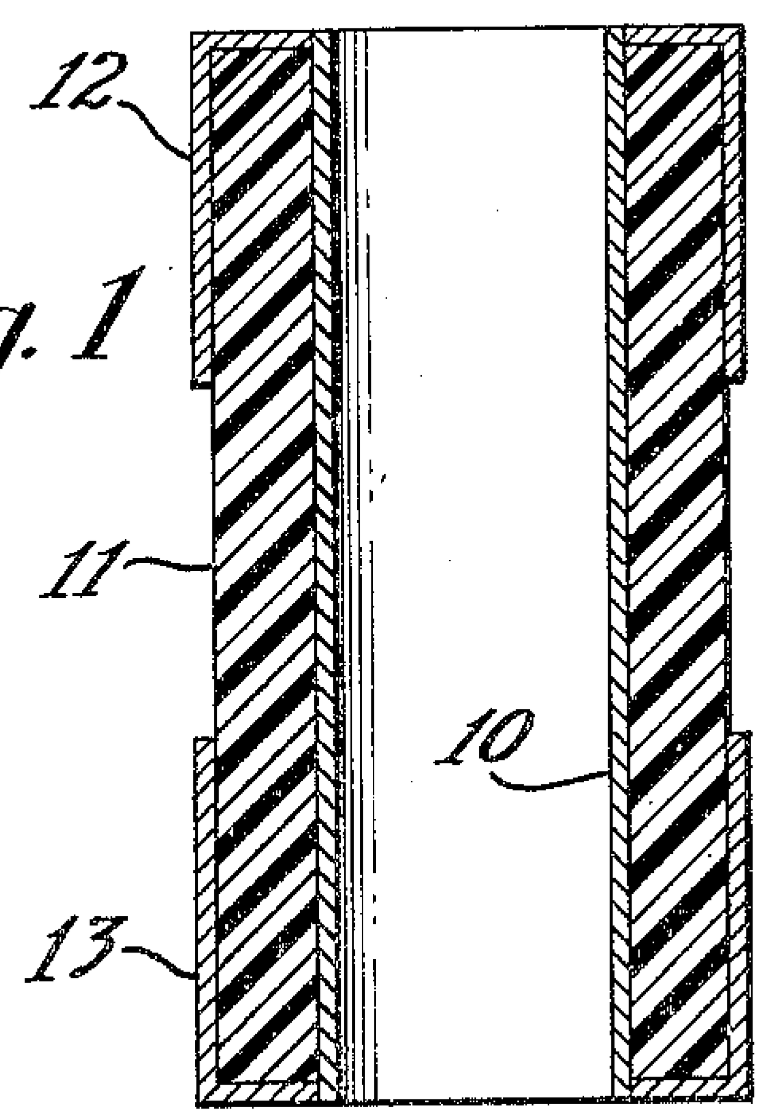


Fig. 1

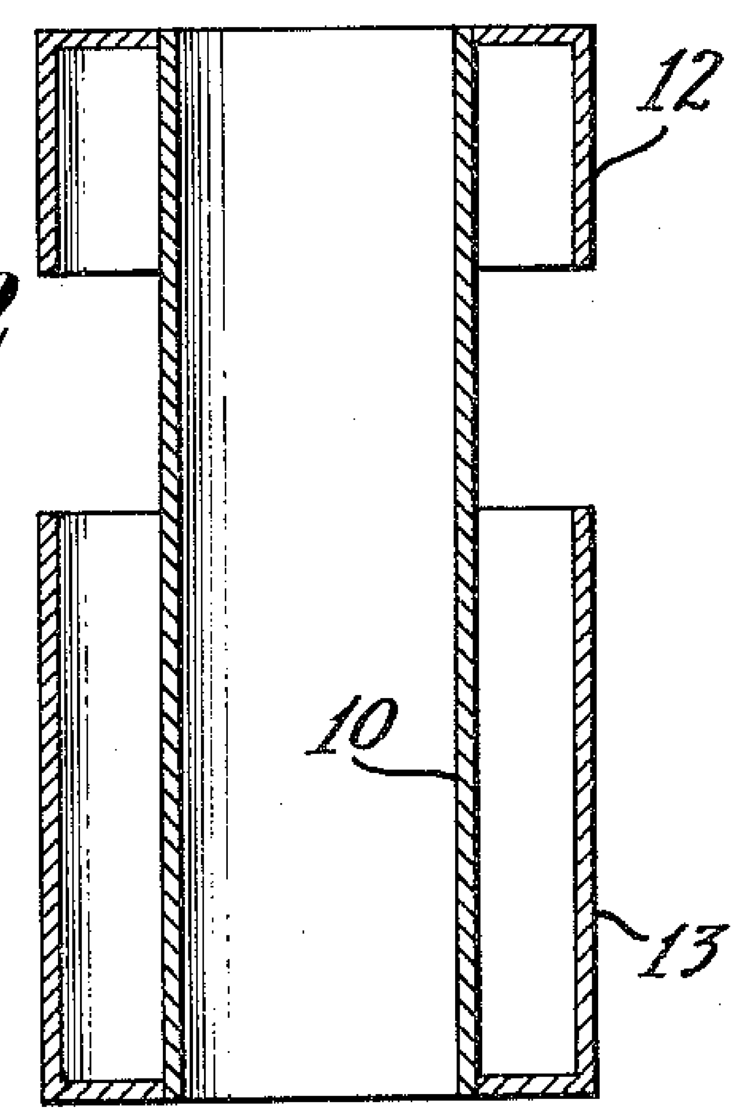


Fig. 2

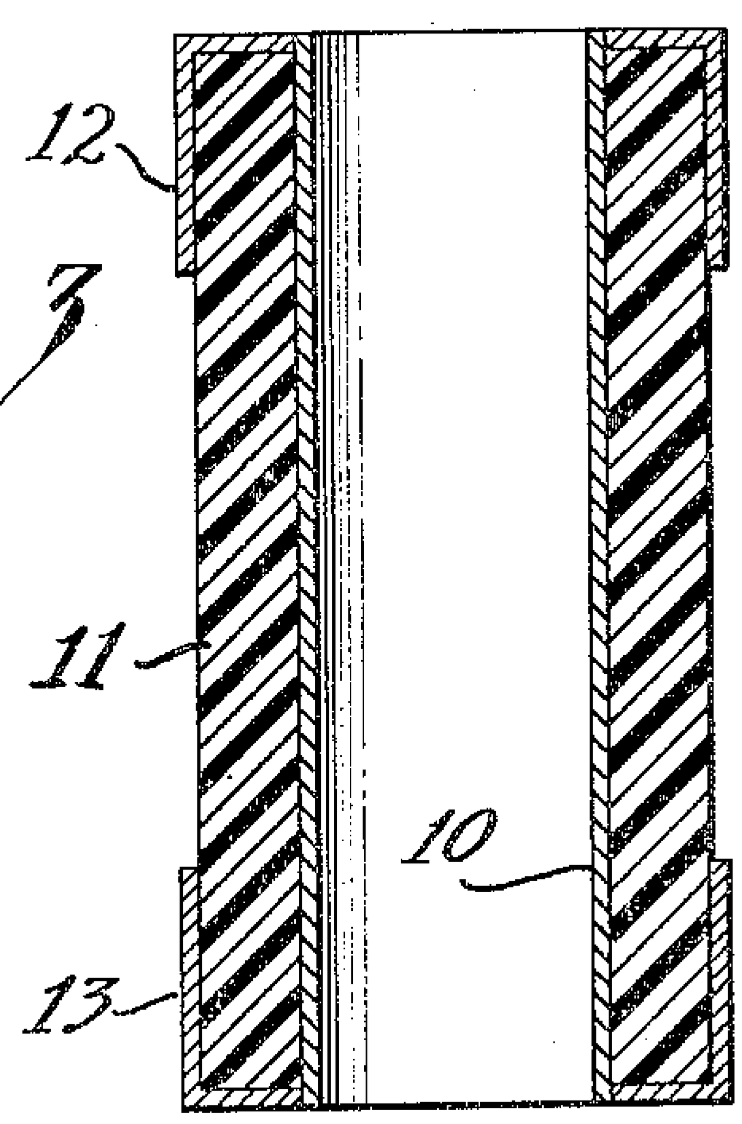


Fig. 3

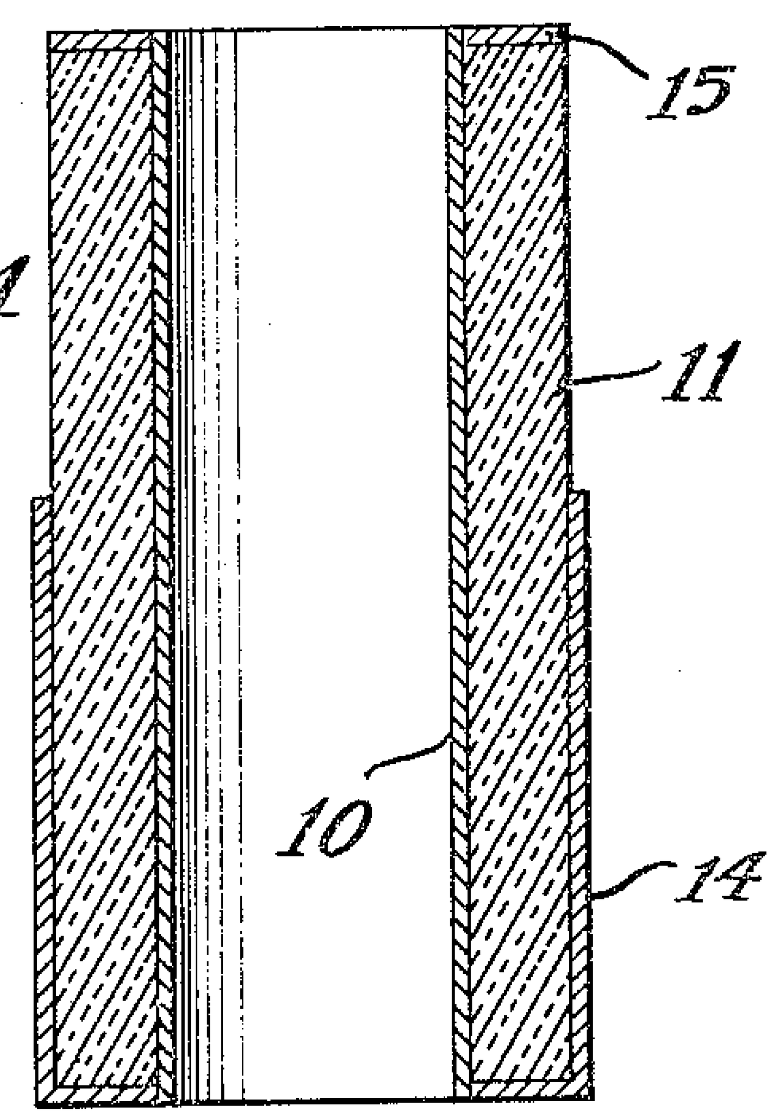


Fig. 4

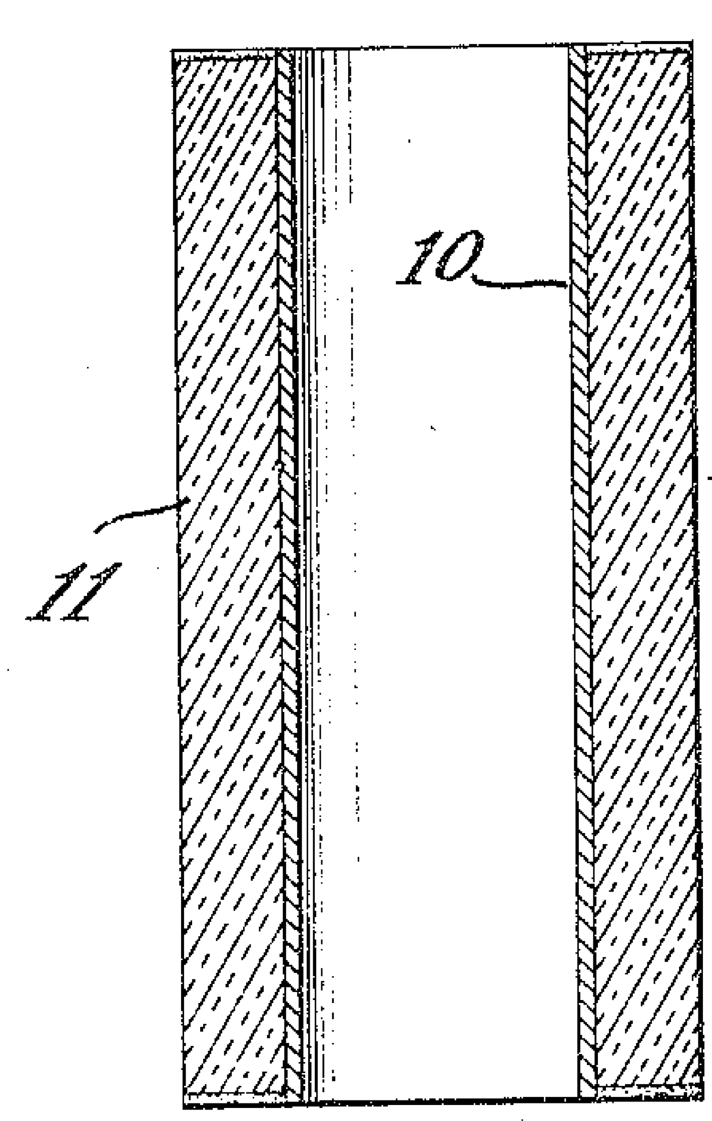


Fig. 5

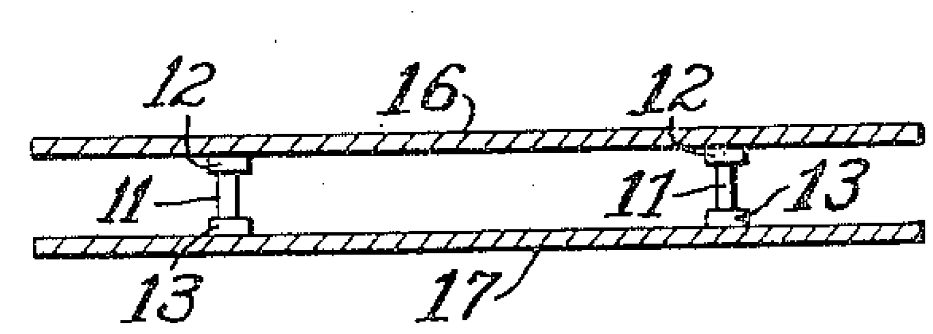


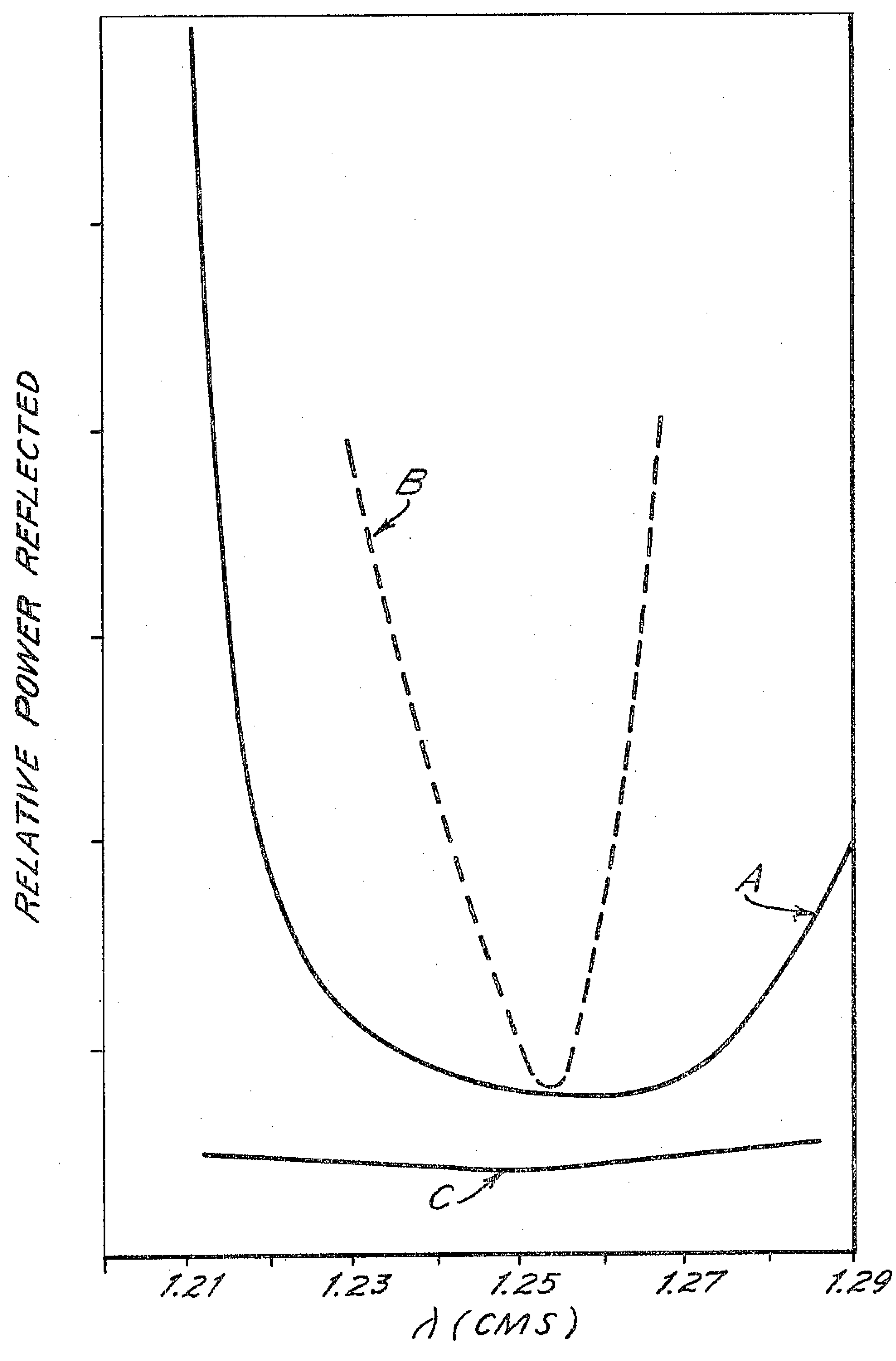
Fig. 7

INVENTOR.
Harley A. Iams
BY [signature]
ATTORNEY.

RADIO WAVE CONDUCTING DEVICE

Filed March 9, 1946 2 Sheets-Sheet 2

Fig. 6



INVENTOR.
Harley A. Iams
BY C. D. Tuska
ATTORNEY.

Patented Oct. 31, 1950 2,528,367

UNITED STATES PATENT OFFICE

2,528,367

RADIO WAVE CONDUCTING DEVICE

Harley A. Iams, Princeton, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Application March 9, 1946, Serial No. 653,258

3 Claims. (Cl. 178—44)

1

This invention relates to radio wave conducting devices such as are useful for focusing, guiding or otherwise controlling the transmission or reception of radio waves having a length of the order of one centimeter or less. It relates more particularly to the provision of means which are effective to maintain a desired spacing between the conductive sheets of such devices without producing undue interference with the power transmitted between the sheets.

In certain radio wave devices, such as beam focusing and deflecting apparatus, parallel metal sheets spaced less than one-half wave length apart are used to confine and direct the radiation. While the spacing of these sheets is not very critical, it is necessary that contact between the sheets and very wide spacing between them be avoided. Also it is desirable that the resulting construction be rigid and light in weight.

The use of spacers between the sheets substantially improves the construction, especially when there are areas of several square feet to be spaced apart by a distance which is a small fraction of an inch. However, when such spacers are simple conducting rods, the currents flowing over them produce reradiation or scattering of the power transmitted between the sheets. When the spacers are insulators, reradiation is also produced by the charging current through them. At wavelengths of 3 centimeters and longer, certain all-metal spacers including a central rod and an outer skirt are known to be effective in reducing these undesired effects. For shorter wave lengths, the dimensions of spacers of this type become so small that the spacer affords very little mechanical support.

The present invention provides a spacer which has the required mechanical strength and is effective over a greater band width than those heretofore proposed. It is particularly effective in the case of wavelengths of 1¼ centimeters and less and is easily fabricated. In general, it includes a central metal core which is resonated by surrounding it with a dielectric sleeve. When this combination is properly tuned, it looks like a high impedance in parallel with the low impedance of the metal sheets so that very little reflection is produced by the spacers.

Important objects of the invention are the provision of an improved means for spacing the conductive sheets of a radio wave conducting device, the provision of a conductive sheet spacing element having its different parts so arranged as to form a resonant circuit whereby scattering of

2

the power transmitted between the sheets is minimized, and the provision of a conductive sheet spacing element wherein a central metal core and a dielectric sleeve surrounding it are so disposed as to present a minimum of obstruction to the passage of a radio wave between the conductive sheets.

The invention will be better understood from the following description considered in connection with the accompanying drawings and its scope is indicated by the appended claims.

Referring to the drawings, Figure 1 illustrates the basic design of the improved spacer,

Figure 2 illustrates a variation of Figure 1 using air for a dielectric,

Figure 3 illustrates a spacer in which the dielectric sleeve is a phenolic compound,

Figure 4 illustrates an unsymmetrical spacer in which the dielectric sleeve is of polystyrene,

Figure 5 illustrates a form of spacer in which the dielectric constant of the dielectric sleeve is made high enough that no conductive cups at its ends are required to produce the required tuning,

Figure 6 is a group of curves showing the relative merits of different types of spacers, and

Fig. 7 is a sectional view of a wave guide showing spacers like those of Fig. 3 interposed between the metal sheets 16 and 17 of which this wave guide is formed.

In the basic type of spacer illustrated by Figure 1, there is a central rod, or member, preferably a good conductor, such as a piece of metal tubing 10 through which a machine screw may be passed for clamping the conductive sheets (not shown) to the ends of the spacer. This tube may be considered as an inductance between the sheets. Surrounding the tube 10 is a dielectric sleeve 11 which reinforces the tube 10 to provide greater mechanical strength and serves to reduce reflection of the transmitted wave. The sleeve 11 may be regarded as a capacitance in shunt with the inductance of the tube 10 by which the two are tuned to present a high impedance to the currents which tend to flow in them and produce scattering of the transmitted power. The spacer also may be provided with metal caps or skirts 12 and 13 which function to adjust the tuning to the required frequency.

The over-all length of the spacer should be such as to provide the required spacing between the metal sheets. In the example illustrated by Figure 1, the length was 0.235 inch and the wave length was 1¼ centimeters. The diameter of the tube 10 should be large enough to pass the desired machine screw but otherwise as small as possible in order to keep the inductance high so that the shunt impedance will be high at resonance. In the example illustrated by Figure 1, the outside diameter of the tube 10 was 0.070 inch and its wall thickness was 0.002 inch which passes a No. 0–80 machine screw. The dielectric sleeve 11 should consist of a material which is reasonably strong mechanically and has relatively low losses. Common materials such as polystyrene, phenolic compound, glass and ceramics are satisfactory.

Having selected the central tube 10 and the dielectric 11 to be used, tuning of the combination to the desired wavelength may be done by adjusting the outside diameter of the dielectric sleeve. The required outside diameter may be computed crudely by determining the inductance of the tube 10, computing the capacitance required to produce resonance at the given frequency and determining the diameter of the dielectric sleeve required to produce the needed capacitance. Actually, because of fringe fields, it is better to determine the proper diameter by a cut and try method.

The usual result of such a determination is to find that the outer diameter of the spacer should be made larger than ¼ the wavelength. This is frequently the case when the central tubing is larger than ⅛ the wave length in diameter and the dielectric constant of the insulator is less than 6. It is found that a spacer having a diameter much larger than ¼ of the wavelength may reflect very little power in one direction and yet considerable power in another direction. In order to make the reflection uniformly small, the outside diameter of the spacer should not be much greater than ¼ the wavelength. Consequently it is desirable to make the outside diameter of the dielectric sleeve about ¼ wavelength and to add any needed capacitance by means of the metal skirts 12 and 13.

It is found that two metal skirts of equal length make the spacer effective over a broader band of frequencies than when only one skirt is used and the metal extends over one of the ends as indicated at 15 in Fig. 4 or when the sleeves are of unequal length as in the case of the spacers of Figure 2, for example. Here too, the exact dimensions are best determined experimentally. The skirt length is greatest when the dielectric is air and becomes less as the dielectric constant of the material in the dielectric sleeve increases. For example, the spacer of Figure 5 includes a dielectric sleeve which is made of polystyrene with a suspension of titanates so that it has a a dielectric constant of 25, thus eliminating the need of the skirts 12 and 13.

Assuming that the spacer of Figure 1 is to be tuned to present a high impedance at a wave length of 1.25 centimeters, that the outside diameter of its dielectric sleeve is 0.125″, that the outside diameter of its central tube is 0.070″, that its over-all length is 0.235″ and that the thickness of the skirts 12 and 13 is 0.005″, it is found that the length of the skirts 12 and 13 should be (1) 0.065″ for polystyrene, (2) 0.057″ for phenolic compound, (3) 0.051″ for heat resistant glass. As the dielectric constant of the sleeve 11 increases, the length of the skirts 12 and 13 become shorter eventually reaching zero after which the spacer is tuned by decreasing the outside diameter of the sleeve 11.

Figure 6 represents the band width obtained from several of the designs. In it, the relative power reflected from the spacer is plotted as a function of the wavelength of the incident radiation. This figure shows, in curve A, that the use of two skirts of unequal length (following the design of Figure 2) gives a broader band than that obtained (see curve B, Figure 6) from the single skirt spacer of Figure 4. However, the band width is still greater (curve C of Figure 6) when the skirts are of equal length, as in the design of Figure 3. Thus it is seen that several different designs of spacers may be made to have low reflection at a given frequency, but that (for most purposes) a symmetrical construction like that of Figure 3 is to be preferred.

These various types of spacers may be made in different ways. The dielectric sleeve is usually made first. Then the metal parts may be cut from flat stock and tubing and soldered in place, or the metal sleeve and end portion may be punched into a cup-shaped piece which is attached to the central tube. Alternatively, the dielectric sleeve may be coated with a film of wax, dusted with copper powder and electroplated. Also metal may be sprayed directly onto the dielectric sleeve. As a final step, the spacer may be coated with water-proof paint to keep the metal from corroding and to keep moisture from affecting the dielectric.

What the invention provides is a spacer which has greater mechanical strength and operates over a wider band of wavelengths than those heretofore provided . The characteristic features by which these results are achieved are (1) the dielectric sleeve which affords greater rigidity and (2) the symmetrical metal skirts which allow the spacer to operate over a wider wave band without undue scattering of the power transmitted between the sheets of the radio wave conducting device in which the spacers are utilized.

I claim as my invention:

1. In a device for maintaining a predetermined spacing between opposed walls which form an electromagnetic wave propagating structure and which provide a relatively low impedance to the passage of high frequency electromagnetic waves, the combination with said opposed walls of an inductive element including a conductive sleeve extending between said walls, and a capacitative element consisting of a dielectric sleeve surrounding said conductive sleeve and having a dielectric constant and an outside diameter such as to minimize the currents produced in said sleeves by the passage of said waves between said walls.

2. In a device for maintaining a predetermined spacing between opposed walls which form an electromagnetic wave propagating structure and which provide a relatively low impedance to the passage of high frequency electromagnetic waves, the combination with said opposed walls of a dielectric sleeve extending between said walls, and a conductive coating extending over the inside, one end and the outer surface of said sleeve to form on said surface a skirt of such length that said device provides a relatively high impedance in parallel with said relatively low impedance.

3. In a device for maintaining a predetermined spacing between opposed walls which form an electromagnetic wave propagating structure and which provide a relatively low impedance to the passage of high frequency electromagnetic waves, the combination with said opposed walls of a dielectric sleeve extending between said walls, and a conductive coating extending over the inside, the ends and the outer surface of said

sleeve to form on said surface at the opposite ends of said sleeve skirts of such length that said device provides a relatively high impedance in parallel with said relatively low impedance.

HARLEY A. IAMS.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,149,356	Mason	Mar. 7, 1939
2,353,952	Yerzley	July 18, 1944
2,408,420	Ginzton	Oct. 1, 1946
2,425,654	Storch	Aug. 12, 1947