Feb. 22, 1955 J. COLLARD 2,702,886

HIGH-FREQUENCY CHOKE

Filed March 21, 1950

FIG. 1.

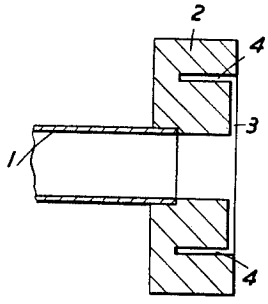


FIG. 2.

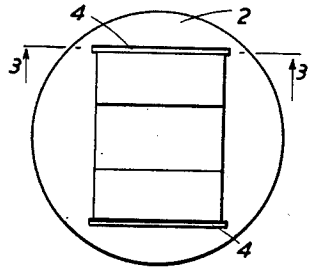


FIG. 3.

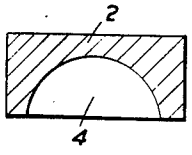


FIG. 4.

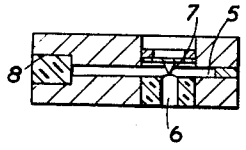
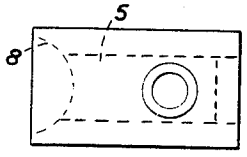


FIG. 5.



Inventor

JOHN COLLARD

By Ralph E. Atherton

Attorney

United States Patent Office 2,702,886
Patented Feb. 22, 1955

2,702,886

HIGH-FREQUENCY CHOKE

John Collard, Hammersmith, London, England, assignor to Electric & Musical Industries Limited, Hayes, Middlesex, England, a company of Great Britain

Application March 21, 1950, Serial No. 150,905

2 Claims. (Cl. 333—98)

This invention relates to high-frequency impedances.

For many purposes in high-frequency electrical apparatus it is necessary to employ an impedance element in the form of a length of hollow conductor one end of which is provided with an end wall. One example of such an impedance element is a so-called high-frequency choke which is employed in waveguide technique for the purpose of preventing or substantially reducing the escape of high-frequency energy. With waveguides when it is desired to couple together two lengths thereof, the adjacent ends of said lengths are provided with flanges which when interconnected serve to couple the two lengths together and owing to the fact that it is difficult to obtain a perfect mechanical contact between the opposing faces of the flanges it is usually the practice to provide said opposing faces with high-frequency chokes. If the waveguides are of rectangular form in cross-section then the faces of the flanges are channelled to a short depth, said channels extending in the direction of the longer sides of the waveguide in cross-section and these channels terminate in impedance elements of the above form, such impedance elements when used for this purpose being colloquially referred to as "ditches." The ditches are disposed at right-angles to said channels and the dimensions of the channels and ditches are so chosen that the ditches provide a high impedance which is transformed by said channels to a low impedance at the adjacent ends of the waveguide so that said adjacent ends appear short-circuited. Heretofore such ditches have been made of rectangular form. Whilst such ditches are satisfactory from the electrical point of view, nevertheless, the fact that they have heretofore been made rectangular introduces considerable inconvenience from the manufacturing point of view since it is difficult to make such a ditch by a simple machining operation.

The form of impedance element referred to above can also be employed as a transformer. Such transformer may be employed for matching the impedance of a waveguide to the impedance of a crystal holder, which latter consists of a length of waveguide having walls separated by only a small amount to enable the contact element of the crystal to be made very small. The transformer is effectively a portion of waveguide having its length and dimensions suitably chosen and it is convenient to form said transformer as a recess in the crystal holder the waveguide forming the crystal holder opening into the end wall of the recess. Heretofore, it has been considered necessary to make said end wall flat, but to make a recess with a flat end wall by a simple machining operation is again difficult to achieve particularly when the apparatus in which the crystal holder is employed is designed for operation at a wavelength of a few centimetres.

Unexpectedly I have found that if the recesses are made in the form of a segment of a circle, that is to say, if the bottom or end wall of each recess is formed as an arc of a circle, substantially the same electrical effect is obtained as compared with the case in which the bottom or end wall is flat. Hence, by making the recesses in the form of segments of circles as aforesaid the recesses can be made more easily since it is possible to form the recesses by a simple milling operation with a circular milling cutter.

According therefore to the present invention in high-frequency electrical apparatus an impedance element is employed consisting of a recess having the shape of a segment of a circle.

In order that the said invention may be clearly understood and readily carried into effect, the same will now be more fully described with reference to the accompanying drawings, in which:

Figure 1 is a cross-sectional view through a portion of waveguide and a coupling element employing a high-frequency impedance in accordance with the invention,

Figure 2 is an end view of Figure 1,

Figure 3 is a cross-sectional view taken along the line 3—3 of Figure 2,

Figure 4 is a longitudinal section of a crystal holder employing a high-frequency transformer in the form of a segmental recess according to the invention, and

Figure 5 is a plan view of Figure 4.

As shown in Figures 1, 2 and 3 of the drawings, the invention is applied to a well known form of coupling which is employed to connect two lengths of waveguide together. Only one part of the coupling is shown in the drawings the other part of the coupling being similar or consisting of a flat plate. As shown, the reference numeral 1 indicates a length of waveguide of rectangular form in cross-section the end thereof being provided with a coupling flange indicated at 2. As usual in this type of coupling, in order to prevent the escape of high-frequency energy the face of each flange 2 is channelled as indicated at 3, each channel 3 as indicated in Figure 2 extending for the width of the longer side of the waveguide cross-section. The length of each channel, that is to say, the dimension of the channel normal to the longer side of the waveguide cross-section is effectively equal in length to a quarter of the wavelength of the operating frequency of the waveguide. Each channel 3 terminates in a high-frequency impedance element in accordance with the invention which is in the form of a recess 4 having the shape of a segment of a circle shown more clearly in Figure 3, these recesses 4 being disposed at right-angles to the channel 3. The recesses 4 have integrally spaced parallel side walls and a bottom having the shape of an arc of a circle extending not more than 180° about an axis parallel to the face of the flange 2. These recesses 4 form the aforesaid high-frequency chokes or ditches and since the bottom of each recess 4 conforms to an arc of a circle they can easily be made by using a milling cutter of appropriate diameter. The radial depth of each recess 4 and the depth thereof can best be found by trial and error. In one specific example of the invention for use with a waveguide having internal dimensions of cross-section of 1" x ½" which is suitable for the transmission of energy of a wavelength of 3.3 cm., the opposing faces of each flange 2 is channelled to a depth of 0.008", the channels 3 being 1" wide and 0.427" long. The ditches or recesses 4 each have a width of 0.08", the bottom of each ditch having a radius of 0.522", whilst the chord of each ditch is 1.021".

Figures 4 and 5 of the drawings illustrate the invention as applied to a high-frequency transformer for matching the impedance of a crystal holder to the impedance of a length of waveguide. The crystal holder comprises a length of waveguide 5 in which a crystal 6 and contact element 7 are mounted in opposite walls thereof. In order to match the impedance of the length of waveguide 5 to another length of waveguide, not shown, a high impedance matching transformer is employed which is formed as a recess 8 in the end of the waveguide section 5. The recess 8 as shown in Figure 5 is in the form of a segment of a circle, the waveguide 5 opening into the bottom or arcuate wall of the recess 8. By making the recess 8 of circular segmental form it can be made by a simple milling operation in the block of metal forming the waveguide 5.

When making high-frequency impedance elements in accordance with the invention by a milling operation it will be appreciated that the segmental recess will in general be less than that of a semi-circle owing to the diameter of the spindle of the milling cutter employed. Although there are some forms of milling operations which can be performed without using a cutter having a spindle, such as those employing chain cutters, it is desirable particularly when employing the invention in apparatus for operation at wavelengths of a few cen-

timetres to make the segmental recess less than that of a semi-circle since spindled milling cutters having the required dimensions can easily be made. When using a milling cutter having a spindle, if w is the radius of the spndle and r the radius of the cutting surface, the maximum depth of the segmental recess is clearly $r-w$. For an air-filled recess, the recess only acts as a quarter-wavelength section of waveguide if w is zero, so that all practical air-filled recesses have a finite positive reactance. When a segmental recess is employed as a choke in accordance with Figures 1, 2 and 3 such a positive reactance is required since the plane of the choke is at right-angles to the junction plane of the flanges 2 and the different cross-sectional dimensions produce an effective capacity at the mouth of the choke. If, however, a segmental recess which is less than that of a semi-circle is employed as a transformer as in the example described in Figures 4 and 5, it is necessary for the recess to be filled with a solid dielectric such as polystyrene which is advantageous for other reasons since, in this case, there is a value of w which will cause the recess to act as a quarter-wavelength matching transformer. When polystyrene is used as the dielectric it is found that

$$\lambda'=2\sqrt{1-w/r}$$

$$r'=\frac{2}{\lambda'\sqrt{8-\lambda'^2}}$$

where $\lambda'=\lambda/a$, $r'=r/a$ and λ is the operating wavelength at which the segmental recess is equivalent to a quarterwave section.

When the segmental recess is used as a transformer its characteristic impedance Z_0 is calculated by the usual formula for the impedance of a rectangular guide, i. e.,

$$Z_0=377\cdot\frac{b}{a}\cdot\frac{\lambda_g}{\lambda}$$

where λ_g=wavelength in the dielectric filled guide corresponding to λ in free space, the a and b dimensions in that formula being taken as the dimensions of the mouth opening of the segmental recess.

What I claim is:

1. A coupling flange for a waveguide, said flange being formed with an aperture for the waveguide and having a face with a recess therein, said face having a channel extending from said aperture and communicating with said recess, said recess extending transversely of said channel and having spaced side walls and a bottom all integral with said flange, said bottom having the shape of an arc of a circle and extending not more than 180° about an axis parallel to said face, and said recess and channel being dimensioned to provide a low impedance at said aperture at the frequency of energy transmitted through said waveguide.

2. A coupling flange for a waveguide, said flange being formed to provide a rectangular aperture therein for the transmission of energy from a waveguide through said flange, said flange having a face formed to provide a channel extending from one of the long sides of said rectangular aperture and communicating with a recess formed in said face, said recess extending transversely of said channel and having spaced side walls and a bottom all integral with said flange, said bottom having the shape of an arc of a circle and extending not more than 180° about an axis parallel to said face, and said recess and channel being dimensioned to provide a low impedance at said aperture at the frequency of energy transmitted through said waveguide.

References Cited in the file of this patent

UNITED STATES PATENTS

2,454,761	Barrow	Nov. 30, 1948
2,475,563	Goldsmith	July 5, 1949
2,567,748	White	Sept. 11, 1951

OTHER REFERENCES

Publication I, "Microwave Transmission Circuits" edited by Ragan, vol. 9 of the Radiation Laboratory Series published by McGraw-Hill May 21, 1948, page 297. (Copy in Div. 69.)