

May 24, 1949.

J. COLLARD
MEANS FOR PREVENTING OR REDUCING THE
ESCAPE OF HIGH-FREQUENCY ENERGY

2,470,805

Filed Aug. 31, 1943

2 Sheets-Sheet 1

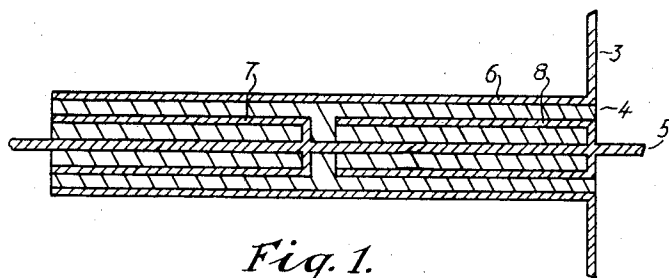


Fig. 1.

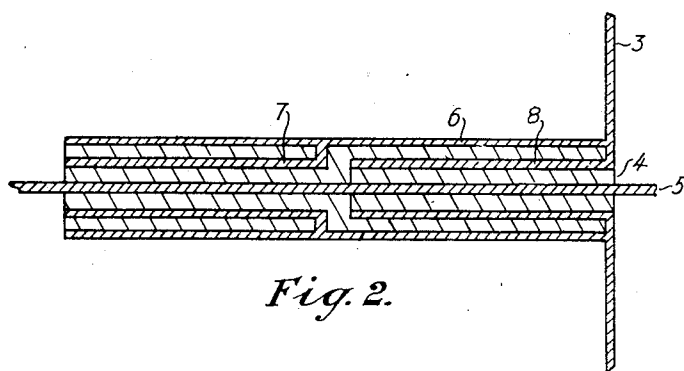


Fig. 2.

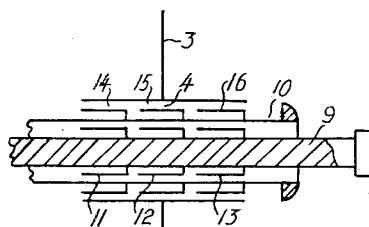


Fig. 3.

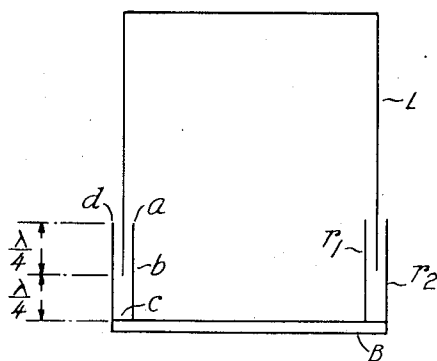


Fig. 4.

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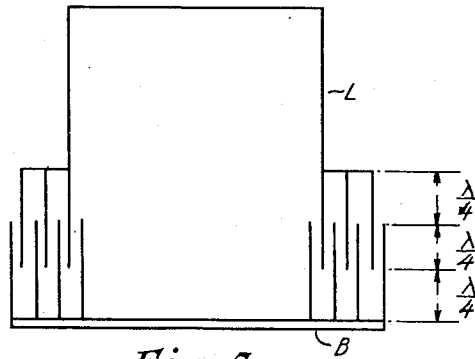


Fig. 5.

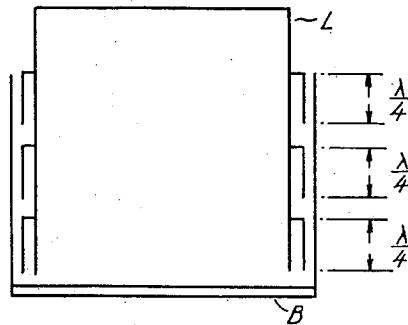


Fig. 6.

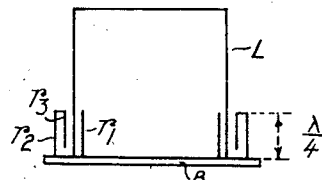


Fig. 7.

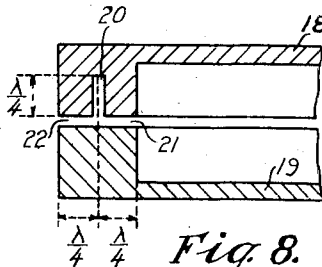


Fig. 8.

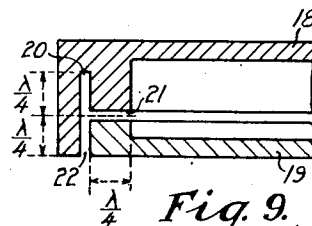


Fig. 9.

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UNITED STATES PATENT OFFICE

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MEANS FOR PREVENTING OR REDUCING
THE ESCAPE OF HIGH-FREQUENCY
ENERGY

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6 Claims. (Cl. 178-44)

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This invention relates to means for preventing or reducing the undesired escape of high frequency energy.

It is common practice in connection with high-frequency apparatus to provide conducting enclosures in screens for those parts which are liable undesirably to radiate high-frequency energy.

The escape of energy can be prevented where the conducting surface is continuous, but where even small gaps occur at the abutting edges of, for example, the lid of a screening box and the box itself, a leakage path is provided permitting energy to escape at ultra-high-frequencies, particularly at centimeter wavelengths. Further, in some cases, it is necessary to provide an aperture or apertures in said enclosure in screen through which one or more conductors are passed. For example, the one or more conductors may comprise leads for supplying D. C. or low-frequency A. C. to the high-frequency apparatus contained within a screening box or said conductor or conductors may comprise a shaft or shafts to enable the apparatus within the screening box to be mechanically adjusted from the exterior of the box. In these cases also, at ultra-high-frequencies, undesirable escape of energy will occur through the said aperture or apertures.

The object of the present invention is to prevent or reduce the escape of energy through a leakage path, due to a discontinuity or a conducting enclosure in screen, provided for example by a gap between the lid of a screening box and the box itself, or being due to the provision of an aperture or apertures.

According to one features of the invention there is provided apparatus comprising a source of high frequency energy and a conducting enclosure or screen for said source wherein, in order to reduce substantially the undesired escape of said energy from a discontinuity in said enclosure or screen affording a leakage path, a path is provided branching from said leakage path, said branch path being so dimensioned as to be resonant at said high frequency to provide a high impedance effectively in series with said leakage path.

Said leakage path is preferably so dimensioned as to be resonant at said high frequency so as to present in effect a low impedance subsequent to and in series with said high impedance.

According to another feature of the invention there is provided a conducting enclosure or screen for high frequency energy wherein, in order to reduce substantially the undesired escape

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of said energy from a discontinuity in said enclosure or screen affording a leakage path, a path is provided branching from said leakage path, said branch path and part or whole of said leakage path being both so dimensioned as to be resonant at a predetermined high frequency so as to present to the energy which tends to escape a high impedance in series with a subsequent low impedance.

According to another feature of the invention there is provided apparatus comprising a source of high frequency energy and a conducting enclosure or screen for said source, said enclosure having a leakage path through which an undesired escape of high frequency energy can occur, wherein said leakage path is made of a length so as to be resonant at said high frequency so that it presents a low impedance to the energy that tends to escape, whereby the escape of said energy is reduced.

The branch path may take a variety of forms as will be hereinafter more fully referred to, but preferably said branch path is effectively substantially a quarter of a wavelength long at said predetermined frequency and is short-circuited at one end.

If desired, said leakage path prior to said branch path can be made resonant to the energy that tends to escape so as to present at the commencement of said leakage path a low impedance whereby the energy which is permitted to flow into said leakage path is smaller than would otherwise be the case.

In order that the invention may be clearly understood and readily carried into effect, various embodiments of the invention will now be described with reference to the accompanying drawings in which:

Figure 1 shows a cross-sectional view of a part of a screen for housing high-frequency apparatus and embodying one construction according to the invention for reducing or eliminating escape of energy through an aperture in a screen through which a conductor passes,

Figure 2 is a view similar to Figure 1 illustrating a modification,

Figure 3 illustrates a form of the invention similar to that shown in Figure 1 as applied to a screen in which a pair of concentric shafts project through an aperture in said screen,

Figure 4 shows diagrammatically in cross-section a simple form of screening box embodying the invention for the purpose of reducing or eliminating the escape of energy between the lid of the screening box and the box itself, and

Figures 5 and 6 show modifications of the construction shown in Figure 4,

Figure 7 is a modification of the construction of screening box shown in Figure 4 with a view to providing a more compact construction,

Figure 8 is a cross-sectional view of a portion of a screening box embodying a further form of the invention, and

Figure 9 is a view similar to Figure 8 illustrating a modification of the arrangement shown in Figure 8.

Referring first to Figure 1 of the drawings, the reference numeral 3 indicates a portion of a conducting screen for surrounding high-frequency apparatus, not shown, the screen having an aperture 4 through which extends a lead 5 serving to supply D. C. or low-frequency A. C. to parts of the apparatus enclosed within the screen 3, the apparatus being assumed to lie on the left-hand side of the screen as viewed in the drawing. With such an arrangement it will be found that high-frequency energy will escape through the leakage path afforded by the discontinuity, i. e., the aperture 4 in the screen. In order to reduce or eliminate this escape of energy a conducting sheath 6 is provided surrounding the lead 5 connected at one end to the screen 3 in the vicinity of the aperture 4. Surrounding the lead 5 in the example shown, are two tubular conductors 7 and 8 each closed at one end and connected at said end to the lead 5 so providing branch paths for high-frequency energy tending to escape through the aperture 4. The space between the sheath 6 and the tubular conductors 7 and 8 and the space between the latter and the lead 5 may be filled, if desired, with suitable insulating material, although this is not essential since air-spacing of these elements is sufficient. The effective length of each tubular conductor 7 and 8 is such as to give quarter wave resonance at the frequency of the high-frequency energy that tends to escape, the physical length of those conductors depending, of course, on the dielectric medium between the conductors and the lead 5. The length of the sheath 6 is sufficient to enclose both the tubular conductors 7 and 8, and although in the example shown two tubular conductors are employed, it will be appreciated that, if desired, only a single tubular conductor, or more than two tubular conductors, may be used, the length of the sheath 6 being suitably chosen accordingly.

It will be observed from Figure 1 that there is no direct connection between the lead 5 and the screen 3 so that the lead 5 is insulated from the screen so far as D. C. or low-frequency A. C. is concerned. Any high-frequency energy, however, which tends to flow towards the aperture 4 through the sheath 6 is confronted by the branch path formed by the conductor 7. Since the length of the conductor 7 is such as to resonate at the high frequency which it is desired to suppress and is short-circuited where it is connected to the lead 5, the impedance presented by the branch path to the energy which tends to escape is very high. The path between the sheath 6 and the conductor 7, which is part of the leakage path, is so dimensioned as to resonate at said high frequency as an open-circuited quarter wave line and hence its impedance, as viewed from the left-hand end of the lead 5 is very low and is in series with and subsequent to the high impedance referred to. The energy which tends to escape is thus confronted by a high impedance in series with a low impedance and hence substantial attenuation occurs. The energy which ultimately

escapes past said high and low impedances is again confronted by two similar impedances, one of these, namely the circuit presented by the lead 5 and the tubular conductor 8, constituting a second branch path which presents a high impedance. The other, namely the circuit constituted by the tubular conductor 7 and the sheath 6 is a further portion of the leakage path and is of low impedance so that further attenuation of high-frequency energy occurs. If it is found that two tubular conductors 7 and 8 with their surrounding sheath 6 are insufficient to produce a sufficient attenuation, further tubular conductors may be employed so as to obtain any desired attenuation. Thus since the escape of energy from the aperture 4 is substantially prevented, the flow of high frequency current along the lead 5 is also substantially prevented.

It is, of course, immaterial which end of each tubular conductor is connected to the lead 5 and, furthermore, it is immaterial whether the sheath 6 and the one or more tubular conductors project within the screen 3 or project on the exterior of the screen 3. Furthermore, it is not essential to short-circuit the tubular conductors 7 and 8 to the lead 5 since, as shown in Figure 2, these conductors can be short-circuited to the sheath 6. The operation of the construction shown in Figure 2 is similar to that described with reference to Figure 1, although in this case the high impedance circuits are presented by the tubular conductors short-circuited to the sheath 6 and the low impedance circuits are presented by the lead 5 and the tubular conductors 7 and 8. It will of course be understood that in Figure 2 the low impedance circuits will still be present even if the lead 5 were omitted.

In Figure 3 an arrangement similar to that shown in Figure 1 described above is illustrated as applied to shafts projecting through a screen 3, the shafts being employed for mechanically adjusting apparatus contained within the screen. In this Figure the shafts project through the aperture 4 in the screen 3, one shaft being indicated by the reference numeral 9 arranged concentrically with respect to the aperture, whilst the other shaft 10 is of tubular construction, concentric and surrounding the shaft 9. Such shafts may, for example, be employed for the coarse and fine adjustment of a hollow resonator. In order to reduce escape of high-frequency energy between the shafts 9 and 10 and the aperture 4, tubular conductors 11, 12 and 13 are attached to the shaft 9 and tubular conductors 14, 15 and 16 are attached to the shaft 10, these conductors being similar to the conductors 7 and 8 described with reference to Figure 1. The function of the construction shown in Figure 3 of the accompanying drawings will, it is thought, be readily appreciated since it is analogous to the operation of Figure 1.

Figure 4 of the drawings illustrates the invention as applied to a circular metal screening box. Such forms of screening box require that the lid of the box be removably mounted in position to permit of access to the apparatus within the box. Providing the lid to the box could be made to fit perfectly to the base of the box no power could escape. However, such a fit is not practicable and, consequently, owing to the discontinuity in the screening between the lid and the base of the box due to the small gaps which will inevitably result owing to the imperfect fit, a leakage path will result and high-frequency energy will escape. In order to reduce or eliminate escape in this

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fashion whilst still permitting the lid of the box to be readily removable the lid L is arranged to extend between the coaxial bands r_1 , r_2 , soldered to the base B of the box. The surfaces of the lids and bands r_1 , r_2 , overlap in such a manner that the distances a to b , b to c and b to d indicated in the drawing are made equal to a quarter of a wavelength at the operating frequency of the high-frequency apparatus contained within the screening box. The branch path in this figure is the path b to c which is effectively a quarter wave-length path, short-circuited at the lower end and thus constitutes a high impedance, as seen from the point b so that in combination with the path from b to d which constitutes a low impedance as seen from b it serves to reduce high frequency energy escaping along the path between b and d . Due to the surface a to b which overlaps the lower edge of the lid L, the leakage path, in effect is extended prior to said branch path and is so dimensioned, i. e., this portion of the leakage path is a quarter of a wavelength long as to present at the commencement of the leakage path i. e. at a a low impedance whereby the energy which is permitted to flow into said leakage path is less than would otherwise be the case.

The principle illustrated in Figure 4 may be extended in the manner shown in Figure 5 and 6 in order more effectively to reduce the escape of energy. It will be seen from Figure 5 that additional quarter wavelength branch paths are provided and the leakage path prior and subsequent to these additional branch paths are extended as with the arrangement of Figure 4. Figure 6 is a modification which is less bulky from the mechanical point of view. A plurality of quarter wavelength branch paths are arranged in series along the wall of the lid and co-operate with a common surrounding band, as shown. In this figure, however, the leakage paths of low impedance prior to the branch paths are not employed and the operation is similar to that described with reference to Figure 1.

The overall height of a screening box and the co-operating bands may be conveniently reduced if desired by using a solid dielectric material having a large dielectric constant (K) as the medium between the overlapping surfaces of the box and bands, or the edge of the box may rest upon such a dielectric material. The requisite quarter wavelength path may thus be reduced in the ratio

$$\frac{1}{\sqrt{K}}$$

In applying such a proposal to the screening box shown in Figure 4, the space between the points a and c is filled with a suitable dielectric material and the distances a to b , b to c and b to d lessened accordingly, although still effectively equal to quarter wavelengths. Alternatively, the space between b and c may be filled with a solid dielectric material and the edge of the lid L may then rest on the dielectric. The distances a to b and b to d in this case will still be equal to a quarter of a wavelength with air as the dielectric, but the distance b to c will be reduced depending upon the dielectric constant of the material selected, although still presenting a quarter wavelength path.

Figure 7 illustrates a further form of screening box in which the lid L can rest directly on the

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base B of the box and projects between two bands r_1 , r_2 , the band r_2 , however, being of the form illustrated, that is to say, it projects upwardly from the base B and is provided with an extension r_3 which extends between the band r_2 and the lid L. The construction shown in this figure provides a single branch path with the leakage path extended prior and subsequent to the branch path as in Figure 4.

Figure 8 of the accompanying drawings illustrates a further embodiment of the invention as applied to a screening box of circular or other suitable form, the box comprising two portions 18 and 19 the periphery of the sections 18 and 19 being enlarged as shown in cross-section in the figure. The portions 18 and 19 are shown spaced apart at their enlarged peripheries, but in practice these adjacent surfaces may abut. In order to reduce or prevent the escape of high frequency energy through the leakage path formed by the abutting surfaces, an annular channel 20 is formed in the portion 18, this channel extending around the periphery of the portion 18. The channel 20 forms a branch path and the length of the said path is arranged to be a quarter of a wavelength at the operating frequency of the high frequency apparatus contained within the screening box. The branch path thus presents effectively a high impedance in series with the leakage path and serves to effect substantial attenuation of high frequency energy. The length of the leakage path indicated at 21 prior to the branch path 20 is also dimensioned to be a quarter of a wavelength long so that the impedance at the commencement of the branch path is low and hence the amount of energy which can pass through the leakage path is smaller than would otherwise be the case. The portion of the leakage path indicated at 22 subsequent to the branch path 20 is also dimensioned to be a quarter of a wavelength long so as to present as low an impedance as possible in effective series relation with said high impedance so that leakage through said leakage path is lower than would otherwise be the case.

Figure 9 is a modification of the arrangement shown in Figure 3. In this figure the arrangement of branch and leakage paths 20, 21 and 22 is similar to that described with reference to Figure 3 except that their disposition is changed relatively to the screening box to enable the periphery of the portion 18 to enclose the periphery of the portion 19.

Although in the various embodiments described above reference has been made to paths which are a quarter of a wavelength long, it will be understood that the invention is not limited to paths of this length since it will be obvious that the dimensions of the paths may be substantially equal in length to an odd number of such quarter wavelengths, which length is effectively equal to a quarter of a wavelength so as to be resonant at the frequency of the energy which tends to escape.

If desired, such branch path may be made effectively equal to a half-wavelength of the high-frequency energy so as to be resonant at the frequency of the energy which tends to escape, said branch path however being open-circuited at its end remote from the leakage path, so as to provide said high impedance. In such a case, in order to prevent energy from escaping at the open-circuited end of said branch path, the latter end may open into a cavity of suitable dimensions. Such an arrangement could be applied to

the embodiment shown in Figure 3 of the accompanying drawings.

What I claim is:

1. Means for preventing the escape of high frequency energy through a discontinuity in a screen for said energy, there being a conducting member passing through said discontinuity, said discontinuity and said conductive member providing a leakage path through said screen, said means including a conducting sheath member surrounding said conducting member and connected to said screen, a supplementary conductor within and lying parallel to said sheath and connected to one of said conducting members, said supplementary conductor having an electrical length of the order of one quarter of the wavelength of said high frequency energy.

2. Means for preventing the escape of high frequency energy through a discontinuity in a screen for said energy, said discontinuity providing a leakage path through said screen, said means including a number of branch paths in series with said leakage path, said branch paths each having an electrical length substantially equal to one quarter of the wavelength of said high frequency energy, and being short-circuited at the end remote from the point of connection in series with said leakage path at least one of said branch paths being connected to said leakage path at a distance equal to one-quarter of the wavelength of said high frequency energy from the interior of said screen.

3. A conductive enclosure for high frequency energy, said enclosure having an aperture therein forming a leakage path for the escape of said energy, said leakage path having one portion communicating with the interior of said enclosure and having an electrical length substantially equal to an odd integral number including unity of quarter wavelengths at the frequency of said energy and another portion communicating with the exterior of said enclosure and having an electrical length substantially equal to an odd integral number including unity of quarter wavelengths at the frequency of said energy, said portions being resonant at the frequency of said energy tending to escape to provide a low impedance thereto, and at least one branch path connected in series with said leakage path at a point intermediate said portions, said branch path presenting a high impedance to said energy tending to escape over said leakage path.

4. A conductive enclosure for high frequency energy, said enclosure having an aperture therein forming a leakage path for the escape of said energy, at least one branch path connected in series with said leakage path at a point intermediate the ends thereof, said branch path presenting a high impedance to said energy tending to escape over said leakage path, and said leakage path having dimensions at which each portion

thereof as measured from said point to the respective ends thereof has an electrical length substantially equal to an odd integral number including unity of quarter wavelengths at the frequency of said energy and is resonant at the frequency of said energy tending to escape to provide a low impedance thereto.

5. An enclosure for high frequency energy including a conductive enclosing wall for maintaining said energy therein, there being an aperture in said enclosing wall forming a leakage path for the escape of said energy, first and second conductive walls arranged in concentric relationship and connected to said conductive enclosing wall, said conducting walls being spaced apart and having dimensions at which a branch path having a high impedance to the energy tending to escape along said leakage path is connected in series with said leakage path at a point intermediate its length and substantially an odd multiple including unity of quarter wavelengths at the frequency of said energy from each end of said leakage path and said leakage path is substantially a quarter wavelength long at the frequency of said energy.

6. An enclosure for high frequency energy including a first conductive enclosing wall and a second conductive enclosing wall in end-to-end abutting relationship, the aperture between said walls forming a leakage path for the escape of said energy, the abutting portion of said walls having a width substantially equal to a half wavelength at the frequency of said energy, and at least one of said walls having a slot therein midway of the width of said wall, said slot having a depth of substantially a quarter wavelength at the frequency of said energy.

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