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APPARATUS FOR THE DETECTION OF DISCHARGES IN HIGH-POWER TRANSMISSION CHANNELS

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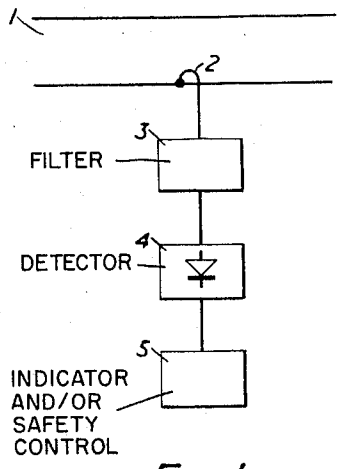


FIG. 1.

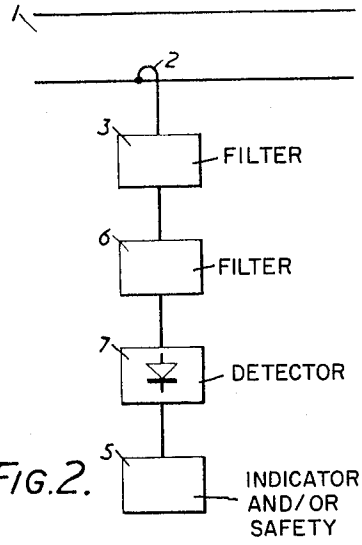


FIG. 2.

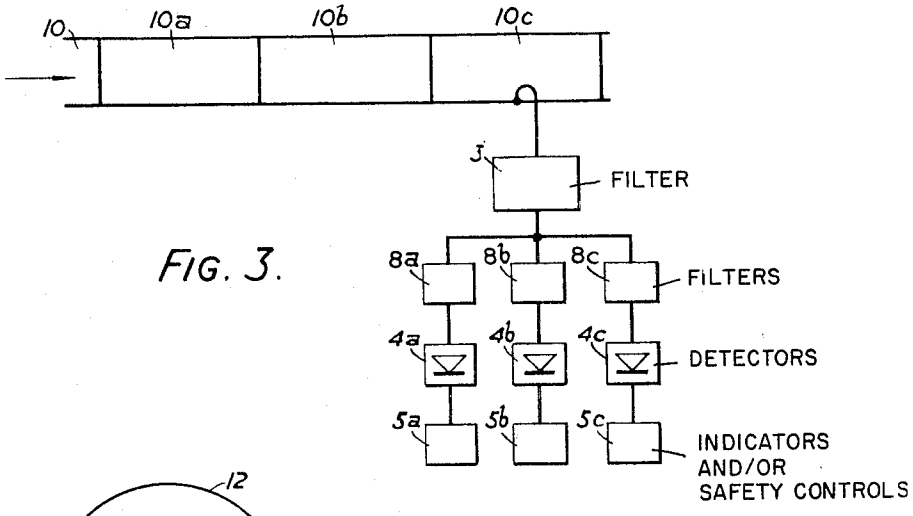


FIG. 3.

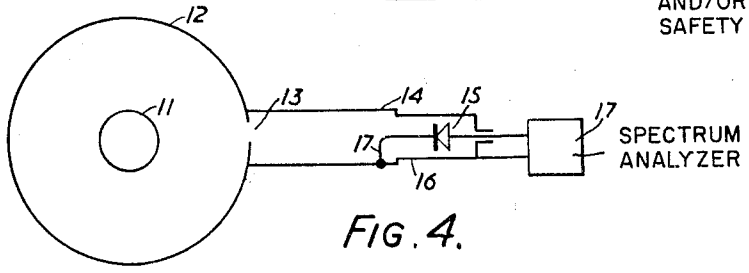


FIG. 4.

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6 Claims. (Cl. 317—53)

This invention relates to apparatus for the detection of corona and arcing discharges in high power transmission channels and has for its object to provide improved apparatus which shall be capable of detecting the presence of discharges at an early stage in their occurrence so that subsequent damage to the transmission channel and/or associated apparatus may be prevented.

In some applications, notably high power radar systems, synchro-cyclotrons, particle accelerators and so forth, a transmission channel is required to carry radio frequency energy at such high power levels that there is considerable danger of corona discharge and arcing occurring at discontinuities (such as waveguide flanges and co-axial conductor junctions) in the channel with resultant damage to, or destruction of, part of the channel or apparatus associated therewith by erosion and/or excessive heating. The arrangements customarily employed at the present time for detecting inch discharging or arcing employ photosensitive devices for detecting the light radiation produced thereby. However such known arrangements are often inadequate to give sufficiently early warning because the discharging or arcing usually commences at a low level and builds up only relatively slowly, over a period of, say, fifteen minutes, to a point at which serious damage results. Accordingly, there would be real advantage in providing a warning or detecting arrangement whereby the presence of the discharge or arcing can be detected at an earlier stage than is possible with known arrangements in which light radiation resulting from the discharge is detected by means of photosensitive devices for, if early warning is given, preventive action can be taken in good time.

The present invention takes advantage of the fact that corona discharging and arcing in high-frequency transmission channels is accompanied by the presence of noise signals.

According to this invention apparatus for the detection of corona and arcing discharges in a high power high frequency energy transmission channel comprises means for tapping off energy from said channel, means for rejecting from the energy thus tapped off energy within the operating frequency band which said channel is designed to transmit, and means responsive to energy outside said band and exceeding a pre-determined threshold strength, for indicating the occurrence of discharging or arcing in said channel and/or for producing a safety control action in response to such occurrence.

The responsive means may be fed with energy tapped off from said channel and of a predetermined harmonic of a frequency in the frequency band of operation of said channel, and may include a detector of noise modulation of said harmonic.

Alternatively the responsime means may be fed with and be responsive to radio-frequency noise energy at a frequency or frequencies outside the operating frequency band of the channel and fed thereto through a rejection filter rejecting said band.

In cases in which corona or arcing discharges giving rise to noise signals of a number of different radio frequencies are likely to occur at a number of known different parts of the channel, the noise detection means are

preferably arranged to be selectively frequency sensitive so that, by identifying the dominant frequency or frequencies in the noise the part giving rise to the arcing or discharge can be identified. Such frequency selectivity may be attained by including in the noise detection means a frequency spectrum analyser or alternatively, thereby providing a number of frequency selective filters, one for each of the different frequencies or frequency bands to be expected, a separate noise detector being provided in association with each filter.

The invention is further described with reference to and illustrated in the accompanying drawings of which FIGURES 1–4 show diagrammatically and schematically four embodiments of the invention.

Referring to FIGURE 1, 1 is a high frequency high power transmission channel exemplified as a rectangular waveguide and designed to propagate radio energy in the dominant H_{01} mode at a predetermined frequency. In accordance with the invention there are provided means, purely schematically shown as a coupling loop 2 inserted into the waveguide, for taking radio frequency energy out of the guide. Although for convenience of drawing, a coupling loop is shown and such a loop can be used, it is, in general undesirable to introduce into a transmission channel any obstacle which is likely to reduce the power handling capacity of the channel. In practice, therefore, it is preferable to couple out energy from the waveguide by means of a coupling hole rather than by a coupling loop. The extracted energy is passed through a filter 3, which is a rejection filter adapted to reject the dominant mode frequency propagated in the waveguide 1 and is preferably constituted by a length of waveguide having its lower cut-off frequency above the frequency of propagation in waveguide 1. Energy passed by the filter is applied to a noise detector 4 whose output noise signals are applied to an indicating arrangement 5 such as a noise receiver and associated indicator (not separately shown).

In operation, corona discharge or arcing occurring in the waveguide 1 will give rise to noise signals over a comparatively wide frequency band and these noise signals will be detected by noise detector 4 and indicated by the apparatus 5. The noise detector 4 and/or the indicator 5 is or are so adjusted that only noise exceeding a predetermined threshold value, corresponding to the level of noise normally present in the absence of corona discharge or arcing, is indicated. The unit 5 may if desired, be automatically responsive and incorporate means for automatically switching off the energy propagated in the waveguide 1 in the event of the predetermined threshold noise value being exceeded. In either case, the component 5, whether operating as an indicator or as a means for automatically switching off the energy propagated in the waveguide 1, produces an effect utilizable for taking preventative action against continuation of the discharges. When the component 5 operates as an indicator, the indicating effect advises that the energy should be cut off by other means (not shown).

In the modification shown in FIGURE 2 radio frequency energy from waveguide 1 is passed through a rejection filter 3 as in FIGURE 1, but the output from filter 3 is applied to a further filter 6 adapted to pass only energy at a predetermined harmonic of the frequency with which energy is propagated in waveguide 1. This harmonic frequency, which will be modulated with noise signals when corona discharge or arcing is occurring in waveguide 1, is applied to a noise detector 7 which demodulates the harmonic frequency signals and applies the resultant detected noise signals to the indicating or automatically responsive apparatus 5.

FIGURE 3 shows a further embodiment adapted to identify a particular section or portion of a transmission channel in which corona discharge or arcing may be tak-

ing place. In this case the high frequency high power transmission channel **10**, exemplified as a rectangular waveguide, is shown as having three sections or portions **10***a*, **10***b* and **10***c*. These sections or portions, although similarly shown in the drawing, are to be presumed as having differing characteristics inter se. They are to be presumed as being of different dimensions or as incorporating different obstacles such as corners, waveguide flanges or the like or to be otherwise such that, should corona discharge or arcing take place in the different sections or portions, noise signals having peak energy at different radio frequencies will result.

As in FIGURES 1 and 2 radio energy is taken from the waveguide **10** and passed through a rejection filter **3** adapted to reject radio energy at the frequency of the dominant H_{01} propagation in the waveguide. The output from filter 3 is however applied in parallel to three further filters **8***a*, **8***b* and **8***c* selective of and adapted to pass the different frequencies corresponding to the characteristic frequencies at which peak noise signals may occur due to corona discharge or arcing in the sections or portions **10***a*, **10***b* and **10***c*, respectively, of waveguide **10**. Each of the filters **8***a*, **8***b* and **8***c* is followed by a noise detector **4***a*, **4***b* or **4***c*, each followed in turn by a unit **5***a*, **5***b* or **5***c*, like unit **5** or FIGS. 1 and 2.

With this arrangement the occurrence of corona discharge or arcing in any one of the sections or portions of waveguide **10** will give rise to a noise signal indication at the corresponding indicating device which will thus provide identification of the section or portion of the waveguide in which the discharge or arcing is occurring. Any other frequency selective means, adapted to separate the characteristic frequencies at which peak noise energy may occur due to discharge or arcing in any one of the sections of the waveguide may be used to identify the section in question. Thus, for example, any suitable form of frequency spectrum analyser known per se may be used.

FIGURE 4 shows another embodiment enabling identification of the part of a channel giving rise to discharge or arcing to be achieved. In FIG. 4 the high frequency high power transmission channel is shown as a co-axial feeder system having an inner conductor **11** and an outer conductor **12** and adapted to propagate energy in the dominant TEM mode. As in the case of waveguide **10** of FIGURE 3 the transmission channel is assumed to be composed of different sections or portions, which may give rise to peak noise energy at different characteristic frequencies on the occurrence of corona discharge or arcing. In the case of a co-axial transmission line such discharge or arcing may, for example, take place at junctions of different parts of the inner conductor where, for example, so-called "garter springs" are used to effect connection.

Radio energy is shown as taken from the co-axial transmission line by means of a coupling hole **13** formed in the outer conductor **12**. The extracted energy is propagated through a length of waveguide **14** dimensioned to have a lower cut-off frequency higher than that of the dominant TEM mode frequency propagated in the co-axial transmission line. A noise detector diode **15** located in a further length of waveguide **16** has one terminal connected via a coupling loop **17** to the wall of waveguide **14** and its other terminal connected to apply signals to any suitable form of frequency spectrum analyser **17** known per se. Noise signals resulting from the occurrence of corona discharge or arcing in the co-axial transmission line are applied as input to the frequency spectrum analyser **17** which is employed in any convenient manner which will be obvious from the preceding description herein to identify the frequency at which peak noise signals occur, thereby identifying the section or portion of the co-axial transmission line **11–12** in which the discharge or arcing is occurring.

I claim:

1. Apparatus for the detection of corona and arcing discharges in a high power high frequency energy transmission channel, said apparatus comprising means for tapping off energy from said channed, means for rejecting from the energy thus tapped off energy within the operating frequency band which said channel is designed to transmit, and means responsive to energy outside said band and exceeding a pre-determined threshold strength, for indicating the occurrence of discharging or arcing in said channel.

2. Apparatus as claimed in claim **1** wherein the responsive means are fed with energy tapped off from said channel and of a predetermined harmonic of a frequency in the frequency band of operation of said channel, said responsive means including a detector of noise modulation of said harmonic.

3. Apparatus as claimed in claim **1** wherein the responsive means are with and are responsive to radio-frequency noise energy at a frequency of frequencies outside the operating frequency band of the channel and are fed thereto through a rejection filter rejecting said band.

4. Apparatus as claimed in claim **1** and comprising means for separating out any of a plurality of different pre-determined frequencies or frequency bands, all lying outside the operating frequency band of the channel, and characteristic of different parts of said channel, and means responsive to noise on the different separated frequencies or frequency bands whereby, by observation of a frequency or frequency band on which noise is present, a part of said channel in which arcing or discharging is occurring may be identified.

5. Apparatus for the detection of corona and arcing discharges in a high power high frequency energy transmission channel, said apparatus comprising means for tapping off energy from said channel, means for rejectfrom the energy thus tapped off energy within the operating frequency band which said channel is designed to transmit, and means responsive to energy outside said band and exceeding a predetermined threshold strength, for producing an effect utilizable for taking preventative action against continuation of such discharges.

6. Apparatus for the detection of corona and arcing discharges in a high power high frequency energy transmission channel, said apparatus comprising means for tapping off energy from said channel, means for rejecting from the energy thus tapped off energy within the operating frequency band which said channel is designed to transmit, and means responsive to energy outside said band and exceeding a predetermined threshold strength, for producing a safety control action in response to such occurrence.

No references cited.

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