May 12, 1959 W. E. McNATT, JR 2,886,744

ELECTRICAL PROTECTIVE APPARATUS

Filed March 21, 1956

Fig. 1

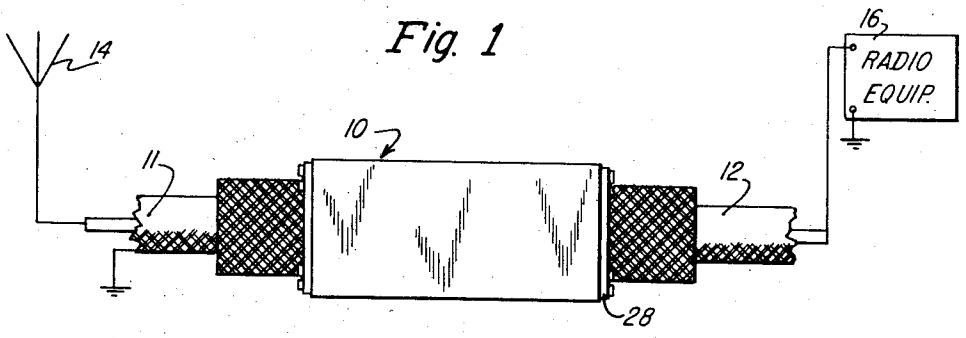


Fig. 2

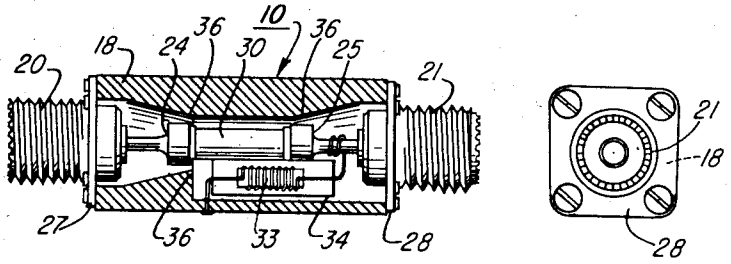


Fig. 4

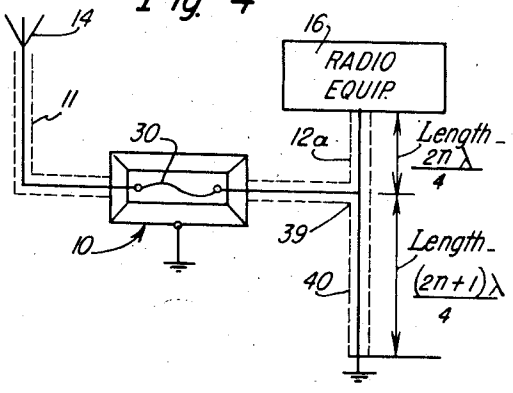
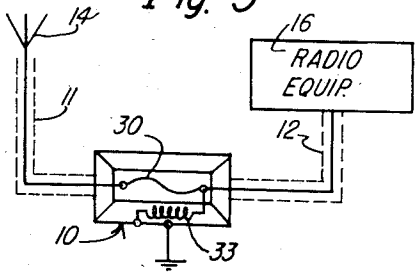


Fig. 3



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ELECTRICAL PROTECTIVE APPARATUS

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4 Claims. (Cl. 317—61)

This invention relates to electrical protective apparatus and more particularly to a device providing isolation of an electric circuit from electrical disturbances such as lightning.

In various types of electronic installations it is necessary to include protection against high currents which might cause damage to the equipment. For example, radio apparatus which is coupled to an antenna exposed to the elements may require means for preventing current caused by lightning from entering the apparatus. It should be obvious, of course, that to be practical any such protective device must not impair normal operation of the radio apparatus and that it should be constructed to respond rapidly to excessive electrical energy or damaging currents in order to isolate the apparatus before any harm is done.

It is accordingly an object of this invention to provide a simple, effective protective device to isolate electrical equipment from damaging currents caused by electrical disturbances such as nearby lightning strikes and the like.

Another object is to provide a fuse device for protecting radio apparatus from electrical disturbances occurring about an associated antenna and/or its transmission line or cable without adversely affecting the performance of the radio apparatus.

Another object of the invention is to provide an inexpensive protective device to be installed in a coaxial cable between radio apparatus and an associated antenna to prevent conduction of excess current through the coaxial cable and to the associated radio apparatus.

A feature of the invention is the provision of an improved protective device including a series connected fusible element and an inductance element coupled from one side of the fusible element to ground so that high current at low frequencies may be discharged through the inductance element thereby open circuiting the fusible element.

Another feature is the provision of a protective device as described in the preceding paragraph in which a series fuse element and shunt inductor are coupled to a coaxial cable used as the antenna lead for radio equipment, and in which the inductor is coupled across the cable at the end of the fuse element coupled to the rapid equipment. The inductor may have relatively high impedance at radio frequencies utilized by the equipment to minimize the effect on the performance thereof and at the same time still furnish a ground path through the fuse element for low frequency lightning disturbances.

Another feature of the invention is the provision of a protective device in which the fuse element and an inductance coil are contained in a grounded housing having a portion in closely spaced relation to the ends of the fuse element in order to furnish a certain amount of capacity for impedance match or equalization of electrical characteristics of the device to the cable and to provide a discharge path for high potential disturbances from the antenna.

Further objects, features and the attending advantages

of the invention will be apparent upon consideration of the following description when taken in conjunction with the accompanying drawing in which:

Fig. 1 illustrates the protective device as used with radio equipment;

Fig. 2 represents a sectional view through the protective device;

Fig. 2*a* shows an end view of the device;

Fig. 3 is a schematic diagram illustrating the electrical features of the device; and

Fig. 4 is a schematic diagram of a modified form of the invention.

This invention provides a protective device to isolate electronic apparatus operable at radio frequencies from damaging electrical energy such as caused by lightning or other source of high current. The device may be used in the antenna lead for such equipment and includes a series connected fuse element adapted to open circuit when carrying current above the normal amount for the circuit. Also employed is an inductor coupled between the end of the fuse element coupled to the radio equipment and earth ground, or a potential reference point for the apparatus. The inductor has appreciable impedance at radio frequencies and so has a minimum influence on the normal function of the radio equipment. However, low frequency currents caused by electrical disturbances such as lightning are readily discharged to ground through this inductor, causing the fuse element to open circuit thus isolating the radio equipment from further current flow through the protective device. The device is preferably enclosed in an electrically conductive housing which is grounded, and this housing may be conveniently series coupled with a coaxial cable used as an antenna lead for the radio equipment. In order to provide impedance matching of the device to the cable, a portion of the conductive housing may be formed in closely spaced relation with the ends of the fuse and this spacing may also furnish a discharge or spark path to ground for high potentials.

Fig. 1 shows the protective device **10** serially coupled with portions of coaxial cable **11, 12**. An outer conductor of the cable **11, 12** is connected to earth ground or a point of zero potential for the environment of the system being described. A center conductor of the cable **11, 12** is connected between antenna **14** and radio equipment **16**. It is contemplated that equipment **16** consists of transmitter and/or receiving apparatus commonly used for communication purposes. Of course, it will be apparent to those skilled in the art that the protective device **10** may be readily used for other applications similar to the one being described herein.

Fig. 2 is a sectional view of the device **10**, which consists of a rectangular metallic housing **18**, to the ends of which are secured respective female couplings **20, 21** to be used for electrically connecting the device in series with the coaxial cable **11, 12**. Suitable fuse receptacle cups **24, 25** are respectively secured to the center terminals of connectors **20, 21** which connectors are removable together with end plates **27, 28** fastened to the ends of housing **18**. A fuse element **30** is supported by cups **24, 25** and therefore is serially connected with the coaxial cable **11, 12**. An inductance coil **33** is supported along the side of fuse element **30** and is connected from the receptacle cup **25** to the housing **18** which is grounded through the outer conductor of the coaxial cable **11, 12** as previously explained. An insulating sleeve **34** may be used to enclose coil **33** to prevent shorting to housing **18**.

The housing **18** includes portions **36** which are spaced by a chosen amount from cups **24, 25** to form a certain capacity and thereby provide impedance matching of the device to cable **11, 12**. Fig. 3 illustrates the connections within the device **10** by way of a schematic diagram and

there it may be noted that the inductance coil 33 is coupled between the center conductor of the coaxial cable 12 and ground on the side of fuse element 30 which is coupled to radio equipment 16. Furthermore, it is apparent that portions 36 provide shunt capacity across the device 10.

It is contemplated that the current rating of the fuse element 30 be somewhat above the maximum current normally carried by the coaxial cable during use of radio equipment. The inductance of coil 33 is selected to present considerable inductive reactance at the frequencies normally encountered during operation of the radio equipment so that there will be a minimum shunting effect of signals by way of this coil. In a practical embodiment of the invention, as used with a radio transmitter operative in the V.H.F. frequency range of 25 to 30 megacycles with a power output of 60 watts and feeding the antenna through a 52 ohm coaxial cable, a fuse rated at 2 amperes, a coil of 1.3 microhenries and shunt capacity of 1 mmfd. were found to provide effective protection and no detectable degradation of operation of the equipment.

The construction of the entire device is such that its characteristic impedance is equal to, or closely compatible with, the characteristic electrical impedance of the coaxial cable utilized in a given system. That is, the construction of inductance coil 33, the electrical resistances of the various portions of the device, as well as the internal capacity, or spacing between conductive portions of the device, are formed so as to present a desirable impedance for a given application and the radio frequencies to be encountered. Accordingly, the device will have a minimum of influence upon normal operation of the radio equipment and with proper design may cause no detectable signal loss or deterioration in operation.

When there is an electrical disturbance at or near antenna 14 sufficient to cause a current flow through coaxial cable 11 which is above the rated capacity of fuse element 30, this element will melt or open circuit thus protecting the radio equipment 16. Of course some finite time will be necessary for element 30 to open and during this time the major portion of any current flow will be conducted to ground through inductance coil 33. Coil 33 will offer but small impedance to such current flow since currents caused by electrical disturbances such as lightning consist largely of low frequency components. Therefore, under most conditions encountered in practice, sufficient current to cause damage will not reach equipment 16. Fuse element 30 may, of course, have a low current rating as compared with currents caused by lightning since in many radio applications the RF current normally conducted in the antenna lead is small. Furthermore, when the radio equipment is designed to operate at high frequencies, the inductance of coil 33 is sufficient to present high impedance and cause a minimal effect on the high frequency radio signals, while at the same time providing a good discharge path to ground for low frequency lightning currents by virtue of the extremely small resistance or reactance of fuse element 30 and coil 33 to low frequency energy.

It may also be seen that the shunt capacity provided by portions 36 and receptacle cups 24, 25 provides a discharge path to ground for lightning energy which is at a high potential with respect to ground. Accordingly, some energy may be dissipated across this path and, in any event, when fuse 30 has opened to a gap wider than the gap provided by portion 36 at the antenna side of the device, current flow will take place across the gap tending to prevent flow over coaxial cable 12 to damage the equipment 16. However, if it should happen that some energy is transferred across element 30 when it is open, this energy may be discharged to ground through coil 33.

Fig. 4 illustrates a modified form of the invention in which the coil 33 is omitted and replaced by a resonant section of coaxial cable. Coupled to the equipment of the device 10 is a coaxial T fitting 39 to which coaxial cable 12a connects the radio equipment 16. Cable 12a should be of a length which is an even number of quarter wavelengths at the frequency at which the radio equipment 16 will operate. Coaxial cable 40 which constitutes a resonant section of such cable, should be made an odd number of quarter wave lengths at the frequency of operation of the system. Accordingly, cable 40 constitutes a grounding stub which has a certain inductance and presents high impedance to the radio signal and thus has a minimum effect on the normal operation of the system. However, low frequency lightning currents may be readily conducted therethrough to ground before fuse element 30 open circuits, and it may be appreciated that cable 40 performs a function similar to that performed by coil 33 in the previously described embodiment.

It should also be pointed out that a pair of the protective devices may be used with a two-wire transmission line in which both leads are above ground potential. In such a case, the fuses are series-connected with the leads, and a coil is connected from each fuse to ground.

This invention provides, therefore, a simple and inexpensive protective device for electrical equipment which is subject to damage by lightning or other electrical disturbances. The device as described will have little or no adverse effect on the performance of the radio equipment with which it is associated but yet it will respond rapidly to excess currents being conducted therethrough. As explained above, the protective device is particularly adapted for use with a coaxial cable transmission line between radio equipment and an association antenna.

What I claim is:

1. Protective apparatus adapted to be coupled between coaxial cables interconnecting radio equipment to an associated antenna which apparatus is provided for protecting the equipment from electrical disturbances intercepted by the antenna, said protective apparatus including in combination a conductive housing adapted to be coupled to the outer conductor of the coaxial cable, a fuse constructed to open circuit when carrying current above a given level, said fuse being supported in said housing and being adapted to be serially connected with the center conductor of the coaxial cable, said conductive housing including a portion in spaced relation with the ends of said fuse to provide a capacity for impedance matching to said coaxial cable and for discharging high potential disturbances, an inductance coil having high reactance for radio signals and low reactance for current flow caused by electrical disturbances, said inductance coil being coupled from the end of said fuse adapted to be coupled to the radio apparatus to said conductive housing for discharging low frequency disturbances.

2. Protective apparatus, adapted to be coupled between coaxial cables interconnecting radio equipment to an associated antenna which device is used for protecting the equipment from electrical disturbances intercepted by the antenna, said protective apparatus including in combination, a conductive housing adapted to be coupled to the outer conductor of the coaxial cable, a fuse holder adapted to support a fuse constructed to open circuit when carrying current above a given level, said fuse holder being supported in said housing to be serially connected with the center conductor of the coaxial cable, said conductive housing having a portion in spaced relation with the ends of said fuse holder, an inductance coil disposed adjacent and substantially parallel to said fuse holder, said inductance coil having high reactance for radio signals and low reactance for current flow caused by electrical disturbances, said inductance coil being coupled from the end of said fuse holder adapted to be coupled to the radio apparatus and to said conductive housing for discharging low frequency electrical disturbances, said inductance coil and the spaced relation of said housing and fuse holder providing im-

pedance characteristics substantially matching those of the coaxial cable.

3. Protective apparatus adapted to be coupled between a first section of a coaxial cable connected to electronic equipment and a second section of the coaxial cable which couples high frequency signals to the equipment, and which apparatus serves to protect the equipment from low frequency electrical disturbances which may be on the second section of the cable, said protective apparatus including in combination, a conductive housing adapted to be coupled to the outer conductor of the coaxial cable sections and connected thereby to ground potential, a fuse constructed to open circuit when carrying current above a given level, said fuse being supported in said housing and being adapted to be serially connected with the center conductor of the coaxial cable sections, said conductive housing including a portion in spaced relation with the ends of said fuse to provide a capacity for impedance matching to said coaxial cable and for discharging high potential disturbances, inductance means having high impedance for high frequency signals utilized by the electronic equipment and low

impedance for current flow caused by the low frequency electrical disturbances, said inductance means being coupled between ground potential and the end of said fuse adapted to be coupled to the electronic equipment for conducting the low frequency disturbances to the ground.

4. Protective apparatus as defined in claim 3 wherein said inductance means includes a transmission line having a length substantially equal to an odd number of quarter wave lengths at the high frequency utilized by the electronic equipment.

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