United States Patent [19]

Tiffany

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[54] **ELECTRICAL SAFETY BARRIER**

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[52] **U.S. Cl.** ..... **317/16,** 317/18 C, 317/31

[51] **Int. Cl.** **H02h 3/20**

[58] **Field of Search** ..... 317/18 C, 16, 31, 33 R, 317/50, 61.5

[56] **References Cited**

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[57] **ABSTRACT**

An electrical safety barrier for providing safe electrical interconnection between a safe area and a hazardous area. A circuit interconnects terminals for apparatus in the hazardous area. The circuit includes, in series, a diode, a current-limiting impedance, and current-interrupting means. Zener diodes, each of the same polarity, are connected on either side of the diode. Accordingly, the zener diodes provide independent fail-safe limiting of the voltage at the terminals in the hazardous area and yet can be independently tested.

4 Claims, 4 Drawing Figures

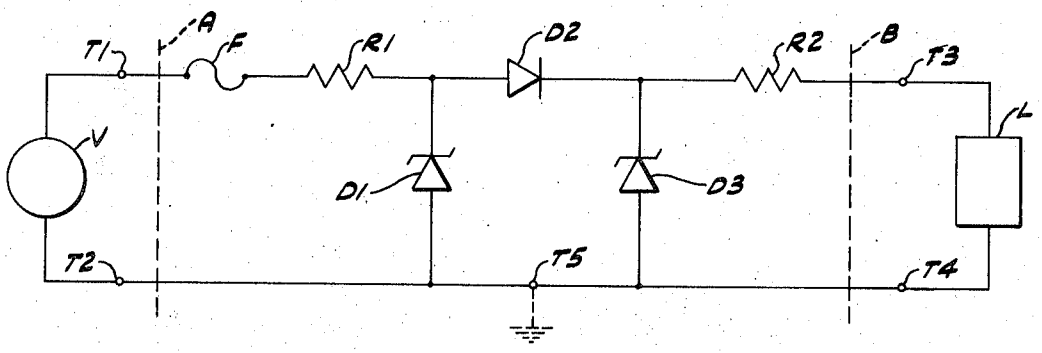


FIG. 1

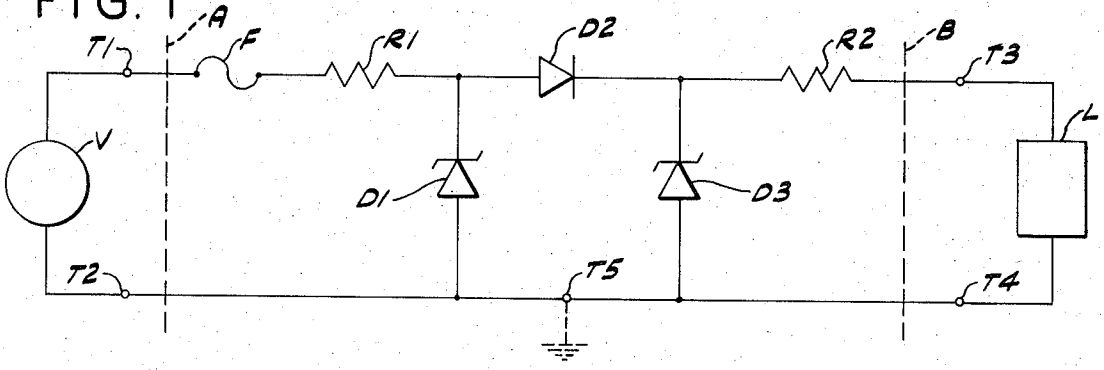


FIG. 2

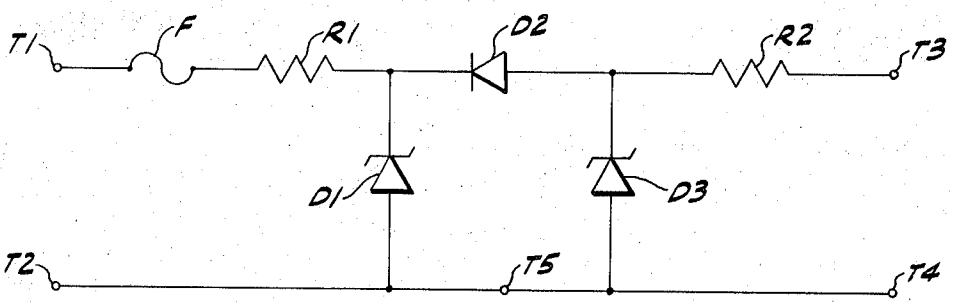


FIG. 3

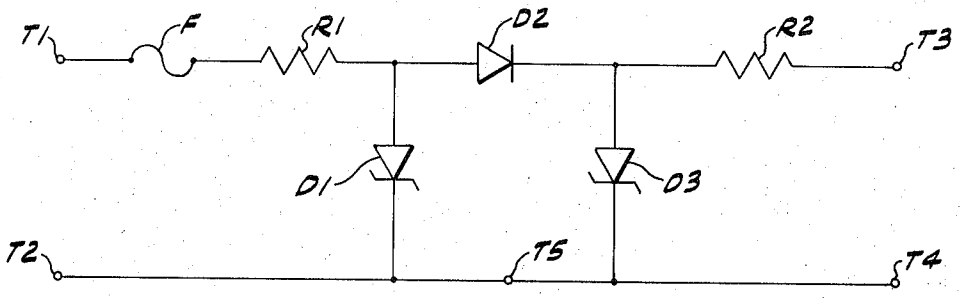
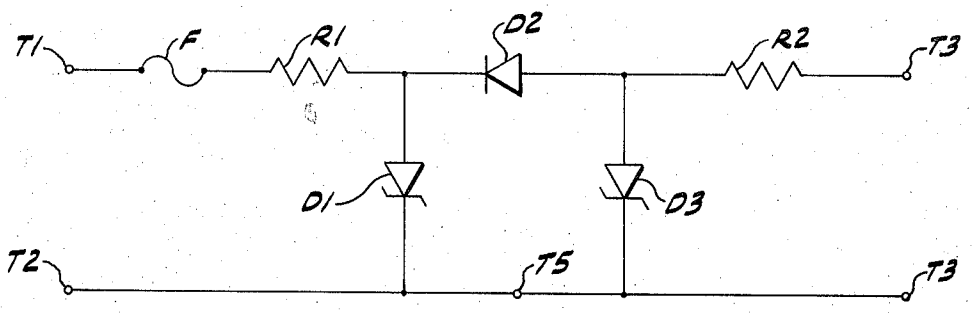


FIG. 4



ELECTRICAL SAFETY BARRIER

BACKGROUND OF THE INVENTION

The invention relates to electrical safety barriers and more particularly to an improved electrical safety barrier of the intrinsic type and providing fail-safe limiting of voltages.

In the field of industrial control in which processes at remote locations are monitored and/or supplied with power from a central station, the use of electrical apparatus to provide the desired monitoring, power supplying, alarming and controlling functions, is increasing rapidly. In the petroleum and chemical industry wherein flammable or explosive materials at the remote locations present a potentially dangerous situation, it is extremely important, and often necessary, that steps be taken to protect against excessive electrical energy caused by various fault conditions or malfunctions.

Heretofore, it has been the general practice to provide an electrical safety barrier which is interconnected with electrical apparatus used in industrial control applications of the type mentioned above. The barrier device is electrically interposed between the safe area and the hazardous area and comprises circuitry which includes fuse devices, resistors, and voltage regulating devices to limit the current and voltage to acceptably safe levels. One form of a typical electrical barrier device is shown in Brown U.S. Pat. No. 3,527,985. Typically, it is required that there be exposed only those terminals of the barrier which are to be connected to circuitry or apparatus in the safe and hazardous areas. Thus, devices of this type are conventionally of encapsulated or potted tamper-proof construction.

Advantageously, such barriers employ a plurality of voltage-regulating devices, such as zener diodes, for redundancy. Since the circuitry of the barrier is inaccessible because of the tamper-proof construction, difficulty may be encountered in periodically testing the zener diodes or other circuit components of the barrier, as is necessary. This has heretofore required the use of zener diodes carefully selected to have zener voltages of very close tolerances, a magnetic switch arrangement for isolating the zener diodes during testing, or the use of a relatively large resistance separating the zener diodes. All of these approaches are objectionable since they may compromise performance, may be complex or more expensive than desirable, or may cause an excessively high loop or insertion resistance between the safe and hazardous areas.

With respect to loop resistance, it should be understood that ordinarily only d.c. signals are transmitted through a safety barrier of the present type. Such signals may be of quite low magnitude. A high insertion resistance of the barrier may preclude monitoring or transmitting a signal of ample magnitude.

On the other hand, the use of a magnetic switch as shown in the aforesaid Brown patent offers no resistance to an a.c. fault current and is inconsistant with the need for a high insertion impedance under fault conditions.

SUMMARY OF THE INVENTION

Among the several objects of the invention may be noted the provisions of an improved electrical safety barrier; the provision of such a barrier which is easily tested, which does not require close tolerance zener diodes in selecting differences in zener voltages, or a large resistance between the zener diodes; th provision of such a barrier which provides a low insertion resistance under normal conditions and a high insertion resistance under fault conditions in order to limit the magnitude of an a.c. fault current supplied to a hazardous area during the fault condition; and the provision of such a barrier which is simple and inexpensively constructed. Other objects and features will in part apparent and in part pointed out hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1-4 are schematic circuit diagrams of alternate configurations of the preferred electrical safety barrier embodiment for use under respective different conditions. Corresponding reference characters indicate corresponding parts throughout several views of the drawings.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, an electrical safety barrier of the invention comprises circuitry which is suitably potted, encapsulated or otherwise protected by a tamper-proof enclosure (not shown). The barrier includes a first set of terminals T1 and T2 for connection to apparatus in a safe area to the left of a dashed line A. Such apparatus is here represented by a d.c. voltage source V supplying a potential to terminal T1 which is positive with respect to terminal T2. A second set of terminals T3 and T4 is provided for connection to apparatus such as a load L in a hazardous area to the right of a dashed line B. These sets of terminals may be at opposite ends of the tamper-proof enclosure, which may be a few inches in length, for example.

Terminals T2 and T4 are commonly connected and may be tied to earth ground by a fifth terminal T5 which is preferably constituted by one or more studs which project from the enclosure for securing the barrier to a grounded bus bar. Such a ground in represented phantom

A series circuit between terminals T1 and T3 includes a fuse F, its small associated intrinsic resistance R1, a diode D2 oriented to permit current flow in the direction from terminal T1 to terminal T3, and an impedance element such as a resistor R2.

Zener diodes D1 and D3 have their cathodes connected on opposite sides of diode D1 and their anodes interconnected with ground terminals T2, T4 and T5. The zener voltages of diodes D1 and D3 are selected so that the potential across terminals T3 and T4 under a fault condition will be regulated by the zener diodes so as not to exceed a safe level. The provision of two zener diodes provides a redundant, fail-safe feature in that each zener diode can independently regulate the potential across terminals T3 and T4 even though one of the zener diodes may experience an open circuit failure. Of course, if either zener diodes experiences a short circuit failure, the closed circuit to ground will prevent any potential from appearing across terminals T3 and T4.

Resistor R2 need be no larger than will limit the current to a safe value which will not ignite explosive mixtures, etc., in the hazardous area assuming short circuit conditions across terminals T3 and T4. Diode D2 is forward biased under normal operating conditions in which current flow is from terminal T1 to terminal T3.

Accordingly, the resistance between terminals T1 and T3 is relatively low and the barrier provides a low insertion resistance.

In the event of a fault condition (such as a short circuit in the safe area) applying an a.c. voltage across terminals T1 and T2, diode D2 advantageously blocks any flow of current in the direction from terminal T3 to terminal T1 and thereby limits the amount of energy which can flow into the hazardous area from the safe area assuming that fuse F1 has not blown. It will be understood that fuse F1 has a rating appropriate to the use of the barrier in a certain application and its function is to interrupt the current flow if the current exceeds a predetermined maximum level.

Although zener diodes D1 and D3 need not have close tolerances and need not have widely different zener voltages, they are selected so that the zener voltage of diode D3 is somewhat greater than that of diode D1. This facilitates testing of the two zener diodes. For this purpose, it is normally sufficient if the lower tolerance for the zener voltage of diode D3 is approximately equal to or greater than the higher tolerance for the zener voltage of diode D1.

All components of the barrier may be easily tested by use of the barrier terminals. First, a small current is established from terminal T1 to terminal T3 to verify that fuse F1 and diode D2 are intact. Then a test is made to insure that no current is passed from terminal T3 to terminal T1, checking proper reverse blocking operation of diode D2. A test is next made to verify proper operation of diode D1. A current is established from terminal T1 to terminal T2 and a potential at terminal T3 is measured to see whether it is equal to the zener voltage of diode D1 less the drop across diode D2 (normally about 0.7 v.) and less the IR drop across resistor R2. If this potential at terminal T3 is correct, diode D1 can be assumed to be operating properly. Finally, a current is established from terminal T3 to terminal T4 to verify that diode D3 is intact and operating properly.

Where the barrier is to be used with very low signal voltages, zener diodes D1 and D3 may each be replaced by a pair of oppositely oriented paralleled semiconductor diodes. Satisfactory regulation at the low signal voltages is achieved by virtue of the clipping or limiting operation provided by each such pair of diodes.

FIG. 2 illustrates a configuration for use where it is desired that current flows from terminal T3 to terminal T1, i.e., from the hazardous area to the safe area, and where terminal T3 is to be positive with respect to terminal T4. This arrangement is thus useful where apparatus in the hazardous area acts as the voltage source and monitoring or other apparatus in the safe area constitutes the load.

FIG. 3 shows an arrangement where current must flow from terminal T1 to terminal T3 but where terminal T1 is negative with respect to terminal T2.

The arrangement of FIG. 4 is useful for situations where current flow is to be from terminal T3 to terminal T1 but where terminal T3 is negative with respect to terminal T4.

In FIG. 4, the zener voltage of diode D3 must be greater than that of diode D1 while in FIGS. 2 and 3 the opposite is true.

In view of the foregoing, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As various changes could be made in the constructions herein illustrated without departing from the scope of the invention, it is intended that all mater contained in the above description shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A fail-safe and easily tested electrical safety barrier for providing safe electrical interconnection between a safe area and a hazardous area, said barrier comprising:

first terminal means for connection with apparatus in said safe area;

second terminal means for connection with apparatus in said hazardous area;

a circuit interconnecting said first and second terminal means, said circuit including in series relationship:

diode means for permitting only unidirectional flow of current between said first and second terminal means, said diode means being forward biased under normal operating conditions to provide low insertion resistance between said safe and hazardous areas;

current-limiting means for limiting said flow of current; and

current-interrupting means adapted to interrupt said flow of current if the current exceeds a predetermined maximum;

first and second voltage regulating devices each connected with said circuit on opposite sides of said diode means, each of said voltage regulating means being adapted for limiting the voltage at said second terminal means to a safe value during abnormal operating conditions, said regulating devices being independent whereby the voltage at said second terminal means is limited regardless of failure of one of said regulating devices, and whereby each of said regulating devices can be independently tested by passing current through either of said first and second terminal means; and

ground terminals respectively associated with each of said first and second terminal means, said ground terminals having a common connection, said zener diodes each having one side connected to said common connection.

2. An electrical safety barrier as set forth in claim 1 wherein said regulating devices comprise respective zener diodes oriented identically with respect to ground potential.

3. An electrical safety barrier as set forth in claim 2 wherein said current-limiting means comprises an impedance element.

4. An electrical safety barrier as set forth in claim 3 wherein said current-interrupting means comprises a fuse.

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