Oct. 25, 1966 J. A. NAVA 3,281,560

EXPLOSION-PROOF CONNECTORS FOR EXPLOSIVE-GAS ENVIRONMENTS

Filed July 16, 1963

Fig. 1

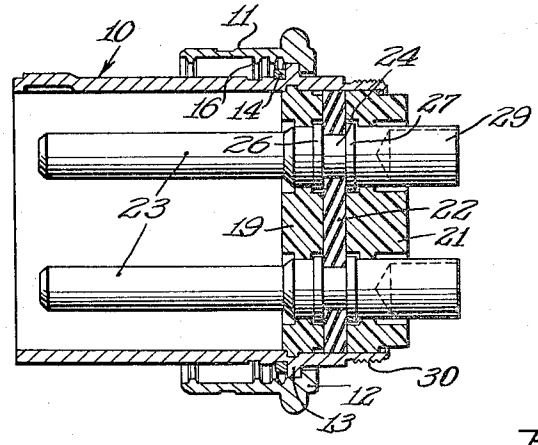


Fig. 2

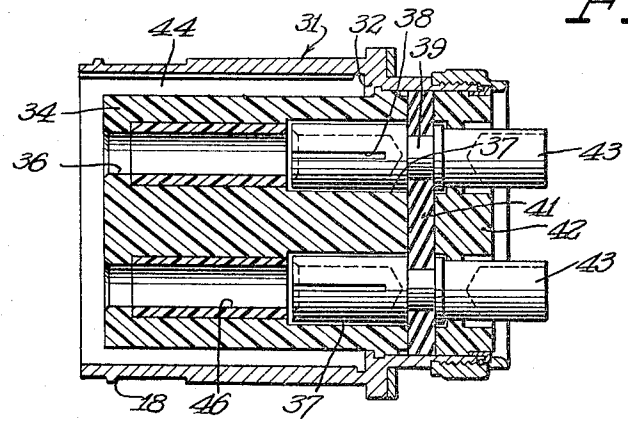
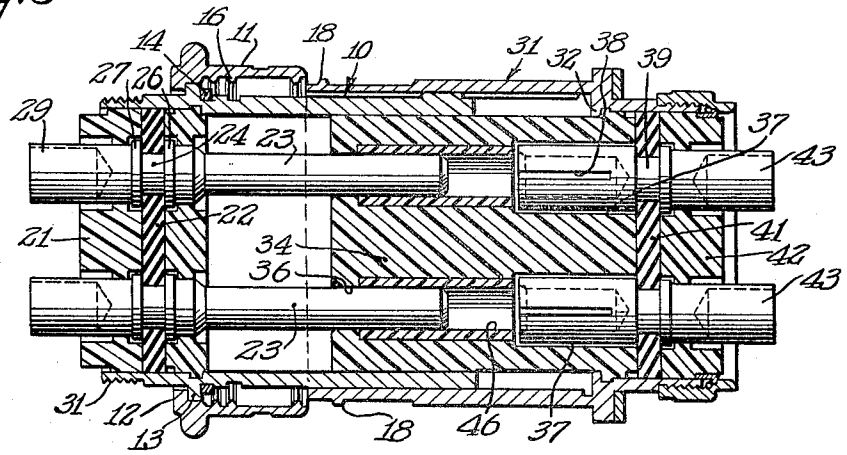


Fig. 3



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EXPLOSION-PROOF CONNECTORS FOR EXPLOSIVE-GAS ENVIRONMENTS

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The present invention relates to improvements in explosion-proof fittings designed to operate in the environment of a combustible or explosive gas mixture.

The prior art is replete with suggestions for materials used as arc extinguishers, that is, materials which under the influence of an electric arc produce gases or vapors which ultimately quench the arc. Some of these materials are quite satisfactory for this limited purpose, but for one reason or another are not completely effective when the problem of arc extinction is complicated by the problem of a combustible gas environment. In such environments, of course, the striking of the arc between the two electrical connectors is likely to ignite the combustible gas, and this combustion may spread to the gas outside the connector.

The connectors of the present invention are designed for use in the presence of any inflammable gas including inflammable vapors. For example, the connectors can be used in environments including hydrogen, acetylene, ethyl ether, cyclopropane, gasoline, hexane, naphtha, benzene, or the like.

The present invention provides a connector with means contained therein for both suppressing an electrical arc caused by bringing the pin and socket elements into close proximity, and also for extinguishing combustible gases which are ignited within the connector itself during coupling or decoupling of the elements so that the ignition of the gases does not spread beyond the interior of the connector. In essence, the present invention provides a pin and socket electrical connector in which the socket has an elongated inlet arranged to receive a pin in sliding relation, the pin being engageable within the socket. The inlet has disposed therearound a sublimable or vaporizable solid material which generates combustion extinguishing gases upon being energized by heat energy, the heat inlet being sufficiently long so that the ignition of the combustible gas therein generates a sufficient amount of extinguishing gases to extinguish the burning gas prior to complete engagement of the pin within the socket. Apparently, the gases which are generated from the sublimable material contaminate the combustible gas atmosphere to render it less hazardous, and the cooling of the ignited material is advanced by substantial transfer of thermal energy from the flaming gas to the sublimable material. Thus, the present invention deliberately uses a flaming combustible gas to initiate a reaction which ultimately extinguishes the gas and prevents the ignition from spreading outside the connector.

When the extinguishing materials described herein are referred to as "sublimable" the word is used in its broad sense of being transformable from a solid to a gaseous phase without going through an intervening liquid phase. Such transformation may and usually does involve chemical reactions which substantially modify the molecular structure of the original solid material.

An object of the present invention is to provide an improved electrical connector for use in hazardous environments containing combustible gases.

Another object of the invention is to provide an explosion proof connector including materials which function not only as arc extinguishers but also extinguishers for burning gases.

Still another object of the invention is to provide an electrical connector with means to confine a flaming gas within the connector and utilizing the flaming gas to initiate reactions which extinguish the flame.

In accordance with the present invention, I use a sublimable material which vaporizes without carbonization or flaming in the presence of an electrical arc discharge. Materials of the type described in U.S. Patent No. 3,002,072 of which the present applicant is a co-inventor, are well suited for this purpose. I particularly prefer to use, as the arc and flame suppressing material, a combination of a cross-linked organic polymer and a dienic copolymer. The latter is preferably a copolymer of butadiene and styrene, and the former is preferably an isobutylene-isoprene copolymer. Other examples of suitable materials will appear in succeeding portions of this specification.

A further description of the present invention will be made in conjunction with the attached sheet of drawings which illustrate the manner in which the invention is applied to a particular type of connector, although it will be realized that the inventive features of the invention can be applied to a wide variety of structural forms of connectors.

In the drawings:

FIGURE 1 is a cross-sectional view of a plug assembly;

FIGURE 2 is a cross-sectional view of a receptacle assembly embodying the improvements of the present invention; and

FIGURE 3 is a cross-sectional view of the plug assembly partially inserted into the receptacle assembly, with the plug turned 180° from the position shown in FIGURE 1.

As shown in the drawings:

In FIGURE 1, reference numeral **10** indicates generally a hollow cylindrical housing or casing. An annular retainer ring **11** is arranged for limited sliding movement along the casing **10**, and has a radially inwardly extending flange portion **12** arranged to abut a peripheral flange **13** formed in the casing **10** to limit the extent of sliding movement of the retainer **11** with respect to the casing **10**. A seal ring **14** is positioned on the other side of the flange **13** to sealingly engage the receptacle, as will appear from a succeeding portion of this description.

The inner wall of the annular retainer **11** is provided with threads **16** which engage threads **18** on the receptacle assembly, as best illustrated in FIGURE 3.

In the interior of the casing **10** there is disposed a pair of insulating discs **19** and **21** separated by a resilient, compressible disc **22**. The insulating discs **19** and **21** may be made of a suitable electrical insulator resin such as phenol-formaldehyde resin, and the resilient disc **22** may be composed of rubber or the like.

A plurality of pin elements **23** are held securely in the casing **10** by the insulator discs **19** and **21**, and the compressible disc **22**. Each of the pins **23** has a reduced-diameter neck portion **24** between a pair of enlarged-diameter flange portions **26** and **27**, the reduced-diameter portion **24** extending through suitable apertures provided in the resilient disc **22**.

The outer ends of the pin elements **23** have socket portions **29** formed therein to accept conductors carrying electric power. The outer end of the plug assembly is provided with threads **30** to accept accessories such as a cable adaptor or similar enclosure.

The receptacle assembly illustrated in FIGURE 2 of

the drawings includes a hollow cylindrical casing 31 which has a radially inwardly extending flange portion 32 along its interior. The flange portion 32 helps to confine a cylindrical block 34 of insulation within the casing 31. The block 34 has a plurality of axially extending bores 36 each of which is provided with a socket contact 37 having slots 38 therein for added flexibility. The contact 37 has a reduced-diameter neck portion 39 extending through a resilient disc 41 composed of rubber or the like, the disc 41 being interposed between the cylindrical block 34 and an insulating disc 42 which closes off one end of the casing 31. The outer ends of the contact 37 are provided with socket contacts 43 for connecting the end of the receptacle to other electrical circuitry. As best illustrated in FIGURES 2 and 3, the spacing between the cylindrical block 34 and the inner wall of the casing 31 is sufficient to provide a clearance space 44 into which the forward end of the casing 10 of the plug assembly fits when the two are mated.

In accordance with the present invention, at least portions of the bores 36 are surrounded by a hollow cylindrical sleeve 46 composed of a sublimable material which generates arc-extinguishing and combustion-extinguishing gases upon being energized by heat or electrical energy. Thus, when the plug assembly of FIGURE 1 is inserted into the receptacle assembly of FIGURE 2, shortly before the pins 23 engage the socket contacts 37, an arc may be drawn between the two metallic elements which will ignite any combustible gas contained within the interior of the bores. If the length of the sleeve 46 is made sufficiently long, the flaming gas can be used to volatilize the material of the sleeve 46, the absorption of energy thus occurring causing a reduction in temperature sufficient to bring the burning gas below ignition temperature. Furthermore, the effluent from the sleeve 46, using synthetic resinous materials of the type heretofore described, contains gases such as nitrogen and carbon dioxide which contaminate the burning gas and thereby reduce its potential to sustain burning.

The following specific examples illustrate the preparation of various compositions which form the preferred materials for use in connection with the present invention.

EXAMPLE I

A particularly preferred material is a mixture of a polyisobutylene-isoprene copolymer and a styrene-butadiene copolymer. The following formula, containing vulcanizing agents, accelerators, and other modifiers has been found to be particularly satisfactory:

Table I

	Parts
Tetramethylthiuram disulfide	2
Tellurium diethyldithiocarbamate	2
Isobutylene-isoprene copolymer (butyl rubber)	100
Stearic acid	2
Zinc oxide	10
Styrene-butadiene copolymer	100
Sulphur	4
Mercaptobenzothiazole	1

In formulating this material, the butyl rubber was banded on an open mill and the stearic acid was added while the roll temperature was at approximately 160° F. Afterwards, the zinc oxide is added and the roll temperature raised to 225° F., whereupon the styrene-butadiene copolymer was added and blended. The mix was removed from the mill and cooled. Then the stock was banded on a cool mill with the addition of the sulphur, the mercaptobenzothiazole, the tetramethylthiuram disulfide and the tellurium diethyldithiocarbamate. After cross-cutting and blending, the compound was removed from the mill. This stock could thereafter be calendered, extruded, or die-cut to form the particular shape required for the electrical connector.

EXAMPLE II

Another suitable material for the purposes of the present invention is the combination of a phthalic anhydride-glycerol-styrene copolymer and a copolymer of butadiene and styrene. One hundred parts of the former in liquid form were combined with 50 parts of the latter in solid form. This composition could be readily molded into any desired shape and was found to possess rapid arc extinguishing properties as well as excellent flame extinguishing properties.

The proportions between the various ingredients in the composition can vary widely within the scope of the present invention. When a cross-linked organic polymer is combined with a dienic copolymer, ranges existing from 1 to 10 to 10 to 1 are generally satisfactory. It is normally preferred, however, to employ a ratio of the cross-linked organic polymer (e.g., isobutylene-isoprene) to the dienic copolymer (e.g., butadiene-styrene) on the order of one quarter to four times.

From the foregoing, it will be understood that the connector of the present invention is capable of operating satisfactorily in the environment of combustible and even explosive gases without danger of igniting the gases outside the connector. It should be evident that various structural modifications can be made in the particular connectors to which the present application is applied without departing from the inventive concept or the scope of the present invention.

I claim as my invention:

1. The new use of a sublimable energy sink made of synthetic resinous material surrounding and confining the point of separation of a current continuing means in an explosion proof electrical connector having separable pin and socket contacts forming a confined chamber for any arc drawn therebetween, which comprises,

operating the connector in a hazardous hydrogen atmosphere such that explosive gas is present in said confined chamber,

igniting the atmosphere inside of said confined chamber with an arc drawn upon separation or engagement of the contacts,

utilizing the flaming hydrogen to set off the energy sink, thereby

(1) contaminating the atmosphere in the connector with effluent generated by the sublimation of the synthetic resinous material of the energy sink to render the atmosphere inside of said connector less hazardous and

(2) cooling the flaming hydrogen by transfer of thermal energy from the flaming hydrogen to the energy sink,

and confining the initial flaming of the hydrogen inwardly of the energy sink inside of said confined chamber to insure chemical and structural transformation of said synthetic resinous material sufficient to contaminate the atmosphere inside of said connector with said effluent for the purposes set forth.

2. The invention of claim 1 in which said sublimable material includes a combination of a cross linked organic polymer and a dienic copolymer.

3. The invention of claim 1 in which said sublimable material includes a combination of a cross linked organic polymer and a copolymer of butadiene and styrene.

4. The invention of claim 1 in which said sublimable material includes a combination of an isobutylene-diene copolymer and a copolymer of butadiene and styrene.

5. The invention of claim 1 in which said sublimable material includes a combination of an isobutylene-isoprene copolymer and a copolymer of butadiene and styrene.

6. The invention of claim 1 in which said sublimable material includes the combination of a phthalic anhydride-

glycerol-styrene copolymer and a copolymer of butadiene and styrene.

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