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Parker

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[54] **DEVICES AND PROCESSES FOR WARNING AGAINST IMPENDING ROCKFALLS IN UNDERGROUND EXCAVATION**

[76] Inventor: **Jack Parker,** Box 465, White Pine, Mich. 49971

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[52] **U.S. Cl.** ..... **116/114 R**

[51] **Int. Cl.** **G01d 21/00**

[58] **Field of Search**..... 116/114 R, DIG. 34; 85/62; 252/188.3; 240/2.25; 206/84

[56] **References Cited**

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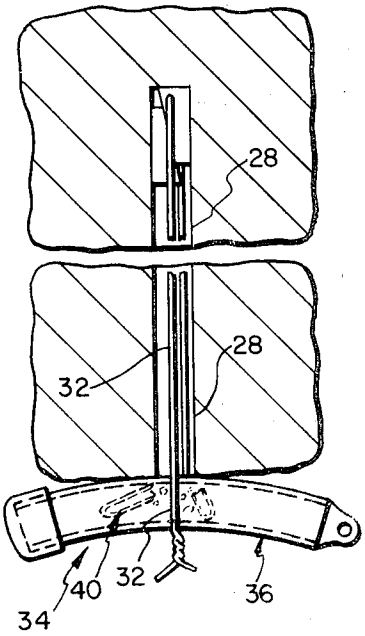
Primary Examiner—Louis J. Capozi

Attorney, Agent, or Firm—Morse, Altman, Oates & Bello

[57] **ABSTRACT**

Warning of an impending roof fall in a mine or the like is given by a normally inactive chemiluminescent unit that includes two isolated reactive components, which when mixed in response to the mechanical deformation that precedes a roof fall, produce chemiluminescent light that serves as a warning. An assemblage containing the isolated reactive components is retained at the lower opening of vertical bore hole in the mine roof, in which a tie extends through an intermediate fracture region between a secure rock region above to the warning assemblage. Preliminary sagging of the intermediate fracture region causes deformation of the assemblage and mixing of its chemiluminescent components. The resulting chemiluminescent glow serves as a warning of an impending rock fall to any miner or other person in the vicinity.

11 Claims, 10 Drawing Figures



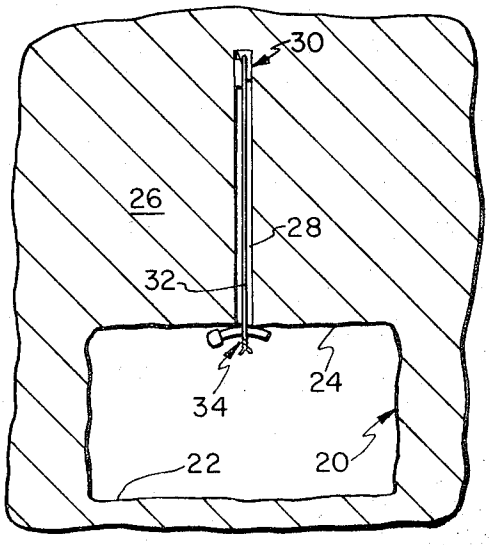


FIG. 1

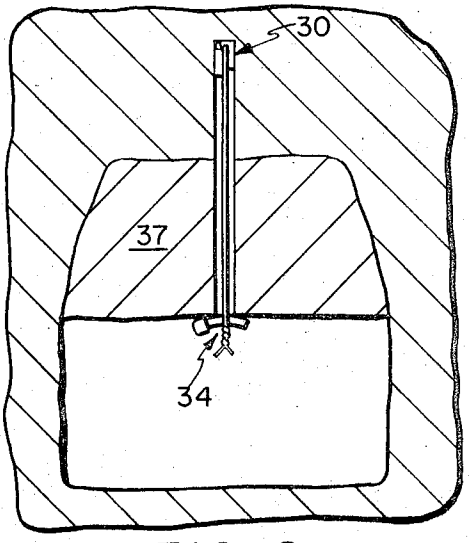


FIG. 2

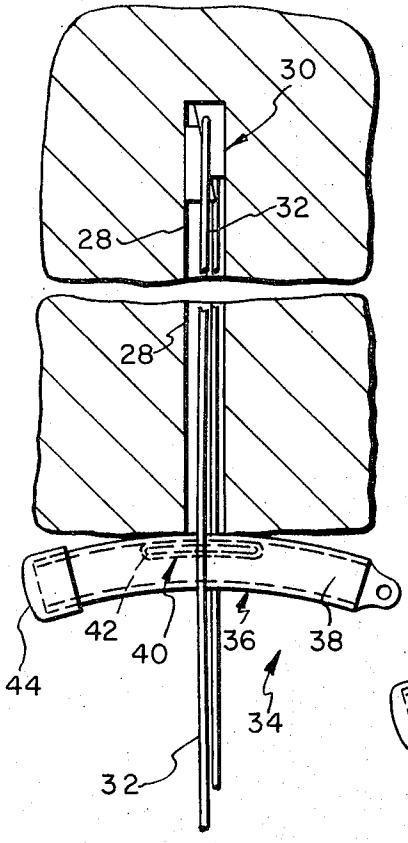


FIG. 3A

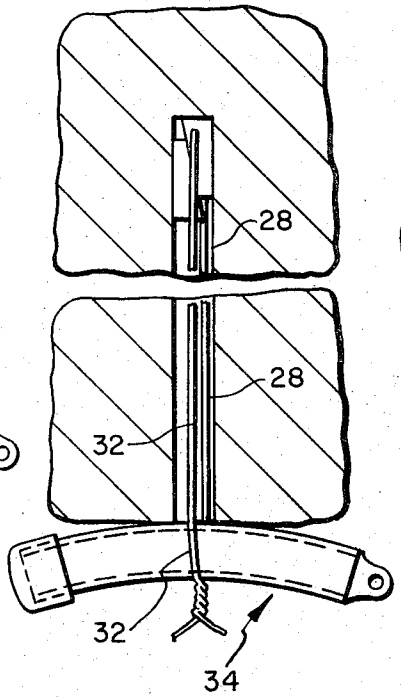


FIG. 3B

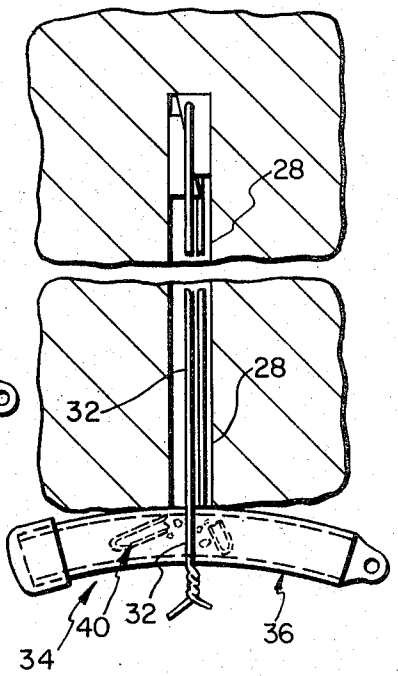


FIG. 3C

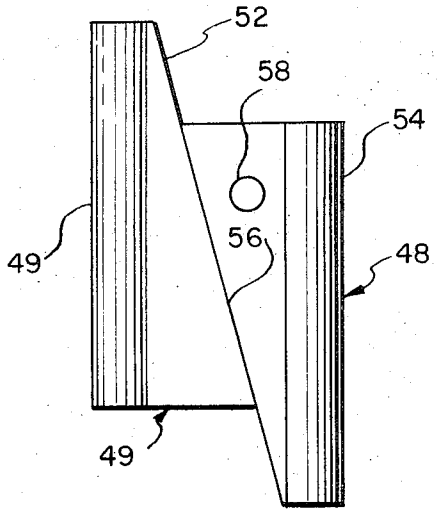


FIG. 4

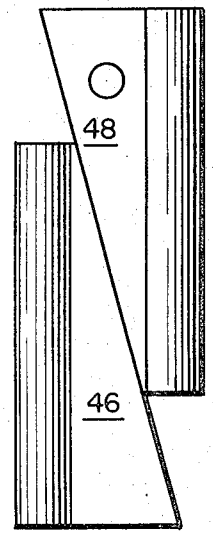


FIG. 6

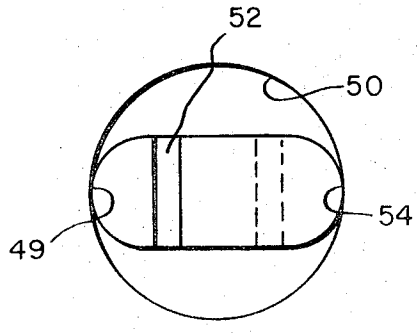


FIG. 5

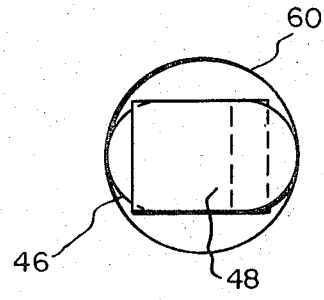


FIG. 7

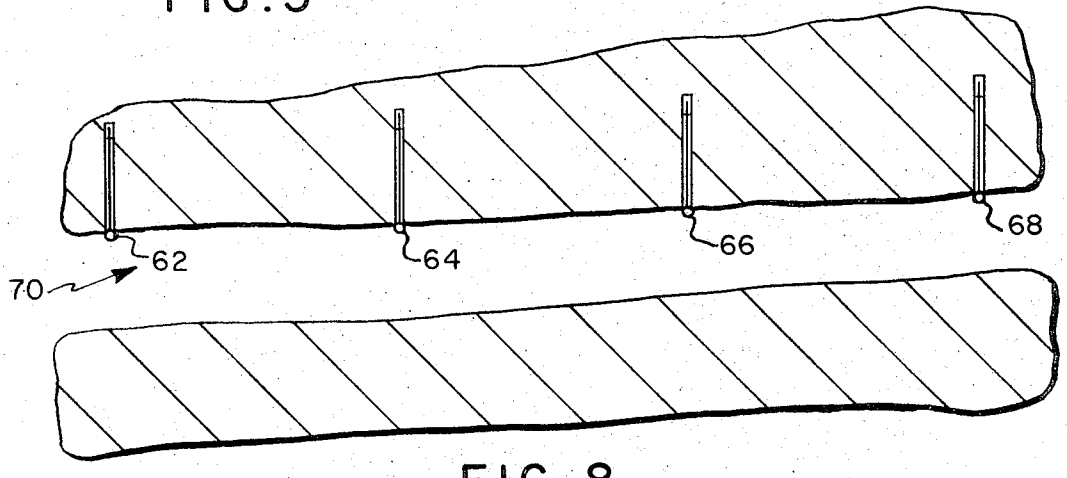


FIG. 8

DEVICES AND PROCESSES FOR WARNING AGAINST IMPENDING ROCKFALLS IN UNDERGROUND EXCAVATION

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to roof fall warning devices for use in mines and other excavations, and, more particularly, to roof fall warning devices which produce an alarm in response to the earliest signs of rock movement that normally precede a roof fall.

2. The Prior Art

Many people are injured or killed by roof falls underground in mines, tunnels and the like, usually because they are too busy to notice the earliest signs of rock movement that usually precede a roof fall. The number of accidents would be greatly reduced if workers had nothing to do but sit quietly, listen and watch. Preceding a roof failure, they would see small dribbles of rock and would hear creaks, groans, and bumps. They would have adequate time to leave safely. Most mine accidents could be avoided if it were feasible to mine only strong underground regions and to design prohibitively large safety factors into desired support systems. Ordinarily such procedures are uneconomic. Unfortunately for miners, the best ore often is found in the worst ground since fracturing usually is a prerequisite of ore deposition. Actually, the large safety factors which are incorporated into ordinary operations are an admission of ignorance in connection with conditions that are considered unpredictable. There is a need for "distant early warning roof fall" indicators capable of warning miners of roof rock movements even when they are busy and cannot hear well above operating noise. Given such an indicator capable of detecting and warning of impending falls of roof, work could proceed with minimal support until it was indicated that a certain area was in danger of falling. At that point, this particular area could be either supported or evacuated. Mining decisions then could be made rationally on the basis of assessable facts.

Various types of "distant early warning roof fall" indicators have been proposed. Such indicators include depth gauges or extensometers attached to dial indicators, horns or lights. Such indicators often require electrical power and electronic monitoring equipment. The presence of electrical power is sometimes dangerous because of the possible presence of explosive gasses and such monitoring equipment sometimes is not efficacious because it requires the attention of trained technicians.

SUMMARY OF THE INVENTION

The primary object of the present invention is to provide devices and processes in which warning of an impending roof fall in a mine or the like is given by a normally inactive chemiluminescent unit that is mechanically activated as a result of the structural deformation that precedes a roof fall. The unit includes two or more initially isolated reactive components, which, when mixed produce chemiluminescent light. Preferably, these components include: (1) an oxalic acid ester; and (2) a peroxide. An assemblage containing these isolated reactive components is retained at the lower opening of a hole in the mine roof, vertical or otherwise, in which a tie extends through an intermediate fractured region between a relatively secure rock region above to the warning assemblage. Preliminary sagging of the intermediate fractured region causes deformation of the assemblage, and mixing of its chemiluminescent components. The resulting chemiluminescent glow serves as a warning of an impending rock fall to any miner or other person in the vicinity.

Other objects of the present invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the processes and devices, together with their steps, components, and interrelationships, which are exemplified in the present disclosure, the scope of which will be indicated in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

For a fuller understanding of the nature and objects of the present invention, reference is to be made to the following detailed description, taken in connection with the accompanying drawings wherein:

FIG. 1 is a cross-sectional view of a mine tunnel, with its roof intact, illustrating the position of a warning device in accordance with the present invention;

FIG. 2 is a cross-sectional view of the mine tunnel of FIG. 1 just prior to a roof fall, illustrating the position of the warning device of FIG. 1;

FIG. 3A, 3B and 3C are detail views of successive steps in the process of using the device of FIG. 1, which is shown partly broken away for clarity;

FIG. 4 is a side elevation of a component of a device of FIG. 3 in one mode;

FIG. 5 is a top plan view of the component of FIG. 4 in position within the bore hole of a mine roof in accordance with the present invention;

FIG. 6 is a side elevation of the component of FIG. 4 in another mode;

FIG. 7 is a top plan view of the component of FIG. 6, in position within another bore hole of a mine roof in accordance with the present invention; and

FIG. 8 is a longitudinal cross-sectional view of a mine, to which a plurality of the devices of FIG. 1 are applied in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 illustrates an underground tunnel **20** having a floor **22** and a roof **24**, above which is an overburden **26**. In accordance with the present invention, a bore hole **28** is drilled upwardly to a point at which solid rock typically can be assured. Typically the bore hole is of a length ranging in excess of 1 foot. Next, by means of an elongated rod, an anchor **30** is interjected upwardly to the upper end of bore hole **28**, with a tie **32** extending downwardly through the bore hole and outwardly through the opening of the bore hole at roof **24**. Typically: tie **32** is a wire, for example, composed of steel, which extends from anchor **30** outwardly from bore hole **28**; or includes a rod, for example composed of steel, that extends from anchor **30** a part of the length of the bore hole and a wire, for example, composed of steel, that extends from the lower end of the rod outwardly from the bore hole. In a preferred form, the wire is threaded through a hole in anchor **30** and its both depending lengths extend outwardly from bore hole **28**. Next, chemiluminescent unit **34**, which is in the form of an elongated tube as shown in FIG. 3A, is positioned against roof **24** at bore hole **28** and, in the preferred form, both depending lengths of wire **32** are

wrapped first around the tube as shown in FIG. 3B and then are twisted about themselves as shown in FIG. 3C. Initially, chemiluminescent unit 34 is inactive as in FIG. 1. However, when there is a roof sag as in FIG. 2 so that some parting of the overburden occurs as at 37, the slight downward motion of roof 24 causes flexure of the outer container and rupture of the inner container. Consequent activation of chemiluminescent unit 34 occurs so that a bright light is emitted. This bright light can be seen by any worker in its vicinity within the mine or other excavation.

As shown in FIG. 3A, chemiluminescent unit 34 comprises an outer flexible plastic (i.e., polymeric) tubular container 36 that is either transparent or translucent. Within tubular container 36 is a frangible glass (i.e., vitreous) tubular container 40. In the form shown, inner tubular container 40 is either bonded to an inner wall of outer tubular container 36 or is fixed within outer tubular container 36 by apertured disks which snugly fit into the opposite ends of outer tubular container 36 and which are apertured to receive the ends of inner tubular container 40. A first chemically reactive component 38 is contained within container 36 and a second chemically reactive component 42 is contained within container 40. At one end of container 36 is a cap 44 which hermetically seals the interior of container 36. Inner container 40 hermetically isolates component 42 from component 38. The axes of tubular container 34 and tubular container 40 are parallel so that when container 34 is deformed, container 40 is ruptured and component 42 and component 38 mix. The resulting reaction between components 38, 42 causes luminescent emission of light through the walls of tubular container 34. It is to be understood that more than two chemical components can be used in accordance with the present invention to achieve chemiluminescence. In such cases two or more frangible internal coaxial or paraxial containers replace frangible container 40.

The chemical system of chemiluminescent unit 34 includes at least two chemiluminescent components comprising: either (a) a component containing a chemiluminescent compound and a component containing a hydroperoxide compound, either or both components containing a diluent, or (b) a dry solid component containing both a solid chemiluminescent compound and a solid hydroperoxide compound and a component comprising a solvent for the solid chemiluminescent compound and the solid hydroperoxide compound. Any other necessary ingredients for the production of chemiluminescent light, or for lifetime control, or for intensity improvement, or for storage stabilization must of course either be included in one of the two system components or included as additional components. In particular with the preferred oxalic-type chemiluminescent compounds of this invention, a fluorescent compound must be included in the system.

The preferred chemiluminescent light is obtained in this invention by the reaction of a hydroperoxide with a chemiluminescent composition which, in combination, comprises a chemiluminescent compound selected from the group consisting of (1) an oxalic-type anhydride, (2) an oxalic-type amide, (3) an oxalic-type O-acyl-hydroxylamine, and (4) an oxalic-type ester, in the presence of a fluorescer compound, and a solvent. Other suitable chemiluminescent compounds are 3-aminophthalhydrazide, 3,4,5-triphenylimidazole, 10, 10'-dialkyl-9,9'-biacridinium salts, and 9-chlorocarbonyl-10-methylacridinium chloride. All of the foregoing provide chemiluminescence when reacted with a hydroperoxide compound in the presence of a base.

The preferred chemiluminescent compound of this invention is an oxalic-type ester selected from the group consisting of (a) an ester of an oxalic-type acid and an alcohol characterized by acid ionization constant in water greater than 1.3×10^{-10}, and (b) a vinyl ester of an oxalic-type ester. Similarly, in a preferred embodiment thereof, the alcohol would be an aromatic alcohol substituted by a substituent characterized by a positive Hammett sigma value. The preferred species of oxalic-type esters include bis(substituted-phenyl) oxalate, bis(2-nitrophenyl) oxalate, bis (2,4-dinitrophenyl) oxalate, bis(2,6 dichloro-4-nitrophenyl) oxalate, bis(2 methyl-4,6-dinitrophenyl) oxalate, bis(2-dimethyl-4,6-dinitrophenyl) oxalate, bis(2,4-dichlorophenyl) oxalate, bis(2,5-dinitrophenyl) oxalate, bis(2-formyl-4-nitrophenyl) oxalate, bis(pentachlorophenyl) oxalate, bis(1,2-dihydro-2-oxo-1-pyridyl) glyoxal, bis-N-phthalimidyl oxalate. The preferred subspecies is bis (pentachlorophenyl) oxalate.

The peroxides employed in the components of this invention may be any hydroperoxide compound. Typical hydroperoxides include t-butylhydroperoxide, peroxybenzoic acid, and hydrogen peroxide. Hydrogen peroxide is the preferred hydroperoxide and may be employed as a solution of hydrogen peroxide compound such as perhydrate of urea (urea peroxide), perhydrate of pyrophosphate(sodium pyrophosphate peroxide), perhydrate of histidine (histidine peroxide), sodium perborate, sodium peroxide, and the like. Whenever hydrogen peroxide is contemplated to be employed, any suitable compound may be substituted which will produce hydrogen peroxide.

The peroxide concentration may range from about 15 molar down to about 10^{-5} molar, preferably about 2 molar down to about 10^{-4} molar. The ester of this invention may be added as a solid or in admixture with a suitable solid peroxide reactant or in a suitable diluent, or alternatively dissolved directly in a solution containing the peroxide reactant.

Typical diluents, which additionally may be used in conjunction with the necessary diluent of this invention, are those which do not readily react with a peroxide, such as hydrogen peroxide, and which do not react with an ester of oxalic acid.

Where a solvent is employed with the hydroperoxide-containing component of this invention, the solvent can be any fluid which is unreactive toward the hydroperoxide and which accomodates a solubility of at least 0.01 M hydroperoxide. Typical solvents for the hydroperoxide component include water; alcohols, such as ethanol or octanol; ethers, such as diethyl ether, diamyl ether, tetrahydrofuran, dioxane, dibutyl-diethyleneglycol, perfluoropropyl ether, and 1,2-dimethox-yethane; and esters, such as ethyl acetate, ethyl benzoate, dimethyl phthalate, dioctylphthalate, propyl formate. Solvent combinations can, of course, be used such as concentrations of the above with aromatic anisole, tetralin, and polychloro-biphenyls, providing the solvent combination accomodates hydroperoxide solubility. However, when oxalic-type chemiluminescent materials are used, strong electron donor solvents such as dimethyl formamide, dimethyl sulfo-

nide, and hexamethyl phosphoramide should not, in general, be used as a major solvent component.

Where a solvent is employed with a component containing the chemiluminescent material, any fluid can be used, providing the fluid solubilizes at least 0.01 M concentration of the chemiluminescent material and is unreactive toward the chemiluminescent material. Typical solvents include ethers, esters, aromatic hydrocarbons, chlorinated aliphatic and aromatic hydrocarbons, such as those cited in the preceding paragraph. For oxalic-type chemiluminescent compounds, hydroxylic solvents such as water or alcohols and basic solvents such as pyridine should not be employed since such solvents used in general, react with and destroy oxalic-type chemiluminescent compounds. Solvent combinations may, of course, be used but such combinations when used with oxalic-type chemiluminescent compounds should not include strong electron donor solvents.

When a component comprising a solid chemiluminescent compound and a solid hydroperoxide is used, the solvent or solvent composition comprising the second component may vary broadly. The solvent, however, should preferably dissolve at least 0.02 M concentrations of both the hydroperoxide and the chemiluminescent compound, and, for oxalic-type chemiluminescent compounds, strong electron donor solvents should be avoided as major solvent components.

The fluorescent compounds contemplated herein are numerous; and they may be defined broadly as those which do not readily react on contact with the peroxide employed in this invention, such as hydrogen peroxide, likewise, they do not readily react on contact with the chemiluminescent compound.

A fluorescent compound is required for light emission when the prepared oxalic-type chemiluminescent compound of the invention is employed. For other types of chemiluminescent compounds a fluorescer is not required but may be used to shift the wavelength of emitted light toward the red region of the spectrum so as to change the color of emitted light. Fluorescent compounds for use with oxalic-type chemiluminescent compounds should be soluble in the reactive solvent at least to the extent of 0.0001 moles per liter.

Typical suitable fluorescent compounds for use in the present invention are those which have a spectral emission falling between 330 millimicrons and 1,000 millimicrons and which are at least partially soluble in any of the above diluents, if such diluent is employed. Among these are the conjugated polycyclic aromatic compounds having at least three fused rings, such as anthracene, substituted anthracene, benzanthracene, phenanthrene, substituted phenanthrene, naphthacene, substituted naphthacene, pentacene, substituted pentacene, and the like. Typical substituents for all of these are phenyl, lower alkyl, chlorine, bromine, cyano, alkoxy (C_1–C_{16}) and other like substituents which do not interfere with the light-generating reaction contemplated herein.

A fluorescent oxalic-type ester, such as the oxalic acid ester of 2-naphthol-3,6,8-trisulfonic acid, does not require a separate fluorescent compound to obtain light. Other typical fluorescent oxalic acid esters include esters of oxalic acid (1) 2-carboxyphenol, (2) 2-carboxy-6 hydroxyphenol, (3) 1,4-dihydroxy-9,10 diphenylanthracene, and (4) 2-naphthol. Thus a reactant including a fluorescent oxalic-type ester would thereby include at least one fluorescent compound.

It has been found that the molar (moles per liter of diluent) concentrations of the major components of the novel composition herein described may vary considerably. It is only necessary that components be in sufficient concentration to obtain chemiluminescence. The ester of oxalic acid molar concentration normally is in the range of at least about 10^{-4} to five molar, preferably in the range of at least about 10^{-3} to about one molar; the fluorescent compound is present in the range from about 10^{-5} to 5, preferably 10^{-4} to 10^{-1} molar; and the diluent must be present in a sufficient amount to form at least a partial solution of the reactants involved in the chemiluminescent reaction. If the ester is liquid, it may serve as either the sole diluent or a partial diluent.

The wavelength of the light emitted by chemiluminescence of the compositions of this invention, i.e., the color of the light emitted, may be varied by the addition of any one or more energy transfer agents (fluorescers) such as the known fluorescent compounds discussed at length above. The wavelength of the light emitted by the composition of this invention will vary, depending upon the particular fluorescent component employed in the reaction. Additionally, it has been found that the superior intensity of chemiluminescence is obtained when the final mixture producing the luminescence is maintained at a temperature of between about −40°C. and 75°C., preferably between about −20°C and 50°C. However, temperature is not critical and the luminescence of Applicant's process is not limited to these ranges.

Chemiluminescent components of the foregoing types are disclosed in detail in: U.S. Pat. No. 3,576,987, issued May 4, 1971 to American Cyanamid Company for "Chemical Lighting Device To Store, Initiate and Display Chemical Light;" and U.S. Pat. No. 3,597,362, issued Aug. 3, 1971, to American Cyanamid Company for "Generation Of Light By The Reaction Of Esters Of Oxalic-Type Acids."

Anchor **30** is shown in FIGS. **4** and **5** as comprising a pair of oppositely directed wedges **46, 48.** Wedge **46** has a curved outer periphery **49,** which is adapted to abut against the inner periphery of a bore hole **50,** and a flat inner face **52,** which converges upwardly toward periphery **49.** Wedge **48** has a curved outer periphery **54,** which is adapted to abut against the inner periphery of bore hole **50,** and a flat inner face **56,** which converges downwardly toward periphery **54.** The angle of face **52** with respect to a paraxial line along periphery **49** is the same as the angle of face **56** with respect to a paraxial line along periphery **54.** In consequence, faces **52, 56** are snugly in contact when the outer peripheries **49, 54** of the wedges are abutted against the inner periphery of bore hole **50.** Tie **32** is connected to an opening **58** in wedge **48** so that downward pressure of the tie merely causes tightening of the wedges against the inner periphery of bore hole **50.** FIGS. **6** and **7** illustrate an alternative mode of operation of anchor **30** with wedge **48** elevated above wedge **46** and with the anchor being positioned within a bore hole **60** that is smaller than bore hole **50** in diameter.

OPERATION

In operation, devices of the type illustrated in FIGS. **1, 2, 3** are installed, as shown in FIG. **8** at intervals **62,**

64, 66, 68, typically every 15 feet, along a mine tunnel **70** so that the number of lights which are activated indicates the extent of any approaching failure. As shown in FIG. **2,** before a mass of broken rocks actually falls there is some separation of the layers of rocks up to some secure height. Anchor **30** is high enough in relatively solid rock so as to provide a reference point with respect to chemiluminescent device **34,** which is positioned at the roof face. When the roof begins to sag, tie **32** tightens and bends chemiluminescent unit **34** in order to break tubular container **40** and to mix its contents with the contents tubular container **34.** The resulting light is a widely visible indication that the roof is moving. Miners in an active heading thereby are warned and are able to take appropriate action, If miners come on shift after a shift change and see active lights, they known which areas to avoid. Installation in sensitive areas such as main intersections, conveyer transfer points and compressor sites can provide timely warning of impending failure and thus allow action to be taken to prevent or allow for costly downtime.

EXAMPLE

In accordance with the present invention, eight chemiluminescent units, or lightsticks, were tested in an Instron testing machine. Each lightstick included external tubular plastic, flexible, translucent container about 6 inches long and ½ an inch in diameter and an internal glass tube about ¼ inch in diameter fixed inside the plastic tube as discussed above. The tests were designed to simulate underground conditions, with thin steel wire passing around any lightstick at the collar of a bore hole.

The purpose of the tests was to check performance features as follows:

a. How much tension is needed in the wire to activate the light.

b. How much deflection (or roof separation) is needed to activate the light.

c. How the above factors are affected by the diameter of the hole drilled in the roof.

d. How consistent and predictable tension and deflection are.

e. How long the light is visible under typical mine conditions.

The following table lists the results:

No.	Hole diam."	Tension lbs.	Deflection"	Life, hrs.	Comments
1	Broken by hand, no test		—	—	—
2	1-⅝	53.5	0.35		
3	1-½	54.5	0.35	12 plus	
4	1-½	57.0	0.38		
5	1-⅛	50.0	0.31	12 plus	
6	1-⅛	63.0	0.33		
7	1-⅜	56.0	0.31	12 plus	
8	1-⅜	34.0	0.26	12 plus	Wire about ¼" off center.

Conclusions

a. 50–60 lbs. of tension is sufficient to activate the light.

b. One third of an inch of deflection will activate the light.

c. Within the range tested (1⅛ to 1⅝ inch) the diameter of the hole has no significant effect on performance.

d. Both tension and deflection are consistent and predictable, provided that the wire is centered in the hole.

e. Life of light at about 70°–75°F is at least 12 hours.

CONCLUSION

Advantages of the process and apparatus of the present invention are as follows:

1. Installation is simple and fast. Holes can be drilled at regular intervals by roof bolter operators.

2. Cost is low, much lower than comparable mechanical or electrical devices.

3. There is nothing to go wrong- no batteries, no bulbs, and no electrical connections.

4. The monitoring is continuous and cummulative-unlike periodic measurements, temporary extensometers, or temporary warning lights.

5. Movement is signalled to anyone passing through the area so that many pairs of eyes can be watching — not just a few trained technicians.

6. Luminescent light is cool so that there is no ignition hazard.

Since certain changes may be made in the above disclosure without departing from the scope of the invention herein, it is intended that all matter contained in the foregoing description or shown in the accompanying drawings be interpreted in an illustrative and not in a limiting sense.

What is claimed is:

1. An alarm for warning of possible roof fall in an excavation, said alarm comprising: a chemiluminescent unit including at least a first container means, at least a first chemical reagent within said first container means, at least a second container means, at least a second chemical reagent within said second container means, said first container means and said second container means being in contiguity, the interiors of said first container means and said second container means being in communication for mixing said first chemical reagent and said second chemical reagent when subjected to an applied force, said first chemical reagent and said second chemical reagent being inactive when separate and being active when mixed to produce chemiluminescent light; anchor means for connection to a mine roof; and tie means extending between and mechanically connecting said anchor means and said chemiluminescent unit; whereby deformation of said chemiluminescent unit as a result of tension in said tie means as a result of said applied force causes mixture of said first chemical reagent and said second chemical reagent.

2. The device of claim **1,** wherein one of said container means is positioned within the other of said con-

tainer means in such a way as to isolate said first chemical reagent from said second chemical reagent.

3. The device of claim 2, wherein said one of said container means is rupturable.

4. The device of claim 1 wherein said first chemical reagent is an oxalic compound.

5. The device of claim 1 wherein said second chemical reagent is a peroxide compound.

6. The device of claim 1 wherein said anchor means includes a pair of oppositely directed wedges.

7. The device of claim 1 wherein said anchor means includes a pair of oppositely directed wedges, one of said wedges having a converging flat surface directed upwardly and the other of said wedges having a converging flat surface directed downwardly, said tie means being connected to said second of said wedges.

8. An alarm for warning of possible roof fall in an excavation, said alarm comprising: a chemiluminescent unit including at least first container means, at least a first chemical reagent within said first container means, at least second container means, at least a second chemical reagent within said second container means, said first container means and said second container means being in contiguity, the interiors of said first container means and said second container means being in communication for mixing said first chemical reagent and said second chemical reagent when subjected to an applied force, said first chemical reagent and said second chemical reagent being inactive when separate and being active when mixed to produce chemiluminescent light; anchor means for connection to a mine roof; and tie means extending between and mechanically connecting said anchor means and said chemiluminescent unit; whereby deformation of said chemiluminescent unit as a result of tension in said tie means causes mixture of said first chemical reagent and said second chemical reagent; one of said container means being positioned within the other of said container means in such a way as to isolate said first chemical reagent from said second chemical reagent; said one of said container means being rupturable; said anchor means including a pair of oppositely directed wedges, one of said wedges having a converging flat surface directed upwardly and the other of said wedges having a converging flat surface directed downwardly, said tie means being connected to said of said wedges; said one of said container means and said other of said container means being paraxial.

9. The alarm of claim 8 wherein one of said chemical reagents is an oxalic compound.

10. The alarm of claim 8 wherein one of said chemical reagents is a peroxide compound.

11. An alarm for warning of possible roof fall in an excavation, said alarm comprising:

a. an outer elongated container composed of a light transmitting, flexible polymeric material;

b. an inner elongated container within said first elongated container and composed of a frangible vitreous material;

c. a first liquid in one of said outer elongated container and said inner elongated container;

d. a second liquid in the other of said outer elongated container and said inner elongated container;

e. one of said first liquid and said second liquid containing an oxalic acid ester;

f. the other of said first liquid and said second liquid containing a peroxide;

g. said inner container being paraxially and fixedly located within said outer container, predetermined flexing of said outer containing causing rupture of said inner container;

h. an anchor for affixation within an elongated bore in a mine roof;

i. said anchor including a pair of oppositely directed wedges having inner flat surfaces and outer curved surfaces, said flat surfaces being operationally contiguous with each other and said curved surfaces being operationally remote from each other;

j. and an elongated flexible tension cord having an upper extremity and a lower extremity, said upper extremity being connected to one of said wedges, said lower extremity being connected to said outer elongated container;

k. whereby when said anchor is fixed within the upper extremity of said elongated bore in said mine roof and said outer elongated container is in abutment against said mine roof at the lower extremity of said elongated bore in said mine roof, predetermined movement of said mine roof causes flexing of said outer elongated container, breaking of said inner elongated container, mixing of said oxalic acid ester and said peroxide, and emission of luminescent light from said outer elongated container.

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