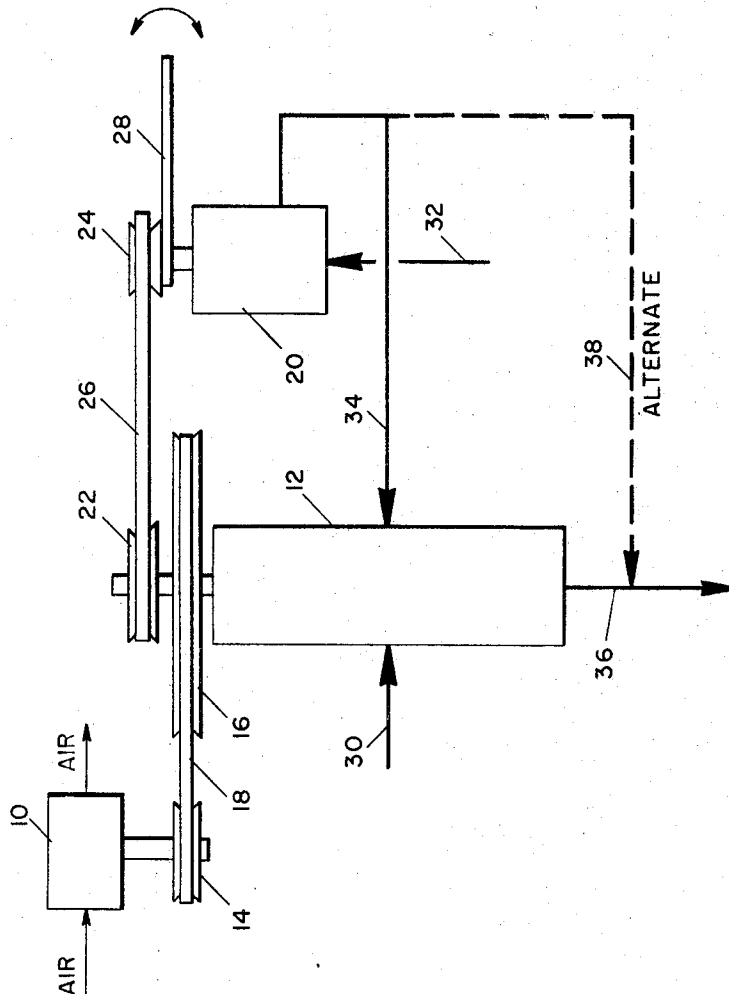


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BULK DELIVERY OF CROSSLINKABLE AQUEOUS SLURRY EXPLOSIVE
WITH CROSSLINKING AGENT IN A SEPARATE FEED
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1

3,523,048

BULK DELIVERY OF CROSSLINKABLE AQUEOUS SLURRY EXPLOSIVE WITH CROSSLINKING AGENT IN A SEPARATE FEED

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Continuation-in-part of application Ser. No. 661,250, Aug. 17, 1967, which is a continuation of application Ser. No. 528,527, Feb. 18, 1966, which in turn is a continuation of application Ser. No. 386,317, July 30, 1964. This application Nov. 16, 1967, Ser. No. 683,495

Int. Cl. C06b 1/00

U.S. Cl. 149—109

10 Claims

ABSTRACT OF THE DISCLOSURE

A method for bulk delivery of an aqueous slurry blasting agent to the packaging unit of an explosive plant or into the borehole of a blasting operation by pumping through a conduit. A suspension is injected into a moving stream of pumpable aqueous slurry blasting mixture containing guar gum under controlled conditions of pH whereby the end product emerging from the conduit is crosslinked to a desired degree of firmness.

This application is a continuation-in-part of my copending application Ser. No. 661,250, filed Aug. 17, 1967, now abandoned, which is a continuation of my application Ser. No. 528,527, filed Feb. 18, 1966, now abandoned, which was a continuation of my application Ser. No. 386,317, filed July 30, 1964, now abandoned.

This invention relates to aqueous slurry blasting agents and particularly to a method for the bulk delivery of crosslinked aqueous slurry blasting agents.

The use of aqueous slurry blasting agents has become widespread in recent years due to the relatively low cost of the ingredients involved. Additionally, it has been common practice to bulk load boreholes or containers with slurry blasting agents by gravity flow, air pressure, water pressure of similar means; here again, in quest of utmost economy. However, more recently the art has converted to gelled and crosslinked aqueous slurry blasting agents particularly in view of their superior in situ properties in respect to water resistance, plasticity and cohesiveness. These crosslinked blasting agents are of firm body and tend to hold their shape but, nevertheless, undergo sufficient innate plastic flow to completely fill a borehole or container. Additionally, the extent of plastic flow which these slurries exhibit is generally such that the slurry will not run out of the borehole into seams, cracks or crevices and will not lose its integrity in the presence of copious amounts of water. Aqueous slurry blasting agents of this type and their method of manufacture are well known in the art.

From the foregoing, it will be appreciated that the firm body imparted to the crosslinked slurry blasting agents mitigates their use for bulk delivery systems, which systems are highly desirable from an economic standpoint in respect to filling boreholes and containers. For example, one of the most satisfactory systems for loading boreholes or containers is by pumping, and the crosslinked aqueous slurry blasting agents as heretofore known and utilized are not entirely suitable for this. For example, the many industrial gums classified of polysac-

2

charides or their derivatives when dispersed in water swell to produce gels, highly viscous dispersions, or solutions. These gums by virtue of their hydratable nature give a delayed action thickening effect and when employed for the purpose of preventing settling out of particulate material in aqueous slurry blasting agents have been found reasonably satisfactory. On the other hand, however, it has been found that the crosslinked gums are quite superior due to their ability to impart higher viscosity to dispersions at lower concentrations and to be fast acting. It is in this latter class of gums to which applicant's copending application is directed and the present invention.

Moreover, it will be appreciated that in using hydratable gums as a delayed action thickening agent or in using crosslinkable gums, that if these gums are initially incorporated into the blasting agent for bulk delivery and some unforeseen exigency arises at the blasting site to delay placement of the bulk blasting agent, that a mass of unpumpable blasting agent may readily be at hand. Furthermore, since it is common practice in some instances of bulk delivery to use mix trucks and to feed together simultaneously all materials at the blasting site which when combined form the aqueous slurry blasting agent, an undesirable condition exists if a prolonged delay occurs.

The method of my copending application, heretofore identified, eliminates the foregoing deficiencies by providing a secondary stream for injection of crosslinking guar gum into a primary moving stream of the blasting agent ingredients. By using this injection technique, the blasting ingredients may be mixed at a plant and hauled to the blasting site or they may be mixed at the blasting site and if any unforeseen exigency arises, the secondary injection stream is simply turned down or off or ingredient controlled until normal operations are resumed. The objects of the present invention, therefore, are similar to those of my copending application with additional objects and advantages including aeration being set forth as will appear hereinafter, the novel features and combinations being set forth in the appended claims.

Generally described, the present invention contemplates a method for bulk delivery of a crosslinked aqueous slurry blasting agent in which the improvement comprises forming a moving stream of pumpable aqueous slurry blasting mixture of the inorganic oxidizer salt type having the discrete ingredients thereof held in suspension or dispersion by the thickening action of a crosslinkable guar gum, forming a moving stream of pumpable injection mixture essentially containing sufficient crosslinking agent to crosslink the crosslinkable guar gum and effectively impart firmness to the aqueous slurry blasting mixture, injecting the moving stream of pumpable injection mixture into the moving stream of pumpable aqueous slurry blasting mixture, and pumping the entire intimate mixture thus formed at a pH of less than 6 through an elongated conduit to effect bulk delivery thereof at a rate of time within said conduit to obtain substantial crosslinking and firmness of the intimate mixture upon discharge from the said conduit.

As a preferred embodiment, the invention contemplates a method for bulk delivery of a crosslinked aqueous slurry blasting agent into a borehole of a blasting operation in which the improvement comprises pumping a primary stream of aqueous slurry blasting mixture of the inorganic oxidizer salt type from a slurry mixture pump through a hose directly into a borehole, said mixture hav-

3

ing the discrete ingredients thereof held in suspension or dispersion by the thickening action of a crosslinkable guar gum, and pumping a secondary stream essentially containing sufficient crosslinking agent to crosslink the crosslinkable guar gum at a pH of less than 6 into the primary stream of aqueous slurry blasting mixture and passing the mixture thus formed through the hose to obtain substantial crosslinking and firmness of said mixture by the time it discharges from said hose.

The preferred embodiment of the invention chosen for purposes of illustration and description is shown in the accompanying drawing which is a diagrammatic plan view of an arrangement of apparatus for carrying the invention into effect for the loading of boreholes in the field.

In the drawing an air-driven motor 10 drives a first Moyno pump 12 by engagement of a motor pulley 14 with a first pump pulley 16 through a belt 18. The air-driven motor 10 also drives a second Moyno pump 20 by engagement of a second pump pulley 22 with a clutch pulley combination 24 through a belt 26. Pump pulleys 16 and 22 are secured to the drive shaft of Moyno pump 12 and pump pulley 24 is affixed to the drive shaft of Moyno pump 20 with the clutch engagement thereof variably controlled by lever arm 28.

An example of operation of this apparatus and the method of the invention follow. A pumpable aqueous slurry blasting mixture containing crosslinkable guar gum from a mix truck, a tank delivery truck or other suitable supply source (not shown) is passed through line 30 into the first Moyno pump 12. Simultaneously therewith, a pumpable injection mixture containing crosslinking agent to crosslink the crosslinkable guar gum from a compartment of a mix truck, a tank delivery truck or other suitable supply source (not shown) is fed through line 32 into the second Moyno pump 20 and pumped therefrom through line 34 into the first Moyno pump 12. The slurry mixture from line 30 and the injection mixture from line 34 are thus intimately mixed in Moyno pump 12 and pumped therefrom into a conduit or hose 36 and therefrom into a borehole (not shown). Alternatively, the injection mixture from line 34 may be pumped directly through line 38 into the moving stream passing through the conduit 36. Intimate mixing is obtained, likewise, with this arrangement. Control valves, check valves, gages, pressure tanks, and the like have not been illustrated since the provision and operation of such auxiliary equipment are commonly understood.

It will be appreciated as generally described that the primary pumpable aqueous slurry blasting mixture contains crosslinkable guar gum which acts as a thickening agent to hold the discrete ingredients in the mixture in suspension or dispersion for an indefinite period of time, when desired or necessary, without any deleterious effect. Such discrete ingredients may include, for example, undissolved inorganic oxidizer salt, such as, ammonium nitrate, sodium nitrate, ammonium and sodium perchlorates; nonexplosive fuels, such as, particulate fuel or immiscible liquid fuel which must be suspended or dispersed throughout the aqueous phase; solid materials, such as solid DNT, coal, sulfur, gilsonite and liquid materials such as liquid DNT, saccharides, glycols, amine nitrates, formamide, urea; explosive materials, such as smokeless powder, nitrostarch, TNT, RDX, HBX, HMX, PETN, Pentolite, Cyclotol; and metal energizers, such as, aluminum, silicon, calcium silicide, calcium boride, silicon

4

blasting mixture may be formulated having all ingredients per se non-explosive as well as formulated having certain ingredients explosive.

The following table presents typical primary pumpable aqueous slurry blasting mixtures and typical secondary pumpable injection mixtures for utilization in accordance with the present invention.

TABLE I
Pumpable Aqueous Slurry Blasting Mixture

Example.....	Percent by weight			
	1	2	3	4
Ingredients:				
Water.....	16.5	17.0	16.5	16.5
Smokeless Powder (ground).....	32.5	30.4	---	---
Ammonium Nitrate (prills).....	38.7	32.5	52.0	53.0
Sodium Nitrate (prills).....	10.0	10.0	15.6	15.6
Aluminum (all thru 20 mesh sieve).....	---	7.8	8.5	---
Silicon (all thru 80 mesh sieve).....	---	---	---	8.5
Coal (ground).....	---	---	1.2	1.2
Glycol.....	1.5	1.5	5.0	5.0
Guar Gum (crosslinkable).....	0.7	0.67	1.0	1.0
Fumaric Acid.....	0.05	0.08	---	---
Pine Oil.....	0.05	0.05	---	---
Total.....	100.00	100.00	100.00	100.00

Pumpable Injection Mixture

Example.....	Percent by weight	
	A	B
Ingredients:		
Potassium pyroantimonate (DW6) (cross-linking agent).....	16.8	114.0
Fumaric Acid.....	25.2	(?)
Glycol.....	58.0	140.0
Sodium nitrate (aeration agent).....	---	11.0
Water.....	---	35.0
Total.....	100.0	100.0

¹ Added together as one component.

² Add acid to adjust pH from about 3.0 to about 5.0.

³ Added together as other component.

Various combinations of the blasting and injection mixtures given in Table I were field tested by pumping into boreholes at rates varying from about 200 to about 600 pounds per minute and were found satisfactory in all respects when shot with conventional boosters. For example, injection mixture A was fed through line 32 into Moyno pump 20 and was pumped therefrom through line 38 directly into the stream of blasting mixture of Example 1 being pumped from Moyno pump 12 and passed through conduit 36. In like manner, injection mixture A was pumped into the stream of blasting mixture of Examples 2 and 3. Injection mixture B was fed through line 32 into Moyno pump 20 and was pumped therefrom through line 38 directly into the stream of blasting mixture of Example 1 being pumped from Moyno pump 12 and passed through conduit 36. In like manner, injection mixture B was pumped into the stream of blasting mixture of Examples 2, 3 and 4.

The amount of secondary injection mixture pumped into the stream of primary blasting mixture was in each case approximately 0.4% by weight of the entire blasting composition. All products were substantially crosslinked and firm upon discharge from the conduit or hose into the boreholes. Table II, which follows, gives the pH and specific gravity in respect to the various combinations of blasting mixture and injection mixture set forth above.

TABLE II

Combinations.....	1-A	2-A	3-A	1-B	2-B	3-B	4-B
pH.....	3.0-4.5	3.0-4.5	3.0-4.5	3.0-4.5	3.0-4.5	5.0	5.2
Maximum Specific Gravity.....	1.4-1.5	1.4-1.5	1.4-1.5	---	---	---	---
Aerated Specific Gravity.....	---	---	---	1.15	1.15	1.13	1.15

carbide, ferro silicon, magnesium, and alloys and mixtures thereof. Thus, the primary pumpable aqueous slurry

With reference to the foregoing Table II, it will be appreciated that the blasting compositions 1-B and 2-B,

although containing explosive sensitizer, were increasingly sensitized by aeration and that the blasting compositions 3-B and 4-B, although containing no explosive sensitizer, were likewise increasingly sensitized by aeration as evidenced more particularly by composition 4-B containing silicon which is characteristic of some metals including certain types of aluminum which contribute little or nothing in respect to sensitization in the absence of aeration. The term an "aeration agent" as used herein means an agent which causes the composition to be combined with or charged with gas. The term "maximum specific gravity" as used herein means the specific gravity of the aqueous slurry blasting agent exclusive of gas, and the term "aerated specific gravity" as used herein means the specific gravity of the aqueous slurry blasting agent inclusive of gas. It is recognized that evenly dispersed air or gas bubbles throughout an explosive can be beneficial to initiation and propagation. Such gas bubbles may be generated as disclosed by Ferguson et al. (U.S. 3,288,658) and Swisstack (U.S. 3,288,661). A preferred aeration agent is sodium nitrite as shown in Table I, Example B. Regardless of the aeration agent chosen, it may simply be incorporated in the injection mixture. This, of course, permits holding the volume of the primary or base blasting mixture to a minimum in the mixing chamber of a mix truck or in the tank of a delivery truck. And this is particularly advantageous when using a fast gas generating material such as sodium bicarbonate, or a mixture such as sodium bicarbonate and sodium nitrite, or air.

Various blasting ingredients which may be utilized in accordance with the present invention have heretofore been set forth with preferred blasting mixtures and injection mixtures being presented in Table I. Generally, however, the various ingredients will be employed approximately as follows.

The inorganic oxidizing salts are shown in the examples as being present in amount of 48-68% of the compositions. If requirements so dictate, these salts could comprise between 30 and 75% of the compositions. The physical form of the salts is not critical, coarse or fine, or mixtures of coarse and fine prilled and/or granular to powdery material all being suitable. In fact, in some preferred applications, the oxidizing salts are introduced into the compositions as an aqueous solution. Ammonium nitrate (AN), because of its availability, is the preferred oxidizing salt but sodium nitrate (SN) in practice almost always makes up a portion of the oxidizing salts, preferably to the extent of about 5% to 25% of the composition, but 0% to about 30% may be used. Although the examples given are all formulated with inorganic nitrates, the use of other inorganic oxidizing salts are within the scope of this invention. For instance, various of the alkali or alkaline earth nitrates may be used for all or a portion of the AN, but in practice, not more than 80% of the AN would be so substituted. A preferred range for the presence of AN is from about 30% to about 75%. In addition, salts selected from the perchlorates and less desirably, the chlorates in the absence of ammonium nitrate may be used. Examples of these are the ammonium, sodium and potassium salts with ammonium and sodium perchlorates being especially advantageous.

The nonexplosive carbonaceous fuels appear in the examples as being present in amount of 1-6% of the compositions. Depending upon the conditions, 3% to 15% of the compositions may be made up of one or more carbonaceous fuels, but 3% to 12% is more commonly used. The nature of the carbonaceous material is not ordinarily critical but at lower levels, soluble fuels, amine nitrates, glycols, such as ethylene glycol and saccharides, such as ordinary granulated sugar, are preferred. Where insoluble particulate carbonaceous fuel or immiscible carbonaceous liquid fuels are used, they must, of course, be suspended in or dispersed throughout the aqueous phase.

Water is shown as 16-17% by weight of the compositions in the examples. Between 10 and 30% of the compositions may be composed of water but in conventional practice 14 to 24% is more commonly employed.

It will be appreciated that the compositions of this invention may be composed of a blend of liquid and solid components. It is essential that the solid phase or non-homogeneous liquid phase, when such is utilized, be uniformly dispersed throughout the liquid phase. Solid materials, such as DNT, coal, sulfur, gilsonite and the like, and the liquid materials such as DNT, nitroparaffins, fuel oil and the like may be so utilized. This is accomplished by employing thickening agents, such as crosslinkable guar gum, which retard or arrest the separation of the solid and liquid materials and yet retain the primary mixture pumpable. Preferred practice is to employ non-inhibited, hydratable, guar gum in the primary mixture and to crosslink (gel) the gum with a suitable crosslinking agent. The crosslinking agent may be combined with the gum as disclosed in my copending application and is commercially available in such form as the inhibited, self-complexing or the non-inhibited, self-complexing type or it may be added as a separate ingredient in very small amounts, usually less than 0.1% of the total composition. The gum may be used in as low amount as 0.4% or thereabouts and up to about 4%, but more generally from about 0.7% to about 1.8% is used having a particle size so that substantially all passes through a 60 mesh sieve. Potassium pyroantimonate at the pH as used in the examples is a preferred crosslinking agent but other crosslinking agents may be used, such as, potassium dichromate, sodium dichromate, and mixtures of antimony sulfides and oxides with alkali metal chromates and dichromates.

The explosive sensitizers, when used, may be pelleted, flaked, grained, ground or liquid as desired and present in an amount of from about 10 to about 40% by weight of the total composition.

The metal energizers, when used, are in particulate form and present in an amount of from about 3 to about 30% by weight of the total composition.

The pH of the composition can be adjusted with acid or base as required. For this purpose, fumaric acid has been demonstrated, but other acids and buffer salts may be used, such as, acetic acid, citric acid, nitric acid, sulfonic acid, hydrochloric acid, and soda ash, and the like. A pH of less than 6.0 is mandatory, and less than 5.0 is preferred for the final composition.

In using the improved technique of this invention in the field, pumping rates of from about 200 to about 1000 pounds per minute are feasible for placing blasting composition into boreholes. When placing blasting composition into packages at a plant site or a blasting site, the rate of pumping is, of course, adjusted to accommodate the desired rate of package production.

From the foregoing, it will be apparent that the advantages of the invention have been demonstrated giving the art a flexibility in the handling, delivery and placing of finished crosslinked aqueous slurry blasting agents which heretofore has not been available.

What I claim and desire to protect by Letters Patent is:

1. A method for bulk delivery of a crosslinked aqueous slurry blasting agent in which the improvement comprises

- (a) forming a moving stream of pumpable aqueous slurry blasting mixture of the inorganic oxidizer salt type having the discrete ingredients thereof held in suspension or dispersion by the thickening action of a crosslinkable guar gum,
- (b) forming a moving stream of pumpable injection mixture essentially containing sufficient crosslinking agent to crosslink the crosslinkable guar gum and effectively impart firmness to the aqueous slurry blasting mixture,

- (c) injecting the moving stream of pumpable injection mixture into the moving stream of pumpable aqueous slurry blasting mixture, and
- (d) pumping the entire intimate mixture thus formed at a pH of less than 6 through an elongated conduit to effect bulk delivery thereof at a rate of time within said conduit to obtain substantial crosslinking and firmness of the intimate mixture upon discharge from the said conduit.
2. The improvement according to claim 1 in which
- (a) the injection mixture is injected into the moving stream of pumpable aqueous slurry blasting mixture by pumping the injection mixture thereinto.
3. The improvement according to claim 1 in which
- (a) the aqueous slurry blasting mixture is pumped to form the moving stream, and
- (b) the injection mixture is injected into said moving stream by pumping said injection mixture thereinto.
4. A method for bulk delivery of a crosslinked aqueous slurry blasting agent into a borehole of a blasting operation in which the improvement comprises
- (a) pumping a primary stream of aqueous slurry blasting mixture of the inorganic oxidizer salt type from a slurry mixture pump through a hose directly into a borehole, said mixture having the discrete ingredients thereof held in suspension or dispersion by the thickening action of a crosslinkable guar gum, and
- (b) pumping a secondary stream essentially containing sufficient crosslinking agent to crosslink the crosslinkable guar gum at a pH of less than 6 into the primary stream of aqueous slurry blasting mixture and passing the mixture thus formed through the hose to obtain substantial crosslinking and firmness of said mixture by the time it discharges from said hose.
5. The improvement according to claim 4 in which
- (a) the secondary stream is pumped directly into the slurry mixture pump.
6. The improvement according to claim 4 in which
- (a) the secondary stream is pumped directly into the primary stream of aqueous slurry blasting mixture being passed into the hose.
7. A method for bulk delivery of a cross-linked aqueous slurry blasting agent in which the improvement comprises:
- (a) forming a moving stream of pumpable aqueous slurry blasting mixture of the inorganic oxidizer salt type having the discrete ingredients thereof held in suspension or dispersion by the thickening action of a crosslinkable guar gum,
- (b) forming a moving stream of pumpable injection mixture containing an aeration agent and essentially containing sufficient crosslinking agent to crosslink the crosslinkable guar gum and effectively impart firmness to the aqueous slurry blasting mixture,
- (c) pumping the moving stream of pumpable injection mixture into the moving stream of pumpable aqueous slurry blasting mixture, and
- (d) pumping the entire intimate mixture thus formed at a pH of less than 6 through an elongated conduit to effect bulk delivery thereof at a rate of time within said conduit to obtain substantial crosslinking and firmness of the intimate mixture upon discharge from the said conduit.
8. A method for bulk delivery of a crosslinked aqueous slurry blasting agent in which the improvement comprises:
- (a) pumping a moving stream of pumpable aqueous slurry blasting mixture of the inorganic oxidizer salt type having the discrete ingredients thereof held in suspension or dispersion by the thickening action of a crosslinkable guar gum,

- (b) forming a moving stream of pumpable injection mixture containing an aeration agent and essentially containing sufficient crosslinking agent to crosslink the crosslinkable guar gum and effectively impart firmness to the aqueous slurry blasting mixture,
- (c) pumping the moving stream of pumpable injection mixture into the moving stream of pumpable aqueous slurry blasting mixture, and
- (d) pumping the entire intimate mixture thus formed at a pH of less than 6 through an elongated conduit to effect bulk delivery thereof at a rate of time within said conduit to obtain substantial crosslinking and firmness of the intimate mixture upon discharge from the said conduit.
9. A method for bulk delivery of a crosslinked aqueous slurry blasting agent into a borehole of a blasting operation in which the improvement comprises:
- (a) pumping a primary stream of aqueous slurry blasting mixture of the inorganic oxidizer salt type from a slurry mixture pump through a hose directly into a borehole, said mixture having the discrete ingredients thereof held in suspension or dispersion by the thickening action of a crosslinkable guar gum, and
- (b) pumping a secondary stream containing an aeration agent and essentially containing sufficient crosslinking agent to crosslink the crosslinkable guar gum at a pH of less than 6 directly into the primary stream of aqueous slurry blasting mixture in the slurry mixture pump and passing the mixture thus formed through the hose to obtain substantial crosslinking and firmness of said mixture by the time it discharges from said hose.
10. A method for bulk delivery of a crosslinked aqueous slurry blasting agent into a borehole of a blasting operation in which the improvement comprises:
- (a) pumping a primary stream of aqueous slurry blasting mixture of the inorganic oxidizer salt type from a slurry mixture pump through a hose directly into a borehole, said mixture having the discrete ingredients thereof held in suspension or dispersion by the thickening action of a crosslinkable guar gum, and
- (b) pumping a secondary stream containing an aeration agent and essentially containing sufficient crosslinking agent to crosslink the crosslinkable guar gum at a pH of less than 6 directly into the primary stream of aqueous slurry blasting mixture being passed into the hose and passing the mixture thus formed through the hose to obtain substantial crosslinking and firmness of said mixture by the time it discharges from said hose.

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149—44, 45, 60; 86—20

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,523,048 Dated August 4, 1970

Inventor(s) Robert B. Hopler, Jr.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4, In Table I under Example 4, " 53.0 "
should read -- 52.0 --.

Also in Table I, after line 30, " Sodium nitrate "
should read -- Sodium nitrite --.

SIGNED AND
SEALED
OCT 20 1970

(SEAL)

Attest:

Edward M. Fletcher, Jr.

Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents

UNITED STATES PATENT OFFICE
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