March 8, 1955 H. B. LEE ET AL 2,703,528

BLASTING PROCESS

Filed Nov. 5, 1953 2 Sheets-Sheet 1

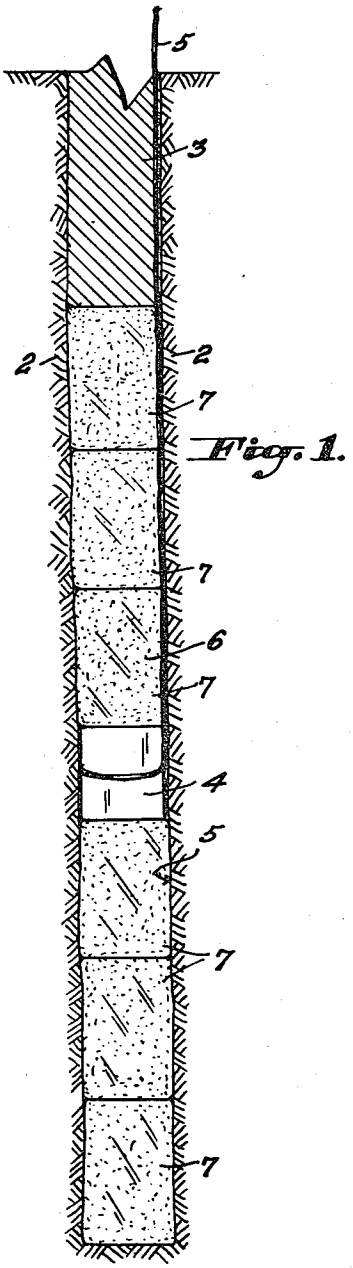


Fig. 1.

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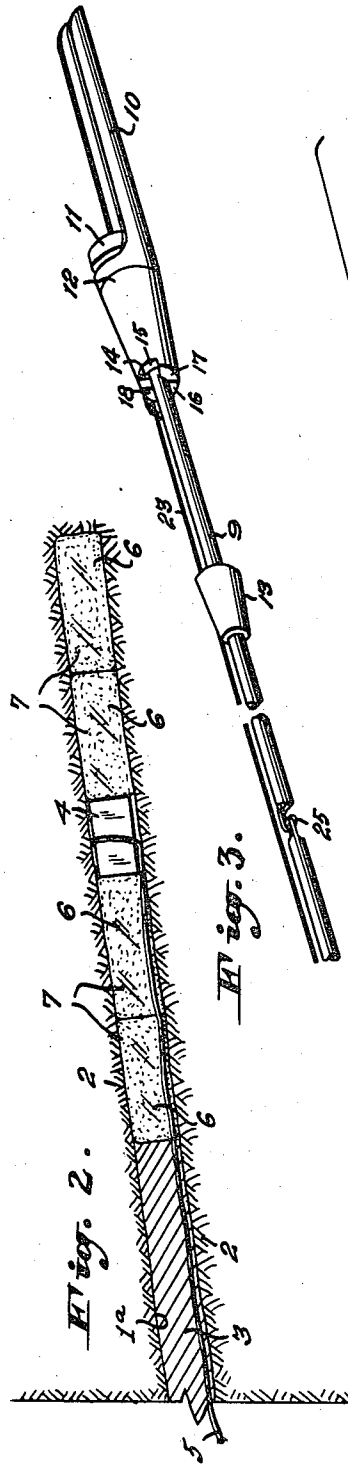


Fig. 2.

Fig. 3.

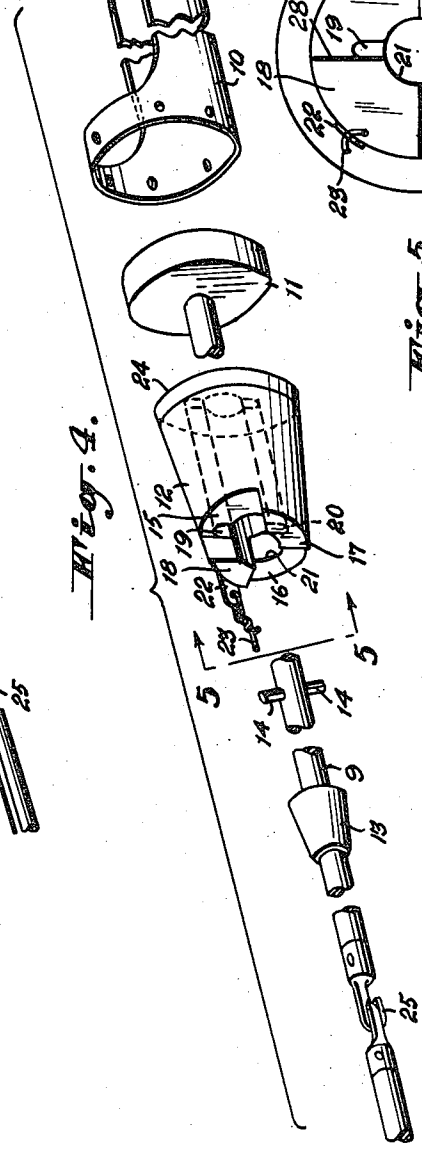


Fig. 4.

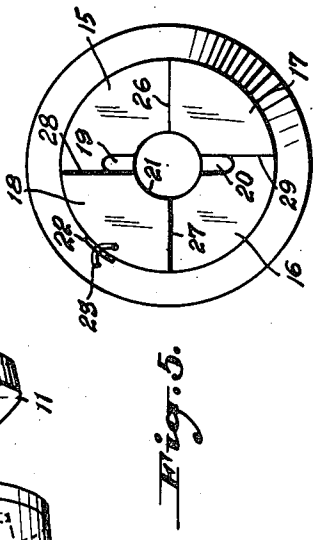


Fig. 5.

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United States Patent Office

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Patented Mar. 8, 1955

2,703,528

BLASTING PROCESS

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Application November 5, 1953, Serial No. 390,384

9 Claims. (Cl. 102—23)

This invention relates to blasting process; and it consists of a method of blasting rock, overburden and the like, which comprises charging at least one substantially dry drill hole in the formation to be blasted with bags containing granular free-flowing ammonium nitrate, containing less than 1½% moisture and mixed with from about 1 to 12% by weight of a combustible material which upon combustion generates gases; said bags having a diameter approaching the diameter of the drill hole, being constructed of a flexible water-proof plastic material and being capable of expanding and deforming without breaking to fill the hole completely; the hole being charged in such manner that the said bags are deformed so as to completely fill the hole with the exclusion of all possible air spaces between the individual bags and between the bags and the wall of the hole; also introducing into said hole at least one cap-sensitive primer charge in such manher that no point in the charge is spaced from a primer charge a distance of more than from about 15 to 35 feet, effectively stemming the charge, when possible with drill cuttings, and detonating the primer charge, thereby detonating the entire charge; all as more fully hereinafter set forth and as claimed.

The original conception of this invention came about through consideration of the cause of the explosion of a ship loaded with ammonium nitrate at Texas City, several years ago. It is said that, after the ship had caught fire and it was found impossible to extinguish the fire, the captain ordered the hatches to be battened down in the hope that the fire would be smothered. The explosion followed. The theory of the cause of this explosion which we developed is that the gases generated by the raging fire which were trapped beneath the hatches caused the ship itself to explode and that this explosion, owing to the high pressure inside the ship, caused the detonation of the ammonium nitrate. It was conceived that, if the conditions of this Texas City explosion could be duplicated in the blasting of rock strata and the like it would be possible to make substantial savings in the cost of blasting explosives since the company with which we are associated had been purchasing blasting explosives at a price several times that at which ammonium nitrate was being sold to farmers as fertilizer, for example. This conclusion led to an extensive series of experiments during the course of which the present invention was developed.

During the course of our early experiments we discovered that, contrary to the belief of explosive experts, it is possible to detonate ammonium nitrate if a granular non-caked charge of the same is tightly packed into a drill hole in rock strata, with exclusion of moisture in such manner as to eliminate all air pockets and then tightly stemmed, provided that a booster charge of dynamite is detonated directly adjacent to the charge of ammonium nitrate. We found that the booster charge will completely detonate a column of ammonium nitrate having about 10 to 15 times the length of the booster charge. In these tests with ammonium nitrate we obtained an explosive effect which was of the order of about 90% or more of that obtained with the conventional charge of ammonia type dynamite blasting explosive. During these tests we used three different fertilizer grades of ammonium nitrate, one coated with about 0.5% rosin and the others with somewhat larger amounts of diatomaceous earth. Little or no difference could be detected between these grades.

Since these charges of ammonium nitrate which we used cost less than one-third the cost of commercial ammonium nitrate explosives, hereinafter called ammonia dynamite, it was immediately evident that a substantial saving in cost would be possible even though the power of the raw ammonium nitrate so employed could not be increased.

Several explosive experts who were present at these early tests were greatly surprised at the results obtained since they had predicted that ammonium nitrate would be only about 70% as effective as an ammonia dynamite. This discrepancy between prediction and practice was explained when rate of detonation tests were made on the charges. The velocities obtained, when the ammonium nitrate was loaded into the drill holes in bulk with elimination of all air spaces, averaged 3680 meters per second while those obtained with a paper-packaged ammonia dynamite, which has been used over a period of many years, averaged 3772. The difference between these values is almost within the experimental error. However, it was also attempted to detonate charges of ammonium nitrate which were packaged in rigid 50 pound paper containers of the same type used in packaging the ammonia dynamite. In these charges, of course, the same air spaces were left between the paper containers and between these and the walls of the drill holes as in the case of the ammonia dynamite packages. The velocities of detonation obtained for the packaged ammonium nitrate charges were consistently below 3000 meters per second and the explosive effects obtained were lower than those obtained with the bulk ammonium nitrate. These tests demonstrated that, in the case of ammonium nitrate charges, the elimination of air spaces in the charges is critical. Ammonium nitrate is less effective as a blasting explosive when not charged into the drill holes in such manner that air spaces are eliminated as far as possible. We believe that we are the first to have discovered these facts.

Our tests with our new explosive charge have all been made on a practical scale and we have determined the effectiveness of our shots by direct comparison with the use of the same amounts of conventional blasting explosives. The comparison is based on the number of cubic yards of material per shot that can be removed by excavating equipment after shooting, the relative fragmentation obtained and the record made by a swing recorder on the excavating equipment, which is a direct measure of the ability of the operator to make a comparable number of cycles per hour in the shot bank. This method of comparison is obviously more accurate and practical than the use of laboratory tests.

Since gases resulting from the explosion of ammonium nitrate contain an excess of oxygen we thought that the explosive effect obtained above might be increased by the addition to the ammonium nitrate of a combustible material. Our theory was that this would improve the oxygen balance of the explosive and that, if the combustible material should be one producing gases upon combustion, the total explosive effect might be increased due to the generation of these gases.

We first tried adding 1½ per cent of carbon black to the ammonium nitrate. An appreciable improvement was noted in the blasting tests. Our numerous tests with this mixture have indicated that the explosive effect obtained is at least equal to that of the conventional ammonium dynamite blasting explosives. A further improvement was noted when the amount of carbon black was increased to 5% by weight. Our tests indicate that comparable results can be obtained when the percentage of carbon black is increased up to about 12% by weight.

As a result of these and many other field tests totaling several hundred we have discovered and established certain critical limits and conditions which are necessary in the use of our blasting method. One of these is that the drill hole should preferably be as free from crevices and cracks as possible and should be completely filled with the ammonium nitrate with the exclusion of air pockets as far as possible. We have demonstrated that the higher the density of the packing of the ammonium nitrate in the hole, the greater the velocity of detonation and the greater the explosive effect. This is directly contrary to prior statements on this subject. The ammonium nitrate must not contain sufficient moisture to cause caking, i. e.

it must not contain more than about 1½% of moisture by weight and moisture must be carefully excluded from the charge. The ammonium nitrate in the charge must not be caked, i. e. it must be granular and free flowing; otherwise inferior shots will be obtained. For improved explosive power the granules of ammonium nitrate should be admixed preferably with at least from about 1½ to 8% of a combustible material which develops additional gases on combustion. At least one booster or primer charge must be used and, if a mixed ammonium nitrate-combustible material explosive is used, no point in the column of ammonium nitrate should be spaced from a primer a distance which is more than from about 15 to 35 times the length of the primer charge for maximum effectiveness. This means that, if a booster charge of gelatine dynamite, for example, having a length of 1 foot is used and if this primer charge almost completely fills the hole no point in the column of ammonium nitrate mixture should be spaced a distance of more than from about 15 to 35 feet as a maximum from the primer. In the case of charges of ammonium nitrates which contain no added combustible material, this distance should be reduced to from about 10 to 15 feet.

The booster charge must be cap-sensitive, of course, and any of the commercially available gelatine or ammonia type dynamites can be used in our method. We prefer to use a booster charge having a diameter approaching that of the drill hole and detonated by means of a detonating fuse, such as a "Primacord," but other conventional ways of detonating the booster charges can of course be used. The booster charge can be placed either at the center, bottom or the top of the drill hole, and, in the case of deep holes, intermediate booster charges may be required.

The grain size of the ammonium nitrate in the charge is not of critical importance, since we have been unable to detect any difference in explosive power between charges having an average grain size of 8 mesh and 30 mesh. Our tests indicate that our method will operate with ammonium nitrates whose average particle size ranges from about 6 mesh down to about 100 mesh. The finer the particle size of the ammonium nitrate the more combustible material it will hold without segregation but the finer products have greater tendency to cake. For these reasons we prefer to use ammonium nitrates whose average particle size ranges from about 8 to 30 mesh.

The bore holes into which our explosive charge is packed can be drilled either by the wet or the dry method. In the wet drilling method the cuttings are flushed out of the hole with water and, of course, after bailing the holes, while substantially dry, have walls which are wet. In one dry method compressed air under a pressure of about 30 pounds per square inch or over is used to blow the cuttings from the hole. The air pressure blows the cuttings into any crevices and fissures in the strata and smooth bores result which are substantially uniform in diameter, free from unfilled crevices and fissures and ideally suited to receive our explosive charges even when loaded in bulk, since it is easy to fill such bores completely with exclusion of all air pockets. Air drilling therefore has several advantages over wet drilling. If the strata drilled are dry, the bore holes produced by air drilling may be bone dry. The ammonium nitrate may be pre-packaged in plastic bags weighing from about 30 to 75 pounds and in the case of vertical holes these bags may be dropped into the holes.

Any type of water-proof flexible material of sufficient strength to avoid breaking or rupturing can be used to construct the bags, such as polyethylene or Pliofilm. When the ammonium nitrate is packed in bags weighing about 50 pounds we have found that polyethylene having a thickness of about 6 mils is required in order to prevent breaking of the bags when they are dropped into the drill holes. But when a single tubular bag is employed a thickness of about 3 mils is sufficient. These bags should have diameters approaching the diameter of the drill holes. When the bags are dropped into a drill hole they expand and deform when they hit bottom and fill the entire hole, leaving substantially no air spaces either between bags or between the bags and the wall of the bore. Thus the cushioning of the shock by air spaces is practically eliminated in our method.

The combustible material which is used in our explosive charge to produce an oxygen balance can be any combustible or oxidizable material which produces gases upon combustion. This includes all dry carbonaceous materials and all types of finely-divided carbon, for example. We prefer to employ carbon black or "gas black." Oat hulls or charcoal or even coal dust is operative. We have applied carbon black by a simple tumbling operation. It is important to obtain the best and most intimate mixture possible since segregation should be avoided as far as possible although a small amount of segregation seems to do no harm.

After the drill holes are charged with our explosive careful stemming is necessary. We have found that the cuttings obtained in air drilling the holes are particularly suited as a stemming material and this is another point in favor of using this method of drilling. The procedures used in stemming the holes are conventional.

The diameters of the drill holes may vary from about 3 inches to 12 inches or more. Charges of ammonium nitrate which are less than 6 inches in diameter are more difficult to detonate and better results are usually obtained with holes of larger diameter.

The conventional way of utilizing ammonium nitrate in blasting explosives at the present time is to package it in rigid paper or metal containers, usually weighing 25 to 50 pounds, and these are charged into the drill holes by dropping the packages into the holes. All of these packages contain sensitizers, and many contain in addition nitroglycerin mixed with the ammonium nitrate. The cost of these explosives is three times or more that of ammonium nitrate of fertilizer grade, for example. Our tests demonstrate that ammonium nitrate, without an admixture of nitroglycerin and/or sensitizers, cannot be detonated in drill holes when charged into the holes in rigid containers without a substantial loss of power. Moreover our tests show that ammonium nitrate cannot be successfully detonated when caked and it is obvious that caking occurs more frequently when rigid containers are used.

It is obvious, of course, that rigid paper or metal containers cannot be filled with ammonium nitrate without leaving an air space at the top and it is equally obvious that when these containers are dropped into a drill hole air spaces are left between the containers themselves as well as between the containers and the wall of the hole which cannot be stemmed by conventional procedures. In our method all such air spaces are eliminated and the result is that even pure ammonium nitrate can be detonated. This results in a substantial saving. Our preferred ammonium nitrate mixture, containing from about 1½ to 8% of carbon black, costs about one-third that of the commercial packaged explosives, for example.

Our invention can be explained in more detail by reference to the accompanying drawing which shows, more or less diagrammatically several operating embodiments of our explosive charge as well as a loading device which can be used in the loading of horizontal or upwardly sloping bore holes. In this showing,

Fig. 1 is a vertical elevation showing an explosive charge in place in a bore hole, the charge consisting of our novel granular explosive packaged in flexible plastic bags,

Fig. 2 is a similar showing of an upwardly-sloping bore hole charged with our explosive packed in plastic bags,

Fig. 3 is a perspective view of a charging device which can be used to charge our packaged explosive into horizontal and upwardly-sloping bore holes,

Fig. 4 is an exploded view of the operating end of the charging device on a larger scale, while

Fig. 5 is an end view of the charging head, taken along the line 5—5 of Fig. 6.

In the various views, like parts are designated by like reference numerals. Referring first to Fig. 1, the bore hole, which is drilled or bored through rock or other strata 2 which requires blasting, is shown generally at 1 in section. This hole is shown charged with our granular explosive 6 packaged in plastic flexible bags 7 which, as shown, fill the hole completely. Stemming material 3 is shown at the top of the hole. A primer cartridge 4 is shown placed substantially centrally of our explosive and this is connected with a "Primacord" 5 for detonation purposes.

In Fig. 2 an upwardly-slanting bore hole 1*a* is shown charged with plastic bags 7 filled with our explosive 6. It is not usually possible to charge a drill hole in this manner using a conventional tamper since the bags of explosive tend to bunch up and to stick in the holes. However, successful results can be obtained with the use of a scoop

or spoon-shaped device somewhat smaller in diameter than the bore hole and mounted at the end of a push rod. One or more bags of explosive are placed on the scoop and the latter is then pushed by means of the push rod to the bottom of the hole with the bags riding on the scoop. The bags are then dumped off by rotating the push rod and scoop through an angle of 180°. The push rod with its scoop is then pulled out of the hole and the bags of explosive are tamped with the conventional tamper until they fill the hole with elimination of air spaces. This procedure is then continued until the hole is charged.

We have developed a novel charging device which is an improvement upon the push rod assembly just described and with which drill holes can be charged more quickly and satisfactorily. This charging device, which in effect combines a tamper with the described push rod assembly is shown in Figs. 3 to 5. This charging device comprises a jointed pole 9, a scoop or spoon 10, a tamping head 11 mounted on the inner end of the pole and a head 12 to which the spoon is secured and which is slidably mounted on the pole. A stop 13 is secured to the pole a short distance away from the head 12 and limits the motion of this head along the pole. The head is adapted to cooperate with nylon pins 14 which are pegged into the pole. As shown in Figs. 4 and 5, the outer end of the head 12 is divided into four sections or quarters. Two diagonally opposite quarters 15 and 16 are depressed while the other two quarters 17 and 18 extend outwardly a short distance for a purpose which will become clear in the following description. The head is provided with a bore 21 which makes a sliding fit with the pole and it is also provided with longitudinal slots 19 and 20 on opposite sides of the bore, these slots being adapted to receive the pins 14 during the tamping operation. A strap 22 is secured to the outer end of the head 12 and a wire 23, which extends the length of the bore hole, is attached to the strap. The distance from the tamping head 11 to the pins 14 is such that, when the tamping head is abutted against the inner face 24 of the head 12, the pins 14 are flush with the faces of the depressed quarters 15 and 16. The distance from the head to the stop 13 is such that the two raised quarters of the head 12 abut the stop when the tamping head is extended to a point a short distance beyond the inner end of the spoon 10. The joints 25 are conventional and enable the pole to be used as a plunger without becoming detached but which can be detached if desired when the pole is bent at the joint.

During the charging operation one or more plastic bags of explosive are placed in the spoon 10 after the pole is adjusted on the head 12 in such manner that the pins 14 abut the upright (clockwise) faces 26 and 27 of quarters 17 and 18 and are flush against the faces of depressed quarters 15 and 16. The charging device is then slid into the bore hole with the plastic bags of explosive riding on the scoop of the spoon and with the nylon pins pressing against the depressed quarters of the charging head to force this head with its attached spoon into the hole. When the spoon has reached the bottom of the hole the pole is twisted in a clockwise direction through an angle of 180°. This causes the pins 14 to press against the faces 26 and 27 and thereby forcing the head 12 and spoon 10 to rotate through a similar angle and causing the bags of explosive to drop off the spoon. The next operation is to bring the pins 14 into registry with the slots 19 and 20 which is accomplished by rotating the pole counter-clockwise through an angle of 180° while the head remains in position with the spoon upside down. The pins then abut the opposite walls (counterclockwise) 28 and 29 of the raised quarters 17 and 18 and simultaneously come into registry with the slots. It is then necessary to pull the head 12 and scoop 10 back out of the way so the bags of plastic can be tamped. This is accomplished by pulling on the wire 23 until the head slides along the pole and abuts the stop 13. During this operation the pins 14 slide through the slots 19 and 20 until they are free from the head. Sufficient pressure should be applied to the pole while the wire is being pulled to keep the tamping head 11 pressed against the rear bag of explosive. This is particularly important in the case of upwardly-slanting holes to prevent the rear bag of explosive from tumbling backwards before it is tamped. The charging device is then in position for the tamping operation which consists in pushing on the pole until the bags of explosive are forced into tight contact with each other and with the wall of the bore. After tamping, the charging device is removed as a whole from the bore hole and is ready for the next load of plastic bags.

The primer cartridges are charged into the drill holes in conventional manner with conventional tampers. The charging device shown in Figs. 3 to 5 will ride safely over "Primacord" provided that safety regulations are complied with in the construction of the charging device. This means that all metal parts must be constructed of copper or bronze with other parts of wood, plastic or rubber. In the case of vertical holes the primer cartridges are merely lowered into the holes. The "Primacord" does not interfere with the further charging of the hole with our packaged explosive.

The following specific examples represent practical scale embodiments of our process and illustrate how it can be conducted with excellent results.

EXAMPLE 1

Following the successive and successful detonation of 12 individual test holes employing ammonium nitrate in bulk, we loaded a multiple shot test in a bank consisting mainly of sandrock and sandshale in a depth of overburden varying from 30 to 48 feet. Spacing of holes was 27′ x 30′ and the diameter of the holes was 10⅝″. Holes were dry, having been drilled with a dry rotary vertical drill. The ammonium nitrate charges varied in accordance with the character of the strata encountered from 250 to 450 pounds, these charges being equal to the amounts of ammonia dynamite explosive usually employed. This ammonium nitrate had a coating of about 0.5% by weight of rosin, otherwise being pure ammonium nitrate. It was purchased in paper cartridges weighing 50 pounds. A screen analysis of this product gave the following results:

Screen analysis

Size:	Percent weight
+8	0.1
8x10	0.2
10x14	4.0
14x28	47.0
28x35	13.5
35x48	6.5
48x60	4.7
60x0	24.0
	100.0
Density	0.808

The primer used consisted of 25 pounds of 60% gelatine dynamite placed at or near the center of the charge and detonated by "Primacord." The total amount of explosive in each hole was the same as that calculated in holes in an adjacent bank which had been shot with a conventional fixed explosive of the ammonia type. All holes were successfully detonated and the blasting results were satisfactory, as indicated by the ease of digging the shot bank in comparison to the bank on either side of it, which had been shot with ammonia type dynamite. The swing recorder on the 1250–B dragline employed in the subsequent excavation indicated fairly comparable speed and ease of digging.

EXAMPLE 2

A multiple shot test was made in a bank similar to that shot in Example 1, at the same mine and having an average depth of 30 feet. The same spacing was used and each hole was charged with 150 pounds of ammonium nitrate admixed with 1½% of carbon black. This mixture was packaged in polyethylene bags each holding 50 pounds and the holes were charged by dropping the bags into the holes. The ammonium nitrate was a fertilizer grade and was coated with diatomaceous earth. Its screen analysis was as follows:

Screen analysis

Size:	Per cent wt.
+6	0.2
6x8	37.4
8x10	33.6
10x14	16.3
14x28	11.0
28x35	0.8
35x48	0.3
48x60	0.1

60x100	0.2
100x0	0.1
	100.0
Density	0.845

The shots were detonated with a primer charge consisting of 12½ pounds of 60% gelatine dynamite placed above the bottom bag of the ammonium nitrate mixture loaded into each hole and detonated by means of "Primacord." The shooting results, as indicated by the ease of digging, fragmentation and the swing recorder on the excavating machine showed an improvement of approximately 10% as compared with the results obtained in Example 1.

EXAMPLE 3

For the purpose of demonstrating the applicability of our method at another mine with different overburden and drilling conditions, adjacent test holes were drilled with a 10" well drill in a 40 foot bank containing two seams of limestone rock with intermediate hard shale. In one test the holes were loaded with 350 pounds of ammonia type dynamite usually employed in shooting this bank and in a second test the holes were loaded with 350 pounds of ammonium nitrate admixed with 1½% carbon black. This ammonium nitrate was fertilizer grade and coated with diatomaceous earth but was purchased from another source. It had a screen analysis as follows:

Screen analysis

Size:	Per cent wt.
+8	0.1
8x10	26.0
10x14	41.9
14x28	21.6
28x35	4.2
35x48	2.5
48x60	0.8
60x100	1.3
100x150	0.5
150x200	0.3
200x0	0.5
	100.0
Density	0.754

Both shots were detonated with 62½ pounds of 60% gelatine dynamite attached to "Primacord" and placed at an intermediate point in the main charges. It was impossible to detect any differences between the two shots either visually or by the swing recorder as a measure of ease of digging. Following these tests another series of shots was made using the ammonium nitrate-carbon black mixture and the results obtained were again similar.

It may be noted that since these initial tests at that mine several hundred thousand yards of bank material have been shot with ammonium nitrate mixture containing 5% of finely divided carbon, and employing only 25 pound primer charges, with greatly improved results.

EXAMPLE 4

A multiple shot test was made at another mine in a series of spaced horizontal holes having a diameter of 6", dry holes bored by an auger type drill. The rock in the bank consisted of shale and sandstone and the bank averaged 65 feet in depth. The holes were spaced 18' apart. Each was charged with 400 pounds of the ammonium nitrate described in Example 3 admixed with 1½% of carbon black and packaged in polyethylene bags. The primer used was 60% gelatine dynamite. Two primer charges weighing 25 pounds each were placed at either end of the main charge and an intermediate primer charge of 25 pounds was also used because of the length of the column, which was 73 feet in a 90 foot hole, and the comparatively small diameter of the hole. The primer charges were detonated with "Primacord." The results of the shooting were at least as satisfactory as those obtained previously using similar conventional charges of ammonia type dynamite.

The advantages of our process can be outlined as follows:

1. Economy of the process due to the fact that the main explosive used costs but a fraction of the usual cost of fixed or liquid oxygen explosives.

2. Safety of the process due to the fact that our explosive mixtures are not cap-sensitive in themselves and can be transported, handled, prepared, stored and charged into drill holes with a minimum of danger.

3. Numerous tests with our method, in which many hundreds of thousands of cubic yards of rock overburden have been shot, indicate that bank preparation using our method is at least as satisfactory or more satisfactory than that obtained with all types of commercial explosives which have been used over a period of many years.

4. Our tests indicate that a decided advantage is obtained in our method through elimination of air pockets in the charge with the consequent elimination of the cushioning effect of these pockets as well as an improvement in the oxygen balance of the main explosive.

5. Our tests indicate that another advantage is obtained by the higher density of loading obtained in our method with a consequent faster rate of detonation and increased explosive effect.

6. The further attendant benefit of a widened drill spacing with consequent reduction in drilling costs so that overall drilling and shooting costs in banks shot by our method are reduced both by a lower cost of explosive and a lower cost of drilling.

While we have described what we consider to be the more advantageous embodiments of our process it is evident of course that various modifications can be made in the specific procedures which have been described without departing from the purview of this invention. For example a practical way of using the invention is to employ a revolving mixer to mix the ammonium nitrate with the carbon black or equivalent, the mixture then being discharged from the mixer directly into polyethylene bags having a thickness of at least 6 mils which bags can be loaded with from about 30 to 75 pounds of the ammonium nitrate and these bags can then be charged into the drill holes. The lower limits with respect to the percentage of primer charge employed vary with the size and character of the drill holes in which the combination charge is shot and consequently no rigid rule for this can be laid down. However, it may be noted that in a vertical hole of 10⅝" diameter we have successfully detonated 600 pounds of ammonium nitrate mixture with a centrally located primer charge of only 12½ pounds. Primer charges may be used which consist of from 30 to 60% gelatine dynamites or ammonium dynamites and these may weight from about 12½ to 100 pounds. Commercial ammonium nitrates can be used which have been previously coated with materials, such as rosin, diatomaceous earth, aluminum stearate or the like, to render them water resistant and non-caking. Some of these commercial coatings tend to improve the oxygen balance of the ammonium nitrate but the maximum weight of such coating used is generally only about 0.5%. This is not sufficient to produce a satisfactory oxygen balance in our explosive; hence these coatings are advantageously augmented by the addition of from about 1 to 12% by weight of carbon black or equivalent. Any conventional drilling method can be employed in making the drill holes used in our process which is capable of producing substantially dry holes and, of course, any conventional way of detonating the charges, such as blasting caps or detonating fuses, can be employed. While most of the preceding description has been directed to the use of bone dry drill holes in our method, it is possible to shoot holes drilled by the wet method since the ammonium nitrate is well protected by the water-proof bags. After the wet-drilled holes are bailed any water which remains is confined to crevices and fissures which are effectively filled or stemmed by this water. Other modifications of our process which fall within the scope of the following claims will be immediately evident to those skilled in this art.

What we claim is:

1. In the blasting of rock, overburden and the like, the process which comprises charging at least one substantially dry drill hole in the formation to be blasted with bags containing granular free-flowing ammonium nitrate containing less than 1½% moisture and mixed with from about 1 to 12% by weight of a combustible material which upon combustion generates gases; said bags having a diameter approaching the diameter of the drill hole, being constructed of a flexible water-proof plastic material and being capable of expanding and deforming without breaking to fill the hole completely; the hole being charged in such manner that the said

bags are deformed so as to completely fill the hole with the exclusion of all possible air spaces between the individual bags and between the bags and the wall of the hole; also introducing into said hole at least one cap-sensitive primer charge in such manner that no point in the charge is spaced from a primer charge a distance of more than from about 15 to 35 feet, stemming the charge and then detonating the primer charge, thereby detonating the entire charge.

2. In the blasting of rock, overburden and the like, the process which comprises charging at least one substantially dry drill hole in the formation to be blasted with bags containing granular free-flowing ammonium nitrate containing less than 1½% moisture and mixed with from about 1 to 12% by weight of carbon black; said bags having a diameter approaching the diameter of the drill hole, being constructed of a flexible waterproof plastic material and being capable of expanding and deforming without breaking to fill the hole completely; the hole being charged in such manner that the said bags are deformed so as to completely fill the hole with the exclusion of all possible air spaces between the individual bags and between the bags and the wall of the hole; also introducing into said hole at least one cap-sensitive primer charge in such manner that no point in the charge is spaced from a primer charge a distance of more than from about 15 to 35 feet, stemming the charge and then detonating the primer charge, thereby detonating the entire charge.

3. In the blasting of rock, overburden and the like, the process which comprises charging at least one substantially dry drill hole in the formation to be blasted with bags containing granular free-flowing ammonium nitrate containing less than 1½% moisture and mixed with from about 1 to 12% by weight of a combustible material which upon combustion generates gases; said bags having a diameter approaching the diameter of the drill hole, being constructed of polyethylene and being capable of expanding and deforming without breaking to fill the hole completely; the hole being charged in such manner that the said bags are deformed so as to completely fill the hole with the exclusion of all possible air spaces between the individual bags and between the bags and the wall of the hole; also introducing into said hole at least one cap-sensitive primer charge in such manner that no point in the charge is spaced from a primer charge a distance of more than from about 15 to 35 feet, stemming the charge and then detonating the primer charge, thereby detonating the entire charge.

4. In the blasting of rock, overburden and the like, the process which comprises drilling at least one substantially dry hole in the formation to be blasted, charging the hole with bags of polyethylene completely filled with granular free-flowing ammonium nitrate containing less than 1½% moisture and mixed with from about 1 to 12% by weight of carbon black; said polyethylene bags having a diameter approaching the diameter of the drill hole and being charged in such manner that the bags are deformed and the hole is completely filled with the exclusion of all possible air spaces between the individual bags and between the bags and the wall of the hole; also introducing into said drill hole at least one cap-sensitive primer charge in such manner that no point in the charge is spaced from a primer charge a distance of more than from about 15 to 35 feet, stemming the charge and then detonating the primer charge, thereby detonating the entire charge.

5. The process of claim 4 wherein said polyethylene bags have a thickness of at least about 6 mils.

6. The process of claim 4 wherein the holes are drilled with air and are stemmed with drill cuttings.

7. In the blasting of rock, overburden and the like, the process which comprises drilling at least one substantially dry vertical hole in the formation to be blasted, dropping into said drill hole bags of polyethylene completely filled with granular free-flowing ammonium nitrate, containing less than 1½% moisture, mixed with from about 1 to 12% by weight of carbon black; said bags having diameters which approach the diameter of the drill hole and expanding and deforming without breaking to fill the hole completely with the exclusion of all possible air spaces between the individual bags and between the bags and the wall of the hole; lowering into the hole at least one cap-sensitive primer charge in such manner that no point in the charge is separated from a primer charge a distance of more than from about 15 to 35 feet, stemming the charge and then detonating the primer charge, thereby detonating the entire charge.

8. In the blasting of rock, overburden and the like, the process which comprises drilling at least one substantially dry hole in the formation to be blasted at an angle to the vertical, charging the hole with bags of polyethylene completely filled with granular free-flowing ammonium nitrate, containing less than 1½% moisture, mixed with from about 1 to 12% by weight of carbon black; said bags having diameters which approach the diameter of the drill hole and being tamped into position in such fashion that the bags deform without breaking to fill the hole completely with the exclusion of all possible air spaces between the individual bags and between the bags and the wall of the hole; also introducing into said hole at least one cap-sensitive primer charge in such manner that no point in the charge is separated from a primer charge a distance of more than from about 15 to 35 feet, stemming the charge and then detonating the primer charge, thereby detonating the entire charge.

9. In the blasting of rock, overburden and the like, the process which comprises drilling at least one substantially dry hole in the formation to be blasted, charging the hole with bags of polyethylene having a thickness of at least about 6 mils and filled completely with granular free-flowing ammonium nitrate, containing less than 1½% moisture and having a particle size of from about 8 to 30 mesh, mixed with from about 1 to 12% by weight of carbon black; said bags having diameters approaching that of the drill hole and being charged in such manner that the bags are deformed so as to completely fill the hole with the exclusion of all possible air spaces both between individual bags and between the bags and the wall of the hole; also introducing into the hole at least one cap-sensitive primer charger in such manner that no point in the charge is spaced from a primer charge a distance of more than from about 15 to 35 feet, then stemming the charge with drill cuttings, and detonating the primer charge, thereby detonating the entire charge.

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