Jan. 3, 1961 J. F. BARCO 2,966,855

EXPLOSIVE-CONTAINING BAG USED IN BLASTING

Filed March 20, 1958 3 Sheets-Sheet 1

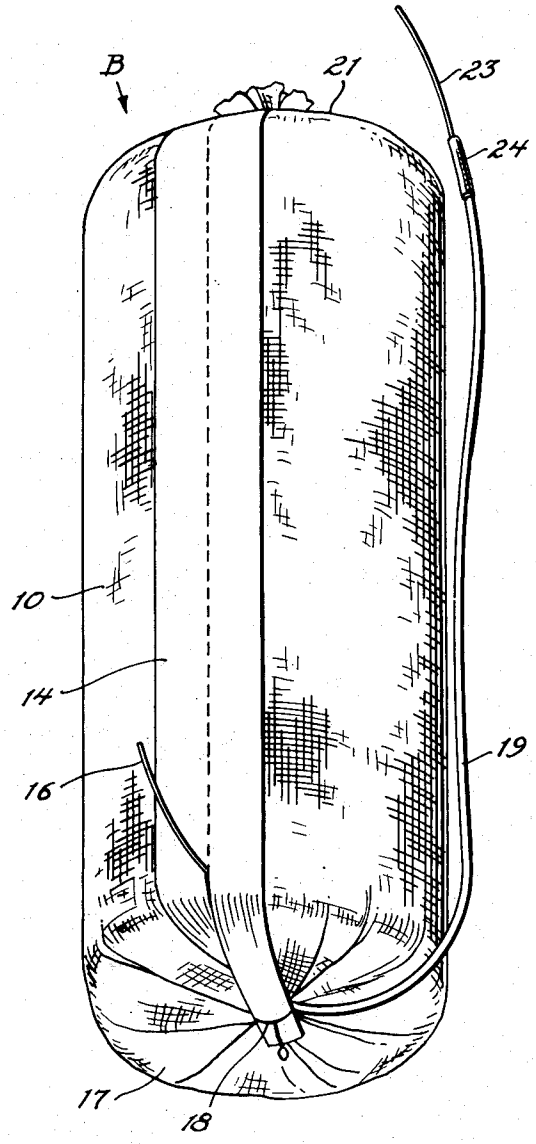


Fig. 1.

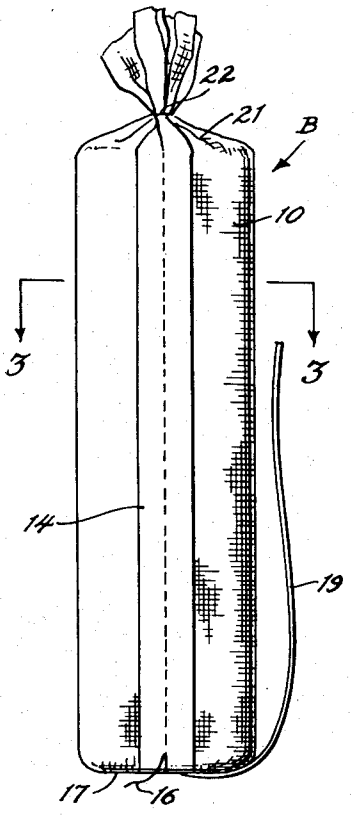


Fig. 2.

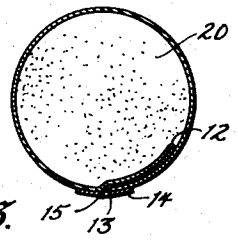


Fig. 3.

INVENTOR.
JOHN FRANK BARCO
BY Robertson and Goethe
ATTORNEYS.

Jan. 3, 1961 J. F. BARCO 2,966,855

EXPLOSIVE-CONTAINING BAG USED IN BLASTING

Filed March 20, 1958 3 Sheets-Sheet 2

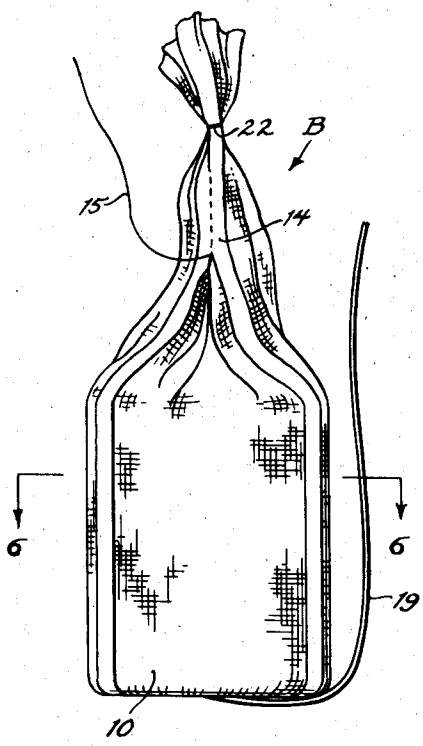


Fig. 5.

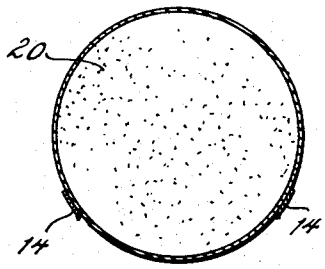


Fig. 6.

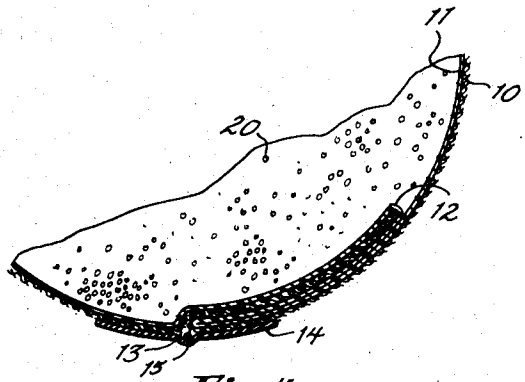


Fig. 4.

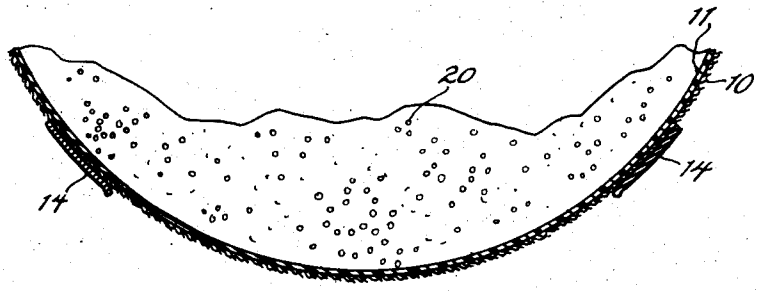


Fig. 7.

INVENTOR.
JOHN FRANK BARCO
BY Robertson and Sanders
ATTORNEYS

Jan. 3, 1961 J. F. BARCO 2,966,855

EXPLOSIVE-CONTAINING BAG USED IN BLASTING

Filed March 20, 1958 3 Sheets-Sheet 3

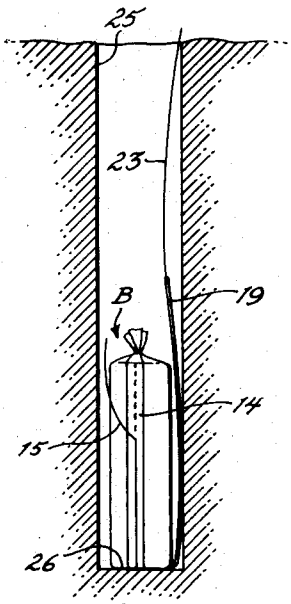


Fig. 8.

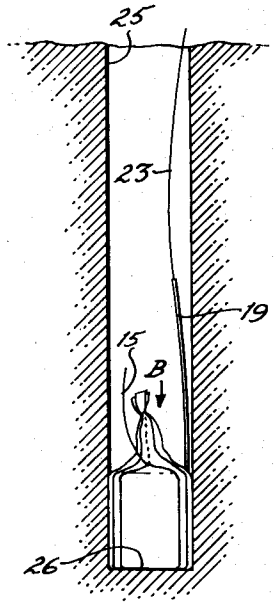


Fig. 9.

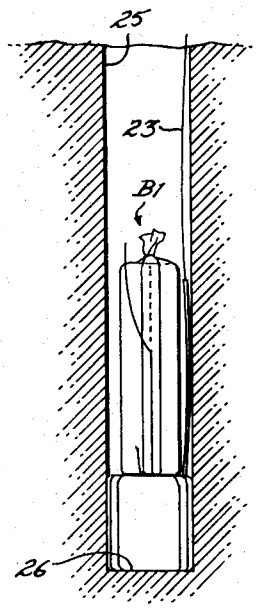


Fig. 10.

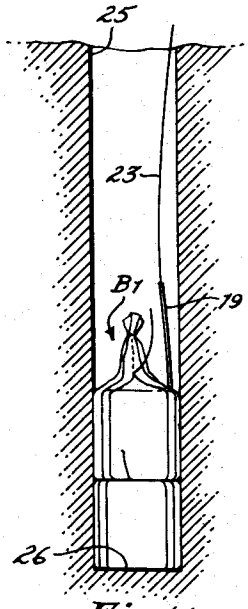


Fig. 11.

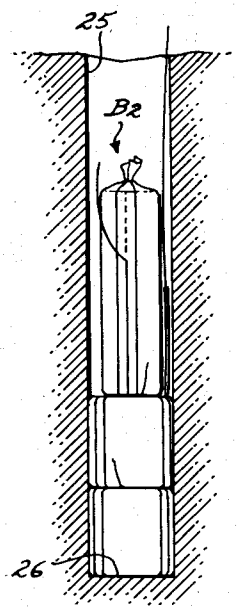


Fig. 12.

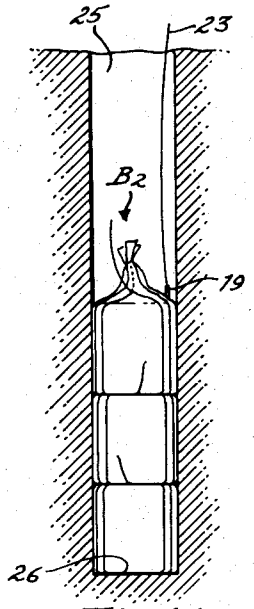


Fig. 13.

INVENTOR.
JOHN FRANK BARCO
BY Robertson and Jouche
ATTORNEYS.

United States Patent Office 2,966,855
Patented Jan. 3, 1961

2,966,855

EXPLOSIVE-CONTAINING BAG USED IN BLASTING

John Frank Barco, Du Quoin, Ill., assignor to Airmite-Midwest Incorporated, Du Quoin, Ill., a corporation of Illinois

Filed Mar. 20, 1958, Ser. No. 722,696

1 Claim. (Cl. 102—22)

The present invention relates to commercial blasting such as commonly employed in strip-mining operations, and is concerned primarily with a novel method of utilizing ammonium nitrate as the blasting explosive, together with an extendable bag employed in such a method. It has long been known that ammonium nitrate mixed with various quantities of carbonaceous material such as oil, or carbon has better explosive qualities than pure ammonium nitrate and many such ammonium nitrate mixtures have been used in blasting during the past thirty years, so whenever the term ammonium nitrate is used herein it should be construed to mean a predominant ammonium nitrate mixture of this sort. A number of such mixtures are now being used in commercial blasting.

In such blasting operations it is important that any type of primer charge be not too far removed from the ammonium nitrate but only recently has it been discovered that the speed of the ammonium nitrate reaction can be greatly increased by putting it in intimate contact with a primer having a speed approximately 21,000 feet per second and by placing practically all the ammonium nitrate constituting the charge in a blast hole within a few inches of a point of contact with such a high speed primer. One subject of this invention is to accomplish this with ammonium nitrate that has been packaged into cartridges. It is also important that all airspaces between the charge and the wall of the blast hole be reduced to a minimum or eliminated. Elimination of air spaces between the explosive and the wall of the blast hole brings the explosive in direct contact with the material to be blasted and permits the maximum quantity of explosive to be loaded in a given length of blast hole both of which add greatly to the blasting effectiveness of the explosive charge.

Prior to advent of this invention, there had been proposed two methods of utilizing granular or prilled ammonium nitrate in commercial blasting operations. In one case, it has been proposed to pour the granular or prilled ammonium nitrate into the blast hole to completely fill any cross-sectional area of the same. Such a method is particularly desirable in that all airspaces are substantially eliminated and maximum loads are accomplished. However, it presents the undesirable aspect of exposing the ammonium nitrate to water and moisture which is often present in the blast holes. Such moisture, of course, greatly impairs the effectiveness of the explosive charge.

A second method which has been proposed is to load the granular or prilled ammonium nitrate into bags to form cartridges. Such cartridges ordinarily must have a diameter appreciably less than that of the drill hole so that they may be dropped therein and fall to the bottom thereof. As a practical matter, under many field conditions it is impossible to obtain a blast hole of uniform diameter throughout its entire length. Thus the cartridges which are dropped must have a diameter

sufficiently small to insure of their free falling. This prevents them from filling the hole completely.

A refinement of the latter method has been proposed in which the granular or prilled ammonium nitrate is packed in bags of polyethylene. Such a method is disclosed in the patent to Lee et al. No. 2,703,528. The theory behind this arrangement is that when a filled bag hits the bottom of the drill hole the impact will cause the bag to expand to the full size of the hole and completely fill any cross-sectional area thereof. Theoretically this arrangement is very good, but as a practical matter it presents certain disadvantages.

In the first place, when the polyethylene bag strikes the bottom of the hole, only the lower portion thereof will fully expand. The upper portion of the bag is not subject to the full force of the impact and will at least partially retain its restricted diameter. Then again, the polyethlyene bags may rupture. This may be due to either on or both of two reasons. One of these is dropping the bags at a great height. A long drop, of course, creates a great impact, which in itself puts a great tensile strain on the bag which is often sufficient to rupture the bag. Then again, as the bag falls down the blast hole, the sides thereof will often frictionally engage projections or irregularities in the wall of the hole; and this frictional engagement will either itself rupture the bag or so weaken the bag that, upon impact at the bottom, rupturing occurs.

With the foregoing conditions in mind, the present invention has in view as its foremost objective the provision of a method of utilizing ammonium nitrate of commercial blasting operations of this type which substantially obviates the above-noted difficulties.

More in detail, the invention has as an object the provision of a method of the type noted which includes the step of positively confining granular or prilled ammonium nitrate in bags or packages of appropriate diameter for handling up to the time when the bag is to be dropped into a blast hole. The confinement of the bag is then partially weakened so that when the bag is dropped into the hole the force of the impact will be sufficient to cause the charge of granular or prilled ammonium nitrate within the bag to extend it to the full size of the drill hole.

Another object of the invention is to provide an explosive-containing bag of the character aforesaid which includes as a characteristic and essential element a captive pleat which, when held in its closed position, maintains the bag at a diameter appreciably less than that of the blast hole into which it is dropped. This captive pleat is maintained closed by a binder tape which covers the mouth of the pleat and under which is positioned a ripcord. During all handling up to the point when the bag is to be dropped into the hole, the binder tape constitutes a positive means for maintaining the pleat closed and preventing extension of the bag. Just before the bag is dropped, the ripcord is availed of to tear the binding strip throughout the lower portion of the bag, which conditions it for dropping into the hole. As the bag is dropped, the granular ammonium nitrate is effective on the captive pleat to maintain the latter closed. However, impact with the bottom of the hole causes the bag to extend to the full cross-sectional area of the hole. Such extension is definitely assured and tensile strain on the bag is avoided by providing an overall circumference of the bag which is slightly greater than that of the blast hole.

Another object of the invention is to provide an explosive-containing bag of the character aforesaid which is made of an appropriate fabric which is essentially nonresilient in character. The extensible or enlarging properties are imparted to the bag by the captive pleat, without

the exertion of appreciable tensile stress on the cloth constituting the bag.

Still another object in view is to provide an explosive-containing bag of the type indicated which has been rendered waterproof. The waterproofing may take the form of providing a thin inner liner of a waterproof material such as Pliofilm or by treating the cloth constituting the bag with parafin or some other waterproofing material.

An explosive-containing bag of the character aforesaid particularly lends itself to the use of a highly simplified type of detonating primer. Ammonium nitrate is a relatively slow speed explosive. After being mixed with about 6% fuel oil, its speed of reaction is not over 12,000 feet per second and under many conditions of detonation may be considerably less. It is capable, however, of being overdriven by means described herein.

The principle of overdrive relates to the property of explosives which enables them to detonate at a rate much greater than their self-propagating rate of detonation. If, for example, a mass of explosive such as ammonium nitrate with a normal rate of detonation of 10,000 to 12,000 feet per second is detonated by a mass of explosive or primer having a rate of 21,000 feet, the ammonium nitrate in contact with and in close proximity to such primer is overdriven and reacts at a speed somewhere between the two, say about 16,000 feet per second.

Conditions necessary to overdrive ammonium nitrate in this manner include, (1) a sufficient mass of high speed primer to initiate the reaction (2) close contact between the primer and the ammonium nitrate and (3) confinement as in a blast hole. Primacord has been used as a detonating fuse in the explosive industry for many years. It is a detonating fuse consisting of a flexible tube filled with an extremely high speed explosive commonly known as PETN and has a rate of detonation of approximately 21,000 feet per second. Ordinary primacord as commonly used in blasting operations contains only 50 grains of PETN per lineal foot which under ordinary circumstances is not sufficiently powerful to detonate the relatively insensitive ammonium nitrate. However, primacord sometimes known as "railroad primacord" and designed for the demolition of railroads and bridges by armed forces, contains 400 grains of PETN per foot or eight times the quantity in the primacord commonly used for blasting and this powerful type of primacord provides sufficient stimulus to detonate and overdrive a mass of ammonium nitrate with which it is in direct contact. Its high rate of detonation of about 21,000 feet per second will cause it to overdrive the ammonium nitrate with which it is in intimate contact for a distance of approximately 8 inches from point of contact beyond which distance the rate of detonation in the mass of ammonium nitrate rapidly diminishes until it reaches the self-progating rate of about 10,000 to 12,000 feet per second.

Raising the rate of detonation of ammonium nitrate from 12,000 feet per second to about 16,000 feet per second by utilizing this principle of overdrive greatly increases its value as an explosive as is indicated by the fact that dynamite having a rate of 12,000 feet per second sells for about 13¢ per pound whereas dynamite with a rate of 16,000 feet per second sells for about 18¢ per pound.

Lowering a strand of 400 grain primacord down a blast hole and then pouring oil treated, prilled or granular ammonium nitrate down the hole to constitute a charge that builds up around and in intimate contact with the primacord, then stemming the hole in the usual manner, has been proved to be a satisfactory method of detonating ammonium nitrate so as to get the higher efficiency of the overdrive effect. Using packaged ammonium nitrate, however, heretofore this procedure has not been effective because the ammonium nitrate must be in very close contact with the primacord. Cartridges dropped down a blast hole must necessarily be of smaller diameter than the blast hole in order to permit them to fall freely and unless such cartridge will expand so as to press against the primacord making intimate contact, the detonating stimulus of the primacord is likely to be insufficient to produce an overdrive effect. The slight expansion of a polyethelene bag filled with ammonium nitrate and dropped down a blast hole is not sufficient to insure its being pressed against a length of primacord previously placed in the blast hole hence this means of detonating packaged ammonium nitrate has not hertofore been used except with bags as described herein.

Thus the bag described herein is detonated preferably by means of heavy primacord containing approximately 400 grains of PETN per foot such primacord being in close contact with the bag. This length of primacord may be lowered down in the blast hole prior to loading the cartridges or it may be secured to the lower end of the first bag to be dropped. A blasting cap at the upper end of the small primacord provides means of detonating the primacord. The section of 400 grain primacord in contact with the expanded bags of ammonium nitrate at the bottom of the blast hole constitutes the detonator for the ammonium nitrate. It might be explained that the purpose of having the large primacord extend only in that portion of the blast hole occupied by the explosive charge and ordinary 50 grain primacord running through the upper portion of the hole is to hold down costs. 50 grain primacord costs about one-fifth as much as 400 grain primacord thus by using the latter only in that part of the blast hole where it is required for detonation and detonating the heavy cord with 50 grain primacord that extends from the surface down to the charge, costs are held to a minimum. It would be possible to detonate the length of heavy primacord by attaching a blasting cap to its upper end and allowing the cap wires to extend upwardly to the mouth of the hole but 50 grain primacord is preferred because it is more positive. The primacord is continued up along one side of the bag and any other bags which may be deposited thereabove; and, by employing a 400 grain primacord disposed along the column of explosive the primacord is utilized as the detonating primer. With such an arrangement, none of the granulated ammonium nitrate is removed from the detonating primer a distance any greater than the diameter of the blast hole. This arrangement is in marked contrast to that of the Lee et al. patent above identified, in which the detonating primer is located intermediate the bags of ammonium nitrate.

Various other more detailed objects and advantages of the invention, such as arise in connection with carrying out the above noted ideas in a practical embodiment, will in part become apparent and in part be hereinafter stated as the description of the invention proceeds.

The invention therefore comprises a novel method of utilizing granular or prilled ammonium nitrate in commercial blasting operations; and which method has as a characteristic and essential step the confinement of granular or prilled ammonium nitrate in a bag having a captive pleat; and which bag, when the pleat is closed, has a diameter substantially less than that of the blast hole into which it is to be dropped. The bag is provided with means for positively closing the pleat during normal handling, but which means is fractured immediately prior to dropping the bag into a hole. Impact of the bag upon hitting the bottom of a hole renders the pleat effective to cause the ammonium nitrate to extend the bag to the full size of the drill hole.

For a full and more complete understanding of the invention, reference may be had to the following description and accompanying drawings, wherein:

Figure 1 is a perspective view of an explosive-containing bag designed in accordance with the precepts of this invention;

Figure 2 is a view in side elevation of the bag shown in Figure 1;

Figure 3 is a transverse section through the bag taken

about on the plane represented by the line 3—3 of Figure 2;

Figure 4 is an enlarged detailed section taken through that portion of the bag formed with the captive pleat and with the pleat closed;

Figure 5 illustrates the condition of the bag after impact with the bottom of the hole;

Figure 6 is a transverse section through the bag with the pleat opened, and is taken about on the plane represented by the line 6—6 of Figure 5;

Figure 7 is a detail section taken on an enlarged scale and corresponding to Figure 4 but showing the pleat opened;

Figure 8 is a section through overburden formed with a blast hole and showing the relative condition of the bag at the moment of impact with the bottom of the hole;

Figure 9 is a view similar to Figure 8 showing the condition of the bag after impact;

Figure 10 is a view similar to Figure 8 depicting the condition of the hole at the moment of impact of a second bag which is dropped;

Figure 11 is a view similar to Figure 10 showing the second bag as expanded by the impact;

Figure 12 is a view similar to Figures 8 and 10 showing the condition of a third bag at the moment of impact; and

Figure 13 is a view similar to Figure 12 showing the third bag as expanded by the impact.

Before referring to the details of the drawing, the advantage of the invention will be explained in connection with a blast hole having a diameter of 10⅝", this being a conventional size meeting with widespread use in strip mining. If the granular or prilled ammonium nitrate in a free-flowing state is poured into a blast hole of this diameter, the granular ammonium nitrate will be present in the amount of about 30.79 lbs. per lineal foot of blast hole. If non-expansible cartridges or bags 9" in diameter are dropped into the blast hole to form a column within the hole, the ammonium nitrate is present in the amount of about 22 lbs. per lineal foot of the blast hole. If ammonium nitrate confined in 9"-diameter polyethylene bags is dropped into the blast hole, the bags will expand slightly so that ammonium nitrate is present in the amount of about 24 lbs. per lineal foot of blast hole. In contrast to this, when the bag of this invention is dropped into a blast hole and expanded by the impact, ammonium nitrate is present in the amount of 30 lbs. per lineal foot of blast hole. Thus, with the method and bag of this invention, it is possible to pack about 25% more ammonium nitrate in any given extent of blast hole as compared to any previously known method involving packaged or bagged ammonium nitrate.

While the density of granulated ammonium nitrate is not entirely uniform among the several manufacturers of prilled ammonium nitrate, still the foregoing figures are taken from the average of 50 lbs. per cubic foot, which is ordinarily the density of prilled ammonium nitrate after it has been vibrated.

Referring now to the drawings, wherein like reference characters denote corresponding parts, a bag is therein illustrated and referred to in its entirety by the reference character B. The bag B is of tubular cylindrical formation and includes as its main body element an outer layer **10** of fabric such as burlap, muslin, canvas, or any other fabric having sufficient strength and toughness. The fabric **10** is rendered waterproof, preferably by an inner liner **11** of Pliofilm. This inner liner **11** of Pliofilm is quite thin, and ordinarily would have a thickness ranging from .0004" to .0015", with the optimum thickness being about .00075". This inner liner **11** is provided solely for its waterproof properties and not because the film is resilient or elastic.

The cylindrical wall of the bag B is formed with an inner captive pleat **12** having a mouth at **13** which extends throughout the length of the bag. This mouth is closed by a strip or tape **14** which is adhesively secured to the outer face of the fabric **10** on opposite sides of the mouth **13**. A ripcord, shown at **15**, is positioned within the mouth **13** beneath the tape **14** before the latter is applied: and before the bottom of the bag is gathered and closed with wire tie **18**, about 4 inches of the rip cord is disengaged from the bag thus the lower end of this ripcord projects outwardly from the tape as shown at **16** in Figures 1 and 2, where it is available for grasping by an operator.

With the tubular wall made up of the laminae **10** and **11** open at both ends, the lower end of the bag, which is represented at **17**, is gathered and secured by a wire tie **18**. Prilled or granulated ammonium nitrate, such as represented at **20**, is now poured into the cylindrical bag structure to fill the same up to a required height. For blast holes of 10⅝" diameter, the length of the cylindrical wall of the bag should be about 10¾". Thus, the bag B has a circumference slightly in excess of that of the blast hole.

The prilled or granular ammonium nitrate shown at **20** will ordinarily include from 2% to 10% of a carbonaceous material such as carbon black or oil, in accordance with the well-known practice in this art. This carbonaceous material is included for the purpose of enhancing the explosive properties of the ammonium nitrate.

The primacord **19** should be a heavy primacord, preferably one of about 400 grains per foot. This heavy primacord is required because it is the primacord which functions as the detonating primer.

The upper end of the bag B is closed by gathering as shown at **21**; and the gathering is secured by another wire tie **22**.

The bags in the condition depicted in Figures 1 and 2 are in condition for any normal handling at the scene of the mining operation. Thus, after being packed by the manufacturer, they may be shipped, loaded in trucks, and deposited in proper numbers at each individual blast hole where they are required. During this handling, the strip **14** positively maintains the mouth **13** of the pleat **12** closed and insures of the bag maintaining its diameter, which in this condition should be about 9". Just before the bag is to be dropped into the blast hole, a length of the primacord **19** is secured to the lower end **17** of the lowermost bag which is to be dropped; and this heavy primacord **19** will have a length corresponding to the number of bags which are to be dropped into any particular hole. Thus, if three bags are to be dropped into a hole, the heavy primacord **19** will have a length sufficient to cause it to be coextensive with these three bags. A small primacord **23** of about 50 grains per foot may be secured to the upper end of the heavy primacord in any preferred manner such as indicated at **24** in Figure 1.

Just before the bag B is to be dropped into the blast hole, the operator grasps the exposed end **16** of the ripcord **15** and fractures the tape or strip **14** for about half the length of the bag, beginning at the bottom. In this condition the prilled ammonium nitrate **20** which is packed against the captive pleat **12** will cause the latter to remain closed; and the diameter of the bag is maintained intact at 9". Thus the bag B may be dropped into a blast hole, such as represented at **25** in Figure 8; and the bag B, having a diameter appreciably less than that of the blast hole, will fall freely in the latter until the lower end **17** of the bag hits the bottom **26** of the blast hole **25**. At the moment of impact, the bag B is in the condition depicted in Figure 8. However, immediately upon impact, all of the granulated ammonium nitrate **20** will tend to move downwardly; and this causes the pleat **12** to open and extend. Thus the bag B, which it is to be remembered has an overall circumference slightly greater than that of the blast hole, is caused to expand and completely fill the

lower portion of the blast hole. This condition is depicted in Figure 9.

Figure 10 shows how a second bag B′ may be dropped on top of the bag B. This second bag B′ will be in all respects similar to the bag B except that the primacord **19** will not be attached thereto because this primacord has been attached to the bag first dropped. The tape **14** of the bag B′ will have been fractured by the ripcord **15** for about two-thirds the length thereof, just as in the case of the bag B. After impact, the bag B′ will extend into the condition depicted in Figure 11.

At this point it is well to note that the material of the bag B above the ammonium nitrate **20**, which has been left free by the ammonium nitrate moving downwardly, will be compacted and compressed between the bag B and B′. It is just possible that slight air spaces will occur where this free fabric is compressed, but this is a minor factor, and particularly so because the full cross-sectional area of the hole is completely filled.

Figures 12 and 13 show how a third bag B^2 may be dropped and extended in exactly the same way.

The blast hole **25** is now stemmed in the usual way ordinarily using the material which has been removed by forming the hole. The light primacord **23** is continued out the top of the hole and is available for detonation of the charge.

It is important to note that when the impact at the end of its drop causes the released bag to spread to the limits of the blast hole it presses tightly against the adjacent vertical strand of primacord throughout the entire length of the charge of ammonium nitrate thus establishing the intimate contact necessary for the overdrive effect to occur when the primacord is detonated also that none of the prilled ammonium nitrate **20** is removed from the heavy primacord **19** a distance greater than the diameter of the blast hole. While all of the ammonium nitrate might not be completely overdriven as the primacord **19** is detonated, still the major portion thereof is overdriven because most of the ammonium nitrate will be located within 8″ of the primacord; and it has been found that the overdriving effect is obtained up to that point. Any of the ammonium nitrate removed more than 8″ will still be effectively exploded.

While a preferred specific embodiment of the invention is hereinbefore set forth, it is to be clearly understood that the invention is not to be limited to the exact steps, dimensions, and constructions illustrated and described, because various modifications of these details may be provided in putting the invention into practice within the purview of the appended claim.

What is claimed is:

In an explosive-containing bag, a cylindrical body of a laminated material comprising an outer fabric layer and an inner liner of Pliofilm attached to and coextensive with said outer fabric layer, said cylindrical body being formed with an inwardly disposed captive pleat presenting an outwardly opening mouth, a frangible strip secured to the exposed face of said outer layer of fabric on opposite sides of said mouth, a ripcord beneath said strip in said mouth and having a projecting end at the bottom of said bag, and ammonium nitrate filling said bag and holding said captive pleat against the inner side of said cylindrical body.

References Cited in the file of this patent

UNITED STATES PATENTS

1,220,208	Ellis	Mar. 27, 1917
1,464,866	Clark	Aug. 14, 1923
1,543,850	Holderer	June 30, 1925
1,543,851	Holderer	June 30, 1925
1,824,141	Hill	Sept. 22, 1931
2,609,750	McFarland	Sept. 9, 1952
2,703,528	Lee et al.	Mar. 8, 1955
2,764,939	Phemister	Oct. 2, 1956

FOREIGN PATENTS

2,423	Great Britain	1878