April 7, 1964 F. I. ALEXANDER 3,127,835

METHOD AND APPARATUS FOR MAKING EXPLOSIVES IN THE PLACE OF USE

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FIG. 1.

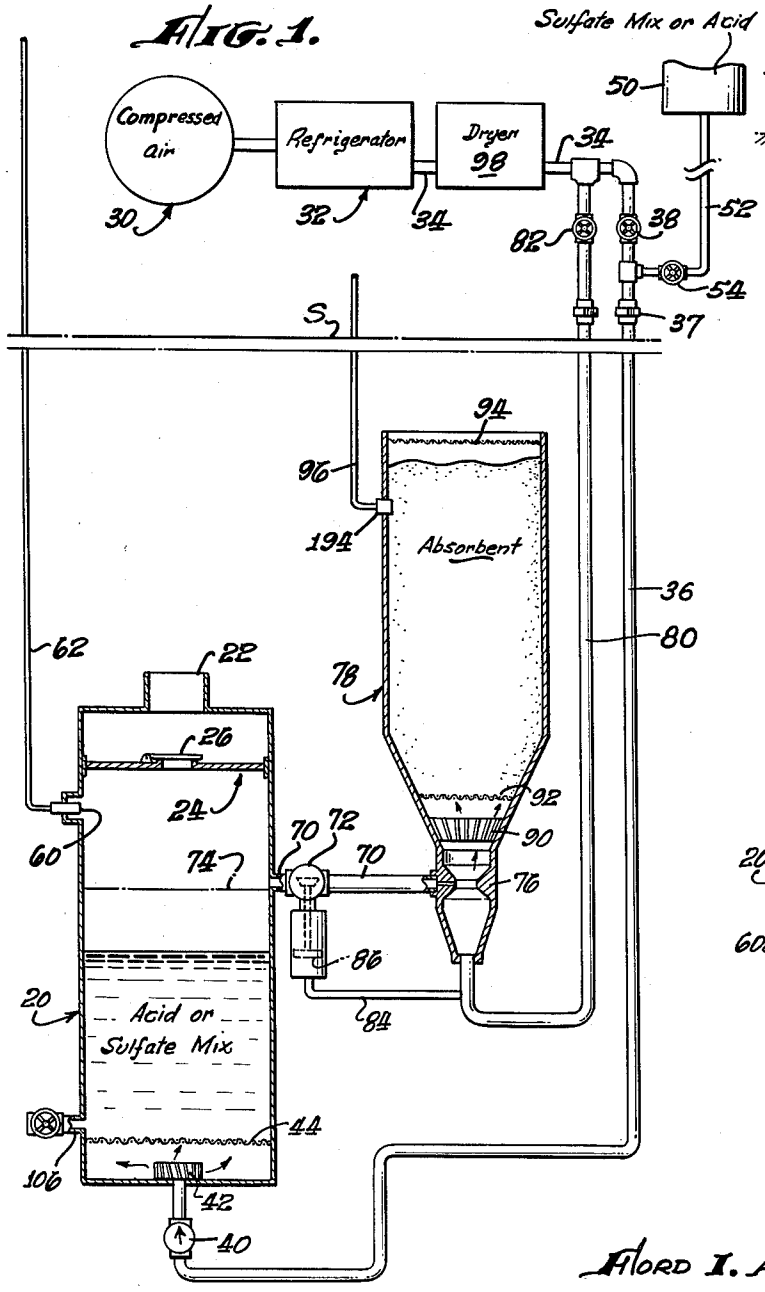
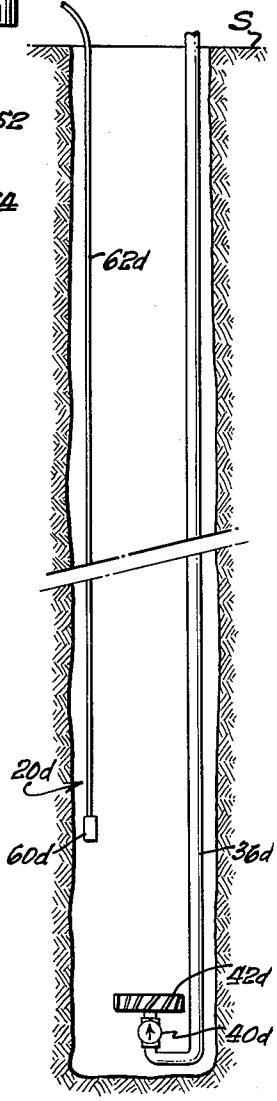


FIG. 1a.



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FIG. 3.

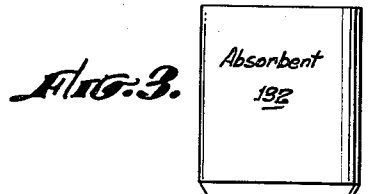
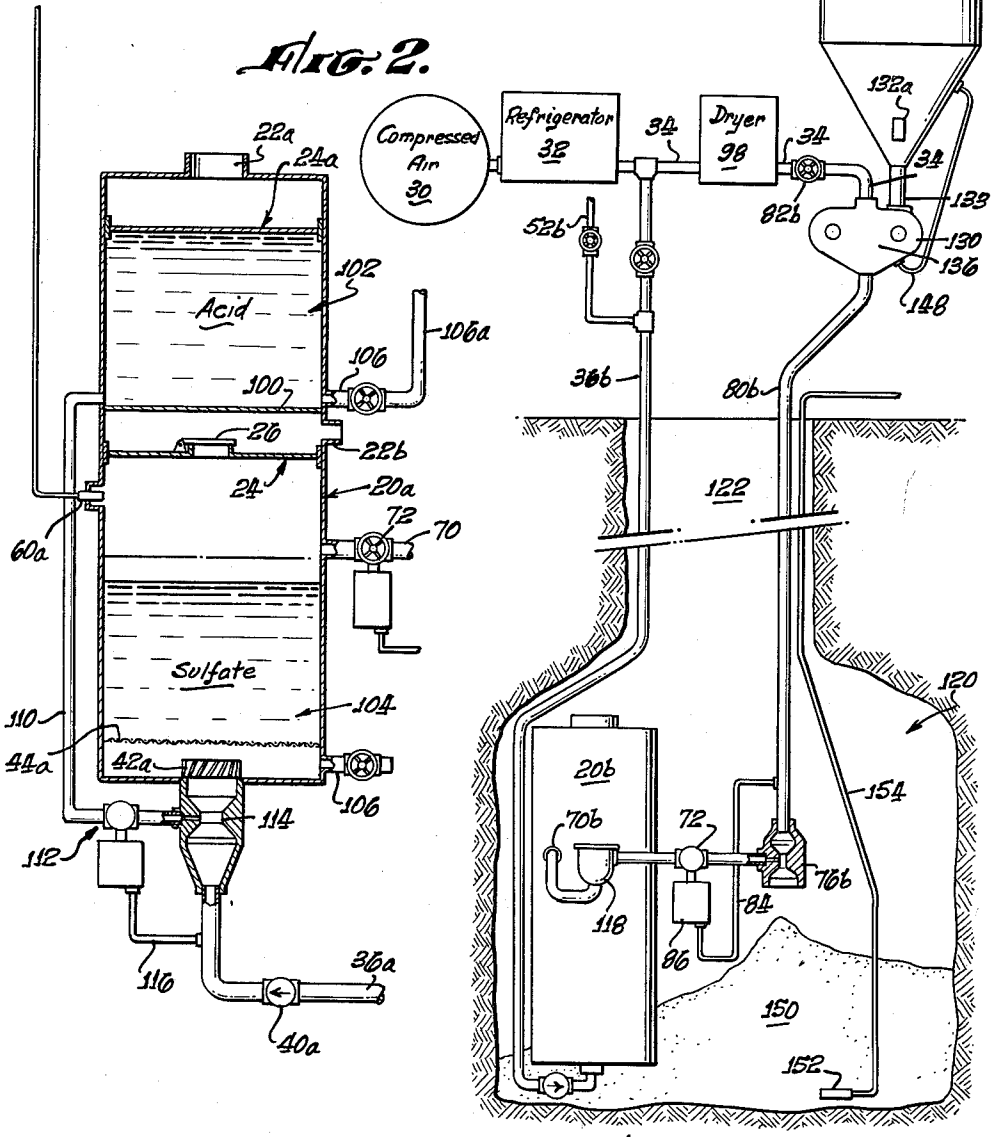


FIG. 2.



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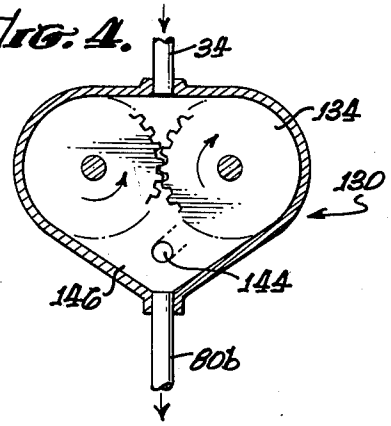
Buckles & Lewis

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FIG. 4.



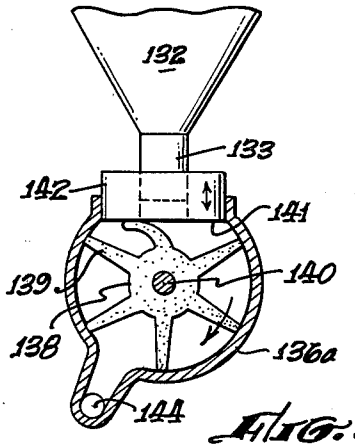


FIG. 5.

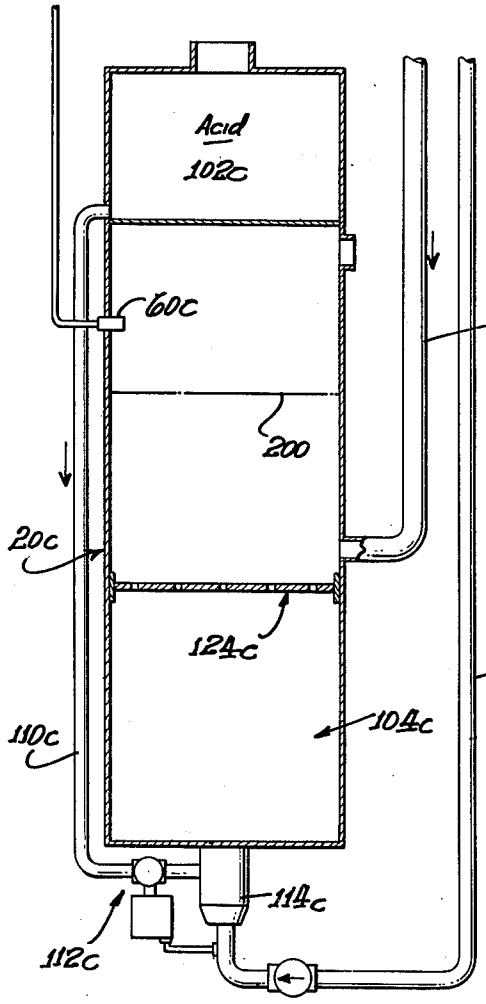


FIG. 6.

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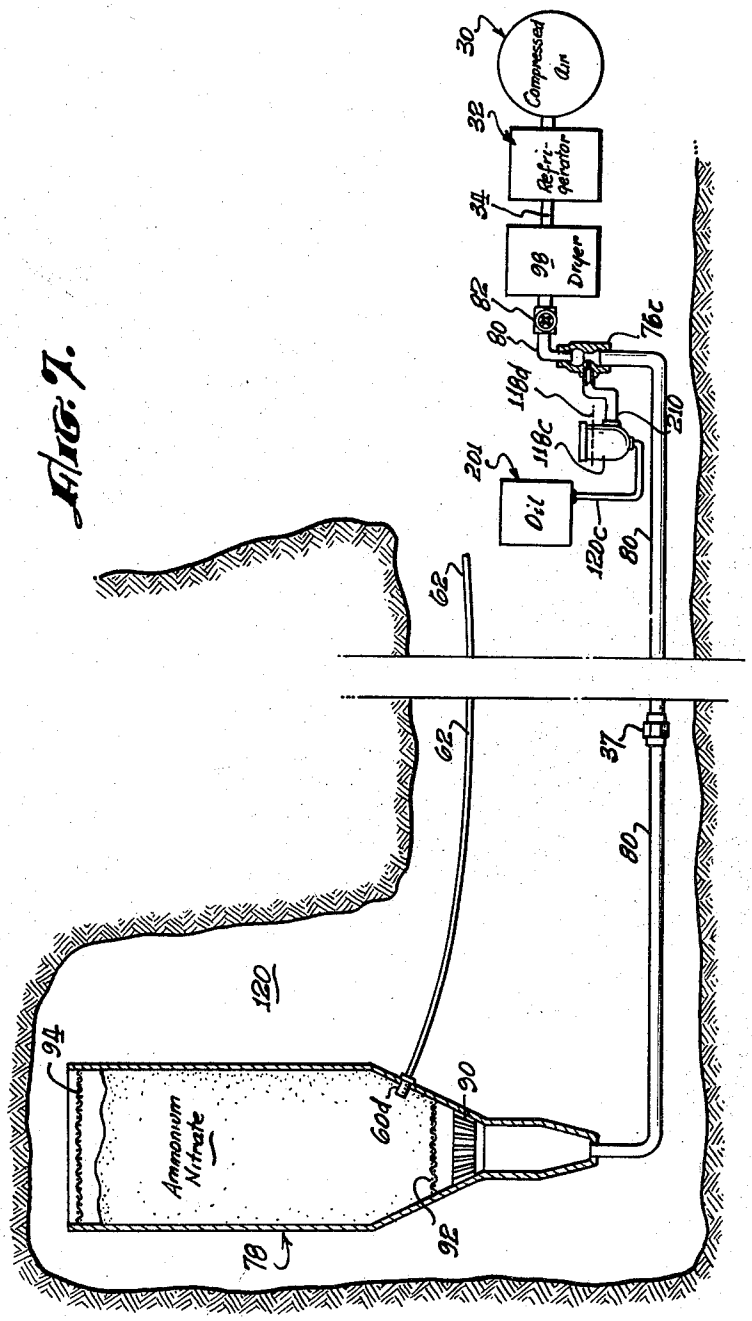
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Fig. 7.



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FIG. 8.

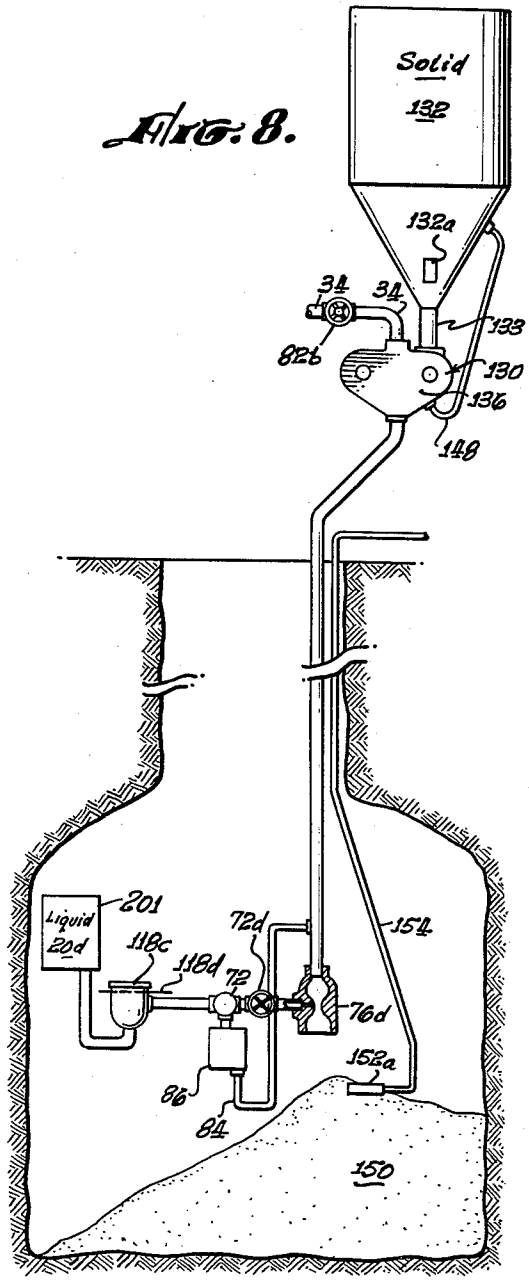
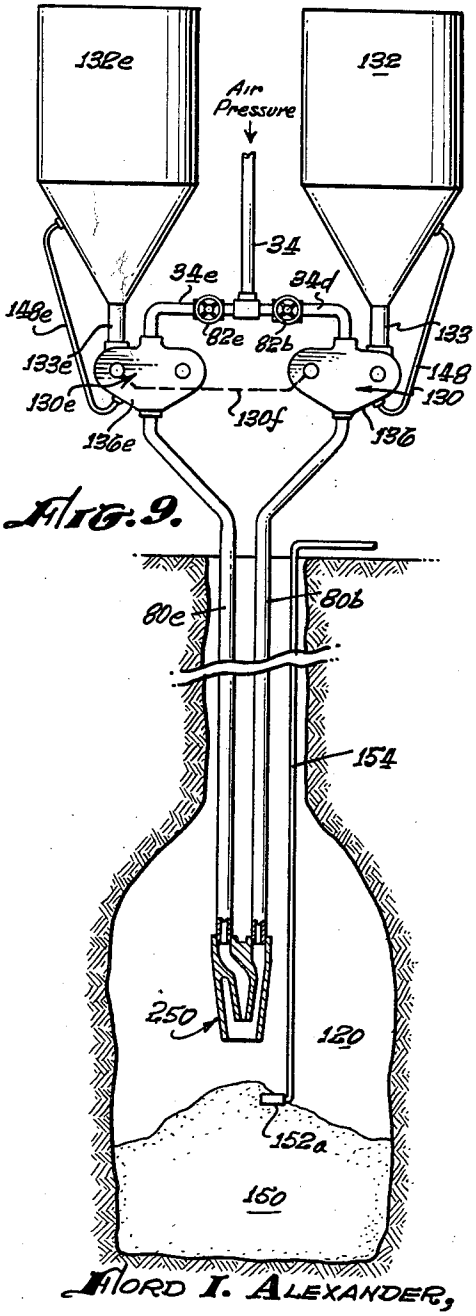


FIG. 9.



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United States Patent Office 3,127,835 Patented Apr. 7, 1964

3,127,835

METHOD AND APPARATUS FOR MAKING EXPLOSIVES IN THE PLACE OF USE

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Filed May 29, 1961, Ser. No. 113,257
10 Claims. (Cl. 102—23)

This invention has to do with the production of explosives from their initial ingredients; a primary object being the provision of practical and effective means, in both process and apparatus, for eliminating the hazards which are always attendant on transport and handling and storage of explosive substances. My invention provides methods and apparatus with which the initial non-explosive ingredients can be admixed, and the explosive produced in the place of final use, with all operations under safe remote control. Various procedures have been proposed in the past for production of explosives in their place of use; but for various reasons they have proved to be impracticable, or not useful in the operations which employ the largest uses of explosives—such operations as surface and quarry blasting and well shooting, etc.

This application is a continuation in part of my previous co-pending application, Ser. No. 516,099, filed June 17, 1955, now abandoned.

In general, the invention is characterized by moving one or more of the non-explosive components of an explosive composition, from a remote location to the point of final detonation, on a gaseous carrier stream or streams; mixing the components on such a stream or streams; depositing the mixed or reacted explosive composition at the point of detonation, and finally detonating at that point. In the following descriptions examples are given for such remote-point control of the formation of explosives involving two or more initial ingredients, for instance nitroglycerin and dynamite and various other explosives involving two or more solid and/or liquid components. The procedures involved with nitroglycerin and dynamite are typical of the procedures with other explosives, as will appear from the following illustrative descriptions.

It is an important characteristic of the invention that, although one or more of the non-explosive components may be placed at the location of final mixing and detonation by, for instance, manual or hoist operation, at least the component or components that finally form the explosive composition is, or are, introduced on the gaseous stream or streams on which mixing takes place. The carrier stream is here spoken of as an air stream, but with the understanding that streams of any suitable or desirable gas are included. And the term explosive or explosive composition is here used in the sense either of an explosive admixture or of a reaction product.

First using nitroglycerin as typical for descriptive purposes here, it may be noted preliminarily that that explosive may be in practice produced in two specifically different manners, in each of which two or more non-explosive ingredients are finally admixed to produce the explosive. In the older method, glycerin and/or glycol or equivalent is nitrated with nitric acid in the presence of sulfuric acid—nitrated with an acid mix of about 40% nitric and 60% sulfuric—at a controlled low temperature. The resultant nitroglycerin separates from the spent acids, rising to the top. The action is exothermic with a large amount of heat thrown off.

In the other known procedure, the glycerine, glycol, etc. is first sulfated with sulfuric acid or sulfuric anhydryde, SO_3, and the resultant non-explosive sulfate mix is then nitrated with an acid mix which typically may be about 85% nitric and 15% sulfuric. One advantage of this latter procedure is that not so much heat is

generated in the final nitrating operation, also not so much water, as in the procedure involving direct nitration of the glycerin etc.

Although my methods and apparatus are applicable equally well to either procedure, as present I prefer to use the second, as my invention has in view, among other things, particularly the production of explosives in confined and sometimes quite hot spaces. Nitroglycerin decomposes rapidly at elevated temperatures, and particularly so in the presence of the waste products (here referred to as waste acid). To prevent its decomposition before firing it is necessary, particularly in closed spaces, to remove the generated heat, and the second procedure generates the lesser heat. For such reasons, I prefer the second procedure and will describe my invention with reference to it, but without implying limitation thereto.

As will appear, in producing nitroglycerin in the place of detonation, either one or both of the components may be carried in from the remote location, and mixed, on the carrier air stream at the place of detonation; and in production of e.g. dynamite the absorbent may be either initially put in place to be impregnated with the nitroglycerin, or may be carried in on air stream, and in either case admixed and impregnated with the nitroglycerin on the carrier air stream.

And, as will further appear, in the production of other typical explosives from non-explosive solid and/or liquid components, one or some of the components may be initially placed at the location of mixture and detonation, or all carried in on a carrier air stream, and in either case admixed on the carrier stream.

The accompanying drawings illustrated schematically several typical forms of apparatus and method illustrative of the invention. In these drawings:

FIG. 1 is a schematic illustration of one illustrative type of apparatus for the production of e.g., nitroglycerin and dynamite;

FIG. 1*a* is a schematic illustration of a modification of FIG. 1;

FIG. 2 is a schematic illustration of another modification of FIG. 1;

FIG. 3 is a schematic illustration of another typical form of apparatus for the same typical explosives;

FIGS. 4 and 5 are schematic showings of illustrative details of FIG. 3; and

FIG. 6 is a schematic illustration of another typical modification for the same typical explosives; and

FIGS. 7, 8 and 9 are schematic illustrations of modifications adapted to other explosive compositions.

Referring first to FIG. 1, a container such as shown at **20** is provided for the mixing operations. The container is open at the top, as at **22**, to allow escape of gases and to provide for pressure equalization between the container interior and the surrounding fluid, gaseous or liquid. If the apparatus is to be used under water or other liquid, the container (typically cylindric) may be provided interiorly with a movable diaphragm such as illustrated at **24**. This diaphragm may typically be in the form of a cupped piston freely movable in the cylinder and of an over-all specific gravity such as to float on the liquids introduced and formed below it, but to sink in such liquids as water or oil in which the container may be submerged (as in well shooting). An upwardly opening flap check valve, as **26**, may be provided to allow escape of gases and, more particularly, the air or other mixing and cooling gas that is introduced during the operation of forming the explosive.

For operations in oil or gas wells, etc. a neutral gas is preferred rather than air; and references to air in the following descriptions will be understood to include any other desired gas. The only purpose of the movable diaphragm is to prevent direct contact of the surrounding

fluid with the liquids under the diaphragm. Where the surrounding fluid (e.g. air or water) is such as not to interfere with or prevent (as by chemical reaction) the formation of the explosive, and is of such specific gravity as not to displace the substances from the container (which is true in general of well liquids), the separating diaphragm may preferably be omitted. In that case the container is simply open at its top.

In typical operation, container **20** is placed in a blasting cavity, or lowered into a well, either empty or carrying one of the two initial ingredients. Both, or the other one of, the ingredients are or is then introduced from outside the blasting cavity or from the top of the well.

FIG. 1 shows schematically a typical suitable system for such introduction of ingredients and for introducing cooled air or other gas to aid and accelerate admixture and to carry off generated heat.

Typically, the apparatus, at the top of a well, or removed a safe distance from a blasting site or cavity, may comprise a source of compressed air—as a compressed air tank or compressor **30**—and a cooler or refrigerator **32** for the compressed air. The cooled compressed air is preferably at a pressure considerably higher than the pressure surrounding and in container **20**, so that the expanded air applied to the container is at a sufficiently low temperature to keep the reacting ingredients and the produced explosive at a temperature that does not induce premature explosions or decomposition of the nitroglycerin. Thus, it may be taken as typically desirable to keep temperatures down to about 20° C. Doing that involves not only removing the heat generated by the chemical reactions, but also, where the surroundings are at a higher temperature (as in some deep wells) removing the heat radiated and conducted into the container from those surroundings. Thus, to maintain the desired temperature, either the temperature or the volume of air put through the container, or both, may be adjustably varied. A dryer **98** may also be incorporated in the system.

As schematically shown in FIG. 1, a pipe or tube conduit **34, 36**, controlled by valve **38** leads from the refrigerator **32** or dryer **98** through a check valve **40**, to the bottom of container **20**. At the point of discharge into the container, a means such as angular vanes **42** and/or screen **44** provide for turbulent and spread delivery of the air into the substances in the container, inducing uniform cooling and thorough admixing.

Operation of the system as so far described may be as follows. One of the ingredients may be put in measured amount in the container before the latter is placed and the system connected up; or the first as well as the second ingredient may be introduced in measured amounts one one after the other from a source such as tank **50** having an outlet connection **52**, controlled by valve **54**, leading to air pipe **36**. Tank **50** will be under pressure, or have a hydrostatic head, greater than the pressure in pipe **36**. In case the first ingredient is introduced through pipe **36**, a current of refrigerated air through that pipe will carry the ingredient into the tank and also precool and agitate it.

After introduction of the measured amount of the first ingredient, the second ingredient in measured amount is then introduced from tank **50** (or another tank connected up in the same manner) and carried through pipe **36** on a current of refirgerated air. Carried on that air into the body of first ingredient in the tank, the second ingredient is thoroughly distributed in and admixed with the first. Reaction immediately sets in as the second ingredient is introduced. The refrigerated air current is continued as long as reaction proceeds after the introduction of the second ingredient is complete, keeping the ingredients mixed, and both those ingredients and the final product cooled.

Although for many explosives, e.g. nitroglycerin, it is preferable to introduce the several ingredients one after the other to container **20**, it is possible to introduce them together on the air current. That is particularly feasible if the temperature is kept low enough during pre-mixing and introduction to inhibit or slow down the explosive-producing reaction; or in operating with explosives wherein the reaction between the initial ingredients is inherently relatively slow.

After reaction is complete, air circulation is then either cut off, or shut down to substantially just the amount necessary to keep the surroundings from unduly raising the temperattrue of the reaction products. During the post-reaction stage while the nitroglycerin is separating by rising to the top, it may be desirable to lower the temperature of the refrigerated compressed air so that the air volume, and the accompanying agitation, will be minimized. After allowing time for the nitroglycerin to separate and rise to the top, it may then be fired by any conventional means, as by an electric cap **60** controlled by the electric circuit **62** extending from a safe distance or from the surfaces at the top of a well.

If the air is dryed to a low humidity, its circulation through the ingredients during the reaction, and afterwards through the final products, tends to reduce the amount of residual water.

In shooting a deep well, the container **20** may be initially lowered, e.g. on a suspending line, into the well to the shooting point and the operations carried on as above. Or, for the convenience of not having to connect up so much pipe as the container is lowered, and also for carrying out the heat producing reaction at a point in the well where the well temperatures are usually not so high as deeper down, the container may initially be lowered only to a safe depth, say four hundred feet. The operations of ingredient introduction and reaction having then been performed as above described, circulation of refrigerated air in large quantity and/or at lowered temperature may then pre-cool the reaction products to a low temperature; and that may be regardless of the accompanying violence of agitation. The pipe connection or connections having then been broken (as at the union indicated at **37**) the container with its reaction products may then be rapidly lowered on its suspending line (not shown) to the shooting point. Separation of the nitroglycerin may taken place wholly or partially on the way down. Then the explosive may be fired via firing circuit **62** immediately on reaching the shooting point or as soon thereafter as separation is complete. With adequate pre-cooling this procedure provides for shooting at great depths in hot wells without the necessity of running connecting pipe lines etc. to those depths.

The container **20** of FIG. 1, and of any of the following figures, may be any kind of walled cavity—not at all necessarily in the form of a metal or similar container. Thus, for example, it may simply be a hole in the ground, as illustrated by way of example in FIG. 1*a*. There a simple hole **20***d* is shown extending from ground surface S. Pipe **36***d*, corresponding to pipe **36** in FIG. 1, may have the check valve **40***d* and distributor **42***d* at its upturned bottom end. The upper end of pipe **36***d* connects with the same apparatus as shown in FIG. 1. Firing cap **60***d* may simply be lowered on its firing line **62***d* to the correct level to fire the nitroglycerin after it has separated. The operations of ingredient introduction, cooling, agitation, separation and firing may be the same as above or hereinafter described.

FIG. 1 additionally shows in schematic form typical apparatus for the production of dynamite in place. Connecting into the container **20** is an outlet pipe **70** controlled by a valve **72**, the point of connection being substantially at the level of separation of the produced nitroglycerin floating above the lower body of waste acids. Such a level is indicated at **74**. (It will be above the acid level if that is the first ingredient introduced to the container; below that of the sulfate mix if that is first introduced.) Pipe **70** leads to the throat of a venturi formation **76** and air (which may or may not be refriger-

ated as heat conditions require) is supplied through pipe **80** under the required pressure (depending on the pressure of the surroundings) to the venturi. The venturi discharges into a container **78** which may be filled initially with a measured amount of any of the absorbents suitable for dynamite manufacture, say sawdust. The amount of sawdust is determined in advance to produce, with the known quantity of nitroglycerin in **20**, dynamite of the desired grade and strength. (Instead of placing the absorbent initially in container **78**, it may be carried into that container on the air current in pipe **80**, as explained below in connection with FIG. 3.)

Valve **72** is normally closed. Pipe **80** for compressed air (refrigerated and dried if desired) leads from **34** to the air entrance of venturi **76**. The air in **80**, controlled in amount by valve **82**, is at a pressure greater than that at the mixing apparatus **76**, etc. The normally closed valve **72** may be opened by any suitable control; for instance by air pressure from pipe **80**, via a connecting pipe **84**, acting on a piston **86**.

Typical operation may be as follows. After the nitroglycerin has been formed in container **20** and has risen to the top, and the sawdust or other absorbent being already in **78**, air under pressure (cooled and dried if desired) is applied to venturi **76** and also to the valve piston **86**. Valve **72** is thus opened simultaneously with the flow of air through the venturi and up through the absorbent. The venturi action draws the nitroglycerin into the air stream which carries it into and distributes it through the mass of absorbent. The expansion of the air above the throat of the venturi will distribute it and the nitroglycerin laterally; or if desired a spiral vaned distributor **90** and/or screen **92** may be used. A screen **94** at the top of **78** may be used to prevent the absorbent from being blown out. After all the nitroglycerin is distributed in the absorbent, the air current (preferably of dry air) may be continued to dry out any water which has remained in the nitroglycerin. The produced dynamite may then be fired in any conventional manner, as by the electric cap **194** controlled by electric circuit **96** which goes to the remote control location.

FIG. 2 illustrates a modification in which both of the starting ingredients may be initially placed in the container separated from each other and then mixed by opening a passage between the separate compartments, after the initially charged container has been placed. In the instance of well shooting the container may be charged with the two ingredients before being placed in the well. In blasting operations, the container may either be charged before placement in the blasting chamber, or after placement if the chamber affords convenient access; or from the remote control point, as explained below.

In FIG. 2 the container **20***a* is divided by partition **100** into upper and lower compartments **102** and **104**. Each compartment is open at its upper end, as at **22***a* and **22***b*, for pressure equalization and gas and/or air escape. And each may have, if desired, the movable diaphragm **24** or **24***a* if desired. The diaphragm **24**, if used in the lower compartment may have the flap valve **26**, as in FIG. 1. But diaphragm **24***a* in the upper compartment needs no valve. The diaphragms, if used, have the specific gravities mentioned before, so that they will float on the explosive and the initial ingredients, but sink in e.g. water.

The heavier ingredient, in this case the acid, may preferably, but not necessarily, be placed in the upper compartment; and the lighter, in this case the sulfate mix, in the lower. If the diaphragms **24**, **24***a* are not used the ingredients may be introduced for instance, through the openings **22***a* and **22***b*. (The same may be said of the form of FIG. 1 and its opening **22**.) If the diaphragms are used, valve controlled filling openings, such as those represented schematically at **106** may be provided.

A pipe or other passage means **110** leads from the lower part of upper compartment **102**, controlled by the pressure

actuated valve **112**, to the throat of a venturi formation **114**. Air pipe **36***a*, controlled by check valve **40***a*, delivers refrigerated air to the venturi air intake. Valve **112** may, for example, be the same as described for valve **72** in FIG. 1; normally closed, and opened by pressure from pipe **36***a* via the connection **116**. The lower part of compartment **104**, immediately above the venturi discharge, may have the disperser **42***a* and/or screen **44***a*, as described for FIG. 1; although the venturi itself has the action of distributing the acid in the air stream and distributing the acid laden air laterally as it passes up into the sulfate. Pipe **36***a* may be considered as having the same air or gas feeds and controls as pipe **36** has in FIG. 1. In fact, FIG. 2 may be considered as showing only modifications of the container and its immediate appurtenances; the remainder of the complete system being the same as described for FIG. 1. Thus, the lower compartment **104** of FIG. 2 may have the outlet **70**, controlled by valve **72**, leading to the dynamite producing equipment, **78** etc., the same as in FIG. 1.

In the operation of the system shown in FIG. 2, after the container **20***a* has been charged and placed and connected up with the other parts of the system, refrigerated air pressure applied via **36***a* will open valve **112**. The air flow through venturi **114** will pick up the acid (or the sulfate ingredient if it is the one placed in **102**) and carry it into the other ingredient in **104**, mixing the ingredients and cooling them. Chamber **104** is large enough to hold both ingredients, and, finally, to hold both the produced nitroglycerin and the waste acids, below the level of the opening at **22***b*. (That, of course, is also true of the container **20** in FIG. 1.) The refrigerated and dried air supply may be continued after completion of the mixing and reaction, as has been described for FIG. 1. The device of FIG. 2 may be used in the same various manners as described for FIG. 1; either for well shooting or general blasting. And, as in FIG. 1, the produced nitroglycerin may be fired by the electric cap **60***a*, or may be drawn off at **70** for production of dynamite as in FIG. 1.

The form of FIG. 2 may also be initially charged, after placement of the container, from the remote point of control. For instance, pipe **106***a* may lead to charging opening **106** from the control point, and through that pipe one ingredient may be introduced to the upper compartment **102**. Then, the other ingredient may be introduced via **36***a* on an air stream in the manner described in connection with FIG. 1; the first ingredient being drawn from **102** and mixed with the second as the latter passes through venturi **114** on the air stream.

FIG. 3 illustrates schematically two further modifications of my system, either one of which may be utilized in the systems of either FIG. 1 or FIG. 2. These two further modifications are: (1) supplying the absorbent, for production of dynamite, from the remote operating and control point external of the space in which the explosive is formed, and (2) delivering the manufactured dynamite into a pile on the floor of the blasting cavity.

In FIG. 3 the container shown at **20***b* may represent either the container **20** of FIG. 1 or **20***a* of FIG. 2; and the nitroglycerin may be produced in **20***b* in any of the manners before described. Container **20***b* is shown, typically, as located in a blasting cavity **120** having an entrance **122**. The pipe **36***b* corresponds to pipe **36** or **36***a* of FIGS. 1 and 2, and pipe **52***b* corresponds to the ingredient introduction pipe **52** of FIG. 1. Air-pressure-operated valve **72** is the same as that of the previous figures, opening to supply nitroglycerin to the throat of venturi **76***b* when pressure exists in pipe **80***b* which delivers air or gas (carrying the absorbent) to the air intake of the venturi **76***b*. To maintain an unvarying head of nitroglycerin at the venturi throat, a float chamber or equivalent device **118** is interposed between the nitroglycerin outlet **70***b* of container **20***b* and the valve **72**. Outlet **70***b* corresponds to outlet **70** in FIGS. 1 and 2.

Compressed air, which may or may not be refrigerated,

is preferably dried in dryer 98 and goes from the dryer, under control of valve 82*b* to a device 130 whose function is to deliver absorbent into the air stream from container 132 in measured volume proportional to the volume of air passing through the device. The air, carrying the comminuted absorbent (e.g. sawdust) leaves device 130 through pipe 80*b*. Passing through venturi 76*b* the air stream draws in nitroglycerin in volume proportionate to the air volume, and therefore, proportionate to the absorbent volume passing through the venturi. By that action the volume of nitroglycerin is maintained in a fixed ratio to the absorbent volume, to produce dynamite of the desired grade and strength. To selectively fix that ratio and grade, the proportion of absorbent to air may be selectively adjusted in the device 130, as will be described.

The action at venturi 76*b* not only draws in the nitroglycerin proportionately but also distributes it in the air stream and therefore in the air-carried absorbent. The delivery from the venturi may go to a container such as the absorbent-containing container of FIG. 1; in which instance the lower screen 92 of that figure will be omitted. But in preparing a blast in a blasting cavity, I prefer merely to deliver the mixed absorbent and nitroglycerin into a pile on the cavity floor, such as shown at 150 in FIG. 3, and which may more or less completely fill the cavity. The piled dynamite may then be fired in any conventional manner, as by an electric cap 152 placed on the floor and controlled by electric circuit 154 from the remote control location outside the cavity. Before firing, all the other apparatus in the cavity may be removed by any suitable means. If, for instance the blasting cavity is one that extends more or less vertically from the surface, the apparatus may be removed, after disconnecting the piping at the surface, by a hoisting line (not shown). For that purpose the apparatus may be compactly arranged around the container 20*b* so that it can be inserted and removed through a relatively small entrance 122. And the entrance may of course be plugged if desired before firing.

FIGS. 4 and 5 are schematic showings of a merely typical measuring device 130 for the absorbent, given by way of example. For instance, the air pipe 34 from control valve 82*b* may lead to a gear motor 134 in casing 136, pipe 80*b* leading from the exhaust side of the motor. Enclosed in a part 136*a* of the same casing is a paddle wheel 138, equipped with flexible paddles 139, mounted on a shaft 140 of one of the gears. The whole wheel may, for example, be formed of a semi-soft rubber-like substance such as neoprene. Normally extending radially the tips of the paddles wipe the interior of the circular casing 136*a*. A part of the interior casing surface is, however, formed by the inner flat face 141 of a radially adjustable plug 142. Wiping over that surface the paddles flex. The volumetric capacity between adjacent paddles is thus reduced, the amount of reduction depending on the adjusted position of plug 142. The outlet 133 from absorbent container 132 extends through plug 142, and the successive inter-paddle spaces each take from the outlet the volume of comminuted absorbent to which they are adjusted. They rotatively then carry that adjusted volume around to the feed outlet 144 communicating with the air outlet passage 146 of the gear motor. There the comminuted absorbent is picked up in the air current and carried on it through pipe 80*b* to the nitroglycerin mixing venturi.

Absorbent container 132 is preferably in the form of a closed tank, and equalizing pressure may be applied to it from the exhaust side of the motor, for instance by a pipe connection 148 shown in FIG. 3.

In operation of the system of FIG. 3, a known amount of nitroglycerin is produced in the container 20*b*. The air feed is set to draw the nitroglycerin into the venturi at a given rate. Device 130 is adjustably set to feed the absorbent at the rate corresponding to the desired grade of dynamite. The quantity of absorbent in tank 132 may be previously measured to correspond to the known quantity of nitroglycerin. However, in order to be certain that all the nitroglycerin is drawn out of container 20*b* and formed into dynamite, it may be preferable to initially charge tank 132 with an excess of absorbent and then continue the operation until all the absorbent is out of the tank. Observation windows in the tank, such as indicated at 132*a*, facilitate the operation. The resulting presence of a small amount of pure absorbent on the pile 150 is of no consequence, whereas the presence, at the end of the operation, of some unused nitroglycerin in container 20*b* may be not only objectionable but dangerous.

FIG. 6 schematically illustrates another typical modification, providing for the formation of dynamite in the same chamber in which the nitroglycerin is produced. In this figure the container 20*c* is, illustratively, in essence the same as 20*a* in FIG. 2; the difference being that lower chamber 104*c* is considerably larger than 104 in FIG. 2. Upper chamber 102*c*, acid transferring passage 110*c*, valve 112*c*, venturi 114*c*, and air introduction pipe 36*c*, may all be the same as the corresponding parts in FIG. 2. Diaphragms 24 and 24*a* of FIG. 2 are omitted as not being necessary, at least where the apparatus is not submerged in liquid. A perforated diaphragm 124*c* is however shown in lower chamber 104*c*, and is designed to have an over-all specific gravity to float on the final spent acid but sink in nitroglycerin. It moves freely in the chamber, and need not fit at all tightly. The procedures of initial charging and making the explosive may be any of those described for FIGS. 1 and 2. As in the form of FIG. 2, nitroglycerin may be produced by, for example, placing the acid in 102*c*, the sulfate mix in the lower part of 104*c*, and then, by air introduction through 36, mixing the acid with the sulfate to form the nitroglycerin. It may be remarked that container 20*c* could be of the same type as in FIG. 1, and the acid introduced to chamber 104*c* from the remote control point on the air current through 36*c*. In any case, the formed nitroglycerin floats to the top of the spent acids in 104*c* through the perforated diaphragm. At the conclusion of separation, diaphragm 24*c* will float for instance in the position shown at the bottom of the body of nitroglycerin, whose upper surface will lie, say, at the level indicated at 200.

The absorbent is then introduced through pipe 80*c* corresponding to pipe 80*b* of FIG. 3 and fed its air and a measured volume of absorbent by mechanism which may be the same as shown in FIG. 3. The connection of pipe 80*c* to chamber 104*c* is just above the calculated level of diaphragm 24*c* so that the air and absorbent enter the lower part of the body of nitroglycerin. The air current cools and drys the nitroglycerin and distributes the absorbent. Perforated diaphragm 124*c* minimizes disturbance of the clean division of the nitroglycerin from the body of spent acid. A light absorbent such as comminuted sawdust is here preferred as it will float upwardly in the nitroglycerin, absorbing the latter in its passage. The end result is that chamber 104*c* above the diaphragm is more or less completely filled with dynamite of the selected grade; the dynamite being finally fired in any suitable manner, as by electric cap 60*c*.

As indicated initially, the production of nitroglycerin has been described here only as typical of my invention, as my processes and apparatus may be applied to the production of many other explosives. And, likewise, the described production of nitroglycerin dynamite is only illustrative of my invention; as the process and apparatus may equally well be applied to other known dynamites, e.g. ammonium dynamite, consisting of other explosives absorbed in an absorbent.

FIG. 7 and following illustrate schematically other forms of apparatus and process for the production of other typical explosives at the place of detonation, under control from the remote location. FIG. 7, for example,

shows one form of apparatus for the production of another explosive composed of a liquid and a solid ingredient. The apparatus here is much like that of FIG. 1. A typical explosive of the liquid-solid type is, for instance, one formed of an admixture of ammonium nitrate and diesel oil. The normal proportions for maximum detonation energy are about one gallon of oil to eighty pounds of the nitrate, but greatest sensitivity is had with a much smaller proportion of the oil.

In FIG. 7 the ammonium nitrate is shown placed in a container **78** (like that of FIG. 1) in a shooting cavity **120**, here shown as horizontally excavated. Airstream pipe **80**, similar to that of FIG. 1, controlled by valve **82**, leads from a compressed air source, here shown as the same as in FIG. 1. Container **78** and its charge of comminuted or granulated nitrate are placed in the cavity, for instance manually, and connected up with air stream pipe **80**. Oil, in quantity proportionate to the quantity of nitrate, say in the ratio for maximum energy, is charged into container **201** and feeds into float bowl **118***c* where the normal level is controlled to such as indicated at line **118***d*. The float bowl feeds, by communication **210**, from a level below normal level **118***d* to venturi **76***c* in pipeline **80**. As shown here, the oil container **201** is located at the remote control point outside the shooting cavity **120**. It and venturi **76***c* and its feed can be located in the cavity like the location of container **20** in FIG. 1. In fact, in the system of FIG. 1, container **20** may contain the oil and **78** contain the nitrate, and the oil be blown through the nitrate as the nitroglycerin is carried into and blown through the absorbent in FIG. 1. Or, the venturi **76***c* and its feeding float bowl **118***c* may be located in the cavity with the oil supply **201** located at the remote control point, feed pipe **120***c* then extending from **201** to the float bowl in the cavity. It is, however, preferred to carry the oil into the shooting cavity on the air stream in **80**, from the remote control point in order to avoid any possibility of contamination of the nitrate by the oil to form the mixture of highest sensitivity.

With the proportionate quantity, or slightly less, of oil in **201**, a fixed blow of air through stream pipe **80** will pick up a fixed proportion of oil at venturi **76***c* (the proportion being determined by orifice size at the venturi or by a control valve in line **210**, as in FIG. 8) and blow that fixed proportion up through the nitrate in **78**; distributing the oil through the body of nitrate in the determined proportion until, as container **201** becomes exhausted, the level in the float bowl falls below the normal **118***d*. From then on, until the bowl is exhausted, the proportionate amount of oil picked up by the airstream becomes lower; with the result that, with the carrier air stream blowing the oil up through the body of nitrate until the air stream is shut off on final exhaustion of the oil, the composition mixture at the bottom of container **78** is leanest in oil and of high sensitivity. Shooting then, with the shooting cap **60***d* located at the bottom of the container insures certain detonation of the formed explosive composition. The system of FIG. 7 is applicable to any explosive composition that may be made up of a solid component (either a single compound or a mixture of several) and a liquid ingredient, which again may be a mixture. That is also true of the systems shown in all other figures.

On the other hand, the solid ingredient of any type in comminuted form may be carried into the shooting cavity on the airstream and mixed with the liquid ingredient of any type and the composition left in the cavity for shooting, by such apparatus as shown in FIG. 3. If, in that figure, the liquid is placed in container **20***b* to feed float bowl **118**, and the comminuted solid is charged into container **132**, then the proportion of the solid picked up by the carrier airstream is controlled by such a device shown at **130** and in FIGS. 4 and 5. The ratio of the liquid picked up by the airstream may be controlled by the size of the feed from **118** to venturi **76***b*, for instance by the usual control valve. And if then the determined proportionate amounts of solid and liquid have been placed in **132** and **20***b*, and if the feed from float bowl **118** to venturi **76***b* is below the normally maintained level, as in FIG. 7, the final part of the explosive composition delivered to the top of pile **150** in the shooting cavity will be relatively lean in its liquid component. With shooting cap **152** then located at the lean top of the pile **150**, detonation will again be certain with any explosive of the characteristics of the nitrate and oil.

FIG. 8, shows such a modification of FIG. 3 adapted particularly for such explosives as the nitrate and oil explosive. FIG. 8, showing the essential parts of FIG. 3 with the same numerals, shows liquid tank **201** feeding float bowl **118***c* where the normal level is maintained at **118***d*. Adjustment valve **72***d* sets the proportion of liquid picked up in venturi **76***d*; and shooting cap **152***a* is shown as the top of the delivered pile **150** of the explosive composition. The particular operation to produce a final composition lean in oil may be the same here as in FIG. 7; or the pressure controlled valve **72**, which opens the feed from **118***c* upon airflow through the venturi, may shut off the liquid feed to the venturi when the carrier airstream is terminated, operating as in FIGS. 1 and 3.

It is obvious that such systems as those of e.g., FIGS. 3, 7, and 8, are suitable for handling any solid and liquid explosive components.

The two procedures just above described show how one or the other of two components may be carried from the remote control point to the point of mixing and detonation. Further variations of method and apparatus will now be described wherein both or all ingredients either solids, or liquids, or solid and liquid, may be carried in on airstreams from the remote control point.

FIG. 9 shows schematically a typical suitable apparatus that is, in essentials, a duplication of certain parts of the apparatus of FIG. 3. Parts of this apparatus are the same as in FIG. 3 and are given the same numerals. As in FIG. 3, the compressed airstream from **34** drives the illustrative measuring device **130** of FIGS. 4 and 5, to which material is delivered from supply **132** and, in adjustably measured amounts, is picked up on the carrier air stream that then flows through pipe **80***b* from the remote control point to the mixing and detonation location.

A duplicate set of that apparatus at the remote control point, designated by the same numerals with the suffix *e*, similarly delivers material from its supply **132***e* in adjustably measured amounts on its carrier air stream to flow through pipe **80***e* to the mixing and detonation location. At that location the two materials are mixed on their carrier streams by any suitable device, for example, the injector type fixture shown at **250**. The carried and admixed materials are then deposited out of their carrier streams into an explosive composition mass such as the pile **150** in the shooting cavity **120**, ready to be dentonated by firing cap **152***a*.

The air pressure feeds to measuring devices **130** and **130***e* are through branches **34***d* and **34***e* controlled for instance by valves **82***b* and **82***e*. The two measuring devices may be drivingly intercoupled, as indicated by the coupling line **130***f*, to operate at the same rotational speed, or may be operated at different speeds under the control of valves **82***b* and **82***e*. In either case the amounts of the two materials proportionate to the volumetric flows of the two carrier air streams may be adjusted at the measuring devices **130** and **130***e*, and the volumetric carrier flows may be adjusted to any set ratios or be equal. The proportionate amounts of the two materials delivered to the mixer **250** may thus be controllably set, or varied during the mixing, to suit the desired proportions of the material components of the finally composed explosive composition delivered to the pile **150**.

The component materials in the two supplies **132** and **132***e* may be either both comminuted solids, both liquids,

or one solid and the other liquid. And either or both of the materials may be either composed of a single non-explosive compound such as the nitrate and oil previously mentioned, or the single composition ingredients of various other known explosives, or composed of a non-explosive mixture of two or more components for the final explosive.

A few examples among the many known explosives, that may be formed and delivered at the detonation place under the remote controls here set out, may be mentioned.

Nitroglycerin is typical of an explosive composition formed of two liquid ingredients. The various dynamites are typical of explosives formed of a soild and a liquid ingredient; as is also the nitrate-oil explosive above spoken of. Black powder (saltpeter and charcoal-sulphur mixture), sugar and potassium chlorate, are typical of explosives of two solid ingredients. Guanidine picrate is again typical of two component liquids—solutions of guanidine nitrate and ammonium picrate. And ammonium picrate is formed of two liquid components, picric acid in water and ammonia water.

It is noted that all the containers in which the explosive composition is deposited are destructible; the other containers and the devices located at the place of detonation, may either be destructible or may be removed before detonating.

In summary, the characteristic features common to all the procedures and systems herein described are as follows. Under control at a remote point, one or all of the non-explosive components of an explosive composition is or are carried to the removed place of final detonation on a gaseous stream or streams. At that removed detonation place (e.g. in a blasting cavity), the ingredients are admixed on the air stream, and the resulting composition is then deposited from the air stream (by depositing at least one of the components to form the composition) at that removed detonation place. And finally, the composition is detonated at that removed place of deposit.

I claim:

1. An apparatus for manufacturing an explosive at the detonation position by dispersing a liquid explosive throughout a solid absorbent comprising a destructible reaction chamber in a blast hole for reacting materials to form a liquid explosive, said liquid explosive being formed as a layer above liquid by-products of the reaction in which said liquid explosive is formed, means for introducing the reacting material into said chamber, conduit means opening into said chamber at an elevated position therein and sufficiently high to draw off substantially only said liquid explosive, an absorption vessel containing solid absorbent adjacent said chamber, said conduit means leading into said absorption vessel and means for drawing said liquid explosive from said reaction vessel to said absorption vessel.

2. An apparatus for manufacturing an explosive at the detonation position by dispersing a liquid explosive throughout a solid absorbent comprising a destructible reaction chamber in a blast hole for reacting materials to form a liquid explosive, said liquid explosive being formed as a layer above liquid by-products of the reaction in which said liquid explosive is formed, means for introducing the reacting materials into said chamber, first conduit means opening into said chamber at an elevated position therein and sufficiently high to draw off substantially only said liquid explosive, aspirator means comprising a second conduit having the diameter of one section thereof reduced, said first conduit means leading into the reduced diameter section of said second conduit, a source of gas at a position remote from said reaction chamber and connected to deliver gas to said second conduit, an absorbent vessel adjacent said chamber, said second conduit means leading into said absorbent vessel, and means for detonating the charge in said absorbent vessel, whereby the flow of gas from said source will create a reduced pressure in the reduced diameter section of said first conduit and draw the explosive liquid therethrough and said gas will blow said explosive liquid into said absorbent vessel and distribute it therethrough to form an explosive charge.

3. An apparatus for manufacturing an explosive as set forth in claim 2 including a valve in said first conduit and means for opening said valve in response to the flow of gas through said second conduit means.

4. An apparatus for manufacturing an explosive at the detonation position by dispersing a liquid explosive throughout a solid absorbent comprising a destructible reaction chamber in a blast hole for reacting materials to form liquid explosive, first conduit means connected to said reaction chamber for drawing said liquid explosive from said chamber, aspirator means comprising second conduit means having the diameter of one section thereof reduced at a position adjacent said reaction chamber, said first conduit means leading into the reduced diameter section of said second conduit means, means for introducing gas into said second conduit means at a position remote from said reaction chamber, and means for introducing absorbent material into said second conduit means, whereby the flow of gas through said second conduit means will create a reduced pressure in the reduced diameter section and thereby draw the explosive liquid from said vessel and said flow of gas will carry the absorbent through said conduit means and into intimate contact with the explosive liquid.

5. An apparatus for forming and detonating a liquid explosive at the detonation position comprising a container having two isolated compartments, first conduit means leading into one of said compartments and having the diameter of one section thereof reduced adjacent said container, second conduit means leading from the other of said compartments to the reduced diameter section of said first conduit means, means for introducing a gas into said first conduit means whereby the flow of gas through said first conduit means will produce a reduced pressure in the reduced diameter section thereof and thereby draw liquid from said other compartment and blow liquid into said one of said compartments, valve means in said second conduit and means for opening said valve in response to the flow of gas in said first conduit, and means for detonating explosive formed in said one of said compartments.

6. The method of manufacturing an explosive in a blast hole by dispersing a liquid explosive throughout a solid absorbent which comprises reacting liquids to form said liquid explosive and by-products in a destructible reaction chamber, withdrawing said liquid explosive from said chamber, dispersing solid absorbent in a gas, blowing said solid absorbent and said gas through an aspirator conduit having the diameter of one section thereof reduced, introducing said liquid explosive into said conduit at the reduced diameter section thereof to form a solid explosive and detonating said solid explosive.

7. The method of manufacturing an explosive at the detonation position by admixture of at least two non-explosive components, which, admixed, form an explosive, said method comprising the steps of blowing at least one said non-explosive component to the detonation position in suspension on a gaseous stream from a point remote from the detonation position and without admixture with another explosive forming component until reaching said detonation position, aspirating another said non-explosive component into the gaseous stream at the detonation position and thereby mixing said components to form the explosive at said position, depositing the formed explosive from the gaseous stream at the place of admixture, and detonating the formed explosive at said place.

8. The herein described method of forming and detonating an explosive composition under control at a remote point, said method including the steps of moving at least one non-explosive component of the explosive

composition from the remote control point in suspension on a confined gaseous carrier stream to the place of detonation, and without admixture with another explosive forming component until substantially reaching said detonation position, mixing such component in controlled proportions with another non-explosive component, said mixing occurring in suspension on said gaseous carrier stream substantially at said place of detonation to form the explosive substantially at the place of detonation, depositing the formed explosive from said gaseous carrier stream at said place of detonation, and detonating said deposited explosive at said place.

9. The method defined in claim 8 and in which said other non-explosive component is also moved from the remote control point to the place of mixing and detonation on another gaseous carrier stream and in which the mixing is accomplished by inter-mixing the two streams at said place.

10. The method defined in claim 9 and also including varying the controlled proportions of mixture of said non-explosive components at said place of detonation by controlling the relative amounts of said components on the gaseous carrier streams at the remote control point.

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