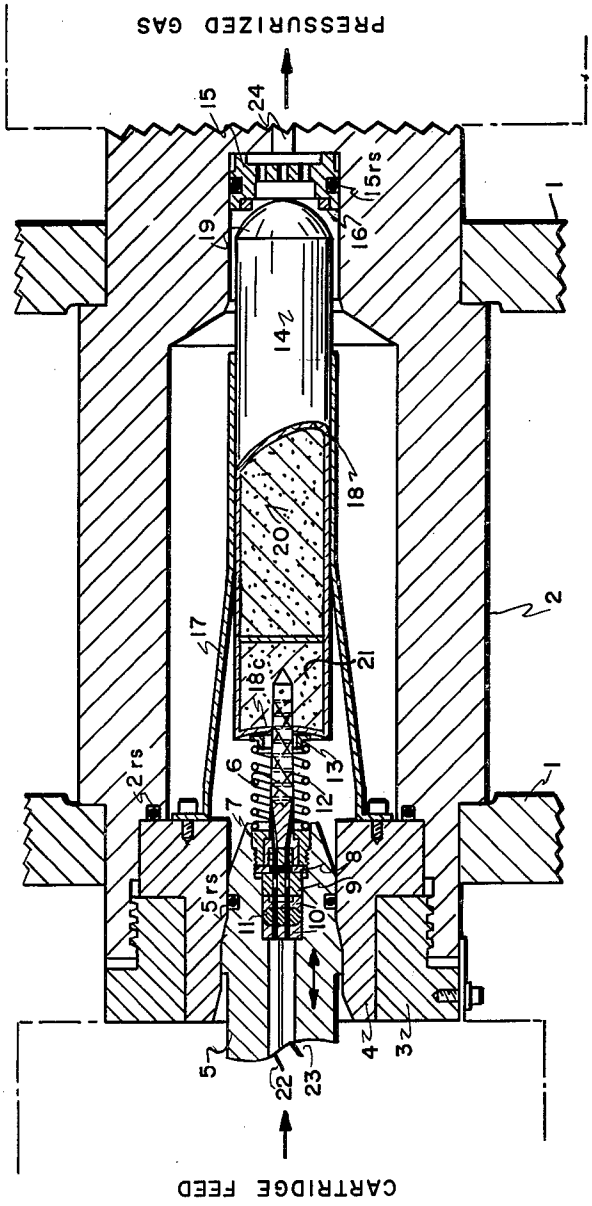
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GAS-GENERATING DEVICE

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EDWARD R. WEBER
INVENTOR.

BY Ernest G. Peterson

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GAS-GENERATING DEVICE

Edward R. Weber, Hueytown, Ala., assignor to Hercules Powder Company, Wilmington, Del., a corporation of Delaware

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This invention relates to a gas-generating device and more particularly to a gas-generating device and method of producing pressurized gas especially adapted to mining.

The need for better blasting action in the production of lump coal and other types of rocks where shattering is to be avoided has been the object of considerable research. This is particularly so in respect to coal-winning where still safer techniques are continually being sought. Heretofore the art has resorted to such well known means as blasting explosives of various types, the rapid heating of compressed or liquefied gases such as air or carbon dioxide, the confinement of gas-generating compositions in pressure-resistant tubes, all of which have disadvantages of one sort or another, but all of which have a common disadvantage in respect to premature or accidental initiation.

More recently, the confinement of solid gas-generating compositions in pressure-resistant tubes or the like such as drills has gained impetus due, primarily, to advances in the art which have demonstrated that devices of this category may be employed in a semiautomatic or automatic manner. Nevertheless, insofar as known, all these devices have the disadvantages which characterize electrically-fired, flame-producing or spark-producing initiating means, since all such means are confined within the pressure-resistant tube at all times after the initial loading. More objectionable, the initiating means is usually confined in the main cartridge or a primer cartridge for use in conjunction with the main cartridge which in either event is quite undesirable from the viewpoint of storage and safety prior to initial loading and firing.

For the mining of coal, or other types of mining where the possible ignition of dust or gas presents a hazard, the art has resorted to electric resistance heaters as a safety measure. However, these resistance heaters are confined either in the main gas-generating charge or in a primer charge to be utilized in conjunction with the main charge which is undesirable. Such arrangements are not conveniently adaptable for semiautomatic or automatic operation and, moreover, are lacking in respect to economy since the resistance heater is difficult to properly package and it is consumed with each shot.

It is, therefore, a primary object of the present invention to provide a gas-generating device and method of producing pressurized gas of improved safety especially adapted for mining and particularly coal mining. A further object is to provide such a device and method giving improved economy, improved ease of utility particularly in conjunction with semiautomatic and automatic operation, and positive and safe ignition control. Other objects of the invention will appear hereinafter, the novel features and combinations being set forth in the appended claims.

Generally described, the objects of the present invention are accomplished by heating a gas-generating composition in a combustion chamber having a rupturable closure at one end of the chamber by force-insertion of a re-utilizable initiating heat element into the composition from the other end of said chamber. It has been found that this may be conveniently accomplished in a gas-generating device especially adapted for a pressure-resistant combustion chamber which has a re-utilizable heating means at one end and a discharge orifice at the other end of the chamber and a cartridge disposed therein

containing a gas-generating composition and having a rupturable closure at one end thereof to seal the discharge orifice and having a penetrable nonconductive closure at the other end thereof to receive the heating means, by forcing said heating means through the penetrable nonconductive closure and into the cartridge to ignite the gas-generating composition.

A preferred embodiment of the inveniton has been chosen for purposes of illustration and description and is shown in the accompanying drawing wherein reference symbols refer to like parts wherever they occur.

In the drawing, which is a part sectional, part elevational view of apparatus illustrating application of the invention, support members 1, forming a part of an automatic blasting apparatus, for example, are rigidly secured to a cylindrical combustion chamber 2 having an aft or feed end for ingress of thermally decomposable cartridges containing a gas-generating composition and a forward end of reduced diameter for the egress of pressurized gas. Threadedly secured to the combustion chamber 2 is a retainer ring 3 which in turn compressively secures a head insert ring 4 between the ring 3 and the chamber 2 with an O ring-seal 2*rs* providing a gas-seal therebetween. A reciprocating firing head 5 slides into the head insert ring 4 and is gas-sealed by an O ring-seal 5*rs*. The firing head 5 is provided with a rigid electrical igniter 6 which is secured to the firing head by a retainer nut 7 which is threaded into the firing head. A compression assembly is then provided by insulated washer 8, socket connector 9, and spacers 10 each side of plastic seal 11. This compression assembly is quite important since it prevents any "blow-back" of high pressure gas through the ignition system since the retainer nut 7 is utilized to impart considerable precompression on the assembly to insure that the plastic seal is sufficiently tight about the lead wires and is firmly seated to withstand the pressures generated in the combustion chamber. A compression spring 12 has one end secured to the retainer nut 7 and its other end provided with a thrust washer 13. The spring in its fully extended position extends to approximately the point of the igniter 6.

In operation of the device, it will be understood, of course, that the reciprocable firing head 5 and the assembly affixed thereto retract into an automatic feed chamber (not shown) whereupon the point of the igniter 6 and the thrust washer 13 engage a cartridge 14 and push it forward to engage a thrust seat 15, which in turn supports a shear ring 16. The thrust seat 15 is gas-sealed to the combustion chamber 2 by an O ring-seal 15*rs*. A cartridge guide 17 affixed to the head insert ring 4 insures that the cartridge is guided to properly engage the shear ring 16. The cartridge 14 comprises a paper shell 18, a heat-resistant rupturable closure element 19 affixed to its forward end, a main gas-generating charge 20, a primer charge 21, and a penetrable fluted end crimp 18*c* for closing its aft or ignition end. When the cartridge 14 is operatively positioned in the combustion chamber 2, the rigid electrical igniter 6 has been forced through the penetrable fluted and crimp 18*c* into the cartridge and has penetrated the cartridge to a depth of about 1¼ inches. The firing head 5 is then locked by suitable means (not shown) and the device is ready for firing. Electric firing current is then delivered via lead wires 22 and 23 to the rigid electrical igniter 6 which ignites the ignition or priming charge 21 which in turn ignites the main gas-generating charge 20. This results in a self-sustained decomposition of the cartridge including its shell and when the resulting high pressure gases reach a predetermined pressure, the rupturable closure element 19 ruptures and disintegrates with sudden release of the gases from the combustion chamber 2 via a discharge orifice 24 to perform useful work, particularly in conjunction with blast-

ing apparatus such as that disclosed in copending application of Robert W. Lawrence and Robert J. Shiel, Serial No. 783,867, filed December 30, 1958, now U.S. Patent Number 3,055,648.

The rigid electrical igniter 6 which is shown represents one type of heating means and has a tapered body member made from an asbestos phenolic molded rod. Eight transverse apertures were provided through the body member and a round pointed steel tip was affixed to the top thereof. Two longitudinal apertures were divergently drilled from the base of the body member and emerged from the body member within the lower half thereof. A resistance element was then wound about the body member and through alternate of the transverse apertures, having each end thereof passing through the longitudinal apertures and connected to socket connector 9 which in turn provided connection to lead wires 22 and 23. The resistance element was No. 22 (.0254"ϕ) Nichrome wire, the projected base portion of the igniter 6 was compatible with and rigidly held by the retainer nut 7, and the lead wires were connected to a suitable source of electrical energy (not shown).

An example of operation of the invention is given for firing a gas-generating device in accordance with the invention wherein the device is especially adapted and safe for coal mining as will be evident by the following. A primer charge essentially consisting of 42 grams of colloided smokeless powder composition was packed into a flame-retardant paper container. The charge was ignited with a non-flaming initiator and did not flame in the atmosphere and would not ignite an exposive mixture of methane and air. The composition was as follows:

Nitroglycerin	15%.
Nitrocellulose	20%.
Nitroguanidine	51%.
Cellulose acetate	7%.
Ethyl centralite	7%.
Calculated flame temp	2330° K.
Particle size	0.053" diameter x 0.9" long.

The above composition also would not ignite or detonate when subjected to impact from 30.06 or 0.22 caliber hollowpoint bullets, or #8 electric blasting caps, or 100-pound weight dropped from a height of 10 feet on a steel plate, or standard friction pendulum tests with steel shoe and anvil. Compositions of this type were then charged into cartridges in accordance with the invention as the primer charge in conjunction with a main charge of the following composition:

	Percent
Ammonium nitrate	49.0
Magnesium nitrate hexahydrate	34.0
Wood flour	17.0
	100.0

Main charge weight ---------- 360 grams

These cartridges were initiated as hereinbefore described in a combustion chamber having a volume of 162 cubic inches resulting in an average time of 4 seconds to rupture the rupturable closure after application of current was applied to the igniter. The current applied averaged 13.5 amperes at 24 volts for approximately 1½ seconds. The average gas pressure generated was from about 8,000 to about 16,000 pounds per square inch which demonstrated that the present invention was suitable for use in conjunction with pressure-resistant tubes or pressure-resistant drills or other cutting devices for the blasting of coal. Utilization of the invention in actual mine tests verified the suitability demonstrated by the above example.

From the foregoing, it is evident that there are several factors which will influence the choice of materials for

the most satisfactory operation of the invention. For example, the shell may be of any suitable material such as paper, plastic sheeting, cardboard or the like and should be nonflammable or be made nonflammable by appropriate coating or other treatment. However, the shell should be thermally decomposable and substantially completely consumed during decomposition of the main charge wherein the decomposition of the shell is essentially a combustion supported by oxygen from the main charge. The penetrable, nonconductive closure for the shell may be the conventional fluted crimp or the shotgun type crimp, or the like, and should be reasonably soft to accommodate penetration of the igniter. The fluted crimp is preferred since it is normally formed with a small central opening permitting easy ingress of the igniter into the cartridge. The cartridge should, of course, be moisture-resistant using suitable shell materials, coatings, or seals where necessary, inasmuch as ammonium nitrate which is the principal constituent of the main charge is hygroscopic. The rupturable closure for the cartridge may be made of any heat-resistant, frangible material of desired strength consistent with the release of the pressurized gas at a pressure adequate for performing predetermined useful work such as the breaking of coal or other hard material. The shape of the rupturable end closure or shear disc may be varied considerably, the important thing being that it serve to form a gas-tight seal for the combustion chamber during generation of gas and thereafter rupture at a desired pressure. A partial hemispherical shape is preferred as shown in the drawing since it readily disintegrates into small particles and is easily fabricated and affixed to the cartridge as by force-fitting, adhesive-sealing and the like. The preferred materials of construction for the rupturable closure are materials such as fiber or plastic which are nonsparking as the disintegrated particles of the closure strike the vent openings of a blasting tube, blasting drill or other metallic implement utilized for the high pressure work.

It will be appreciated from the foregoing that the igniter or heating means is reciprocable and re-utilizable and should be sufficiently rigid to pierce the penetrable closure and to penetrate the primer charge or the main charge, as the case may be, within the cartridge. Although a suitable type of igniter and its construction have been desribed, other forms of such heating means may be employed providing they are capable of force-insertion of the heating element into the cartridge and they are safe and reliable.

The primer charges which may be used preferably contain a major proportion of smokeless powder. As a permissible, such primers, of course, should be non-flaming in the atmosphere and incapable of igniting an explosive mixture of methane and air. Primer charges which have been found quite satisfactory for meeting the rigorous requirements of coal mining comprise from about 10 to about 20% of nitroglycerin, from about 15 to about 25% of nitrocellulose, from about 50 to about 55% of nitroguanidine or guanidine nitrate, from about 5 to about 10% of cellulose acetate and from about 5 to about 10% ethyl centralite or other stabilizer, by weight, and conventionally colloided, extruded and cut to have a particle size of from about 0.03 to about 0.10 inch diameter and from about 0.01 to about 0.10 inch long. Moderants such as cryolite, potassium sulfate, barium nitrate, potassium nitrate, and the like may be added in small amount, not over about 1%, to the extent that they do not alter the principal characteristics of the primer composition which are: nonflammable in the atmosphere; will not ignite explosive mixtures of methane and air; insensitive to standard sensitivity tests, such as rifle bullets, friction, blasting caps; and consistently and reliably cause main gas-generating charges to react under pressure. The quantity of primer charge utilized may be varied depending on the amount of the main charge, with from about 30 to about 70 grams usually found suitable for use in

conjunction with main charges used for blasting and similar operations. The primer charge may be conveniently packaged in a decomposable plastic bag or the like prior to placing into the cartridge or the primer and main charges may be placed in direct contact with each other. The calculated flame temperature for the primer composition insofar as permissibility is concerned may be varied from about 1500° to about 2500° K. It will be understood, of course, that in instances where permissibility is not a factor, other primers may be used for carrying the invention into effect and in instances where the main charge is made sufficiently heat-sensitive and prolonged ignition time tolerated, the primer charge may be dispensed with entirely.

Compositions suitable for use as the main charge comprise ammonium nitrate alone, desirably of relatively coarse granulation, or ammonium nitrate, as the principal gas-generating constituent, that is, over 40% present, with other material such as the following typical compositions: ammonium nitrate 49.0%, magnesium nitrate hexahydrate 34.0%, carbonaceous (nut meal, pulp, starch) 17.0%; ammonium nitrate 75.0%, calcium carbonate 25.0%; ammonium nitrate 90.0%, starch 10.0%; and ammonium nitrate 65.0%, calcium formate 34.9%, calcium stearate 0.1%.

From the foregoing, it will be seen that the gas-generating device and the method in accordance with this invention provide advantages heretofore not realized by the art in respect to a high degree of safety, ease of operation particularly in respect to semiautomatic and automatic operation, and economy. Furthermore, although the present invention has been described more particularly in respect to a combustion chamber suitable for utilization with automatic blasting apparatus, it may, of course, be utilized for other applications such as in conjunction with pressure-resistant blasting tubes, bolt-driving devices, catapult devices and the like where repeated firing is desired for obtaining a source of very high pressure gas.

Still further, it will be seen that this invention may be carried out by the use of various modifications and changes without departing from its spirit and scope, with only such limitations placed thereon as imposed by the appended claims.

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

1. A gas-generating device comprising in combination:

(*a*) a cylindrical pressure-resistant combustion chamber,

(*b*) a slidable and reciprocable firing head at one end of the combustion chamber, said firing head having a reutilizable resistance heating element affixed thereto,

(*c*) a discharge orifice at the other end of the combustion chamber, the firing head, the heating element, the discharge orifice and the combustion chamber being in coaxial alignment,

(*d*) a cylindrical cartridge having a thermally decomposable shell supported within the combustion chamber and radially spaced therefrom in coaxial alignment with the firing head and the discharge orifice, said cartridge having a rupturable closure at one end thereof adapted to engage and seal the discharge orifice and having a penetrable nonconductive closure at the other end thereof adapted to engage and receive the heating element,

(*e*) a primer charge of nondetonating heat-producing composition disposed in the cartridge adjacent the nonconductive closure adapted to receive and be initiated by the heating element, and

(*f*) a main charge of nondetonating gas-generating composition disposed in the remainder of the cartridge adapted to be initiated by the primer charge, whereby upon initiation a self-sustained gas-generating reaction to a predetermined gas pressure is effected and the gas pressure ruptures the rupturable closure to permit the escape of high pressure gas through the discharge orifice.

2. A gas-generating device as defined in claim 1 wherein the primer charge consists essentially of colloided smokeless powder having a particle size of from about 0.03 to about 0.10 inch diameter and from about 0.01 to 0.10 inch long of the following composition by weight percent:

Nitroglycerin	10–20
Nitrocellulose	15–25
Nitroguanidine	50–55
Cellulose acetate	5–10
Ethyl centralite	5–10

3. A gas-generating device as defined in claim 1 wherein the main charge consists essentially of at least 40% by weight of ammonium nitrate.

4. A gas-generating device as defined in claim 1 wherein the primer charge consists essentially of colloided smokeless powder having a particle size of from about 0.03 to about 0.10 inch diameter and from about 0.01 to 0.10 inch long of the following composition of weight percent:

Nitroglycerin	10–20
Nitrocellulose	15–25
Nitroguanidine	50–55
Cellulose acetate	5–10
Ethyl centralite	5–10

and wherein the main charge consists essentially of at least 40% by weight of ammonium nitrate.

5. A gas-generating device as defined in claim 1 wherein the primer charge consists essentially of colloided smokeless powder having a particle size of from about 0.03 to about 0.10 inch diameter and from about 0.01 to 0.10 inch long of the following composition by weight percent:

Nitroglycerin	10–20
Nitrocellulose	15–25
Guanidine nitrate	50–55
Cellulose acetate	5–10
Ethyl centralite	5–10

6. A gas-generating device as defined in claim 1 wherein the primer charge consists essentially of colloided smokeless powder having a particle size of from about 0.03 to about 0.10 inch diameter and from about 0.01 to 0.10 inch long of the following composition by weight percent:

Nitroglycerin	10–20
Nitrocellulose	15–25
Guanidine nitrate	50–55
Cellulose acetate	5–10
Ethyl centralite	5–10

and wherein the main charge consists essentially of at least 40% by weight of ammonium nitrate.

References Cited in the file of this patent

UNITED STATES PATENTS

389,448	Day	Sept. 11, 1888
2,007,223	Spaeth	July 9, 1935
2,704,978	Loving	Mar. 29, 1955
2,736,261	Davis	Feb. 28, 1956
2,789,043	Maxwell et al.	Apr. 16, 1957
2,868,058	Dom	Jan. 13, 1959
2,916,993	Smith et al.	Dec. 15, 1959
2,955,535	Show et al.	Oct. 11, 1960

FOREIGN PATENTS

386,311	Great Britain	Jan. 13, 1933
519,341	Great Britain	Mar. 21, 1940
654,958	Great Britain	July 4, 1951