Nov. 12, 1963 J. W. OTT 3,110,845

ELECTRICAL IGNITER

Filed June 7, 1960 2 Sheets-Sheet 1

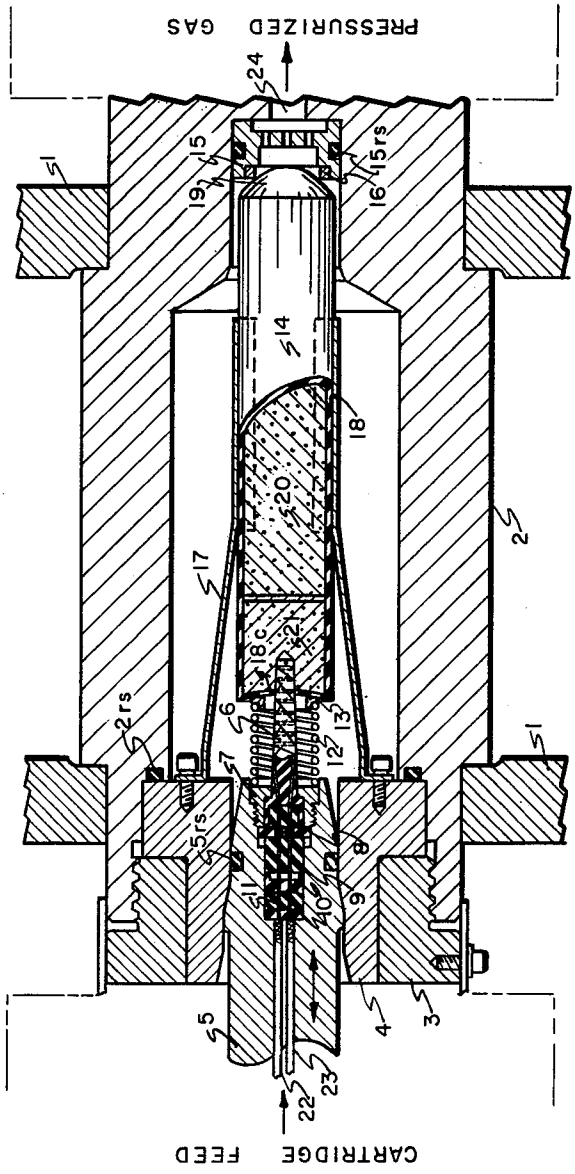


FIG. 1

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FIG. 11

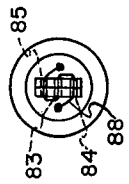


FIG. 10

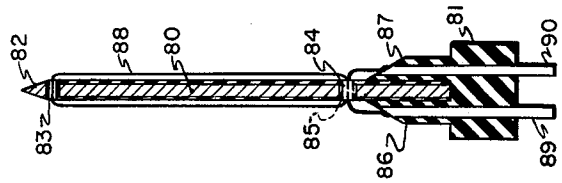


FIG. 9



FIG. 8

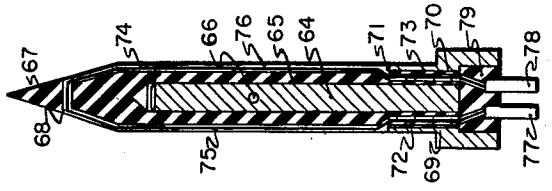


FIG. 7

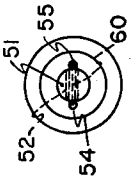


FIG. 6

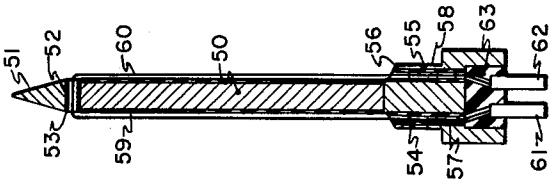


FIG. 5

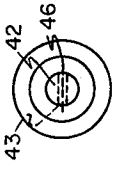


FIG. 4

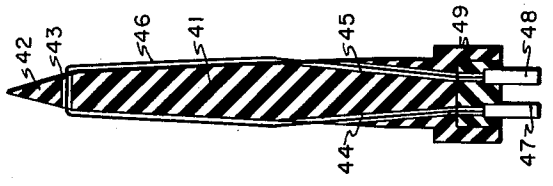


FIG. 3

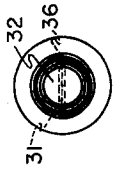
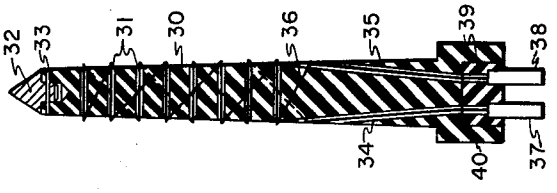


FIG. 2



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ELECTRICAL IGNITER

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Filed June 7, 1960, Ser. No. 34,418
4 Claims. (Cl. 317—80)

This invention relates to devices for igniting thermally decomposable gas-generating charges. More specifically, it is related to electrical igniters for igniting gas-generating charges in which the igniter is repeatedly utilized.

The various types of electrical igniters heretofore utilized in the explosives art have been of the perishable type. That is, for the most part, they have been "one-shot" devices which are usually destroyed or consumed with the explosive that they were employed to initiate. However, with the advent of blasting methods which employ re-utilizable apparatus such as pressure-resistant tubes and pressure-resistant drills in conjunction with thermally decomposable gas-generating charges, the requirements of electrical igniters take on an entirely different aspect. Such electrical igniters must then be re-utilizable, capable of repeatedly resisting extremely high pressures and temperatures, and must possess outstanding characteristics in respect to safety, reliability and longevity.

A primary object of the present invention is to provide devices meeting the aforesaid requirements. Other objects of the invention will appear hereinafter, the novel features and combinations being set forth in the appended claims.

Generally described, the present invention comprises an electrical igniter for a gas-producing cartridge especially adapted for penetration of the cartridge and repeated utilization having in combination a rigid longitudinal body member having a pointed end, at least one aperture extending through the body member adjacent the pointed end, a pair of electrical terminals opposite the pointed end of the body member, and an electrical resistance element extending through said aperture having a substantial portion of its length supported by and disposed exteriorly of the body member and connected to the terminals.

Representative embodiments of the invention have been chosen for purposes of illustration and description and are shown in the accompanying drawings wherein reference symbols refer to like parts wherever they occur.

FIG. 1 is a part sectional, part elevational view of apparatus utilizing igniter means according to the invention; and

FIGS. 2 and 3, 4 and 5, 6 and 7, 8 and 9, 10 and 11 are views in section and in plan, respectively, showing representative embodiments of igniter means constructed in accordance with the invention.

In FIG. 1, support members 1, forming a part of an automatic blasting apparatus, are rigidly secured to a cylindrical combustion chamber 2 having an aft or feed end for ingress of thermally decomposable cartridges containing gas-producing 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 an 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 Teflon seal 11. This compression assembly with the seal 11 interposed between

the spacers or rigid compression elements 10 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 Teflon seal is sufficiently tight about the lead wires and is firmly seated to withstand the pressures generated in the combustion chamber. Although Teflon, which is a polytetrafluorcethylene resin, is preferred as the seal material, other resins and compressible sealing materials which are suitable for high temperature and high pressure service may be used. 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 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-producing 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 end 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 man gas-producing 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 blasting apparatus such as that disclosed in copending application of Robert W. Lawrence and Robert J. Shiel, Serial No. 783,867, filed December 30, 1958.

Referring now to FIGS. 2 to 11, inclusive, various types of electrical igniters within the purview of the invention are illustrated, and it will be noted that FIGS. 2 and 3 depict in detail the electrical igniter 6 which is shown in FIG. 1. This igniter represents a preferred embodiment of the invention and has a tapered body member 30 made from an asbestos phenolic molded rod. Eight transverse apertures represented by 31 were provided through the body 30 and a round pointed steel tip 32 was affixed to the top thereof and secured by a pin 33. Two longitudinal apertures 34 and 35 were divergently drilled from the base of the body member and emerged from the body member within the lower half thereof. A resistance element 36 was then wound about the body member and through alternate of the transverse apertures, having each end thereof passing through apertures 34 and 35 and connected to terminals 37 and 38 of base plug 39. The resistance element was No. 22 (.0254" ϕ) Nichrome wire, the projected base portion 40 was compatible with the retainer nut 7, and the terminals 37 and 38 were compatible with socket connector 9. All igniters hereinafter described are, likewise, uniform

in respect to length, base portion, and terminal connections and, accordingly, can be used interchangeably.

Another embodiment of the invention is depicted with reference to FIGS. 4 and 5 wherein a tapered body member 41 made from asbestos phenolic molded rod was terminated at its top by a round pointed tip 42. A transverse aperture 43 was provided through the body member 41 adjacent its pointed end 42. Two longitudinal apertures 44 and 45 were divergently drilled from the base of the body member and emerged from the body member within the lower half thereof. A resistance element 46 was then threaded through the aperture 43 downwardly, having each end thereof passing through apertures 44 and 45 and connected to terminals 47 and 48, respectively, of base plug 49. The resistance element was No. 23 (.0226" ϕ) Nichrome wire.

Still another embodiment of the invention is depicted with reference to FIGS. 6 and 7 wherein a body member 50 made of steel was provided with a round pointed end 51. A transverse aperture 52 was provided through the body member 50 adjacent its pointed end 51 and was lined with a fiber glass sleeve 53. Two vertical apertures 54 and 55 were drilled from the base of the body member and emerged at an offset portion 56 near the base. The apertures 54 and 55 were lined with ceramic insulation beads 57 and 58, respectively. A heat-resistant electrical insulation tape 59 was wrapped about the steel body member 50 from the insulation beads to the fiber glass sleeve. A resistance element 60 was then threaded through the fiber glass insulation sleeve 53 downwardly over the insulation 59, having each end thereof passing through the insulation beads 57 and 58 and connected to terminals 61 and 62, respectively, of base plug 63. The resistance element 60 was No. 23 Nichrome wire.

Still another embodiment of the invention is depicted with reference to FIGS. 8 and 9 wherein a steel support member 64, also forming the base of the device, has an asbestos phenolic molded sleeve 65 fitted over the support member 64 and secured thereto by a pin 66 to form the body member. The sleeve 65 was provided with a round pointed end 67. A transverse aperture 68 was provided through the sleeve 65 adjacent its pointed end 67. Two vertical apertures 69 and 70 were drilled from the base of support member 64 and emerged at an offset portion 71 near the base thereof. The apertures 69 and 70 were lined with ceramic insulation beads 72 and 73, respectively, and the bottom end of the sleeve 65 was tapered inwardly to communicate with the apertures of the insulation beads. A resistance element 74 was then threaded through the aperture 68 downwardly through grooves 75 and 76 formed in the sleeve 65, having each end of the resistance element passing through the insulation beads 72 and 73 and connected to terminals 77 and 78, respectively, of base plug 79. The resistance element 74 was No. 23 Nichrome wire.

Still another embodiment of the invention is depicted with reference to FIGS. 10 and 11 wherein a steel body member 80 is coated with porcelain and is rigidly secured in a base member 81 of asbestos phenolic molded material. The porcelainized member 80 was provided with a chisel-like pointed end 82. A transverse aperture 83 was provided through the body member 80 adjacent its pointed end and two horizontally spaced apart apertures 84 and 85 were provided near the base thereof. The interior of these apertures was insulated by the porcelainization of the body member 80. Two vertical apertures 86 and 87 were drilled through the base member 81 and emerged near the apertures 84 and 85. A resistance element 88 was then threaded through the aperture 83 downwardly with one end thereof threaded through aperture 84 and connected to a terminal 89, and the other end thereof passed downwardly and threaded through aperture 85 and connected to a terminal 90. The terminals 89 and 90 were rigidly secured in apertures 86 and 87, respectively, and the resistance element was No. 23 Nichrome wire.

With reference to the several embodiments of electrical igniters heretofore described, it will be appreciated that the devices are capable of penetrating hard cartridge casings with hard interior substances as well as soft cartridge casings with soft interior substances or any combination thereof. It will be further appreciated that the igniters of this invention afford positive ignition when utilized with hard or firmly packed explosive charges since their design prevents the formation of any "hollow" about the resistance element as well as providing full support to the resistance element to prevent its breakage. Still further, although the invention has been described in conjunction with automatic operation wherein the reciprocating firing head pushes the cartridge into the combustion chamber and is suitably locked without rotative movement, the devices shown in FIGS. 2, 3 and 8, 9 are particularly adapted for rotative movement wherein it is desired to use a rotative breech-lock or the like.

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

Nitroglycerin	percent	15
Nitrocellulose	do	20
Nitroguanidine	do	51
Cellulose acetate	do	7
Ethyl centralite	do	7
Calculated flame temp	° K	2330

Particle size 0.053" diameter x 0.09" 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 as the primer charge in conjunction with a main charge of the following composition:

Ammonium nitrate	percent	49.0
Magnesium nitrate hexahydrate	do	34.0
Wood flour	do	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 igniter of 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 to be used in combination for the most satisfactory operation for the igniters of this 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, non-conductive 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 moistureproof 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 serves 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 of the invention is reciprocable and reutilizable 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.

The primer charges which may be used preferably contain a major proportion of smokeless powder. As a permissible, such primers, of course, should be nonflaming 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 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 in conjunction with the igniters of this invention 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, desirable 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%

Although the present invention has been described more particularly in respect to molded asbestos phenolic compositions as the principal insulating material for the body member of the igniter, other nonconductor or insulator materials may be utilized such as porcelain, asbestos, glass, and the like. Furthermore, although Nichrome wire has been disclosed as a preferred material for the resistance element, other materials such as Chromel C, Ohmax and the like may be used. Nichrome is a nickel-chromium-iron alloy containing 60% nickel, 24% iron, 16% chrominum and 0.1% carbon; Chromel C is a nickel-chromium-iron alloy containing 60% nickel, 16% chromium, and the balance mainly iron; and Ohmax is a chromium-iron-aluminum alloy containing 20% chromium, 8.5% aluminum, and the balance mainly iron.

From the foregoing, it will be seen that the igniters 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 semi-automatic 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. An electrical igniter which is designed to penetrate one end of a gas-producing cartridge having a soft nonconductive container and to ignite the cartridge for the production of high pressure gas in a combustion chamber, said igniter comprising in combination:

(*a*) a rigid longitudinal nonconductive body member having a pointed end at one end thereof to form means for ease of penetration into the aforesaid cartridge and having an enlarged cylindrical portion at the other end thereof containing a pair of electrical terminals sealed therein to withstand the aforesaid high pressure gas;

(*b*) a plurality of transverse apertures extending through the body member adjacent the pointed end thereof, and

(*c*) a continuous electrical resistance element alternately passing through said transverse apertures, said element having a substantial portion of its length supported by and disposed exteriorly of the body member in complete nonconductive relationship with the body member and said element having each of its ends connected to each of the pair of electrical terminals whereby the aforesaid cartridge is ignited when a substantial portion of the continuous electrical resistance element has penetrated thereinto.

2. The electrical igniter as defined in claim 1 having a round pointed end of metal.

3. The electrical igniter as defined in claim 1 including sealing means adjacent said electrical terminals to prevent the escape of high pressure gas thereabout.

4. The electrical igniter as defined in claim 1 including precompressed sealing means adjacent said electrical terminals to prevent the escape of high pressure gas thereabout.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,110,845 November 12, 1963

John W. Ott

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 39, for "man" read -- main --; column 6, lines 59 and 60, strike out "member adjacent the pointed end thereof, and" and insert instead -- member, and --; lines 61 and 62, for "afternately" read -- alternately --.

Signed and sealed this 28th day of April 1964.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents