June 15, 1937. A. HARRIS 2,083,706

BLASTING APPARATUS

Filed July 17, 1933 2 Sheets-Sheet 1

Fig. 1

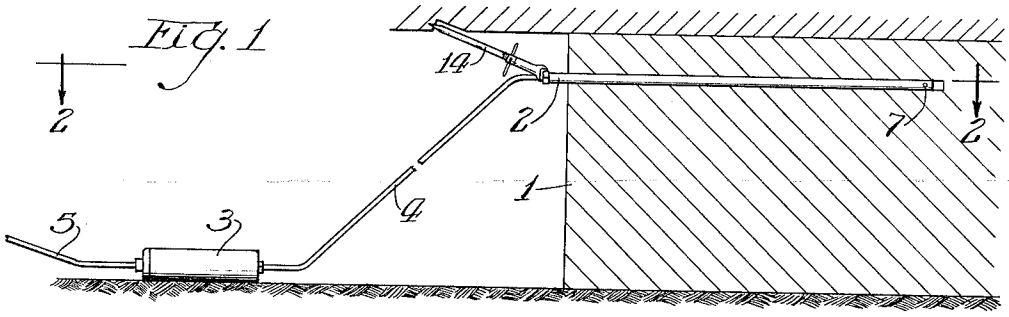



Fig. 2

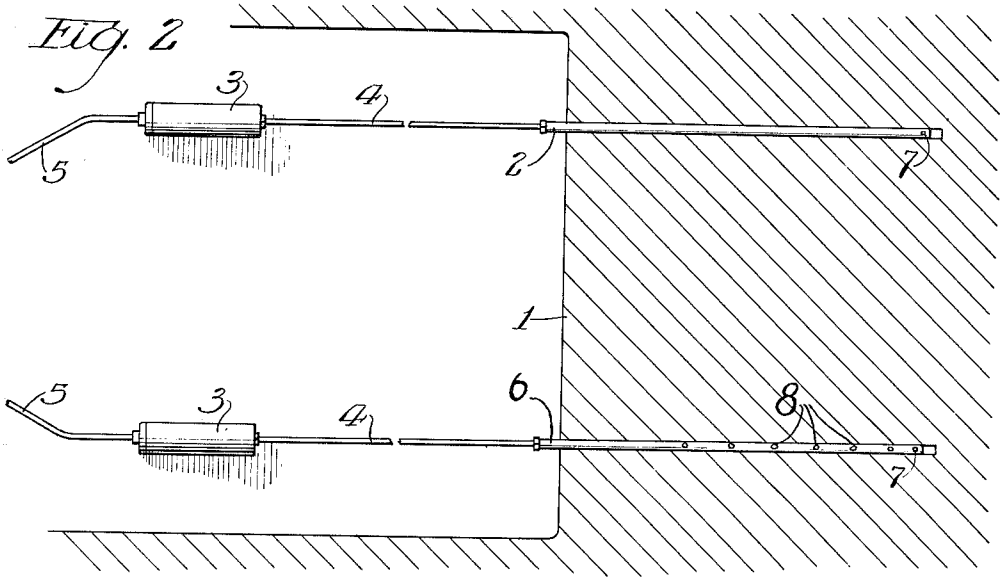
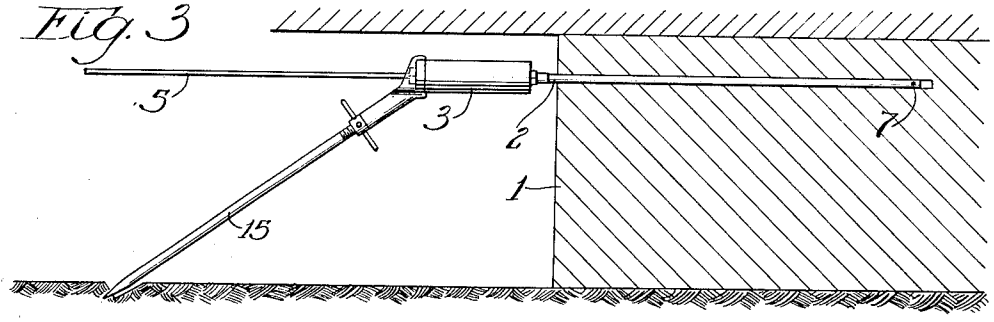



Fig. 3




Inventor
Allyn Harris
By Atty.

June 15, 1937. A. HARRIS 2,083,706

BLASTING APPARATUS

Filed July 17, 1933 2 Sheets-Sheet 2

Fig. 5

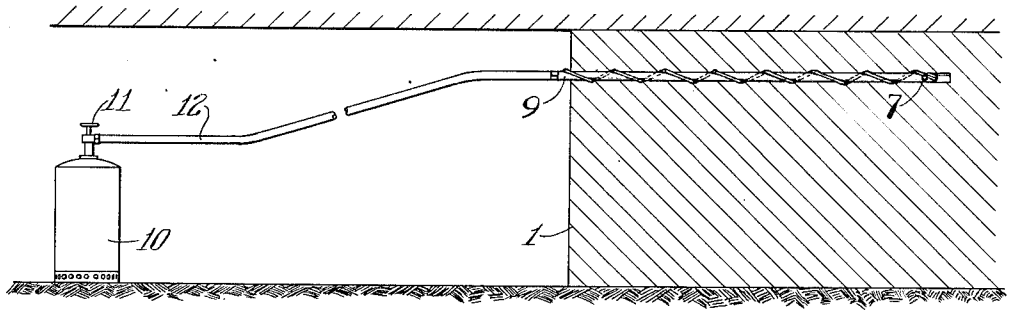
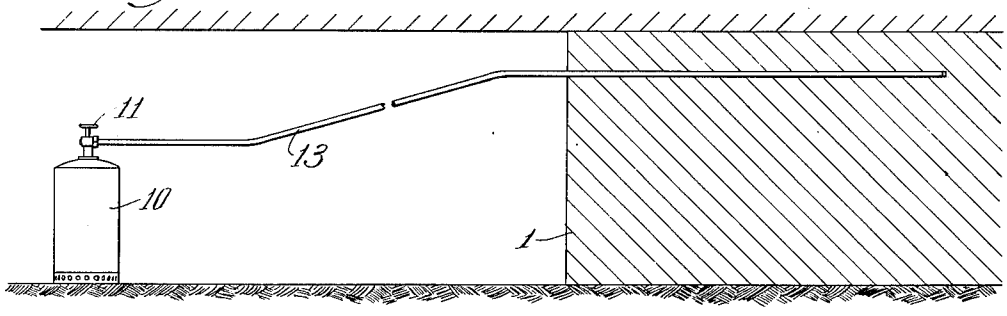



Fig. 6



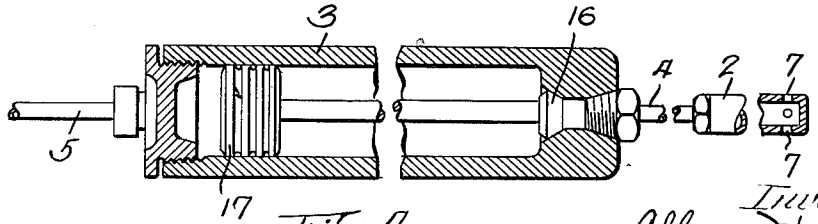




Fig. 4.

Inventor
Allyn Harris
By
Atty.

Patented June 15, 1937 2,083,706

# UNITED STATES PATENT OFFICE

2,083,706

## BLASTING APPARATUS

Allyn Harris, Wheaton, Ill., assignor to Safety Mining Company, a corporation of Illinois

Application July 17, 1933, Serial No. 680,757

5 Claims. (Cl. 102—5)

The present invention is concerned with a new method and apparatus designed particularly for the blasting or breaking down of coal in connection with coal mining but applicable to a wide range of other uses and involves, in addition to a new method for the application of energy or potential energy to the work, a form of energy or potential energy which has not in itself been applied successfully heretofore to this general class of work. The form of energy contemplated for use in connection with the present invention is high pressure air, or other suitable gases compressed to relatively high pressures.

Since the development and application of ordinary explosives to the work of breaking down coal the conventional practice has been to drill a number of holes in the coal to be broken and to place in these holes charges of explosives having potential energy appropriate to the work to be performed. In order to minimize the hazards incident to the use of ordinary explosives in the shooting of coal and to promote efficiency, the practice has developed of dividing the total amount of work to be done and of providing a number of individual explosive charges in a corresponding number of drill holes. This practice not only minimizes the dangers involved but also minimizes the undesirable destructive shattering effect of the explosives on the coal. In other words if the total amount of energy required to bring down a given face of coal were provided in a single charge of explosives placed in a single drill hole there would result an extremely dangerous condition and also the tremendous force concentrated at one point would result in destruction of an excessive amount of the coal, as well as undue shattering of the overlying strata of rock.

In order to further decrease the amount of work to be done by the explosive and to thereby further minimize both the danger involved and the destructive effect of the explosives upon the coal the practice of undercutting has been quite generally adopted. In accordance with this practice a relatively wide kerf is cut at the bottom or top of the face to be broken down thereby considerably reducing the effort required in the breaking operation. Undercutting, of course, is a costly operation but has nevertheless rather generally been found to be economical as compared with costs and results of using the amount of explosives required in the absence of undercutting. Also, owing to the extreme hazards involved, the blasting of coal with explosives without undercutting has been prohibited by law in a number of States.

Numerous blasting devices have been suggested as substitutes for explosives and one device in particular has attained a fairly widespread use by reason of its inherent safety and its mild action upon the coal as compared with the action of explosives. This device consists of a steel cartridge having a discharge orifice which is normally closed by a rupturable steel disc and in which a charge is placed consisting of a quantity of compressed or liquefied carbon dioxide and a chemical heater unit designed to be energized by electricity. The energization of this cartridge results in a rapid expansion of the liquid carbon dioxide with a consequent increase in pressure up to a point at which the rupturable disc is calculated to fail. The high pressure carbon dioxide is then discharged directly into the coal and brings about the breaking down of the coal by an expansive action which affords a very desirable minimum of destructive effect upon the coal. In the use of this blasting device, however, it is necessary to provide a separate drill hole for each cartridge and to provide an appropriate number of drill holes and cartridges for the particular amount of work to be performed, the same as is true of explosives. Each such cartridge represents a definite cost, as is true with explosives, and, of course, the total cost of breaking down the face of the coal increases according to the number of shots required to be performed in the work. Under these circumstances it will be readily appreciated that this blasting device is subject in many respects to the same limitations as govern the use of ordinary explosives and particularly as regards the economic balance between the number of shots required to bring down an undercut face and the number of shots required to bring down a face which has not been undercut. It should be understood, of course, that in addition to the definite and fixed cost of each unit of potential energy whether it be in the form of ordinary explosives or the type of blasting device herein above mentioned there is a definite and substantial cost for each drill hole provided in the coal for the reception of these units of potential energy.

The primary object of the present invention is to definitely overcome or to avoid the limitations as regards cost of production herein above set forth and explained in relation to existing and commonly used forms of potential energy and the method of their use.

It is an object of the present invention to

utilize a form of potential energy and to provide a method for its application whereby costly drilling of shot holes may be reduced to a minimum very substantially below the most efficient practices prevailing today.

It is also an object of the present invention to utilize a form of potential energy and to provide a method of its application which shall make possible the elimination of the costly undercutting operation without at the same time adding correspondingly or even materially to the cost of the blasting operation.

Other objects of the invention will appear in connection with description and explanations which follow.

Referring to the drawings Figure 1 is a view in sectional elevation illustrating one form of apparatus suitable for carrying out the method of the present invention.

Figure 2 is a sectional plan view along the line 2—2 of Figure 1.

Figure 3 is a view in sectional elevation illustrating the application of a slightly modified form of apparatus.

Fig. 4 is a view in longitudinal section of the blasting cartridge embodied in the forms of the invention shown in Figs. 1 and 3.

Figures 5 and 6 illustrate modifications of the apparatus represented in the preceding figures.

Referring first to Figures 1 and 2, the coal to be broken down is indicated at 1 and in Figure 1 there is shown a discharge pipe 2 positioned in a suitable drill hole formed in the coal 1. This discharge pipe is closed at its remote end but is there provided with a plurality of radial discharge ports 7. Located on the mine bottom or floor is a cartridge 3 of large volumetric capacity. For the purpose of the present disclosure this cartridge may be assumed to be of the general type illustrated in the copending application of Raymond W. Dull, Serial Number 673,146, filed May 27, 1933. On reference to this copending application it will be observed that the cartridge embodies, as shown in Fig. 4, a differential valve 16, controlled by a piston 17 secured to the valve, and this valve permits of the cartridge being charged and discharged from a remote point, the charging being effected by passing high pressure air, or other gas, through a supply pipe such as is illustrated at 5 in Figures 1 and 2 of the present drawings and the operation of the differential valve to permit discharge may be effected by simply venting the supply pipe to the atmosphere at the remote point. As described in the above mentioned Dull application, high pressure air is introduced, through pipe 5 to the cartridge container and the initial effect of the pressure air will be to exert considerable pressure on the larger area of the piston 17, thereby moving the latter, together with the valve 16, inwardly to bring the valve into firm sealing engagement with its seat. This having been accomplished, which of course occurs instantaneously, the pressure air somewhat gradually passes around the piston into the main charge receiving chamber of the cartridge. After a charge of the desired volume and pressure has been introduced into the main chamber of the cartridge, it is intended that the piston 17 be operated to unseat the valve, thereby permitting the escape of the entire charge through the discharge pipe 2 into the material to be broken. This is accomplished in an exceedingly simple manner, by merely reducing the pressure at the larger area of the piston 17. Thus by venting the pipe 5 to atmosphere, the small volume of pressure air at the larger area of the piston readily escapes through the pipe 5 into the atmosphere, thus causing an instantaneous drop in pressure at the large area of the piston. This of course gives rise to a differential pressure condition wherein the pressure in the main chamber acting on the smaller area of the piston greatly exceeds that at the vented side of the piston, thereby resulting in a rapid axial movement of the piston in a direction to unseat the valve. This is followed, of course, by a practically instantaneous escape of the entire volume of pressure air through the pipe 2 and discharge ports 7 into the surrounding material to be broken. Thus, referring to the drawings in the present application the large capacity cartridge or cartridges 3 may be charged from a high pressure air compressor or receiver located at a remote point, the high pressure air passing into the cartridge 3 through a supply pipe 5 and the discharge of the cartridge being effected by venting the pipe 5 to the atmosphere at a remote point thereby causing operation of the differential valve. In the present instance, however, instead of providing the cartridge with a discharge cap designed to direct the high pressure air directly into the coal through radial discharge ports, the discharge of the cartridge or cartridges 3 is conducted through intermediate pipe 4 into the discharge pipe 2 positioned in the drill hole. In order to overcome whatever force there may be tending to eject the discharge pipe 2 from the drill hole there may be provided a suitable anchoring or holding device such for example as the roof jack shown at 14.

Bearing in mind that the cartridge 3 may be of any desired volumetric capacity without affecting in any material respect the cost of applying the energy to the work to be performed, it will be readily appreciated that it is entirely possible to do with a single cartridge, such as illustrated at 3 a quantity of work which would normally require a considerable number of individual cartridges or other units of potential energy and, of course, a corresponding number of drill holes. It should also be readily appreciated that according to the method just described such additional energy or potential energy as may be required to compensate for the absence of undercutting may likewise be readily provided without materially affecting the cost of application of the energy to the work. It should also be mentioned at this point that with high pressure air as the energy medium the concentration and application of an extremely large volume at one point in the coal does not give rise to the destructive effects which follow similar practices with the use of explosives and, of course, does not present any of the hazards which are inevitable where large quantities of explosives are used. In a great many cases it may be possible to accomplish the desired work with a single large capacity cartridge, although it is contemplated that in some cases perhaps two and even more of such cartridges may be used to advantage.

Referring to Figure 2 it will be observed that two such cartridges are employed in conjunction with two discharge pipes positioned in drill holes in the coal. Where it is desirable to progressively mine an area of uniform dimensions it may be advisable to use two such cartridges and perhaps in some cases three or four. Thus the width of room being mined as illustrated in Figure 2 for example may in some cases be handled best by the use of two cartridges to each face, thereby

resulting in a minimum of cleanup work supplementary to the shooting operations. Referring to the second discharge pipe 6 illustrated in Figure 2 it will be noted that a number of discharge ports 8 are shown. Thus the discharge of the high pressure air from the cartridge or cartridges 3 may be effected through a series of discharge ports extending throughout any desired portion of the length of the discharge pipe or through the discharge ports 7 at the remote end of the pipe as desired and as found most satisfactory under various conditions encountered.

In the modification illustrated in Figure 3 the large capacity cartridge 3 is screwed directly on to the outer end of the discharge pipe 2 thus doing away with the intermediate pipe 4 of Figures 1 and 2. It should be mentioned in this connection that the pipe 4 of Figures 1 and 2 is preferably a flexible armored tubing capable of sustaining relatively high pressures. The cartridge 3 of Figure 3 will be in all respects the same as the corresponding cartridge of Figures 1 and 2. An anchoring device in the form of a floor jack 15 may be used for holding the cartridge in position and for resisting whatever force there may be tending to eject the discharge pipe from its drill hole. Charging and discharging of this cartridge will be effected by means of the supply pipe 5.

Figures 5 and 6 illustrate the idea of introducing high pressure air or other gas direct from a large storage receiver or from a high pressure compressor into the coal. This method will not be suitable in all cases but may have its own limited field of application. In most cases, however, it will be found desirable to segregate and confine a charge of desired proportions at a point adjacent to the coal face and under circumstances such that the entire charge may be instantaneously released into the coal. Referring particularly to Figure 5 there is shown a discharge pipe 9 which is provided on its surface with a screw thread calculated to embed itself in the coal forming the wall of a drill hole as the pipe is introduced into the hole by means of a drill or other form of a rotary machine. Thus the pipe 9 is securely anchored in the coal to resist any tendency of the pressure introduced into the coal toward ejecting the pipe from its drill hole. Suitable discharge orifices 7 are provided in pipe 9. After the discharge pipe 9 has been introduced securely into the drill hole it may be connected by means of suitable coupling to a supply pipe 12 extending back to a remote point to a source of high pressure air 10 which is under the control of a suitable valve 11. In Figure 6 there is shown a source of high pressure air 10, a control valve 11 and a small diameter copper tube 13 extending from the source to and into a drill hole formed in the coal. Copper tubing is particularly suitable for the handling of high pressure air owing to its non-shattering qualities and to its flexible nature. It is contemplated that under certain circumstances useful work may be performed by simply conducting high pressure air into the material to be broken down by means of a small diameter copper tube say ½ to ¾ inch outside diameter and permitting the high pressure air to discharge directly from the end of the tubing into the coal or other material. When the work to be performed requires the rapid application of quite large volumes of energy the method represented in Figures 5 and 6 will probably not be suitable.

The pressures contemplated in the practice of the methods disclosed herein will of course, vary considerably according to the nature of the material to be broken and to other conditions affecting the work to be performed. In general, however, it is contemplated that the most useful range of pressures will be from five to fifteen thousand pounds per square inch although it should be understood that these are not specified as limiting values.

Referring again to the nature of the cartridges contemplated for use in the practice of these methods as disclosed, particularly in the copending application referred to above, it is well to remember in analyzing the capabilities of the present methods that the differential valve cartridge of the general type disclosed in said application is capable of being charged from a remote point to any desired pressure within accurately controlled limits and that it may likewise be discharged at accurately controlled pressures. Thus having at hand the volumetric capacity required for performance of the work under a given set of conditions the actual performance of the work in the most effective manner depends only upon the exercise of judgment in effecting discharge of the cartridge or cartridges at the exact pressure calculated on the basis of experience to be best suited to the performance of the work. In this connection it should be mentioned that the use of high pressure air in the breaking down of coal has been found to possess some most desirable characteristics particularly in relation to the production of an exceptionally large percentage of large blocky coal in perfectly sound condition. Thus the use of high pressure air for this work almost entirely eliminates the costly shattering of the natural coal structure as normally occurs to a very considerable extent with the use of explosives.

It is understood that the present invention as regards both the methods involved and the apparatus is not limited to the use of energy or potential energy in the form of high pressure air or other suitable gases not withstanding the fact that this particular form of energy has been found exceptionally well suited for this class of work from the standpoint of economy, efficiency and safety. One of the principal features of the invention particularly as regards the methods disclosed is the idea of introducing into the coal or other material to be broken down variable quantities of energy to meet the requirements of the work without thereby introducing corresponding variations in costs, efficiency and safety. From this standpoint alone it may be considered that the particular form of energy used is in a large measure immaterial to this important phase of the invention. Thus it might well be possible to use a variety of other forms of energy or potential energy including those which have been herein particularly referred to although on analysis of the application of other forms of energy to this method it will readily be found that for the most part they do not begin to present the economic advantages of high pressure air. In other words variations in volume of high pressure air over a considerable range may be had without substantial variations in cost.

It should also be understood that the apparatus herein shown is for purposes of illustration only and that the equipment may differ in type and in detail from that shown. For example instead of using the differential valve type of cartridge as herein suggested the cartridge may be simply a large capacity receiver having a

rupturable disc at its discharge orifice designed to fail at a pressure at which it is desired to introduce the charge of potential energy into the coal. It might also be mentioned that the discharge pipe may be dispensed with and that in lieu thereof the cartridge be provided with a short discharge nozzle designed to be inserted in the mouth of the drill hole and to be held securely in that position. Many other variations within the range of past experience and of normal future developments may readily find a place in the practical application of the methods and apparatus of the present invention. The primary purpose herein has been to disclose the basic principles underlying the invention and to some extent to suggest the economic considerations involved. The exact scope of the invention, subject, however, to all existing principles of interpretation, is defined in the following claims:

1. An apparatus for breaking coal or other materials comprising a cartridge positioned outside of the material and adapted to receive, retain, and discharge a desired volume of compressed air, means for conducting the air discharged from said cartridge freely directly into the material and controlling its direction of release, and pressure responsive differential valve means embodied in the cartridge for confining the compressed air in the cartridge and for effecting discharge at will of the compressed air from the cartridge.

2. In a blasting cartridge, a container of relatively large volume for receiving a blasting charge and positioned adjacent to but outside of the material to be broken, means insertible in a blast hole drilled in the material to be broken for conducting the blasting pressure from the container into the material, and pressure responsive differential valve means embodied in the cartridge for confining the blasting charge in said container and controllable at will for releasing the blasting charge from the container to said conducting means.

3. In a blasting cartridge, a container of relatively large volume for receiving a blasting charge and positioned adjacent to but outside of the material to be broken, means insertible in the blast hole drilled in the material to be broken for conducting the blasting pressure from the container into the material and having a free discharge orifice at its inner extremity, and pressure responsive differential valve means embodied in the cartridge for confining the blasting charge in said container and controllable at will for releasing the blasting charge from the container to said conducting means.

4. In a blasting cartridge, a container of relatively large volume for receiving a blasting charge and positioned adjacent to but outside of the material to be broken, means insertible in the blast hole drilled in the material to be broken for conducting the blasting pressure from the container into the material, means for charging said container while said conducting means is in blasting position within the blast hole, and charge pressure operated release valve mechanism within the container and controllable at will for releasing the blasting charge from the container into said conducting means.

5. In a blasting cartridge, a container of relatively large volume for receiving a blasting charge and positioned adjacent to but outside of the material to be broken, means insertible in the blast hole drilled in the material to be broken for conducting the blasting pressure from the container into the material and having a series of free discharge orifices spaced along its length, and a pressure responsive differential valve means embodied in the cartridge for confining the blasting charge in said container and controllable at will for releasing the blasting charge from the container to said conducting means.

ALLYN HARRIS.