July 16, 1957 A. H. MANDT 2,799,488

METHOD OF AND APPARATUS FOR THE CONTINUOUS MINING OF MINERAL MATERIAL BY COMBINED DRILLING, UNDERCUTTING AND SHOOTING OPERATIONS

Filed May 12, 1955 3 Sheets-Sheet 1

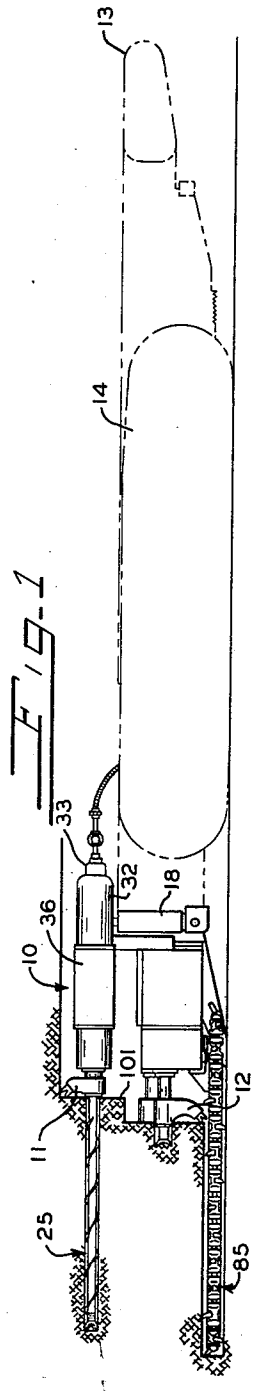


Fig. 1

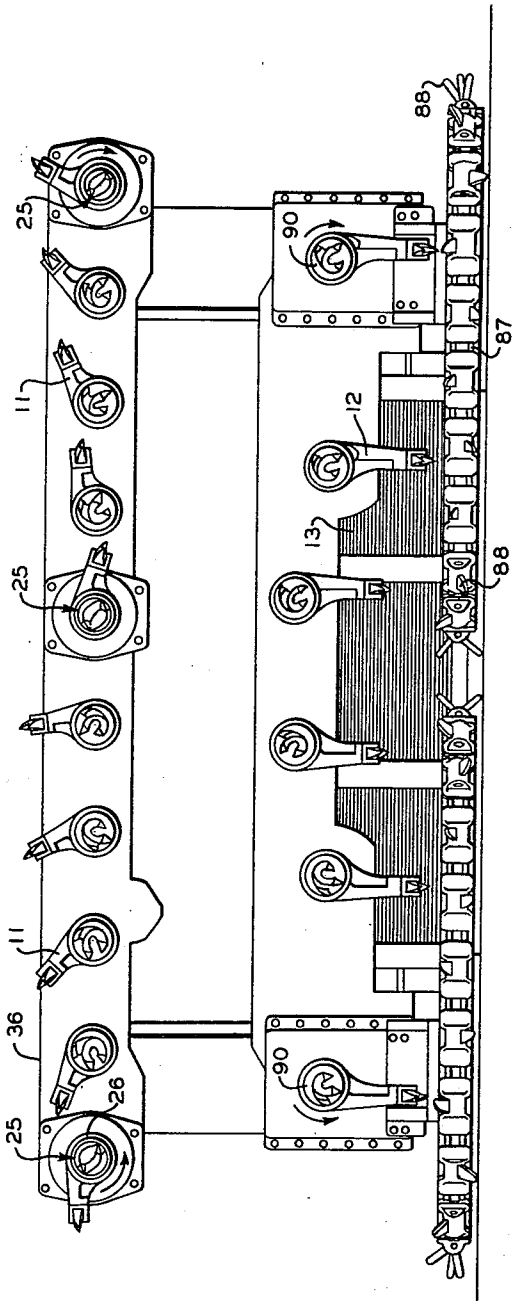


Fig. 2

INVENTOR.
AMBROSE H. MANDT

BY
DES JARDINS, ROBINSON & KEISER
Howard K. Keiser
HIS ATTORNEYS

July 16, 1957 A. H. MANDT 2,799,488

METHOD OF AND APPARATUS FOR THE CONTINUOUS MINING OF MINERAL MATERIAL BY COMBINED DRILLING, UNDERCUTTING AND SHOOTING OPERATIONS

Filed May 12, 1955 3 Sheets-Sheet 2

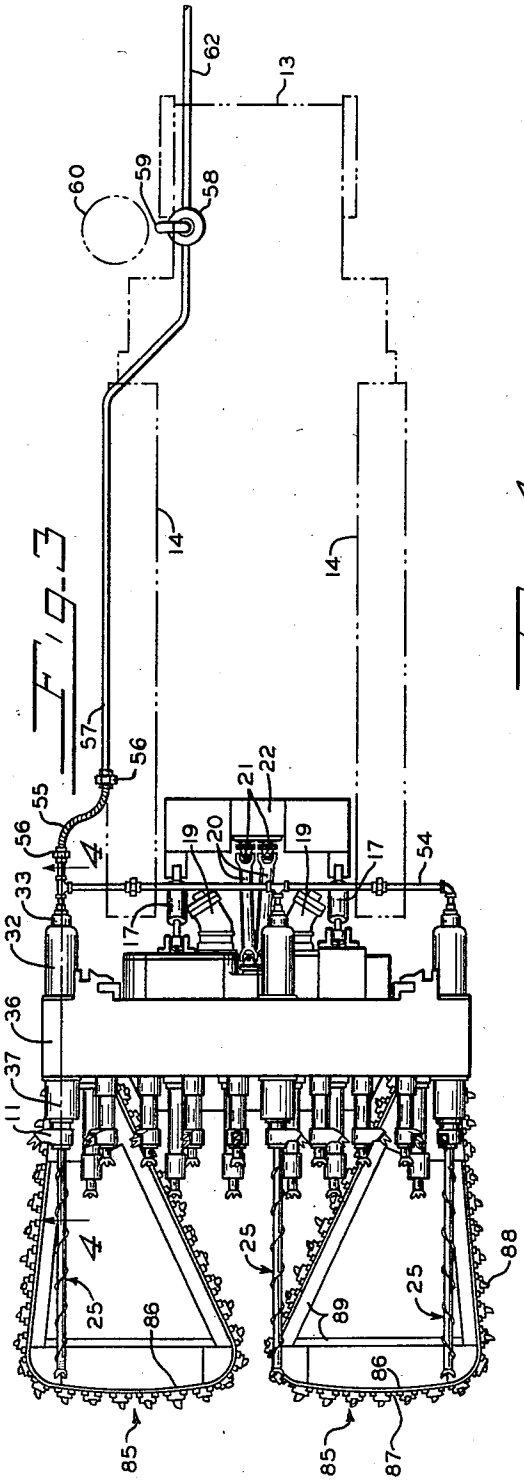


FIG. 3

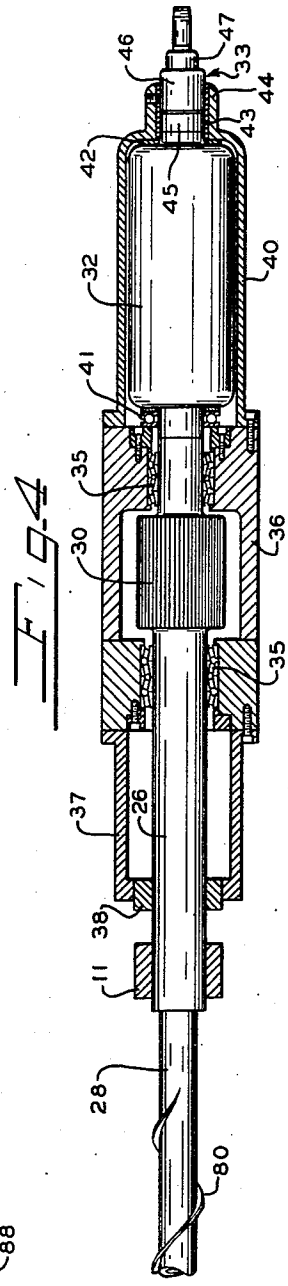


FIG. 4

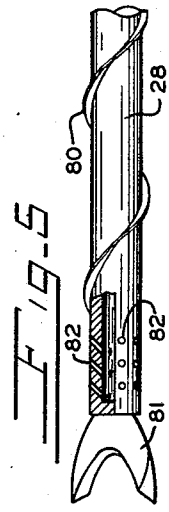


FIG. 5

INVENTOR.
AMBROSE H. MANDT

BY
DES JARDINS, ROBINSON & KEISER
Howard T. Keiser
HIS ATTORNEYS

July 16, 1957 A. H. MANDT 2,799,488

METHOD OF AND APPARATUS FOR THE CONTINUOUS MINING OF MINERAL MATERIAL BY COMBINED DRILLING, UNDERCUTTING AND SHOOTING OPERATIONS

Filed May 12, 1955 3 Sheets-Sheet 3

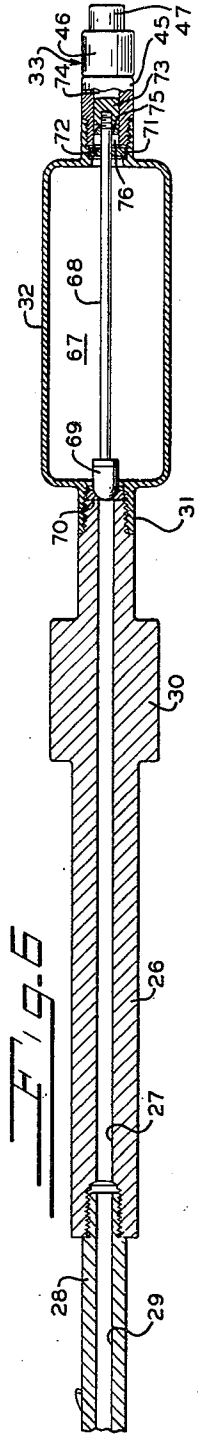


FIG. 6

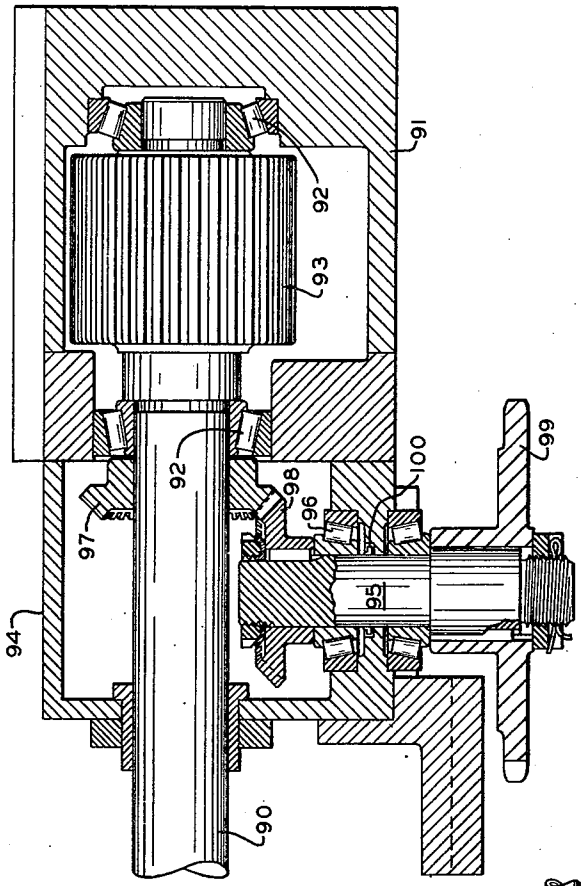


FIG. 8

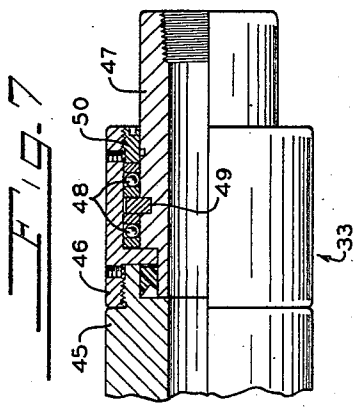


FIG. 7

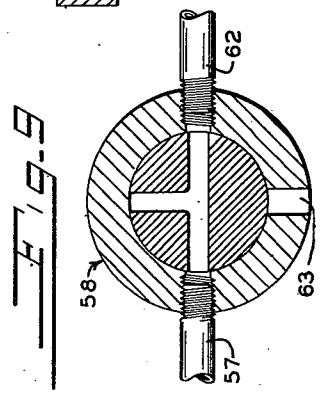


FIG. 5

INVENTOR.
AMBROSE H. MANDT

BY
DES JARDINS, ROBINSON & KEISER
Howard R. Keiser
HIS ATTORNEYS

United States Patent Office 2,799,488 Patented July 16, 1957

2,799,488

METHOD OF AND APPARATUS FOR THE CONTINUOUS MINING OF MINERAL MATERIAL BY COMBINED DRILLING, UNDERCUTTING AND SHOOTING OPERATIONS

Ambrose H. Mandt, Manton, Ky.

Application May 12, 1955, Serial No. 507,869

19 Claims. (Cl. 262—9)

This invention relates to a novel method and apparatus for removing coal or other material from a vertical face or wall of limited height. In accordance with my invention, the material is removed from the face by combined drilling, undercutting and shooting operations which may be performed either alternately or simultaneously as may be found most suitable under the circumstances.

Of recent years, considerable attention has been given to the development of a fully mechanized mining machine which will operate continuously to remove coal from the coal face and deliver it to a mine car or conveyor which then carries it out of the mine. One of the machines of this character with which I am familiar is constructed with a cutter head on which is mounted a series of rotatable cutter arms for removing the coal from the face and sweeping it onto a conveyor which delivers it into the mine cars or onto the conveyor. Where hard, solid coal is encountered at the face, however, it has been found that the traction devices of the machine are unable to produce sufficient tractive effort on the floor of the mine room to force the revolving cutters to dig into the coal face. Accordingly, at times the cutters will merely groove the coal face and will be ineffective to break the coal therefrom. To overcome this difficulty, I have discovered a way to intermittently shoot the coal as the digging proceeds to thereby fracture the same and insure easy removability of the coal from the face.

Accordingly, it is an object of this invention to provide a method of continuously drilling and shooting the material being mined without the necessity of removing the drill stem from the bore hole before shooting takes place.

Another object of the invention is to provide a method of simultaneously removing material from the face and drilling a bore hole therein as the mining operation proceeds.

Another object of the invention is to provide a method of continuously mining coal or other mineral material by simultaneously drilling and undercutting the material and periodically shooting the same to break down the material in advance of the face.

Another object of the invention is to provide an improved form of apparatus for continuously mining coal or other material by combined drilling, undercutting and shooting operations.

Another object of the invention is to provide a combined shell and drill for permitting shooting of the material being mined without the necessity of removing the drill from the bore hole before it is shot.

With these and other objects in view which will become apparent from the following description, the invention includes certain novel procedures for facilitating the mining of coal and other mineral materials and certain novel features of construction and combinations of parts of a mining apparatus, the essential elements of which are set forth in the appended claims and a preferred form or embodiment of which will hereinafter be described with reference to the drawings which accompany and form a part of this specification.

In the drawings:

Fig. 1 is a side elevation of a commercially available type of mining machine to which I have shown my invention applied, the rear part of the machine being shown in phantom outline.

Fig. 2 is a front view of the machine shown in Fig. 1 on an enlarged scale.

Fig. 3 is a plan view of the machine shown in Fig. 1 with the rear part of the machine again shown in phantom outline.

Fig. 4 is a detail view, partially in cross-section, showing the hollow shaft with the cartridge mounted on one end and the drill and shell unit on the other.

Fig. 5 is a detail view showing the forward end of the drill and shell unit.

Fig. 6 is a cross-sectional view, with the housing removed, of the structure shown in Fig. 4.

Fig. 7 is a detail view, partially in cross-section, of one of the high-pressure swivel fittings.

Fig. 8 is a detail, cross-sectional view of the bevel gear drive for the kerf cutter.

Fig. 9 is a diagrammatic view of the high-pressure valve for controlling the charging and discharging of the cartridge.

As heretofore stated, the present invention includes a new method of mining coal or other mineral material which consists in drilling bore holes into material at the same time that the material is being cut or broken away from the face. By combining these operations, the required number of bore holes are continuously being drilled into the material as the cutting and breaking operation proceeds so that the holes are present and ready for shooting at recurring intervals to fracture the coal or other material and thereby facilitate its removal from the face.

The invention also includes the method of undercutting the face at the same time that the bore holes are being drilled therein and the material is being removed therefrom by the cutting or breaking thereof from the face. Hence, a bottom kerf will be produced simultaneously with the drilling of bore holes in the face so as to prepare the coal or other material for shooting as the mining operation proceeds. Undercutting of the face is desirable where shooting is employed since it provides room for expansion of the material and assists in the fracturing thereof.

The invention also includes the method of intermittent shooting of the mineral body either simultaneously with the drilling and breaking operations or at the conclusion of such operations when further fracturing and breaking of the material by shooting is required.

The method of the present invention also includes the steps of advancing the drilling, shooting, undercutting and breaking apparatus toward the face and for removing the broken material from the face and carrying it to the rear of the apparatus where it may be loaded into mine cars and taken out of the mine.

For the purpose of enabling my novel method of operation to be carried out expeditiously and in the manner intended, I have devised a mining apparatus which is comprised of several novel features of construction and combinations of parts not heretofore known or used, so far as I am aware, in mining operations. The specific form of apparatus which I have invented to fulfill this purpose is shown in the accompanying drawings and will now be described in detail though it is to be understood that other forms of apparatus coming within the scope of the claims appended hereto might be used for carrying out the method if so desired.

In the drawings I have shown my invention as applied to a mining machine of known type which need not be shown or described other than in a very general manner

for an understanding of the present invention. As shown in Figs. 1, 2 and 3, this machine includes a frame on which is mounted a two-section cutting head 10 consisting of an upper row of cutting or breaker arms 11 and bottom row of cutting or breaker arms 12. Also carried by the frame is a conveyor 13 extending lengthwise thereof and running from a position beneath the breaker arms to the rear end of the machine where it discharges its burden into a mine car or conveyor for removal from the mine. Also mounted on the frame of the machine are tramming devices consisting of a pair of endless, track-type treads 14 by which the machine may be advanced toward the coal face. The machine may be caused to follow a winding or sinuous seam by tilting the cutting head 10 on the frame about a horizontal axis by means of hydraulic jacks 17 (Fig. 3). Additional hydraulic jacks 18 (Fig. 1) are provided for adjusting the two sections of the cutting head closer together or farther apart for adapting the machine to seams of different heights.

In accordance with known practice, the cutting or breaker arms 11 and 12 are supported on a series of parallel shafts suitably journaled for rotation in the two sections of the cutting head. The shafts are arranged to be driven through intermeshing spur gears from power provided by hydraulic motors 19 (Fig. 3) which are supplied with hydraulic fluid under pressure from a pump driven by an electric motor in the conventional manner. The drive of the upper and lower breaker arms 11 and 12, respectively, by the two motors is maintained in synchronism by a pair of drive shafts 20 fitted at either end with universal joints 21. The shafts 20 are caused to rotate in unison by intermeshing gears contained in a gear case 22 so that the two rows of breaker arms driven by motors 19 will be caused to rotate in synchronism.

To this machine, as described above, I have applied the additional components hereinafter to be described which serve to adapt the machine for use in carrying out my novel mining method.

In the present embodiment of the invention, the machine is provided with three combined drill and shell units 25 which, for convenience, are each secured to one of the parallel shafts on which the breaker arms 11 are mounted. Each of the breaker arm shafts on which the units 25 are mounted are hollow, one of these shafts being shown in Fig. 6 where it is numbered 26. The three shafts 26 are identical and a description of one will suffice for all. As shown, the shaft is provided with a longitudinally extending bore 27 which is threaded at its forward (left-hand) end to receive the threaded end of the stem 28 of the drill and shell unit associated therewith. The stem 28 like the shaft 26 is hollow and contains a bore 29 communicately connected with the bore 27 of the shaft. The shaft 26 also carries a drive gear 30 which is connected by intermeshing gears with the other breaker arm shafts of the upper section of the cutting head 10. At its rear end, the shaft 26 is externally threaded to receive the internally threaded neck 31 of a cartridge 32 which is supplied with high-pressure air or gas through a swivel fitting 33.

As shown in Fig. 4, the hollow shaft 26 is, like the other breaker arm shafts, journaled in roller bearings 35 supported within a housing 36 which forms a part of the upper section of the cutting head. Secured to the forward face of this housing is a cylindrical cover 37 provided with a bearing or bushing 38 through which the shaft 36 passes. The breaker arm 11 of the particular shaft in question is mounted on the forward end thereof beyond the bushing 38.

Secured to the rear face of the housing 36 is a casing 40 within which the cartridge 32 is journaled for rotation by thrust bearings 41 and 42 and a sleeve type bearing or bushing 43 received within an extension 44 of reduced diameter provided on the rear end of the casing 40 which engages a neck 45 formed on the rear end of the cartridge. Hence, as the shaft 26 is revolved by means of drive gear 30, the stem 28 of the drill and shell unit 25 will be rotated and the cartridge 32 will rotate with the shaft 26.

As heretofore mentioned, high-pressure air is supplied to the rear end of the cartridge by the swivel fitting 33. As shown in Fig. 7, the swivel comprises a sleeve 46 which is screwed onto a threaded tenon formed on the rear end of the neck 45. Within the sleeve 46 is a nipple 47 mounted for rotation therein by ball bearings 48. The fitting 33 is of a commercially available type and is provided with the customary sealing baffles and gaskets to prevent the escape of high-pressure air from the swivel connection provided by the fitting. The nipple 47 is retained within the sleeve 46 by a ring 49 encircling the nipple, and a threaded retaining ring 50 which screws into the end of the sleeve 46. The rear end of the nipple 47 is internally threaded to receive a correspondingly threaded fitting to which high-pressure air is delivered to the swivel 33.

As shown in Fig. 3, the three swivels 33 are connected by a common conduit 54 which mechanically ties the swivels together and at the same time provides means for delivering high-pressure air thereto. Air is delivered to the conduit 54 by a flexible hose 55 which is connected by a union 56 with a conduit 57 which extends to the rear of the machine where it is connected with one of the ports of a high-pressure control valve 58. This valve is provided with a handle 59 which may be manipulated by an operator who is normally stationed at the position shown by the dot-and-dash circle 60 where he is able to manipulate the controls of the machine.

As shown in Fig. 9, the valve 58 may be of any suitable type which will withstand the high pressures involved and which will provide for selective interconnection of three ports thereon. In the plug-type valve herein shown, the line 57 leading to the cartridge 32 may be selectively connected by manipulation of the handle 59 to a line 62 connected with a compressor unit (not shown). This unit may either be located outside the mine or it may be mounted on a movable support so as to enable it to follow the mining machine as it moves into the seam. Alternatively, the line 57 may be connected with a vent port 63 on the valve by suitable manipulation of the handle 59 to thereby vent the line 57 to atmosphere.

When the handle 59 of the valve is turned so as to connect the compressor line 62 with the line 57, the cartridge will be charged with air or gas under high pressure delivered thereto by the compressor. After the cartridge has been thus charged, it may be discharged by turning of the handle to the position in which the line 57 is vented to atmosphere whereupon the high-pressure air or gas within the cartridge will be discharged through a port in the forward end thereof which is communicatively connected with the interior of the shaft 26 and stem 28.

The interior construction of the cartridge is shown in Fig. 6, but inasmuch as this device is of a commercial type which is well known to the mining industry today, the description thereof will be limited to so much as is necessary for an understanding of the manner in which this device functions to produce the result desired. The interior of the cartridge 32 is hollow so as to provide a pressure chamber 67 for receiving the high-pressure air or gas from the compressor through the line 57. Extending longitudinally of the cartridge within the chamber 67 is a piston rod 68 which is fitted at its forward end with a valve 69 adapted to seat against an annular gasket which is backed up by an annular valve seat 70. At its rear end, the piston rod 68 passes through a stationary sealing disc 71 which is provided with a small vent hole 72. Secured to the rear end of the rod 68 is a piston 73 which works loosely within a cylindrical

bore formed within the neck 45. Mounted upon the forward face of the piston 73 is a plunger leather 75 which effects sealing of the piston within the cylinder 74 against the escape of high-pressure air from the space 76 lying between the disc 71 and the piston 73.

The operation of this device is as follows:

When high-pressure air or gas from the compressor is delivered to the rear end of the cartridge, the piston 73 will be moved forward to close the valve 69 and seal the chamber 67 against the escape of high-pressure air or gas. The pressure within the chamber will build up gradually as the air or gas passes around the loosely fitting piston 73 and through the vent hole 72 until the pressure within the chamber is equal to that delivered by the compressor. When it is desired to discharge the air or gas within the cartridge through the valve 69, the handle 59 of the valve 58 is turned so as to vent the line 57 to atmosphere and reduce the pressure on the rear face of piston 73 to substantially atmospheric pressure. The high-pressure air or gas trapped in the space 76 between the sealing disc 71 and the piston 73 will, since the area of the piston is greater than that of the opening in the seat 70, force the piston 73 rearwardly, the leather 75 tending to seal the air or gas within the space 76 against escape. The valve 69 will thereupon be removed from its seat and the high-pressure air or gas in the chamber 67 permitted to discharge into the hollow shaft 26. This will cause a blast of air or gas to be transmitted through the shaft 26 into the interior of the drill and shell unit 25. After the cartridge has been discharged, it may again be charged by turning the handle of the valve 58 to a position in which the compressor line 63 is connected to the line 57 leading to the cartridge.

As shown in Figs. 4 and 5, the stem 28 is provided with a spiral flight 80 and a cutting bit 81 of conventional design. The stem 28 is also provided at its forward end with a series of blast ports 82 which are arranged circumferentially around the stem. Hence, when the blast of air or gas is released from cartridge 32, it will pass through the hollow shaft 26 and stem 28 and issue from the ports 82 with explosive force and cause fracturing of the coal or other material being mined.

To increase the effectiveness of the blasting or shooting operation and to provide room for the coal to expand, the machine is provided with a pair of kerf cutters 85 each of which consists of a chain guide 86 having the shape of a hollow triangle and suitably secured to the cutter head 10 at its rear end. Running on each guide 86 is a cutter chain 87 which carries a series of staggered cutter bits 88 (see also Fig. 2) for cutting a kerf in the coal as the chain travels around the guide 86. Suitable bracing 89 may be provided for the chain guides 86 to provide the necessary strength thereto.

The power required to drive each of the chains 82 may conveniently be derived from the shafts of the outermost breaker arms 12 of the bottom section of the cutting head. As shown in Fig. 8, a breaker arm shaft 90 of one of said arms is journaled within a housing 91 by roller bearings 92. The shaft has fixed thereon a spur gear 93 which meshes with an adjoining gear in the gear train which drives the breaker arms 12 and causes these arms to be rotated in unison by power derived from the hydraulic motors 19. Secured to the forward face of the housing 91 is a gear casing 94 in the bottom of which a jack shaft 95 is journaled for rotation by roller bearings 96. The shaft 95 is driven from the shaft 90 by a pair of meshing bevel gears 97 and 98 and the shaft carries at its lower end a chain sprocket 99 which engaged with the cutter chain 87 and causes it to be driven as the shaft 90 rotates. An oil seal 100 may be provided in the bottom of the gear casing 94 to seal the opening therein, through which the shaft 95 passes, against the escape of oil. The kerf cutters 85 are supported from the framework of the cutting head 10 so as to tilt with the head and thereby follow any deviations in the seam in the same manner as the drill and shell units 25 and the breaker arms 11 and 12.

The operation of the mining machine heretofore described is as follows:

The machine is trammed toward the coal face 101 (Fig. 1) in the usual manner by means of the tracks 14. Thereupon, the kerf cutters 85 and the drill and shell units 25 penetrate into the face 101 (Fig. 1) of the coal or other material being mined and the breaker arms 11 and 12 engage the face and break the coal loose therefrom. To shoot the coal and thereby assist the breaker arms in removing the coal from the face, the operator of the machine, who is normally stationed at 60 (Fig. 3), turns the valve 50 to connect the line 62 from the compressor with the line 57 to the cartridge 32 and, after the cartridge has been charged, turns the handle to vent the line 57 to atmosphere. As previously explained, this causes the valve within the cartridge to open and permits a blast of high-pressure air or gas to pass through the hollow shaft 26 and stem 28 of the drill and to issue with explosive force through the blast ports 82 (Fig. 5). Since the coal has been undercut by the kerf cutters 85 slightly in advance of the end of the drill, the coal will be readily fractured and knocked down so that the arms 11 and 12 can readily clean up the face and remove any coal which was not knocked down by the blast. The conveyor 13 of the machine (Fig. 2) has its forward end disposed immediately behind the breaker arms where it will be in position to receive the broken coal and transport it to the rear of the machine. As indicated by the arrows in Fig. 2, the breaker arms turn inwardly so as to sweep the coal in toward the conveyor.

After the machine has advanced a sufficient distance to again bring the breaker arms into contact with solid coal, the operator may again manipulate the valve 58 to shoot the coal and thereby permit rapid advance of the machine into the seam. With this means of fracturing and breaking the coal independently of the action of the breaker arms, less slack will be produced and a better quality of coal obtained.

The shooting operation may be performed while the drills and kerf cutters are operating or, if desired, the operator may stop these elements at the time of shooting so as to reduce the strain on the machine. In either event however rapid, economical mining of coal or other mineral material which is susceptible to this form of mining will be obtained.

Having thus described my invention in connection with one possible form of apparatus and having used, therefore, certain specific terms and language herein, it is to be understood that the present disclosure is illustrative rather than restrictive and that changes and modifications may be resorted to without departing from the spirit or scope of the claims that follow.

What I claim as new and useful and desire to secure by United States Letters Patent, is:

1. A mobile mining machine comprising a frame, a cutting head on said frame and including a plurality of breaker arms mounted on a plurality of rotatable shafts arranged in substantially parallel relationship and so positioned with respect to one another that upon rotation of said shafts substantially coplanar circles are described by said breaker arms, a bore hole auger mounted on at least one of said shafts in axial alignment therewith for drilling a bore hole in the material being mined in advance of said breaker arms, said auger extending a sufficient distance in advance of said breaker arms to provide a bore hole of sufficient depth to enable additional material to be blasted loose after the breaker arms have cleaned off the loose material from the face, and power driven means for advancing the machine toward the face of the material.

2. The mining machine of claim 1 including a kerf cutter supported on said frame for undercutting the mate-

rial being mined in advance of said breaker arms and below said auger.

3. The mining machine of claim 2 wherein said kerf cutter includes a loop-shaped chain guide that is open in the center so as to provide room for expansion of the material when it is shot with the kerf cutter in place beneath the material.

4. A drilling and blasting device for use in mining operations comprising a frame for supporting said device, a hollow auger rotatably mounted on said frame for drilling a bore hole in the face of the material being mined, blast ports in the forward end of said auger, power means for rotating said auger, a cartridge adapted to be charged with air or gas under pressure and having a discharge orifice through which the air or gas may be released, and means communicatively connecting said discharge orifice with the rear end of said auger for causing the blast of air or gas from said cartridge to be delivered to the forward end of said auger where it passes through said blast ports into the bore hole.

5. The device of claim 4 wherein said cartridge is rigidly secured to the rear end of said auger so as to rotate therewith during drilling and shooting operations.

6. The device of claim 4 including a compressed air line for supplying high pressure air to said cartridge for charging the same, and a swivel fitting for connecting said air line to the rotatable cartridge to permit charging of the cartridge while said drill is rotated.

7. A drilling and blasting device for use in mining operations comprising a drill having a tubular drill stem, a cutting bit on the forward end of said stem for drilling into the material being mined, a spiral flight on said stem for removing the material loosened by the bit, means for delivering a blast of air or gas into the rear end of said stem, and a plurality of circumferentially arranged blast ports passing through the wall of the stem at the forward end thereof for conducting the air or gas delivered into the stem into the end of the bore hole.

8. A mobile mining machine comprising a frame, power operated means on said frame for removing material from the face, a hollow auger rotatably mounted on said frame and projecting forwardly thereof for drilling a bore hole into the material being mined, a plurality of blast holes in the forward end of said auger, power means for rotating said auger, means communicatively connected with the rear end of said auger for delivering a blast of air or gas through said auger and said blast holes into the bore hole to fracture the material being mined, a kerf cutter supported on said frame for undercutting the solid material in advance of said moving means and below said auger, and power means for tramming the machine toward the face.

9. A mobile mining machine comprising a frame, a cutting head on said frame having a plurality of breaker arms mounted on a plurality of rotatable shafts arranged in substantially parallel relationship on said frame and so positioned with respect to one another that upon rotation of said shafts substantially coplanar circles are described by said breaker arms, a hollow auger rotatably mounted on said frame for drilling a bore hole in the material being mined in advance of said breaker arms, power means for rotating said auger, a plurality of blast holes in the forward end of said auger, means communicatively connected with the rear end of said auger for delivering a blast of air or gas through said auger and said blast holes into the bore hole to fracture the material being mined, and power means for tramming the machine toward the face.

10. The mining machine of claim 9 including a kerf cutter on said frame for undercutting the solid material in advance of said breaker arms and below said auger.

11. The method of removing material from the face of an underground seam which consists in breaking the material away from the face of the seam and simultaneously drilling a bore hole into the seam beyond the face, and periodically shooting the material as the mining operation proceeds to fracture the material and facilitate its removal from the face.

12. The method of claim 11 wherein shooting of the material is performed simultaneously with the drilling and breaking operations to thereby enable continuous mining of the material.

13. The method of claim 11 wherein the material being mined is undercut below the bore hole simultaneously with the breaking and drilling thereof.

14. The method of claim 13 including conveying the broken material away from the face simultaneously with the breaking, drilling and undercutting operations.

15. A mobile mining machine comprising a frame, a cutting head on said frame and including a plurality of breaker arms mounted on a plurality of rotatable shafts arranged in substantially parallel relationship and so positioned with respect to one another that upon rotation of said shafts substantially coplanar circles are described by said breaker arms, a bore hole auger mounted on at least one of said shafts in axial alignment therewith for drilling a bore hole in the material being mined in advance of said breaker arms, said auger and its associated shaft each being of tubular construction so as to provide a tubiform passage extending from the rear end of said shaft to the forward end of said auger, means for producing a blast of air or gas, means communicatively connecting said means with the passage at the rear end of said shaft, and means for advancing the machine toward the face of the material.

16. The mining machine of claim 15 wherein said blast producing means includes a cartridge fixed to the rear end of said shaft and rotatable therewith.

17. The mining machine of claim 16 including an air line supported on said frame, and a swivel fitting communicatively connecting said air line with said cartridge so as to permit said cartridge to rotate relative to said air line.

18. The mining machine of claim 17 including means for venting the air line to atmosphere after the cartridge has been charged to thereby discharge the cartridge and cause a blast of air or gas to issue from the forward end of said auger.

19. The mining machine of claim 8 wherein said kerf cutter includes a loop-shaped chain guide that is open in the center so as to provide room for expansion of the material when it is shot with the kerf cutter in place beneath the material.

References Cited in the file of this patent

UNITED STATES PATENTS

307,379	Craven	Oct. 28, 1884
1,315,271	Young	Sept. 9, 1919
1,408,975	Black	Mar. 7, 1922
1,603,621	McKinlay	Oct. 19, 1926
1,726,963	McKinlay	Sept. 3, 1929
2,083,981	Armstrong	June 15, 1937
2,151,328	Noble	Mar. 21, 1939
2,281,503	Levin	Apr. 28, 1942
2,520,040	Levin	Aug. 22, 1950
2,562,841	Compton	July 31, 1951
2,694,562	Synder et al.	Nov. 16, 1954