Jan. 4, 1938. G. L. BENNETT 2,104,579

METHOD OF AND APPARATUS FOR MINING COAL AND THE LIKE

Filed April 17, 1935 3 Sheets-Sheet 1

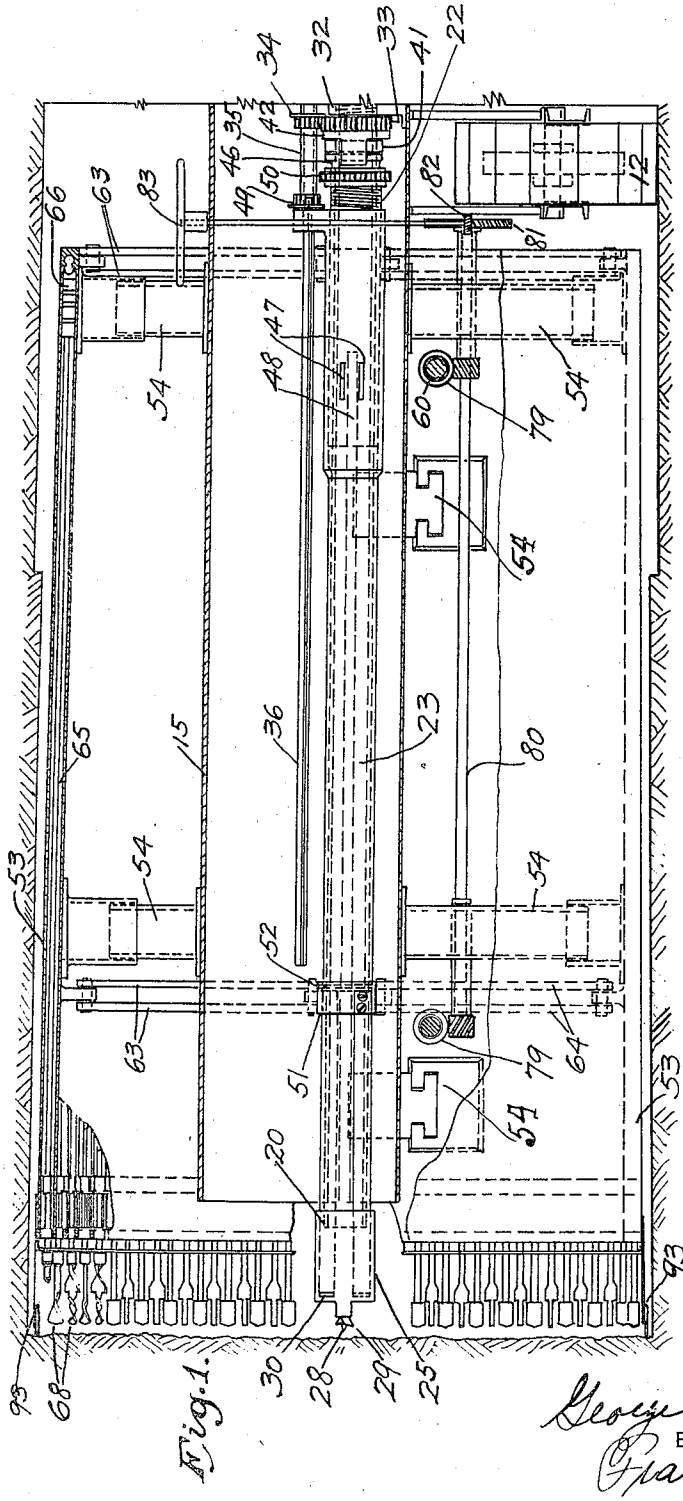


Fig. 1.

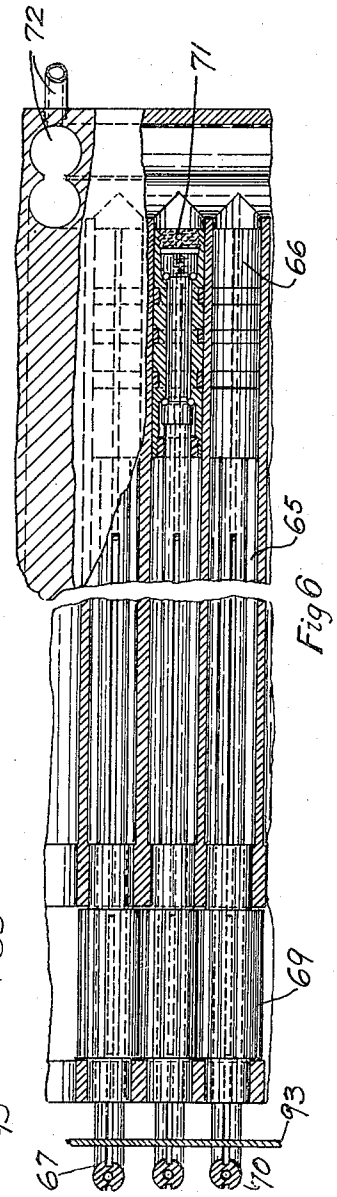


Fig. 6

INVENTOR

George L. Bennett

BY

Francis G. Wentworth

ATTORNEY.

Jan. 4, 1938. G. L. BENNETT 2,104,579

METHOD OF AND APPARATUS FOR MINING COAL AND THE LIKE

Filed April 17, 1935 3 Sheets-Sheet 2

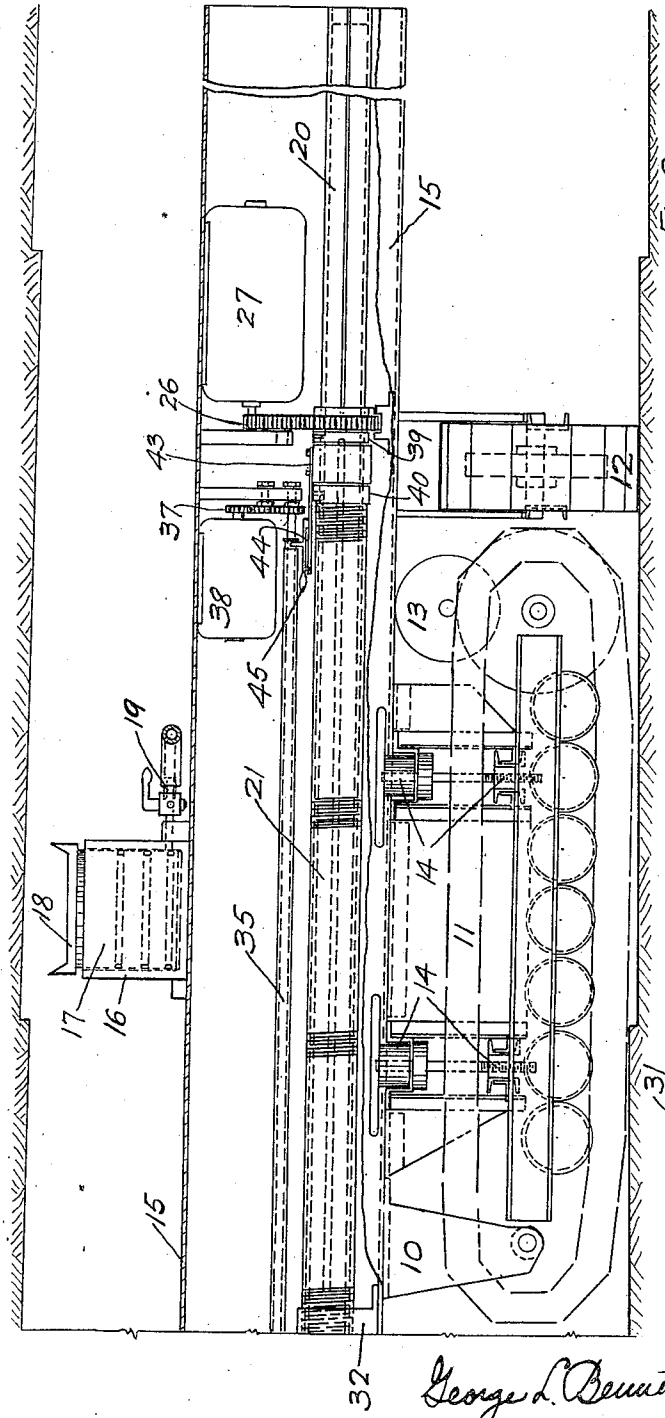


Fig 2

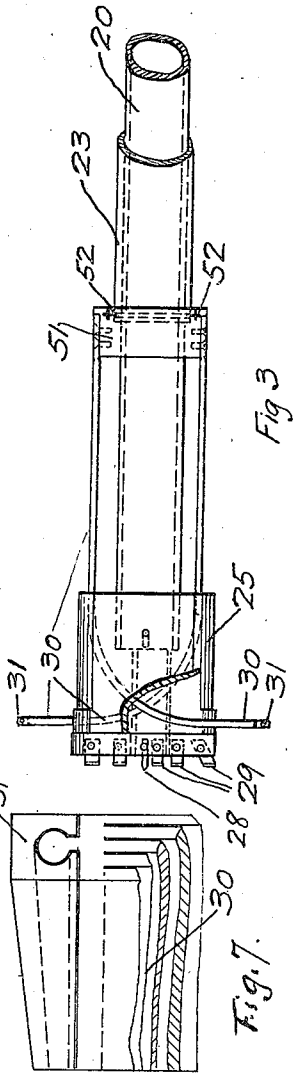


Fig 3

Fig 1.

George L. Bennett INVENTOR

By Francis V. Wentworth

ATTORNEY.

Jan. 4, 1938. G. L. BENNETT 2,104,579

METHOD OF AND APPARATUS FOR MINING COAL AND THE LIKE

Filed April 17, 1935 3 Sheets-Sheet 3

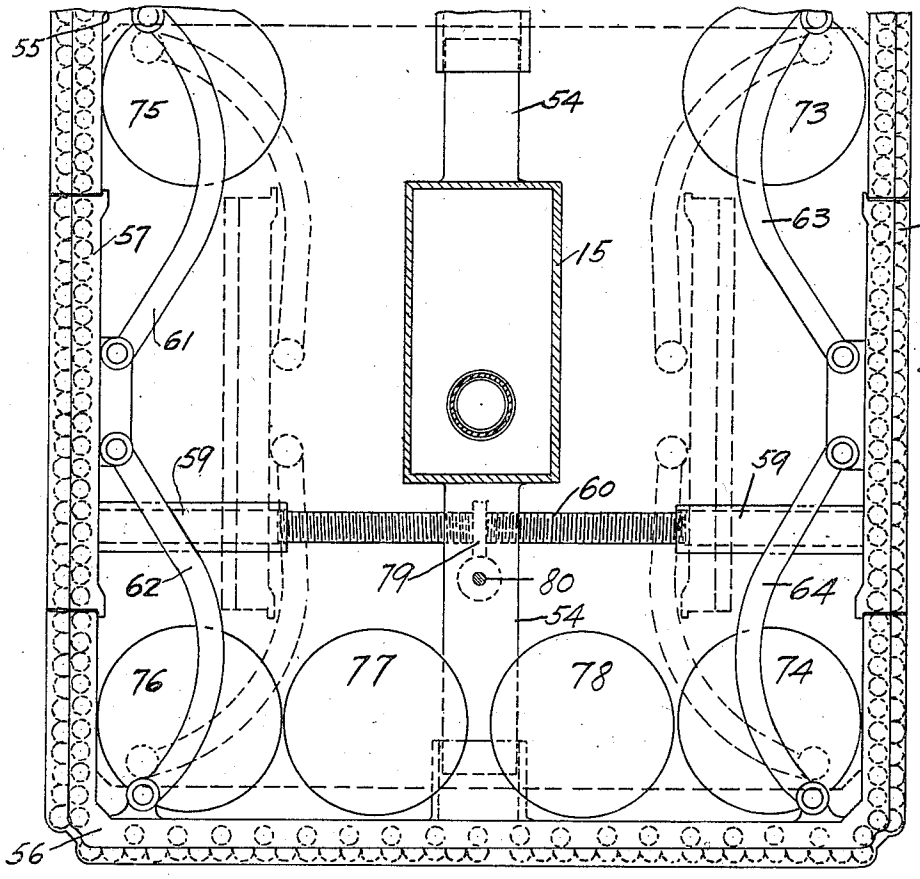


Fig. 5.

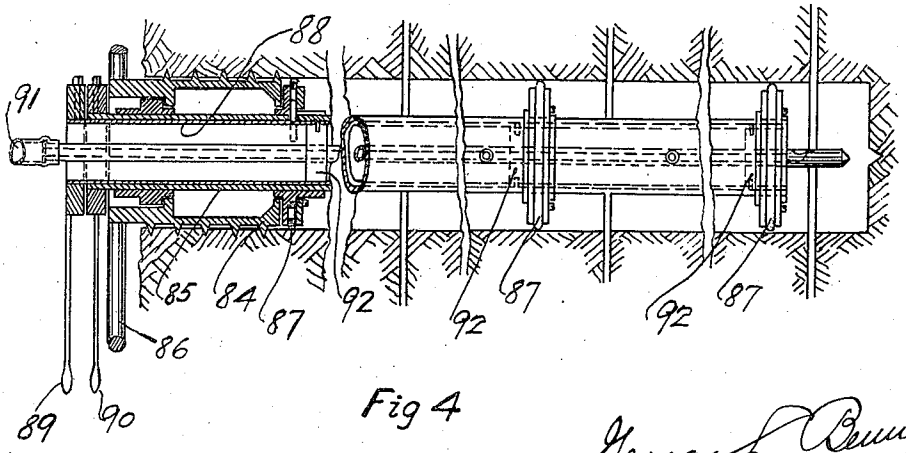


Fig 4

George L. Bennett
INVENTOR

BY Grant P. Wentworth
his ATTORNEY.

Patented Jan. 4, 1938 2,104,579

UNITED STATES PATENT OFFICE

2,104,579

METHOD OF AND APPARATUS FOR MINING COAL AND THE LIKE

George L. Bennett, Terre Haute, Ind.

Application April 17, 1935, Serial No. 16,792

16 Claims. (Cl. 262—4)

The invention relates to a method of, and apparatus for, mining coal and the like, and more particularly to a method which may be practiced without the use of explosives, and apparatus used in the practice of this method.

The invention will be described more particularly in its relation to coal mining which, notwithstanding that modern practices and machinery have reduced materially the dangers inherent thereto, is still a hazardous occupation.

In the mining of coal, the practice usually followed is to remove the coal from the seams in the galleries or in the rooms leading therefrom by approximately defining the volume of coal to be removed, undercutting and overcutting the seam adjacent the gallery or room floor and the top of the seam is resorted to, the undercut and overcut being approximately six inches in height, and in some instances being connected by vertical shears to reduce the wedging action of the coal upon its removal from the vein by a blasting operation. The holes for the explosive are then drilled, and the coal blasted from the seam by means of powder, dynamite or some other explosive. It is essential to remove the chain cutter from close proximity to the coal to be removed before the drilling operation, and to remove the drills before the blasting operation.

The coal removed by the blast is loaded upon the mine cars by a loading machine, said cars being moved either by mules or by an electric locomotive. The labor item in mining coal by present methods is high, and the wastage of coal because of the shattering of the mass removed by blasting is great, since the under and over cutting and the shearing result in a high percentage of small particles of coal compared with the mass removed from the seam during each blasting operation, and a considerable volume of small fragments results from the power exerted by the explosives. Furthermore, many of the larger pieces of coal are so shattered that they subsequently become disrupted by a contact with the outside atmosphere.

With the above conditions in mind, I have devised a method of mining coal and like material whereby the seam of coal is bored throughout a small area thereof to a desired depth and the bottom of this bore is counterbored or undercut to an extent to substantially define the width, height and thickness of the mass to be removed. After the boring and counterboring has been completed, the bore opening is sealed and a fluid under pressure is delivered to the counterboring, back reaming or undercutting, sufficient energy thus being exerted over a large area of coal to force the mass of coal outwardly of the seam.

It is preferable, to avoid unnecessary and undesirable fracturing of the coal as a result of the high pressure active throughout a considerable area thereof, to define the height and width of the mass of coal to be removed by piercing the seam of coal at a plurality of closely adjacent points about, and spaced from, the bore opening, thus weakening the top, bottom and side edges of the block or mass of coal to be removed. These piercings, however, are spaced from the counterbore, back reaming or undercutting sufficiently to avoid dissipation through said piercings of the force developed by the fluid pressure when separating the block or mass from the seam.

By this procedure, fracturing of the coal in the mass is reduced to a minimum, and yet there will be sufficient breakage to permit the loading of the mine cars and the conveyance of the mined coal from adjacent the seam in the usual manner. During the boring and counterboring, back reaming or undercutting in each block of coal to be removed, the chips may be conveyed from adjacent the opening being formed as such chips are produced, thus avoiding interference with the drilling and boring operations. Such chips may be deposited upon the floor of the gallery or may be delivered directly to conveyances, thus avoiding an accumulation of coal dust and small particles of coal about the apparatus being used. If delivered upon the floor of the gallery, they may be removed by shovel into the conveyances for removing them from the gallery.

In the practice of the method of the invention, I employ a special apparatus embodying therein a boring rod, the head of which has a center point and cutting tools upon the end thereof and radially expansible counterboring tools normally retracted within the bore head. The boring tool and the expansible counterboring tools are so actuated as to be simultaneously advanced through the body of the seam, the counterboring tools being capable of independent operation following the advancement of the bore tool to the desired point within the mass. In forming the counterbore, back reaming or undercut, the means for advancing the bore tool is made inoperative, and other mechanisms are thrown into gear to advance the expansible counterboring tools.

This apparatus embodies therein means whereby, concurrently with the boring of the mass in the manner above referred to, a plurality of drills defining the width and height of the block may be

actuated to pierce the coal or other material in the seam about the central bore opening and spaced therefrom a desired distance to prevent the piercings made by the gangs of drills from entering the counterbore or undercut.

The boring tool and the various drill rods must be axially collapsible to permit the moving of the apparatus during the progress of the mining operation; and the apparatus itself, notwithstanding that it possesses considerable weight, must be mobile to permit of sufficiently rapid succeeding operations of the apparatus to make the use thereof economical. It must also embody therein means for holding it immobile during the drilling and boring operations, particularly as in the operation of the apparatus the aggregate pressure developed in the operation of the bore and the various drills is considerable and displacement of the apparatus as a whole will interfere with the operation of the apparatus.

The invention consists in a method of mining coal and the like embodying therein the novel steps and practices, and in an apparatus for use in the practice of said method, all as hereinafter set forth and described and more particularly pointed out in the claims hereto appended.

Referring to the drawings,

Fig. 1 is a side elevation of the boring and drilling end of a machine;

Fig. 2 is a similar view of the opposite end of the machine;

Fig. 3 is a detail view of the head and adjacent parts of the boring and counterboring mechanism;

Fig. 4 is a detail view of the sealing-off and pressure applying mechanism;

Fig. 5 is a rear view of the drill frame;

Fig. 6 is a longitudinal view, partly in section, of one of the drill rods and its actuating mechanism disclosing the manner of advancing same; and

Fig. 7 is an enlarged view showing the separable cutting end **31**, attached to the supporting arm **30**.

Like numerals refer to like parts throughout the several views.

In practicing the method of the invention, I bore a hole substantially centrally of the face of a mass of coal or like material which is to be removed from a seam. The floor and the ceiling of the gallery define the limit of the vertical dimensions of this mass, and the depth of the mass is determined by the depth of the bore. When boring has proceeded to the desired depth, I counterbore, back ream or undercut the mass of coal to substantially define the width of the mass to be removed. It is preferable, during the boring operation, to deliver compressed air to the bore adjacent the boring head in a manner to force the chips and dust from the bore and from the undercut.

The central bore, after the completion of the boring and counterboring operation, is utilized to deliver fluid under heavy pressure into the counterbore, the diameter of said counterbore being sufficiently great to ensure a pressure area adequate to develop the force required to separate the mass from the seam as a result of the expansive force of the fluid within the restricted space of the counterbore. When delivering the fluid to the chamber resulting from the counterbore, back reaming or undercutting it is necessary to seal-off or plug the bore at the face of the seam.

The above steps of boring, counterboring, sealing-off or plugging and applying expansible pressure to the back of the mass to be removed may be adequate when the coal or other material is sufficiently soft to rupture readily, or, under certain conditions, where substantial regularity in the shape of the mass removed is not essential or desirable. With harder material and under other conditions, it may be desirable to limit the effective action of the expansible fluid, and to so weaken the top and sides of the mass to be removed as to ensure a limitation on the amount of material removed with each application of pressure.

When the above conditions are desirable, I define the height and width of the mass of coal to be removed, by a series of drill holes adjacent the floor and ceiling of the gallery and at the opposite sides of the mass. These drill holes are so located and of such a depth as to leave a sufficient barrier of coal or other material between the inner ends thereof and the counterbore, back ream or undercut to preclude the escape of the compressed fluid through these drill openings. The weakening of the material of the seam by the removal of the material along well defined lines, limits the resistance to the separation of the mass of coal or other material to the strength of the material between these drill holes and the counterbore, back ream or undercut. Preferably, the drill holes overlap to limit the dimensions of the connections between the mass to be removed, as defined by these openings, and the seam from which this mass is to be removed. This defining of the height and width of the mass to be removed, is done before sealing-off or plugging the center bore opening and delivering fluid under pressure to the chamber formed back of the mass to be removed.

By the above procedure, a mass of coal weighing approximately six long tons may be removed with each application of fluid pressure, and this coal will be in sufficiently large pieces to avoid wastage from the shattering of the coal. Yet these pieces will not be sufficiently large to preclude their proper loading in cars to be conveyed to breakers which will reduce them to a desired size of coal. In this manner, coal may be removed in a form which will give it the highest market value.

By using suitable apparatus, the complete removal of the mass of coal above referred to may be accomplished in between two and three minutes. Such apparatus is shown in the accompanying drawings.

The apparatus above referred to consists of a carriage **10** having two sets of caterpillar tractor mechanisms **11** and **12**, those of one set **11** extending perpendicular to those of the other set **12**. Each caterpillar track has its own motor as **13** so as to impart the desired mobility to the said carriage. The caterpillars of one set **11** are provided with a lift mechanism shown at **14** so that when the apparatus is being used for boring and drilling, these caterpillars may be raised out of contact with the floor of the gallery and the caterpillars of the other set **12** allowed to rest upon said floor. This will offer some resistance to movement of the carriage during the drilling and boring operation, although preferably it is not solely relied upon. When the caterpillars **11** are thus elevated, the carriage may be moved along the seam to permit successive boring and drilling of different portions of the seam.

Supported from said tractors is a hollow frame **15** supporting the boring and drilling mechanisms and inclosing same.

Upon the top of this frame is a pneumatic

cylinder 16 having a piston 17, the head of which carries a plate having a plurality of spurs or studs 18. A valve controlled air line 19 communicates with the cylinder 16 so as to permit the elevation or lowering of the piston 17 to engage or disengage the spurs or studs 18 with the roof of the gallery. Throughout the machine fairly high fluid pressure is used so that with a large area of piston 17, the chains or the treads of the tractors of the set 12 may not only be forced under great pressure against the floor of the gallery, but the spurs or studs 18 will be forced into the roof of the gallery in a manner to prevent any possible movement of the carriage during the boring and drilling operations.

The details of construction shown and above referred to are desirable in the apparatus, but it is obvious that any of the well known structures for imparting mobility to various kinds of different mechanisms may be employed, and that the cylinder 16 and its appurtenances could be dispensed with if sufficient weight were provided in the carriage structure. It is also obvious that other means of anchoring the carriage may be employed.

The carriage details above referred to are shown in Fig. 2 of the drawings and are embodied in one end of the apparatus.

Within the hollow frame 15 is a bore shaft 20, an exteriorly screw threaded bore shaft feed 21 loosely mounted upon said shaft toward one end thereof, a second exteriorly screw threaded counterbore feed 22 loosely mounted upon said bore shaft adjacent the forward end thereof, and a counterbore feed sleeve 23 non-rotatably mounted in relation to, but operative upon a rotary counterbore sleeve 24 carried by a bore head 25. The bore shaft 20 is connected directly with the bore head 25. Acting upon the bore shaft 20 through a gear train 26 is an electric motor 27, which during the boring operation, is continuously rotated at high speed.

The bore head 25 is provided with a center spur 28 and cutting tools 29 upon the face thereof. Also carried by the bore head 25 are expansible cutting or counterboring tools 30, which during the operative moment of the cutting tools 29 are retracted within the bore head 25, but which may be projected from the head during the counterboring operation when the tools 29 are inoperative, for the purpose of producing by a counterboring operation, a chamber of a diameter commensurate with the volume of coal to be removed from a seam, but of a capacity to permit the development of the desired expansible force of fluid pressure to separate the mass of coal from the seam.

The counterbore tools or blades 30 may take a variety of different forms, it being required, however, that they shall possess sufficient flexibility in at least one direction to permit their projection radially from the bore head, or their withdrawal within said head.

In the drawings, these counterboring tools are shown as being of a laminated flexible steel structure carrying a separable cutting end 31, so that said end may be removed and replaced to permit the sharpening of the counterbore tool from time to time or the substitution of new for worn cutter ends upon said tools.

The bore shaft feed sleeve 21 is mounted in a fixed nut 32 and has rigidly mounted thereon, a gear 33 for imparting rotary movement to said feed sleeve. The gear 33 is driven from a pinion 34 carried by a sleeve 35 splined or otherwise slidably mounted upon a guide shaft 36, counter to the shaft 20. The shaft 36 is driven by the gear train 37 from a low horsepower reversible motor 38. Carried by the bore shaft 20 are three collars 39, 40 and 41, the last of which is adjacent a forked plate 42 carried by the feed sleeve 21 adjacent the gear 33.

The application of power through the motor 27 to the bore shaft 20 merely rotates said bore shaft and the head 25. The bore shaft 20 is mounted in a bearing block 40 positioned between the collars 39 and 40 and connected by the mechanism 44 with the sleeve 35 so that this sleeve receives axial movement with the bore shaft 20. The mechanism 44 includes therein a shift lever 45 by means of which the sleeve 35 may be moved axially to disengage the pinion 34 from the gear 33 and thus interrupt forward movement of the bore shaft 20 and its head 25.

With rotation of the gear 33, the feed sleeve 21 acts upon the collar 41 through the yoke plate 42 to impart lineal traverse to the bore shaft 20, while said bore shaft is being rotated. During this period, travel is imparted through the yoke member 42 and a channelled collar 46, to the feed sleeve 22 and the counterbore sleeve 23, there being, however, during this interval, no movement of said sleeve 23 in relation to the shaft 20. The sleeve 23 is held against rotation by gibs 47 carried by the shaft 23 and acting in guide grooves 48 upon said housing 15.

Also carried by the sleeve 35 is a pinion 49 adapted to be enmeshed with a gear 50 carried by the counterbore feed screw sleeve 22 so that when this sleeve 35 is shifted by the lever 45, the gear 34 is moved out of mesh with the gear 33, thus interrupting the forward movement of the counterbore shaft while it is still rotating and the pinion 49 is enmeshed with the gear 50 to so turn the sleeve 22 as to impart lineal movement to the sleeve 23 for the purpose of projecting the counterbore cutters 30 from within the head. This occurs while the bore shaft 20 is still rotating.

The hollow stem or sleeve 24 of the tool head 25 rotates with the bore shaft 20, and is connected with the sleeve 23 by a joint permitting rotation of the sleeve 24 in relation to said sleeve 23.

A detailed description of the counterbore mechanism follows:

The cutter blades 30 are rigidly mounted on a blade clamp member 51 slidably mounted upon the bore shaft 20 so as to be capable of movement toward and from the bore head 25. This clamp member is provided with feathers 52 entering a groove in the end of the shaft 23.

As stated above, the counterbore tools are preferably made of strips of flexible steel, two such tools being used. Said counterbore tools are positioned upon opposite sides of the longitudinal center of the bore head to provide necessary clearance for the movement of the tools during the counterboring operation. The strips of steel of which these boring tools are made are of sufficient width to impart thereto the desired rigidity in the direction of their angular movement. These tools are of a length to be projected beyond the head 25 to permit counterboring to the desired diameter, and the screw threads upon the sleeve 22 and the speed of rotation of said sleeve are such as to secure a gradual outward movement of the counterbore tools in proportion to the cutting speed possible with such tools. Of course, such speed is capable of considerable variation in

adapting the machine for work upon materials in which the resistance to the tools varies.

As heretofore stated, it may be desirable in some mining operations to outline the mass of coal to be removed by a plurality of drill holes for the purpose of weakening the coal or other material to an extent to limit the expansive force required to separate a mass of coal from the seam, or to prevent excessive fracturing of the coal due to the development of such high pressure.

With this in mind, I have provided a rectangular drill head 53 mounted upon the housing 15 by means of supports 54. The frame of this housing is made in four sections, a top section 55, a bottom section 56 and side sections 57 and 58. These side sections are provided respectively with interiorly screw threaded bosses 59, co-operating with which is a lead screw 60, the opposite ends of which have threads oppositely pitched. The top and bottom sections are connected with the side sections 57 and 58 by links 61, 62, 63 and 64, so that when the side sections are drawn inwardly, the top and bottom sections will be moved toward each other, these parts being slidably mounted upon the supports 54.

Toward one end of the top, bottom and side members of the frame, cylinders 65 are formed, these cylinders being closely adjacent each other. Each of these cylinders has a piston 66 therein, the stem of each piston supporting a drill rod 67.

Each of the piston stems, toward the forward end thereof, in which end the drills 68 are mounted, is acted upon by a gear 69, a plurality of gears being enmeshed with each other, and different groups of gears being simultaneously driven from independent motors. Each gear 69 is splined to a piston stem 67 so as to permit axial movement of the piston stems and of the drills, as the drilling operation progresses. The various piston stems or drill rods have an axial opening 70 therethrough, and each piston preferably has a check valve 71 permitting air to pass from the cylinders through the rods for the purpose of removing chips during the drilling operation. The use of pneumatic pressure for advancing the drills is desirable, in that it permits a variable operation of the different drills to permit them to adjust themselves to varying resistances encountered during the drilling operation. Each cylinder has an air supply pipe 72.

The motors actuating the drills are shown at 73, 74, 75, 76, 77 and 78.

The particular manner of applying power to the various drills is largely a matter of engineering design. Due to the large number of drills, however, and the movability of different sections of the main frame supporting the drills, a plurality of motors is necessary, these motors being movable with the frame part with which they are associated.

There is one lead screw 60 adjacent each pair of supports 54, and each of these lead screws carries a worm wheel 79 enmeshed with worm wheels upon a shaft 80, which shaft carries a main gear wheel 81 enmeshed with a worm wheel 82 upon a hand operated shaft 83. By turning this shaft 83, it is possible to partially collapse the drill frame when it is desired to move the apparatus as a whole preparatory to succeeding boring and drilling operations.

As will more fully appear hereinafter, after the boring, counterboring and drilling operations, when the latter is resorted to, the bore opening is closed by means of an exteriorly screw threaded plug 84 having well spaced threads which, by biting into the material adjacent the end of the bore, will prevent displacement of the plug. This plug is mounted upon a tube 85 and is actuated by a hand wheel 86. This outer tube also carries a plurality of packing rings 87 adapted to be expanded by means of an inner tube 88, the inner and the outer tubes being actuated by means of handles 89 and 90, relative movement of such tubes causing expansion of the packing rings.

Passing through the inner tube 88 is an air line 91 having an outlet opening beyond a stuffing box 92. With this construction of sealing off mechanism it is possible to deliver compressed air to the bore closely adjacent the counterbore and prevent any blow-out through the bore.

In the practice of the method of the invention, a hole is bored by means of the cutting tools 29, substantially centrally of a mass of coal or other mineral to be removed. When this hole has been bored to the desired depth, the inner end of the hole is enlarged by counterboring, thus forming a shallow chamber of fairly large diameter well within the seam. If outline drilling is not to be resorted to, after the removal of the boring apparatus, the bore opening, at the face of the seam, is sealed or plugged and air or other fluid under heavy pressure is delivered through the seal or plug into the counterbore chamber, the expansive power of this fluid forcing a mass of coal forwardly of the counterbore into the gallery or chamber. The expansive force of the fluid is sufficiently great to break up the mass of coal thus forced from the seam, but without undue fracturing of the larger particles thereof.

By outlining the mass to be removed by drilling in the manner above described, the force required to separate a mass of coal is less than without such drilling, and consequently the degree of fracturing of the coal is much less than when the outline drilling is not resorted to.

The operation of the herein described apparatus is substantially as follows:

The tractors 11 are raised out of contact with the floor of a gallery, and the tractors 12 are used to move the apparatus sidewise along the gallery until the face of the seam to be worked upon is reached. The mechanisms 14 are then actuated to force the tractors 11 into contact with the gallery floor and raise the whole apparatus, including the tractors 12 to permit movement of the carriage toward the seam. The tractors 11 are then raised and air is admitted to the cylinder 16 driving the spurs or spuds 18 into the ceiling of the gallery, thus effecting the anchoring of the carriage in position. Before admitting air to the cylinder 16, the tractors 11 are used to force the bore head 25 into contact with the face of the seam.

When an outline drilling mechanism is used in the apparatus, the frame of this mechanism will be collapsed during this handling of the apparatus, but after the apparatus has been positioned, the drill frame will be expanded so as to bring the top drills close to the ceiling of the gallery and the bottom drills close to the floor thereof. The drill frame, as to its forward edge, will be spaced somewhat from the face of the seam and a substantially airtight shield positioned between this frame and said face. Such a shield is shown at 93 in the drawings.

The various motors of the apparatus are then energized so as to have the boring and drilling occur at the same time followed by counterboring. Power from the motor 27 is used solely

to rotate the boring shaft 20. Power from the motor 38 is used successively to advance the drill rod 20 and its head 25 as boring progresses; to actuate the feed sleeve 22 upon the completion of the boring operation and during counterboring, and to retract the bore shaft and counterboring tools. As the bore shaft is advanced through the action of the collar 41 adjacent the gear 33, the sleeve 23 will also be advanced by the yoke plate 42 and the feed sleeve 22 carrying the gear 50.

After the completion of the counterboring operation the motor 38 is reversed while the pinion 49 is still enmeshed with the gear 50, thus withdrawing the counterbore blades 30 within the bore head 25. When these blades have been fully withdrawn, and while the motor 38 is still operating in reverse, the sleeve 35 is shifted to enmesh the pinion 34 with the gear 33 and thus reverse the movement of the feed sleeve 21 so as to withdraw the bore head 25 from within the mass of coal or other mineral.

When the outlining drills are used during the boring operation, electric power from the various motors operative upon the numerous drill rods or piston stems will rotate these drills at high speed, air admitted to the cylinders 65 advancing the numerous drill rods so as to ensure a continuous drilling operation. If any drill meets greater resistance than other drills, the pressure in the cylinder will be maintained so as to advance that drill as rapidly as the drilling operation will permit. Air passing through the drill rods will blow out chips and dust, the shield 93 preventing the escape of this dust into the gallery or chamber.

After the completion of the drilling operations, sub-atmospheric pressure is developed in the various cylinders so as to withdraw the drills, the various cylinders being open at their forward ends for the admission of air to the cylinders for this purpose. Upon the completion of the boring and drilling, and after the various parts have been, as described, restored to their original position, the tractors 12 are used to move the apparatus a sufficient distance to permit it to operate upon an adjoining section of the seam. When this operation has been repeated a number of times, the seal or plug 84 with the two tubes 85 and 86 is mounted in the bore opening, and air under pressure is introduced to the counterbore chamber to force a mass of coal or other material outwardly of the seam into the gallery or chamber as a result of the expansion of this air and the gradual development of sufficient force to break the material from the seam.

It is obvious that the use of outline drilling will greatly facilitate the separation of this mass of coal from a seam with less fracturing of the coal in the mass. Under some conditions, however, the drilling mechanism will make the handling of the device more difficult and impart thereto a weight beyond what is desirable in the apparatus. Under such conditions, outline drilling need not be resorted to, and the drilling mechanism may be removed from the apparatus or may not be incorporated therein. Under such circumstances, boring and counterboring only may be resorted to, and this may be effectively used to effect the removal of coal in lumps sufficiently large to permit the subsequent reduction of these lumps to desired commercial sizes by means of ordinary breakers. The amount of small sized coal and dust, even when boring and counterboring alone are relied upon, will be relatively small as compared with the use of dynamite or blasting powders or other well known mining methods.

It is obvious that when there has been a succession of boring and counterboring operations before the separation of any coal from the seam the volume of coal defined by each counterbore or by outline drilling, when such is used, may be readily removed without the loss of any substantial pressure because of adjacent counterboring, since the mass of material between counterboring will be sufficiently great to prevent the fracture of the coal along lines connecting such counterborings.

By means of an apparatus embodying the invention, coal may be removed very rapidly from a seam.

The time required to shift the apparatus along the face of the seam is not great, and, in the machine shown in the drawings, the boring and counterboring operations, and the drilling operation when such is resorted to, are carried on at high speeds. It is estimated that the complete boring, drilling and shifting operation will occupy about three and one half minutes, so that with one man operating the apparatus and another man operating the air pressure and plug mechanism, fifteen blocks of coal per hour may be separated from the seam. The tonnage per hour, of course, will vary with the size of the blocks removed.

The rapidity with which the work may be done permits the removal of coal from a seam more economically than with the use of explosive agencies, and the removal of such coal without the introduction of those hazards attendant upon the use of explosives. Furthermore, the quality of the coal mined by means of the method of the apparatus of the invention will be superior to that in which explosives are used during mining. The wastage of coal is also materially less than with the older methods.

The method of the invention involves the separation of coal in a mass, defined by a narrow counterbore chamber positioned well within the seam, by means of a progressively increasing expansive force, as distinguished from an explosive force. While breakage of the coal will occur as a mass thereof is being forced from a seam, the extent of this breakage is not comparable with that incidental to the mining of coal by explosives.

As fast as the boring and drilling is completed, air may be delivered to the counterbore chamber for "pushing" a mass of coal into the chamber or gallery, thus enabling a gang of two or three men to work continuously in separating the coal from the seam, this separation being sufficiently rapid to ensure high economy. After the separation of the coal from the seam it is loaded in cars and removed from the mine in the usual manner, subsequent sizing of the coal being accomplished by machinery well known in coal mining.

It is not my intention to limit the invention to the precise details of construction shown in the accompanying drawings, it being apparent that the structure of the apparatus shown is subject to wide variation without departing from the spirit and scope of the invention.

The essential characteristic of the method is the formation of a narrow counterbore chamber of fairly large diameter having a central bore leading in from the face of the seam and communicating with said chamber so as to permit the introducing of air under high pressure to said chamber, and utilization of the expansive force of the air to gradually separate a mass of the material being mined from the seam.

As stated, outlining drills may be used to better control the volume of coal removed with each application of compressed air to a counterbore chamber, so as to minimize the expansive force required to separate a mass of coal from the seam, and at the same time permit the removal of the coal in larger pieces than when the exertion of greater force is required.

Having described the invention, what I claim as new and desire to have protected by Letters Patent, is:—

1. The herein described method of mining coal and the like embodying therein the steps of boring a hole into a seam of the material to be mined, forming a narrow counterbore at the end of said bore, said counterbore being of a diameter substantially equal to the width and height of the mass of coal to be removed, plugging the outer end of said bore, and delivering fluid under pressure through said bore to said counterbore, whereby the expansive force of said fluid pressure will separate the material from the seam.

2. The herein described method of mining coal and the like embodying therein the steps of boring a hole into a seam of the material to be mined, forming a narrow counterbore at the end of said bore, said counterbore being of a diameter substantially equal to the width and height of the mass of coal to be removed, plugging the outer end of said bore, and delivering compressed air through said bore to said counterbore, whereby the expansive force of said compressed air will separate the material from the seam.

3. The herein described method of mining coal and the like embodying therein the steps of boring a hole into a seam of the material to be mined, forming a narrow counterbore at the end of said bore, said counterbore being of a diameter substantially equal to the width and height of the mass of coal to be removed, defining the other two dimensions of the mass of coal to be removed by a plurality of outlining drill holes, plugging the outer end of said bore, and delivering fluid under pressure through said bore to said counterbore, whereby the expansive force of said fluid pressure will separate the material from the seam.

4. The herein described method of mining coal and the like embodying therein the steps of boring a hole into a seam of the material to be mined, forming a narrow counterbore at the end of said bore, said counterbore being of a diameter substantially equal to the width and height of the mass of coal to be removed, defining the other two dimensions of the mass of coal to be removed by a plurality of outlining drill holes, plugging the outer end of said bore, and delivering compressed air through said bore to said counterbore, whereby the expansive force of said compressed air will separate the material from the seam.

5. Apparatus for mining coal embodying therein a mobile carriage, a bore shaft mounted therein, means rotating said shaft, a bore head carried by said shaft having cutting tools on the end thereof, and expansible counterboring tools adapted to be projected radially of said head, means imparting feeding movement to said bore shaft during the boring operation, means whereby the feeding movement of said shaft may be interrupted, a movable support for said counterboring tools, means moving said support axially of said bore shaft, and a reversible power mechanism acting upon said means imparting feeding movement to said bore shaft, and said means moving said counterbore support axially of said bore shaft.

6. Apparatus for mining coal embodying therein a mobile carriage, a bore shaft mounted therein, means rotating said shaft, a bore head carried by said shaft having cutting tools on the end thereof, and expansible counterboring tools adapted to be projected radially of said head, an exteriorly screw threaded feed sleeve rotatably mounted upon said bore shaft, a fixed nut enmeshed with said sleeve, a gear carried by said sleeve, collars upon said bore shaft engageable by said sleeve, whereby rotation of said sleeve will impart axial movement to said bore shaft during the boring operation, a movable support for said counterboring tools, a rotatable exteriorly screw threaded sleeve upon said bore shaft, a gear carried thereby, an axially movable sleeve acted upon by said last named screw threaded sleeve and operative upon said movable support, a rotatable counter shaft, a reversible power mechanism acting therefor upon said shaft, a sleeve slidably mounted upon said counter shaft, pinions upon said sleeve, and means whereby said pinions may be selectively engaged with the gears upon said screw threaded sleeves.

7. Apparatus for mining coal embodying therein a mobile carriage, a bore shaft mounted therein, means rotating said shaft, a bore head carried by said shaft having cutting tools on the end thereof, said head having an axially and radially extending opening therethrough, a laminated counterboring tool, flexible in one direction only, mounted in said opening, means whereby said tool may have gradual longitudinal movement imparted thereto to project the cutting end thereof radially of said head, means imparting feeding movement to said bore shaft during the boring operation, means whereby the feeding movement of said shaft may be interrupted, a movable support for said counterboring tool, means moving said support axially of said bore shaft, and a reversible power mechanism acting upon said means imparting feeding movement to said bore shaft, and said means moving said counterbore support axially of said bore shaft.

8. Apparatus for mining coal embodying therein a mobile carriage, a bore shaft mounted therein, means rotating said shaft, a bore head carried by said shaft having cutting tools on the end thereof, said head having an axially and radially extending opening therethrough, a laminated counterboring tool, flexible in one direction only, mounted in said opening, means whereby said tool may have gradual longitudinal movement imparted thereto to project the cutting end thereof radially of said head, an exteriorly screw threaded feed sleeve rotatably mounted upon said bore shaft, a gear carried by said sleeve, collars upon said bore shaft engageable by said sleeve, whereby rotation of said sleeve will impart axial movement to said bore shaft during the boring operation, a movable support for said counterboring tool, a rotatable exteriorly screw threaded sleeve upon said bore shaft, a gear carried thereby, an axially movable sleeve acted upon by said last named screw threaded sleeve and operative upon said movable support, a rotatable counter shaft, a reversible power mechanism acting upon said counter shaft, a sleeve slidably mounted upon said counter shaft, pinions upon said sleeve, and means whereby said pinions may be selectively engaged with the gears upon said screw threaded sleeves.

9. Apparatus for mining coal embodying therein a mobile carriage, a bore shaft mounted therein, means rotating said shaft, a bore head car-

ried by said shaft having cutting tools on the end thereof, and expansible counterboring tools adapted to be projected radially of said head, means imparting feeding movement to said bore shaft during the boring operation, means whereby the feeding movement of said shaft may be interrupted, a movable support for said counterboring tools, means moving said support axially of said bore shaft, a reversible power mechanism acting upon said means imparting feeding movement to said bore shaft, and said means moving said counterbore support axially of said bore shaft, anchoring means carried by said carriage, and means for actuating said anchoring means to engage same with the ceiling of a gallery or chamber to develop downward pressure upon said carriage.

10. Apparatus for mining coal embodying therein a mobile carriage, a bore shaft mounted therein, means rotating said shaft, a bore head carried by said shaft having cutting tools on the end thereof, and expansible counterboring tools adapted to be projected radially of said head, means imparting feeding movement to said bore shaft during the boring operation, means whereby the feeding movement of said shaft may be interrupted, a movable support for said counterboring tools, means moving said support axially of said bore shaft, a reversible power mechanism acting upon said means imparting feeding movement to said bore shaft, and said means moving said counterbore support axially of said bore shaft, a pneumatic cylinder at the top of said carriage, a piston within said cylinder, a plate carried by said piston having a plurality of upwardly directed spurs engageable with the ceiling of a gallery or chamber, and means whereby fluid pressure may be delivered to said cylinder to force said spurs outwardly of said cylinder and develop downward pressure upon said carriage.

11. Apparatus for mining coal embodying therein a mobile carriage, a plurality of right angularly arranged tractors supporting said carriage, means whereby some of said tractors may be vertically moved to permit movement of said carriage parallel with, or at right angles to, the face of a seam, a bore shaft mounted therein, means rotating said shaft, a bore head carried by said shaft having cutting tools on the end thereof, and expansible counterboring tools adapted to be projected radially of said head, means imparting feeding movement to said bore shaft during the boring operation, means whereby the feeding movement of said shaft may be interrupted, a movable support for said counterboring tools, means moving said support axially of said bore shaft, and a reversible bore mechanism acting upon said means imparting feeding movement to said bore shaft, and said means moving said counterbore support axially of said bore shaft.

12. Apparatus for mining coal embodying therein a mobile carriage, a bore shaft mounted therein, means rotating said shaft, a bore head carried by said shaft having cutting tools on the end thereof, and expansible counterboring tools adapted to be projected radially of said head, means imparting feeding movement to said bore shaft during the boring operation, means whereby the feeding movement of said shaft may be interrupted, a movable support for said counterboring tools, means moving said support axially of said bore shaft, a reversible power mechanism acting upon said means imparting feeding movement to said bore shaft, and said means moving said counterbore support axially of said bore shaft, an outlining drill frame, a plurality of adjacent drills carried by said frame, means rotating said drills, means whereby said frame is mounted in relation to said bore shaft, and means simultaneously applying power to all of said drills to advance them during the drilling operation.

13. Apparatus for mining coal embodying therein a mobile carriage, a bore shaft mounted therein, means rotating said shaft, a bore head carried by said shaft having cutting tools on the end thereof, and expansible counterboring tools adapted to be projected radially of said head, means imparting feeding movement to said bore shaft during the boring operation, means whereby the feeding movement of said shaft may be interrupted, a movable support for said counterboring tools, means moving said support axially of said bore shaft, a reversible power mechanism acting upon said means imparting feeding movement to said bore shaft, and said means moving said counterbore support axially of said bore shaft, an outlining drill frame supporting a plurality of adjacent cylinders, a piston in each cylinder, a drill rod carried by each piston, means whereby fluid pressure may be admitted to said cylinders to advance said drill rods during the drilling operation, means simultaneously rotating said drills, and means whereby said frame is mounted in relation to said bore shaft.

14. Apparatus for mining coal embodying therein a mobile carriage, a bore shaft mounted therein, means rotating said shaft, a bore head carried by said shaft having cutting tools on the end thereof, and expansible counterboring tools adapted to be projected radially of said head, means imparting feeding movement to said bore shaft during the boring operation, means whereby the feeding movement of said shaft may be interrupted, a movable support for said counterboring tools, means moving said support axially of said bore shaft, a reversible power mechanism acting upon said means imparting feeding movement to said bore shaft, and said means moving said counterbore support axially of said bore shaft, an outlining drill frame supporting a plurality of adjacent cylinders, a piston in each cylinder, a drill rod carried by each piston, means whereby fluid pressure may be admitted to said cylinders to advance said drill rods during the drilling operation, means simultaneously rotating said drills, a valve controlled opening axially of each said piston and each said drill rod, the opposite ends of which open into said cylinders and outwardly of the drill rod adjacent the drills, whereby chips will be removed from the drill opening during the drilling operation, and means whereby said frame is mounted in relation to said bore shaft.

15. Apparatus for mining coal embodying therein a mobile carriage, a bore shaft mounted therein, means rotating said shaft, a bore head carried by said shaft having cutting tools on the end thereof, and expansible counterboring tools adapted to be projected radially of said head, means imparting feeding movement to said bore shaft during the boring operation, means whereby the feeding movement of said shaft may be interrupted, a movable support for said counterboring tools, means moving said support axially of said bore shaft, a reversible power mechanism acting upon said means imparting feeding movement to said bore shaft, and said means moving said counterbore support axially of said bore shaft, an outlining drill frame supporting a plurality of adjacent cylinders, a piston in each cylinder, a drill rod carried by each piston, means

whereby fluid pressure may be admitted to said cylinders to advance said drill rods during the drilling operation, means simultaneously rotating said drills, an opening axially of each said piston and each said drill rod, the opposite ends of which open into said cylinders and outwardly of the drill rod adjacent the drills, whereby chips will be removed from the drill opening during the drilling operation, a check valve controlling each said opening, whereby sub-atmospheric pressure may be developed in each cylinder to retract a drill, and means whereby said frame is mounted in relation to said bore shaft.

16. Apparatus for mining coal embodying therein a mobile carriage, a bore shaft mounted therein, means rotating said shaft, a bore head carried by said shaft having cutting tools on the end thereof, and expansible counterboring tools adapted to be projected radially of said head, means imparting feeding movement to said bore shaft during the boring operation, means whereby the feeding movement of said shaft may be interrupted, a movable support for said counterboring tools, means moving said support axially of said bore shaft, a reversible power mechanism acting upon said means imparting feeding movement to said bore shaft, and said means moving said counterbore support axially of said bore shaft, an outlining drill frame, said drill frame comprising a plurality of relatively movable sections, means whereby said sections may be actuated to collapse said drill frame to permit some of said drills to be positioned adjacent the floor and adjacent the ceiling of a gallery or chamber or to be withdrawn toward the bore shaft to permit movement of the carriage, a plurality of adjacent drills carried by said frame, means rotating said drills, means whereby said frame is mounted in relation to said bore shaft, and means simultaneously applying power to all of said drills to advance them during the drilling operation.

GEORGE L. BENNETT.