

United States Patent [19]**Poundstone**[11] **B 3,922,015**[45] **Nov. 25, 1975**

- [54] **METHOD OF MINING WITH A PROGRAMMED PROFILE GUIDE FOR A MINING MACHINE**
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- [73] Assignee: **Consolidation Coal Company**, Pittsburgh, Pa.
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- [44] Published under the Trial Voluntary Protest Program on January 28, 1975 as document no. B 425,345.
- [52] U.S. Cl. **299/1; 175/50; 175/62; 175/94; 235/151.1; 299/12; 299/18; 299/30**
- [51] Int. Cl.² **E21C 41/00**
- [58] Field of Search **299/1, 10, 12; 235/151.11, 235/151.1**

[56] **References Cited****UNITED STATES PATENTS**

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|-----------|---------|------------------|-------|
| 3,232,688 | 2/1966 | Moon..... | 299/1 |
| 3,485,531 | 12/1969 | Risse et al..... | 299/1 |

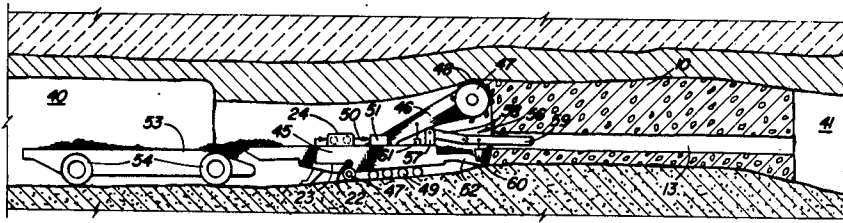
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[57]

ABSTRACT

A method for mining a mineral deposit underground in a vein having an underburden and an overburden which comprises boring a pilot hole into the vein between the underburden and the overburden. The thickness of the material is then measured at predetermined distances along the pilot hole, between the pilot hole and the overburden, and between the pilot hole and the underburden. The information measured is stored in a storage mechanism which relates the measurements to the distance in the borehole. A mining machine is then controlled in accordance with the distance between the borehole and the overburden, and the borehole and the underburden.

The invention further contemplates a method of mining where the tunnel being mined is sealed off and filled with an inert atmosphere. This method will provide an explosion-free environment during the mining operation.

6 Claims, 6 Drawing Figures

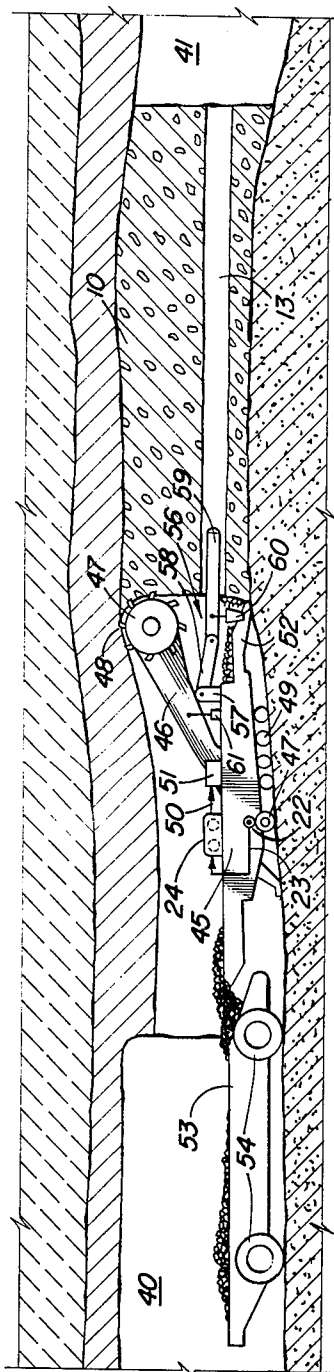


FIG. 3

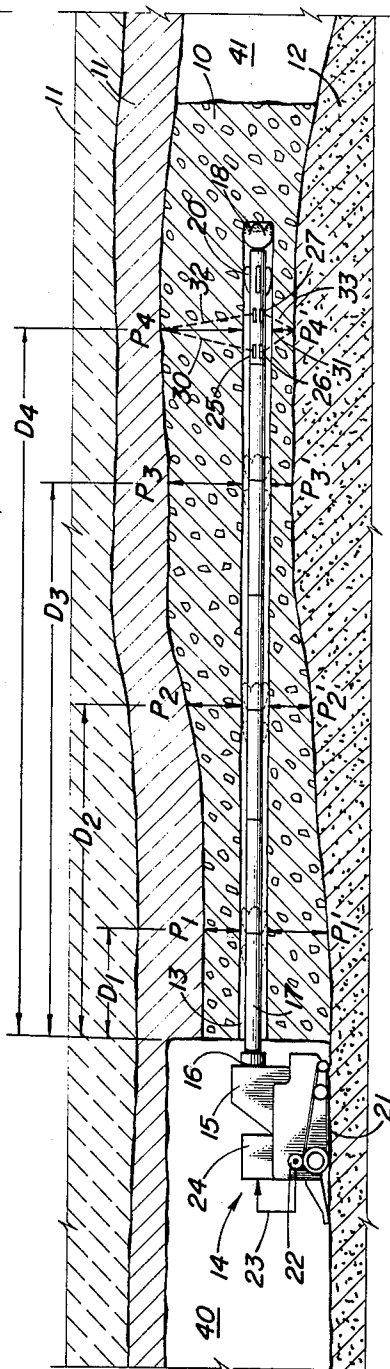


FIG. 1

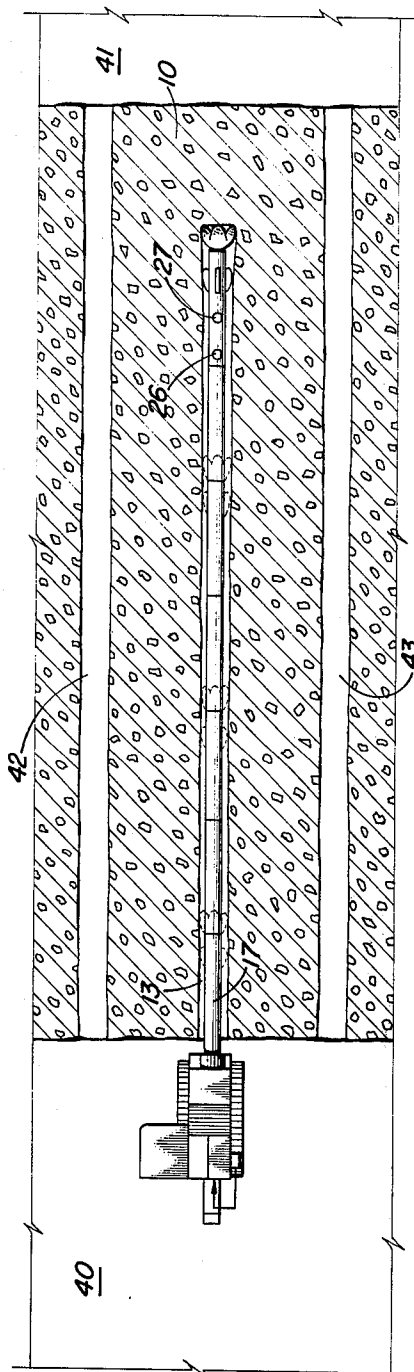


FIG. 2

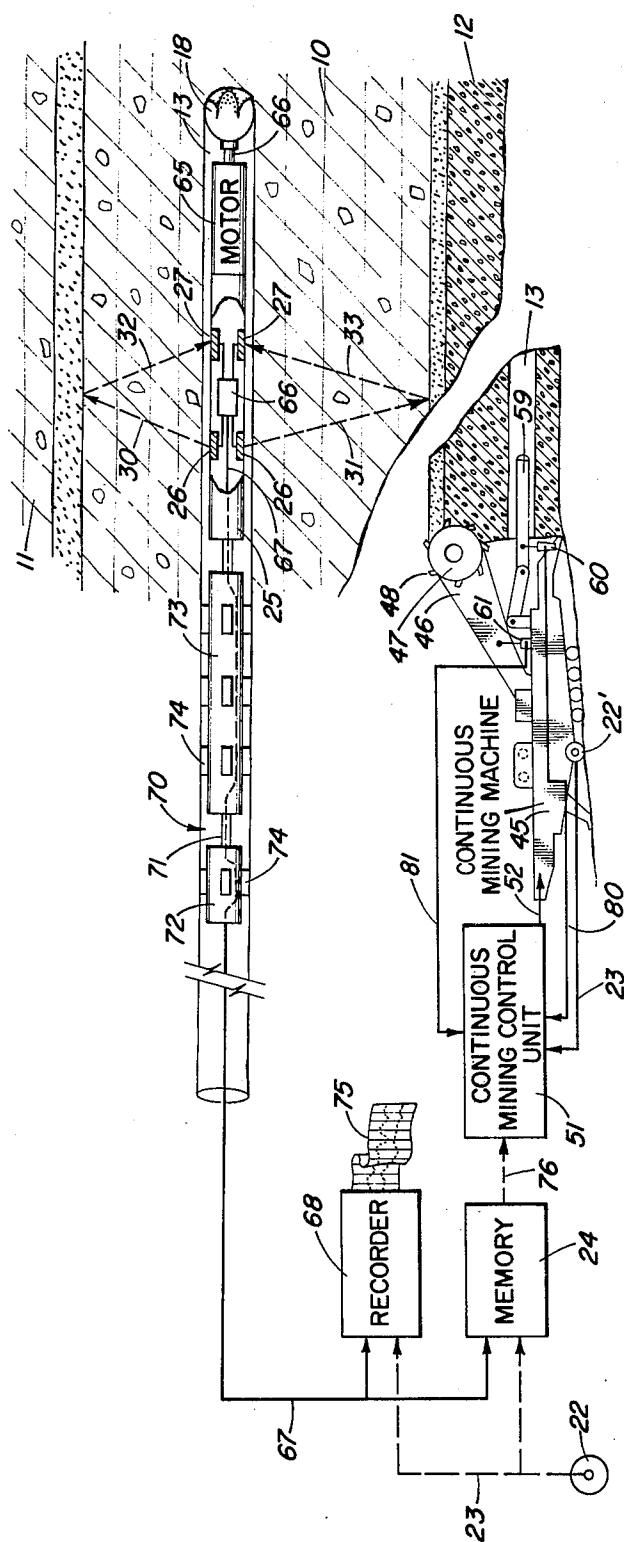


Fig. 4

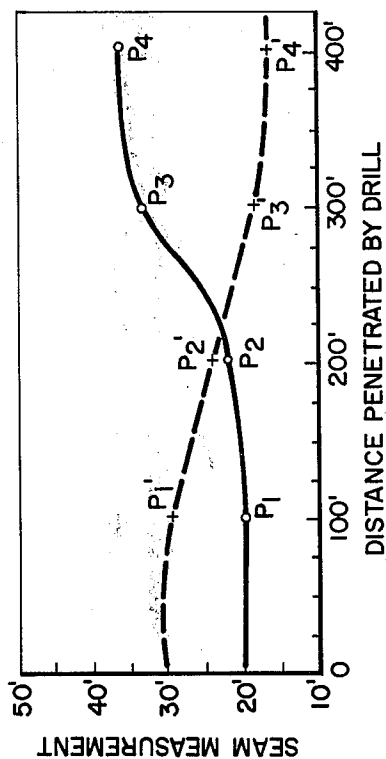


Fig. 5

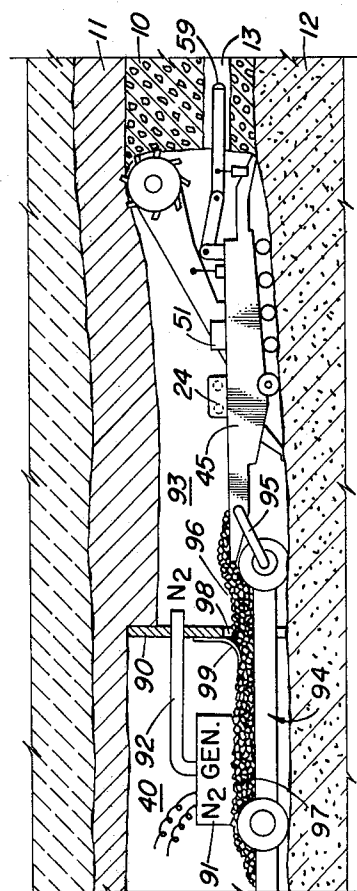


Fig. 6

METHOD OF MINING WITH A PROGRAMMED PROFILE GUIDE FOR A MINING MACHINE

BRIEF DESCRIPTION OF THE PRIOR ART

Controlled mining machines are well known in the art. The patents to Risse et al., No. 3,485,531; Moon, No. 3,232,688; Hartley et al., No. 3,294,449; and Carnegie, No. 3,362,750, are exemplary of those type patents relating to controlled mining machines. For example, in the patent to Moon, the mining machine is constructed to include a control system for operating the mining machine from a position that is remotely located with respect to the mine face. The patent to Hartley et al includes means for measuring the coal thickness on the mining machine as the mining machine progresses into the coal face and includes means for adjusting the operation of the mining machine in accordance with the thickness thus measured.

The patent to Carnegie discloses a coal digging machine which includes a preset programmer in which is stored information regarding the height of the cutting machine according to its position along the working face. The programmer compares the actual height of the cutting machine with the programmed height according to the distance of the cutting machine from the predetermined location, such as a roadway. Any error is transmitted to a comparator which corrects the height to the predetermined distance of travel of the cutting machine. The patent also contemplates an information storage device which takes the information from an initial run and utilizes this information on subsequent runs.

The patent to Risse et al also discloses a tape-controlled preprogrammed mining machine; however, the tape in this machine is more for modifying the particular type bore cutting than it is the operation of the mining machine along a predetermined direction.

BRIEF DESCRIPTION OF THE INVENTION

This invention contemplates a method for mining a material such as coal which is deposited underground in a vein having an overburden and an underburden. The method essentially consists of boring a pilot hole into the vein between the underburden and the overburden. At predetermined distances along the bored hole, the thickness of the vein is determined by use of a radioactive source and a radioactive detector inserted into the hole. The radiation received from the radioactive source which is back scattered from the interface between the coal for example and the overburden will be an indication of the thickness of the coal. It is also known that the shale between the coal and the overburden is self-radioactive; therefore, a radioactive detector alone can be inserted into the hole and the thickness of the coal measured by comparing the radiation level in the hole with the known radiation level at the interface. The thickness being determined in the above manner, the information is recorded on a permanent record, such as for example a magnetic tape. The tape will contain the thickness of the coal with its corresponding distance in the pilot hole. The stored information will then be used to control a mining machine. The invention further contemplates sealing off the area being mined and filling the sealed area with an inert atmosphere. Since the mining machine can be controlled completely by the predetermined information relating to the particular vein being mined, no personnel need be in the

mine area controlling the continuous mining machine. With the area completely sealed and filled with an inert atmosphere, no possibility of explosion exists during the mining operation.

BRIEF DESCRIPTION OF THE FIGURES

FIG. 1 is a side view of an area being mined illustrating the formation of the pilot hole;

FIG. 2 is the top view of the formation of the pilot hole illustrated in FIG. 1;

FIG. 3 is a view of the mining method utilizing the pilot hole as a guide for the mining machine;

FIG. 4 is a second method for boring a pilot hole using a horizontal drilling apparatus. FIG. 4 also illustrates the radioactive source and the radioactive detector, along with block diagrams of the apparatus required to control the continuous mining machine;

FIG. 5 is a chart illustrating the measurements taken by the apparatus shown in FIGS. 2 and 4; and

FIG. 6 is a cross-sectional view of a tunnel being mined by a continuous mining machine where the tunnel is filled with an inert atmosphere.

DETAILED DESCRIPTION OF THE INVENTION

Referring to all of the FIGS. but in particular to FIGS. 1 and 2, a vein 10 which is to be mined lies between an overburden generally referred to by the number 11 which lies above the vein, and an underburden 12 which lies below the vein. Overburden 11 may be composed of shale, rock, and other usual materials. Underburden 12 may likewise be composed of clays, shale, and other well-known rocks. Material to be mined may for example be coal. In order to perform the method of mining using a fully automated process, a pilot hole 12 is drilled into vein 10 by a pilot hole drilling machine generally referred to by the number 14. Pilot hole drilling machine 14 comprises a motor 15 which has attached thereto a head 16 which rotates a drilling pipe 17 which has attached at its terminus a rotary drill 18. Drill pipe 17 may also carry stabilizers 20 along the drill pipe in order to stabilize the drilling operation. Pilot hole drilling machine 14 may have for example a driving mechanism comprising a track 21. A distance measuring tachometer 22 is connected to track 21 and will measure forward movement of the track only. A circuit means 23 connects tachometer 22 to recording equipment 24. An instrument housing 25 contains a radioactive source 26 and a radioactive detector 27. Radioactive source 26 comprises two sources which radiate in the direction of 30 and 31. Radioactive detectors 27 detect along a path 32 or 33, measuring the radiation returned from the overburden 11 and underburden 12, respectively. At predetermined distances, d_1 , d_2 , d_3 , and d_4 , radiation strengths are measured which will determine the thickness, p_1 and p_1' with respect to d_1 , p_2 and p_2' with respect to d_2 , p_3 and p_3' with respect to d_3 , and p_4 and p_4' with respect to d_4 . These distances are plotted in an illustrative graph shown in FIG. 5 to be later described.

FIG. 2 is a top view of the area being mined which is illustrated in FIG. 1 and illustrates a first room 40 and second room 41 with previously bored pilot holes 42 and 43 communicating therewith. A pilot hole 13 is being formed parallel to holes 42 and 43 which will likewise communicate with rooms 40 and 41.

FIG. 3 illustrates the method of mining utilizing a continuous mining machine which has a pilot attachment added to the frame of the mining machine. The

mining machine essentially consists of a frame 45 which has a hydraulically controlled or operated arm 46 attached thereto. A cylindrical coal dislodging device 47 is rotatably attached to arm or boom 46 and has a plurality of picks 48 attached thereto. A means not shown rotates cylinder 47 in a direction to dislodge the coal 10. A drive means 49 is attached under frame 45 and provides a means of propelling the coal digging machine. A tachometer 22 is attached to drive means 47 and communicates to a wire 23 to recorder 24. Recorder 24 is electrically connected to a wire 50 to a continuous mining machine control unit illustrated by a box 51. The coal once dislodged by picks 48 drops and is conveyed by conveyor 52 to a shuttle car 53 which has its own conveyor for handling and storing the material therein. A plurality of wheels 54 propels shuttle car 53 to a point where it may be unloaded. Attached to the continuous mining machine frame 45 is a pilot hole probe apparatus generally referred to by the number 56 and consists of a mount 57; and arm 58 which is pivotally attached to mount 57, and a probe assembly 59 which is pivotally attached to arm 58. A position sensing apparatus 60 is attached between frame 45 and probe 59 and primarily relates the position of the probe to the frame and relays this information back to the control unit 51. A second position control 61 determines the position of hydraulically controlled arm 46 with respect to frame 45. This information is likewise continually transmitted to control unit 51. Referring to FIG. 4, an alternate method for drilling a pilot hole is illustrated and essentially comprises a horizontal drilling apparatus which includes a motor 65 which is coupled through a shaft 66 to drill 18. Instrument package 25 as previously described contains radiation sources 26, radiation detectors 27. An amplifying apparatus 69 is coupled through a wire 67 to memory 24 and a mechanical recorder 68. Power to drive the drill motor 65 is provided by a hydraulic propulsion unit for example generally referred to by the number 70 and essentially comprises a shaft 71 which is connected directly to instrument package 25 and to a reset hydraulic cylinder 72. Main propulsion unit 73 which contains a hydraulic piston (not shown) which is attached to shaft 71 which is in turn connected to instrument package 25. A plurality of pressure feet 74 is attached to both the main propulsion unit 73 and the reset cylinder or unit 72. The unit operates by the propulsion unit 73 being nearly adjacent to instrument package 25. Hydraulic fluid is then applied to the left side of the main propulsion unit 73 which drives shaft 71 toward the right of the drawing. Once reset unit 72 nearly reaches main propulsion unit 73, hydraulic pressure is dropped on both the pressure feet 74 and the left side of propulsion unit 73. The pressure feet associated with reset cylinder 72 are then pressurized and hydraulic fluid is applied to the right side of main propulsion unit 73 driving it once again toward instrument package 25. The reverse procedure is then followed, and the instrument is ready for again propelling drill 18 into the formation. Such a device is manufactured by Drillco Corporation of Midland, Tex., and is well known in the art.

Information from the radiation detectors 27 as previously mentioned is conveyed through wire 67 to a recorder 68 and a memory system 24. Distance measuring tachometer 22 from the drill is also communicated through wires 23 to the recorder 68 and memory 24. In the case of recorder 68, the distance tachometer may be used to determine the rate of feed of the recorder

paper 75 and the method in which the information is stored on memory 24. Paper recording 75 provides a visual information for the operator of the system during the pilot hole drilling process. If the operator is satisfied with the recording information received from the horizontal drill, then the information stored in memory 24 is applied through circuit 76 to a continuous mining control unit 51. Position sensor 60 communicates the position of probe 59 as previously mentioned to continuous mining control unit 51 through a wire 80. Sensor 61 communicates its information through a wire 81 to continuous mining control unit 51. Information from control unit 51 is applied to a wire 55 to various hydraulic control circuits contained on the frame 45 of the continuous mining machine.

Operation

The method of mining described herein comprises two distinct operations. The first operation is the drilling of a pilot hole illustrated in FIGS. 1, 2, and 4. The pilot hole is formed by a drilling apparatus, such as 14 illustrated in FIGS. 1 and 2, which has the drill rod 17 mounted on a chuck 16 with drill 18 connected at the end of drilling apparatus 14. As motor 15 rotates drill pipe 17, drill 18 will penetrate the seam or vein 10. As the drilling apparatus 14 proceeds forward, track 27 will turn tachometer 22 which will measure the forward advance of drilling apparatus 14. If for any reason, for example the insertion of the new drill pipe, the drilling apparatus will reverse its direction of travel, tachometer 22 will not measure the reverse direction. In fact, it would be preferable to interconnect motor 15 with tachometer 22 so that the tachometer is recording forward movement only while the drill is rotating. This will account for any incidental forward or backward movements necessitated by the drilling apparatus to position additional drill pipe to remove a defective drill or other reasons well known in the drilling art. As the drilling apparatus penetrates pilot hole 13 at for example distance d_1 , sensitive detectors combined with a radioactive source will measure the distance, for example p_1 and p_1' , which is indicative of the thickness of the coal seam between the pilot hole being drilled and the overburden in the case of p_1 , and the pilot hole and the underburden in the case of p_1' . This distance is directly relatable to the amount of back scatter received by the detector. It is also well known that shale which generally lies between the coal seam 10 and the overburden 11 is naturally radioactive. If the above exists, then a detector need only be used to measure the natural radioactivity of the shale which will be an indication of the thickness of the coal between the overburden and the underburden with respect to the pilot hole 13. As the drill progresses to for example a point d_2 , d_3 , and d_4 , the respective thicknesses p_2 , p_2' , p_3 , p_3' , and p_4 , p_4' will be measured and recorded on recording apparatus 24. It should be noted that recording apparatus 24 is recording both the distances and the measured radiation levels for each of the corresponding distances. The recorder will generally comprise (see FIG. 4) a mechanical recorder which will provide a visual output 75 for an operator so that the progress of the drilling apparatus and its operability can be continually ascertained. In addition to the recording apparatus, a memory 24 may also be incorporated which will normally magnetically record the data being recorded in recorder 68. The magnetic memory, if satisfactory, which can be determined by the record 75, then memory 24 will be

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used in a subsequent mining process in combination with the continuous mining machine. Referring to FIGS. 3 and 4, a continuous mining machine is shown removing the material 10 between the overburden 11 and the underburden 12. A probe 59 is inserted into the borehole. Position sensing device 60 and 61 will continuously relay through wires 80 and 81 to the continuous mining control unit the exact position of the probe 58 with respect to the frame 45 and the position of boom 46 with respect to frame 45. Since the coal thickness between the pilot hole and the underburden is known, the distance between probe 59 and conveyor 52 should correspond to the predetermined distance. Boom 46 will be operated against the coal face to maintain the distance between the pilot hole and the underburden in accordance with the predetermined distance. Boom 46 will also be operated so that the distance between the pilot hole 13 and the overburden 11 is removed in accordance with the predetermined thickness of the coal. The tachometer 22' through wire 23 will continually provide distance information to the continuous mining control unit. Once the distance of the unit is known, which is continually compared from memory circuit 24, the position of the mining machine with respect to its cutting apparatus is known and continually conveyed to the continuous mining control unit 51 through wires 80 and 81, will remove the material 10 in accordance with the predetermined thicknesses above and below the pilot hole 13.

Referring to FIG. 5, an illustration of the data shown on the graph 75 is depicted. The horizontal axis represents the distance penetrated by the drill and illustrative distances are for example 100, 200, 300, and 400 feet, respectively, for d_1 through d_4 . The seam thickness measurements are represented by the vertical axis and correspond to 10 to 40 feet, respectively. The plot of p_1 through p_4 is illustrated as increasing from 15 to approximately 35 feet, while p_1' decreases from 25 to approximately 15 feet. The information illustrated in FIG. 5 as previously discussed is applied to recorder 68 and memory 24. Memory circuit 24, of course, may be a tape unit which is easily transferrable to the continuous mining machine. Any form of continuous mining machine can be used. A drum mining machine is illustrated; however, other well-known types can be obviously adapted using the principles discussed above. A probe 59 is illustrated as one means of following the pilot hole 13. Other well-known systems can be incorporated, for example, a light beam can be utilized to follow the pilot hole. Lasers can also be used. The invention is not restricted to the particular pilot hole probe illustrated in the drawings.

Referring to FIG. 6, an important feature of the method is illustrated. One of the greatest hazards in continuous mining is the possibility of roof falls and explosions due to the release of methane gases in the environment where the mining operation is taking place. The invention disclosed can be continuously operated without the presence of a human mining operator. Under these conditions, a mine room 40 can be sealed off with a partition 90. A nitrogen generator 91 located in the mine can convey nitrogen through a pipe 91 into tunnel 93 being mined. a conveyor generally referred to by the number 94 can be attached to a beam 95 to the frame 45 of the continuous mining machine. As the machine moves forward, conveyor 94 will move with it. The coal material 96 conveyed from the continuous mining machine will fall onto a belt 97 and be conveyed

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through an opening 98 outside partition 90. A plurality of hanging members 99 can substantially close the opening which provides a passage for the conveyor and the material. If nitrogen should pass from room 93 into room 40, no hazard to mining personnel will be present since breathable air contains 80 percent nitrogen. The usual mine ventilating system will remove any excess nitrogen that will normally accumulate.

It is obvious that other changes and modifications may be made in the method as described and claimed in this application. It is also obvious that other types of apparatus can be utilized to carry out the method described herein and still be within the spirit and scope of the specification and appended claims.

What I claim is:

1. A method for mining a mineral deposited underground in a vein having an underburden and an overburden comprising:

- a. boring a pilot hole into said vein between said underburden and said overburden;
- b. measuring a first mineral thickness between said pilot hole and said overburden at periodic distances along said pilot hole;
- c. measuring a second mineral thickness between said pilot hole and said underburden at periodic distances along said pilot hole;
- d. storing said first and second measured mineral thickness each with respect to its respective distance along the axis of said borehole from a common point of origin;
- e. controlling a mining machine in accordance with said stored information whereby the total mineral removed and the direction of the progress of the mining machine is controlled by said pilot hole and said memory.

2. A method as described in claim 2 wherein said first and second mineral thickness is measured as said pilot hole is formed.

3. A method as described in claim 1 wherein said first and second mineral thickness is measured as said pilot hole is formed and additionally including the step of controlling the direction of said pilot drill to maintain said pilot hole equi-distant between said overburden and said underburden.

4. A method as described in claim 1 wherein said step of controlling said machine by said pilot hole and said memory comprises;

- a. probing said pilot hole from said mining machine;
- b. determining the orientation of said mining machine from said probed pilot hole;
- c. communicating said determined orientation to a mining machine control unit along with said stored measured mineral thickness; and
- d. operating a mineral removal apparatus with the output from said mining machine control unit whereby said material can be removed by said mining machine in accordance with said measured mineral thickness.

5. A method as described in claim 1 including the step of:

- a. sealing said mined portion between said overburden and said underburden at least at said point of origin; and
- b. filling said mined portion and said pilot hole with a noncombustible gas.

6. A method as described in claim 5 wherein said non-combustible gas is nitrogen.

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