United States Patent [19]

Oudenhoven

[11] **3,892,076**

[45] **July 1, 1975**

[54] **LONG SHIELD MINING METHOD**

[75] Inventor: **Martin S. Oudenhoven,** Lakewood, Colo.

[73] Assignee: **The United States of America as represented by the Secretary of the Interior,** Washington, D.C.

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[52] **U.S. Cl.** **61/35;** 299/11

[51] **Int. Cl.²** **E21C 41/00;** E02D 3/12

[58] **Field of Search** 61/35; 299/11

[56] **References Cited**

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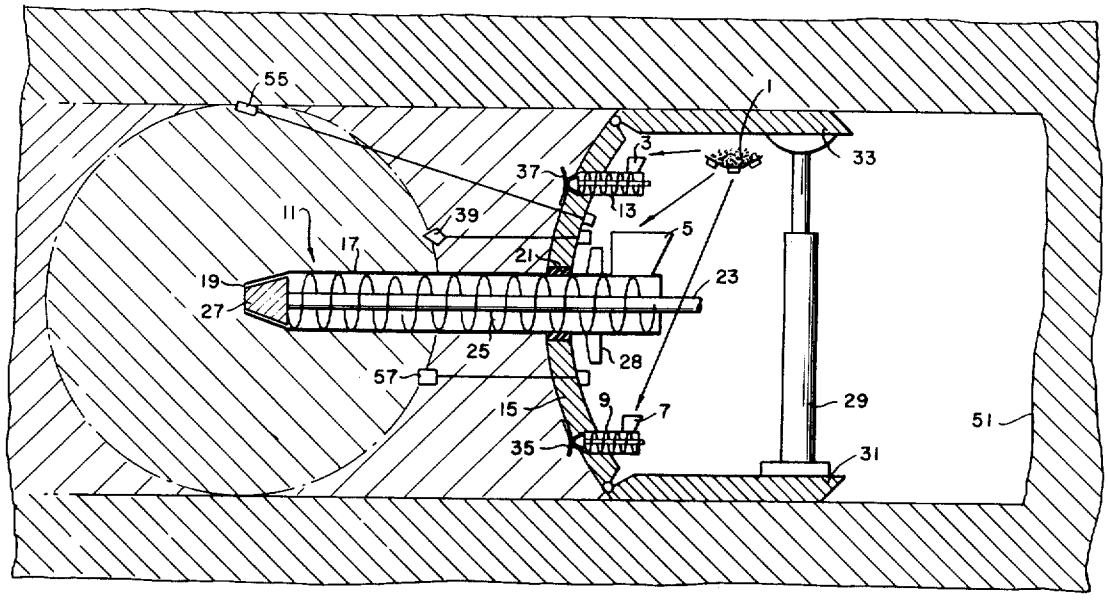
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Primary Examiner—Robert L. Wolfe
Assistant Examiner—Alexander Grosz
Attorney, Agent, or Firm—Thomas Zack; Donald R. Fraser

[57] **ABSTRACT**

A mining recovery method that utilizes the waste material from a mine to refill mined out areas. Particular suitability is in the oil shale mining field where spent oil shale is used to support the overburden. The method contemplates a long shield being placed in an underground opening and spent oil shale or other waste material conveyed underground from the surface and placed behind the shield under low pressure. Next, a conveyor-compressor, like an auger with a compressor cone, forces additional waste material at a high pressure into the previously placed material behind the long shield to form a high pressure inclusion for the support of the overburden. Before the expanding inclusion of high pressure waste material reaches the shield, a pressure sensing device includes a predetermined pressure level has been reached. This triggers the activation of low pressure conveyor-compressors to disengage the shield from its adjacent waste material wall and move it forward toward the mining face. The combined reaction of low pressure material along with the continued reaction of the high pressure compressor is used for this forward motion. Once disengaged and advanced the proper distance, the process is repeated to form another line of high pressure supporting inclusions behind the shield that overlaps the first line of inclusions. A series of these lines of high pressure inclusions can be used to support the overburden on one cut level with different levels of supported cuts being possible.

7 Claims, 4 Drawing Figures



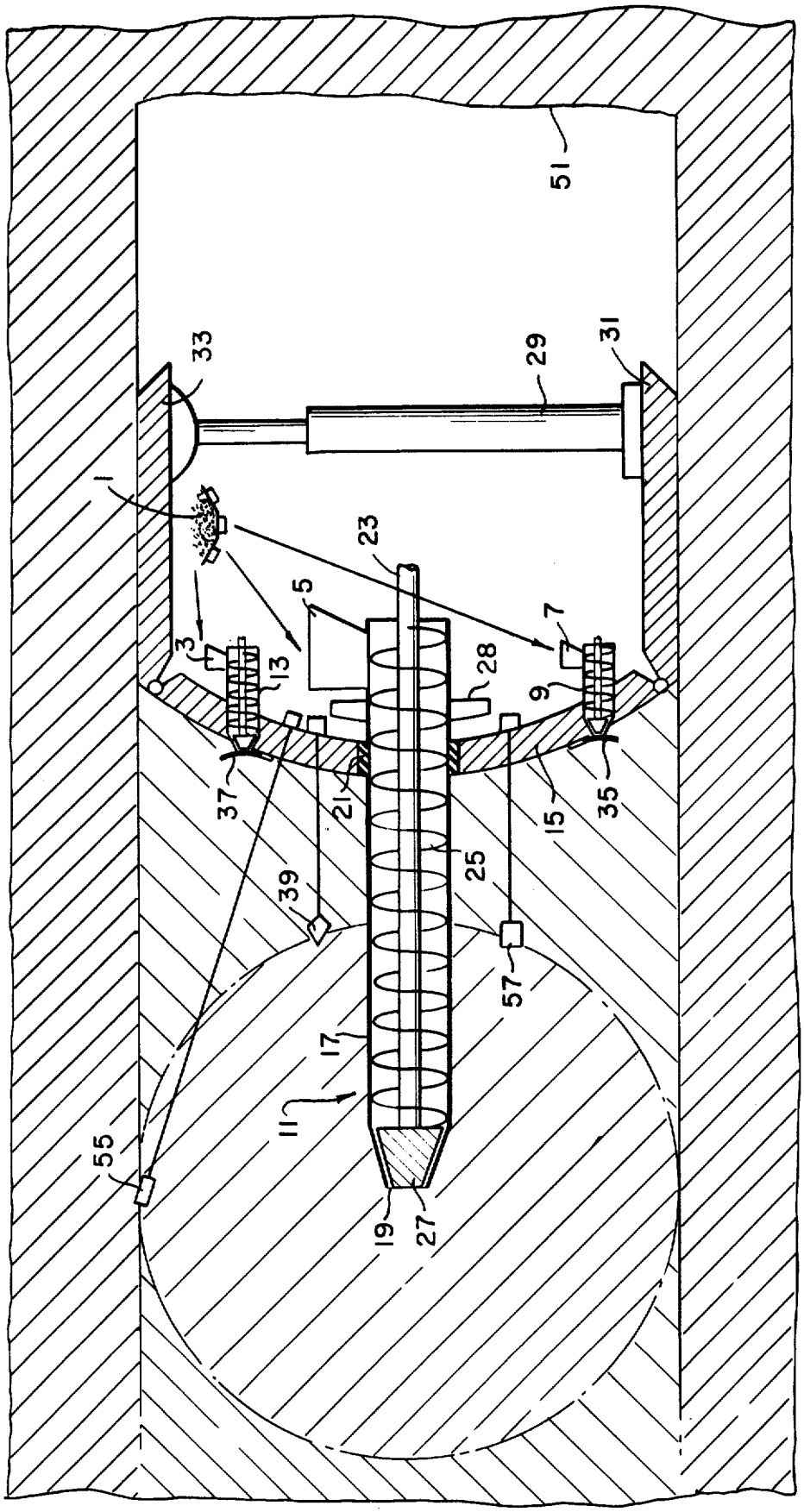


FIG. 1.

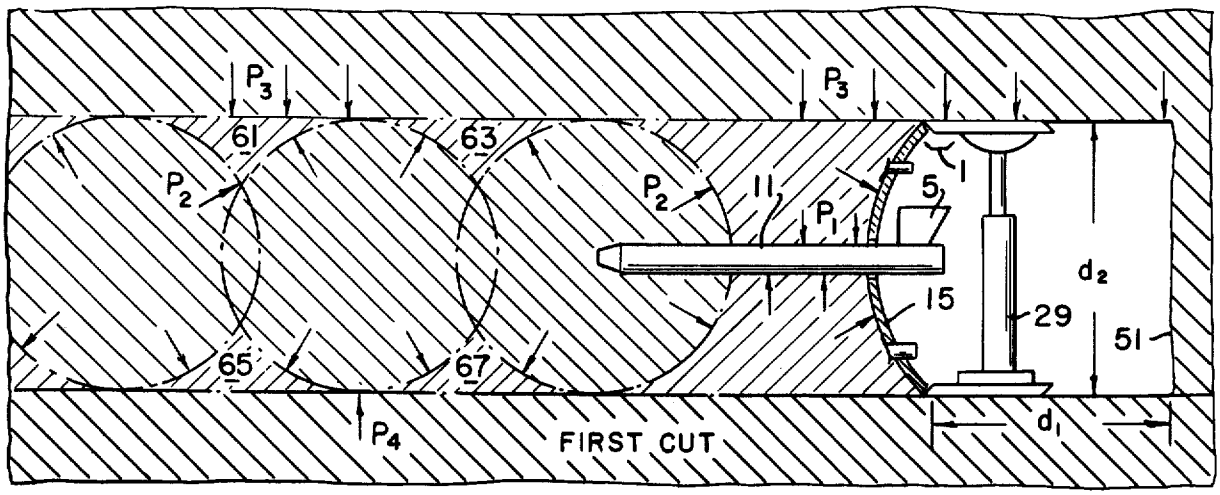

P3
P3
61
63
P2
P2
11
5
1
P1
d2
15
29
51
65
67
P4
FIRST CUT
d1

FIG. 2.

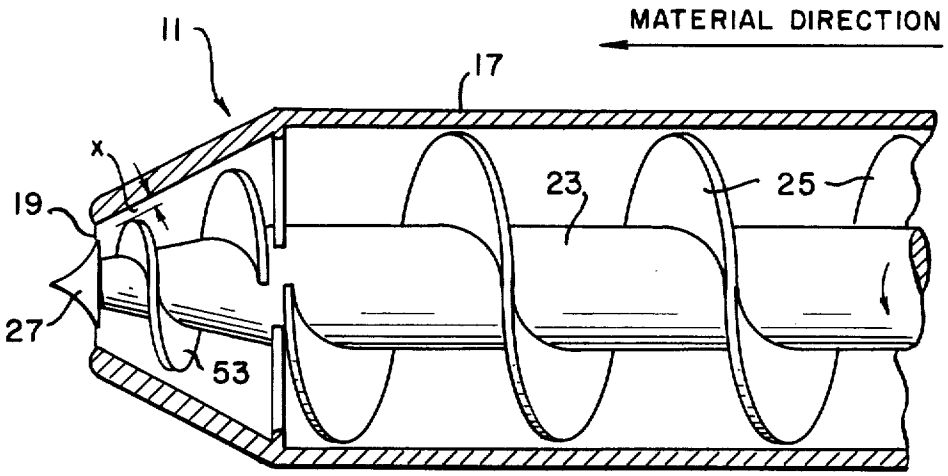

MATERIAL DIRECTION
11
17
x
19
23
25
27
53

FIG. 4.

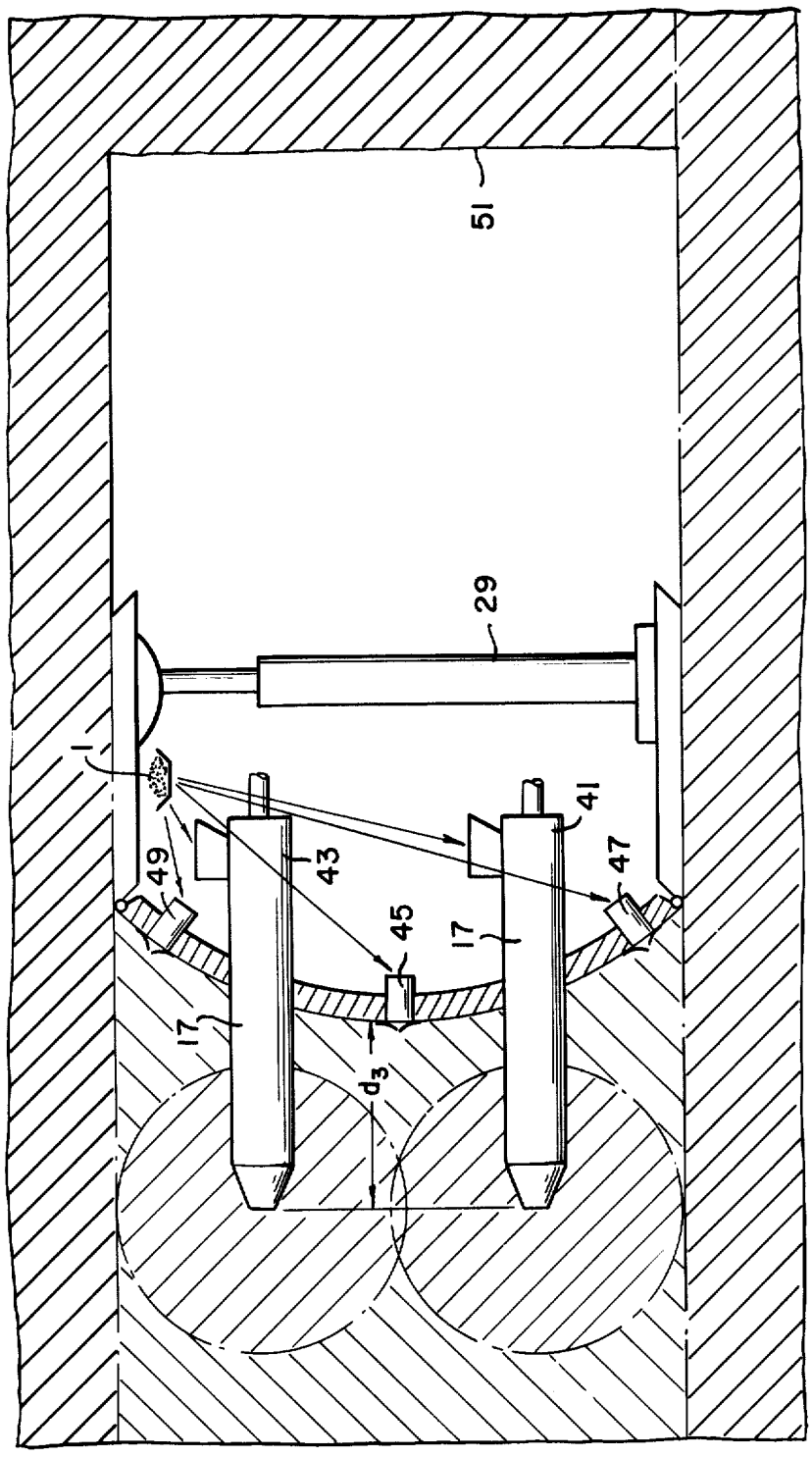


FIG. 3.

LONG SHIELD MINING METHOD

BACKGROUND OF THE INVENTION

1. Field of the Invention:

This invention is a method of using recovered waste material for filling in previously mined out areas. More specifically, it is a method that creates high pressure spherical inclusions with waste materials used to support the overburden.

2. Description of the Prior Art:

Back filling of mined out areas has been used for some time to produce stabilization of the earth and to fill in a cavity with the mined waste materials. In one reference, U.S. Pat. No. 2,627,169 to J. W. Poulter, spheres of pressure are produced by pumping a cementitious material in a liquid form beneath the earth from the surface. These spheres act to support the earth or overburden. Spent oil shale has also been used to backfill mined out areas as mentioned in U.S. Pat. No. 3,588,175 to J. M. Whiting.

One method of mining commonly used to recover oil shale and other minerals is the room and pillar mining method. This method calls for using the in situ materials to be mined out to form supporting pillars for the overburden. Usually, the deeper the mined out area, the pillars must be progressively wider to give adequate support. For example, oil shale mined at depths of about 1000 feet has been cut into rooms 60 feet across having pillars 60 feet wide for overburden support. This type of supporting arrangement is not only wasteful of the oil shale left in the pillars, but reportedly is unsafe under some circumstances.

Another problem encountered in mining oil shale by the room and pillar method has been what to do with the spent oil shale recovered after the surface oil recovery method is employed. Much of the time this spent oil shale is simply piled in a convenient location on the surface creating an unsightly condition and an ecological problem. When contemplated large scale operations take place, the volume of piled spent oil shale can actually amount to mountains. My invention attempts to alleviate to a large degree this disposal problem by returning the spent oil shale to the earth and at the same time providing support for the overburden. It does this by creating spent oil shale high pressure zones that act as pillars to support the overburden. These created pillars are formed behind a long shield at the same time mining can be taking place at the mine face. Thus, my invention contemplates the maximizing of the benefits of backfilling, earth support, and continuous mining to a degree heretofore unknown in the prior art.

SUMMARY OF THE INVENTION

My invention is a long shield mining backfill method that conveys and then compresses the processed waste material from a mined out area, like wetted spent oil shale, behind a shield until a predetermined high pressure is detected. Once detected, lower pressure compressors are actuated to move the shield away from the waste material surface. Next, this operation is repeated beginning with filling the material under low pressure compression between the mine wall and new shield position. Thereafter, high pressure compression takes place again until a predetermined high pressure is detected. Then, as before, low pressure compression is activated to free the shield. This same sequence can be repeated as many times as desired at different cut levels.

The principle object of this invention is an improved method of backfillinng waste material in a mined out area.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram of the equipment used to practice the process.

FIG. 2 illustrates three high pressure zones formed on a second cut.

FIG. 3 is a modification of the apparatus used in FIG. 1.

FIG. 4 is an engaged view of the FIG. 1 high pressure compressor.

The basic apparatus to practice my method is shown in FIG. 1. Assuming the mined material is oil shale, it is initially mined at the mine face and then sent to a high temperature retort system on the earth's surface where it is then brought up to temperature to yield a form a liquid crude petroleum. Whatever the process to recover the crude petroleum, such forms no part of my invention and, therefore, further discussions on it are unwarranted. Once processed, the spent oil shale is the waste or residual material. This material is then conveyed by a motor operated conveyor system 1 (FIG. 1) to the discharge end opposite the mine face. At the discharge end, the spent oil shale goes to the supply bins 3, 5 and 7. These bins supply, on a cross section of the shield, three material conveyor-compressor systems. Conveyor-compressor systems 9 and 13 are substantially identical to each other and function to move and then compress the spent oil shale under a low pressure behind the long shield 15. The other conveyor-compressor 11, fed by bin 5, is the high pressure compressor and is several times larger than the two low pressure units.

Each of the three conveyor-compressor units consists of several basic parts. These will be explained with respect to the high pressure system, it being understood that the two low pressure units have similar functioning parts. The heavy steel barrel 17 of conveyor-compressor 11 is tapered at its open end 19. This hollow barrel fits through a rubber gasket 21 firmly fixed in a hole in shield 15. Within this same barrel, a rotatable shaft 23 driven by a motor (not shown) has a series of auger blades 25 attached to it to convey the spent oil shale towards the frontal opening 19. At the front end, a compression cone 27 compresses the material being fed by the auger and discharges it through opening 19. As will be explained with respect to FIG. 4, the amount of compressive pressure exerted on the oil shale is dependent to a large extent on the geometry of the cone 27 and how it relates to tapered frontal section of barrel 17. Behind the shield, a roof supporting hydraulic jack 29 with a lower floor engaging shoe 31 and an upper roof engaging shoe 33 may be attached to the shield to give added support to the overburden. Another feature worthy of note in FIG. 1 are the two one-way valves 35 and 37 associated with low pressure conveyor-compressors 9 and 13, respectively, that allow spent oil shale to pass only through the shield into the low pressure waste area. Retaining collar 28 is firmly attached to and encircles barrel 17 and acts to retain it and shield 15 when the system is moved towards the mine face 51.

The only other features of FIG. 1 not already described are the two pressure sensors 55 and 57 and the anchor shield 39. The sensors act to detect the pressure build up of compressed spent oil shale and convey this information via cables to electronic display circuitry on the other side of shield 15. In this way, as compressor 27 compresses the material, the pressure can be constantly monitored at two different locations on the high pressure zone. Anchor 39, whose purpose will become meaningful when the process is described in detail, functions to keep shield 15 in an upright position when pressure is exerted by the compressors 9 and/or 13.

The basic steps to practice my method will now be described making references to the FIG. 1 apparatus. Initially, a cavity exists to the left of the long shield. This cavity is first filled with spent oil shale by both low pressure conveyor-compressors 9 and 13. This oil shale is constantly being conveyed from the surface by system 1 and water with 10 to 20 percent (by weight) addition along the way. By adding water, the ease of extrusion of the material through the augers and cones of all conveyor-compressors is greatly increased. Once this cavity is filled to a low pressure, only the high pressure compressor with its sensors operates to add additional spent shale to compact a high pressure zone to a predetermined pressure. Tests have shown this zone to initially appear generally as an ellipsoid and then to configure itself upon greater pressure and expansion as a high pressure sphere. This sphere starts several feet in from the shield at the front of the cone compressor and expands outwardly until pressure sensors 55 and 57 detect the predetermined desired pressure. Placement of the sensor is important. Sensor 55 is usually placed near the in situ overburden so that contact is made therewith. Sensor 57 is placed forward of the shield to insure that the high pressure zone will not actually be transmitted to the shield. If this zone was to contact the shield, the shield would probably be forced towards the jack 29, creating an extremely hazardous situation.

Once the high pressure has reached the desired predetermined level, it now remains to remove both sensors 55 and 57. The shield and the high pressure conveyor-compressors are then advanced toward the mine face by the low pressure compressors forcing spent shale through their respective one-way valves. Anchor 39 insures an unbalanced pressure condition will not topple the shield. By altering the amount of material fed to either compressor 9 or 13 and the speed of their respective feed augers. The pressure can be manipulated to obtain a balanced disengagement of the shield. As disengagement takes place, the high pressure compressor continues to operate at a somewhat reduced speed to successfully fill the opening left, by the high pressure conveyor-compressor, in the waste material. When the new shield position has been reached the low pressure compressors are stopped and the high pressure compression takes place again until a predetermined high pressure is detected.

Another way of assisting in disengaging the high pressure conveyor-compressor 11 from its high pressure zone would be to add a lubricant to the barrel 17. This lubricant could be water ejected at the surface of the barrel by high pressure jets (not shown) or any other means.

My complete process calls for the foregoing steps to be completed again and again at different mining levels. Beginning at the lowest level at which mining is to take place, a first severally horizontal cut is made. Then after sufficient room is dug out, the long shields are placed in the mine. Then the steps are repeated again and again at this cut as mining takes place at the face. Once the first cut is completed, the second cut immediately above may be started, then after this is completed, the third cut begun, etc.

In FIG. 2, several overlapping high pressure zones are shown on the second cut. The first cut, previously completed, consists of a plurality of these overlapping overburden supporting high pressure zones. Support P4 is used to represent the pressure exerted by first cut zones, P2 the pressure of the second cut high pressure spheres, P3 the overburden pressure for the second cut, and P1, the low pressure between the shield, overburden, first cut, and high pressure sphere. Generally, for the overburden to be supported, P2 must be equal to P3. The low pressure zones between the high pressure zones have been designated by the numbers 61, 63, 65 and 67. However, because zones 61, 63, 65 and 67 continuously occur the high pressure spheres tend to relax into those zones and thereby slowly drop the pressure P2. To compensate for this pressure drop and to obtain a final P2 pressure equal to P3 usually pressure P2 will exceed the overburden pressure P3. As a rule of thumb, usually the pressure is about 1 psi per foot of depth below the surface. Hence, the pressure P2 of the spheres would run in a range of about 500 psi to 4000 psi for most oil shale mining operaions. The lower pressure, P1, could be expected to be in the 5 psi to 50 psi range under the same circumstances. Variations in the material making up the spheres as well as the moisture content would, of course, cause gradient variations in the pressure when measured from the sphere center.

One of the advantages my invention has over the room and pillar method is that it requires less working space and yet still allows mining to be simultaneously accomplished at the mine face. For example, instead of requiring rooms 60 feet wide with pillars 60 feet in diameter, I contemplate a working area having no wasted oil shale pillars and with dimensions (see FIG. 2), where $d1$ is about 30 feet and $d2$ about 10 to 30 feet.

FIG. 3 is a modification of the basic FIG. 1 apparatus that employs multiple high pressure conveyor-compressors. The major differences between this modification and FIG. 1 are that FIG. 3 has two high pressure conveyor-compressors (41 and 43) and three low pressure conveyor-compressors (45, 47, and 49). Functionally, the two pressure units produce two high pressure overlapping zones that are spherical in shape. This type of arrangement allows the distance d3 between the shield and compressor openings to be shorter than when one high pressure conveyor-compressor is used. The corollary of this distance diminution is to allow less contact by high pressure spheres with the heavy steel barrels 17 and to bring the spheres closer to the adjacent long wall face 51 by shortening the heavy steel barrels 17.

FIG. 4 is an enlarged view of the front end of the high pressure conveyor-compressor 11 previously shown in FIG. 1. The rotating motor driven shaft 23 conveys the spent oil shale by its continuous spiral protrusions 25 to the compression cone 27. At this point, the shale starts to pile up between the shaft and the inner surface of barrel 17. An opening between the tops of spirals 53 of the cone and the tapered front end of the barrel is designated by the letter x. This distance varies so that

it increases as material is forced towards the opening **19** as spirals **53** rotates in unison with shaft **23.** The material thus forced through opening *x* is placed under a compressive pressure. When it exists, the actual pressure it is under will depend to a large extent on the geometry of cone **27** and the distance *x*.

The shield **15** through which the various compressors and sensors pass is a long flexible shield that extends 50 to 100 feet along the mine face. These shields may be constructed in sections to give the necessary flexibility. To prevent the high pressure zones from prematurely reaching the shield, a bonding agent may be placed in the spent oil shale.

Several of the disclosed features could easily be eliminated or modified without altering the essence of this invention. For example, if the roof is stable, the jacks and shoes could be eliminated. Likewise, if the spent oil shale bonds well, the one-way valves in the shield could be eliminated. Also as regards the rotating of the high pressure compressor and predetermined readings to be sent, the readings may be higher than is actually needed because a pressure drop will occur when the compressor is removed from its spherical zone. To minimize this drop, the auger can be kept rotating as it is retracted.

Other variations in the steps performed or equipment used are, of course, possible. None should be used to limit the scope of my invention which is set forth in the claims that follow.

I claim:

1. A long shield mining method for filling in previously mined out areas comprising the steps of: conveying processed mined waste material to the mining area where a long shield is placed near a mine wall; forcing the material through the shield under pressure behind said shield to form a spent material wall until a predetermined high pressure is reached and an overburden supporting high pressure zone formed; detecting the amount of predetermined high pressure developed and the appropriate location of said zone; forcing additional waste material through said shield at a lower pressure after said predetermined high pressure is detected to enable disengagement of the shield from the spent material wall; and repeating the forcing step to develop a high pressure zone and the forcing disengagement step so as to create a different high pressure zone that overlaps with said first zone.

2. The method of claim **1** wherein part of said conveying step takes place between the earth's surface and an area adjacent said mining area.

3. The method of claim **1** wherein said predetermined high pressure is at least 500 pounds per square inch and said lower pressure at least 5 pounds per square inch.

4. The method of claim **1** including the additional step of lubricating said material before it is forced through said shield.

5. The method of claim **1** including the additional step of forcing the material between the shield and mine wall under low pressure before said high pressure step.

6. The method of claim **1** wherein said detecting step takes place simultaneously at a plurality of different locations.

7. The method of claim **1** including the additional step of anchoring said shield in an upright position as it is being disengaged generally horizontally from the mining wall.

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