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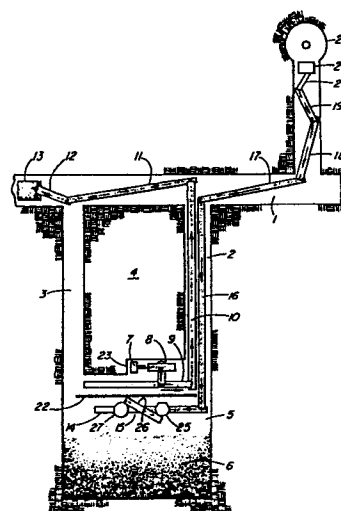
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54 **Underground mining method for mineral deposits.**

57 Mineral extraction in underground mines, particularly adapted to the mining of potash, whereby simultaneously with extraction and refining of the ore the waste tailings are returned to the excavated area (5) in the mine, and the space opposite to where the ore is being removed is backfilled by the tailings in order to support the mine roof. The ore is transported from the area being mined by a first set of conveyors (8, 9, 10, 11, 12) and the tailings are returned by a second set of conveyors (14, 16, 17, 18, 19), the whole conveyor system being automated and interlocked so that the failure of one conveyor unit causes shut-down of the system.



TITLE MODIFIED
see front pageField of the Invention

This invention relates to a system and process of mining and more specifically to an optimized mineral extraction system and process whereby the waste mineral tailing from a mineral refining process is returned to the underground workings of a mine to support the mine roof. It is particularly, though not exclusively, adapted to the mining of potash.

Background of the Invention

When ore is removed from an underground mine some provision must be made to avoid collapse of the mine roof as the excavated area increases. A traditional method of avoiding such collapse is to leave areas of unexcavated material which may take the form of pillars or panels at sufficiently close spacing to one another so that the intervening roof will safely support itself. This method has the obvious disadvantage that some of the ore is left behind in the supporting pillars or panels thus reducing the total quantity of ore which can be extracted.

Present mining and mine waste disposal methods commonly treat both the winning of mineral and the disposal of the resultant waste tailings as separate systems, operationally independent of one another.

It has also been a common practice after processing of the ore to pile the waste tailings above ground. This is very unsightly and quite undesirable from the environmental standpoint and also uses up

large ground areas.

It is already known to return waste material or tailings of a mineral processing operation to the underground site from which the ore has been removed in order to avoid collapse of the strata above the excavation. An example of such mining practice is described in U.S. Patent 2,536,869, issued January 2, 1951 to Philip B. Bucky. The method comprises breaking the ore throughout the height of a stope within the ore body and withdrawing the broken ore at the stope bottom. Waste fill is added at the top of the stope as the broken ore is withdrawn. However, the mining operation described in the abovenoted patent of BUCKY differs substantially from that of the present invention. BUCKY does not describe a mining operation in which the material being mined is cut from a face or panel while the opposite side of the excavated area is being backfilled with waste material in order to support the mine roof as in the mining system of the present invention.

Summary of the Invention

In the optimized mineral extraction system of the present invention the winning of the ore and the waste tailings disposal system are combined and coordinated in such a manner as to allow for complete extraction of the ore body and for an environmentally acceptable waste disposal while at the same time providing effective support for the mine roof.

The present invention relates to underground mining operations and is particularly applicable to the mining of potash but is envisaged as being capable of use for other mining as well.

In the area from which ore is to be removed two more or less parallel roadways are excavated and one or more cross pathways are also excavated between the two roadways. In the removal of the ore a mining machine takes successive cuts from the face of the panel constituting one side of a cross roadway, moving along the length of the panel from the one roadway to the other. An ore face conveyor is located along the length of and adjacent to the panel being cut. As the mining machine moves along the panel the ore which is removed is transferred to the ore face conveyor and carried thereby to a loading point at one of the roadways where the ore is loaded onto an ore panel conveyor, which carries it to the main line transport system. The main line transport system feeds the ore to an underground ore storage bin. From this point on the ore is handled by standard mining methods as feed to the mill/refinery where the ore is processed into product and waste tailings.

The mineral product is the commodity which is marketed and the mineral waste tailings are delivered to the mill "mineral waste tailings" draw point.

After the milling operation the mineral waste tailings are transported to the "surface surge location" for moisture conditioning and process flow control. They

are then fed to the vertical transport system by which they are delivered underground to the mine waste tailings portion of the main line transport system. From the main line transport system the mine waste tailings are transferred to the mine waste tailings panel conveyor. This conveyor is preferably located in the same roadway as the ore panel conveyor and may form part of the same conveyor. Alternatively, the mine waste tailings may be conveyed along the other roadway to the excavated area.

A mine waste tailings face conveyor is located along the length of the panel on the side of the excavated area remote from the mining machine. The mine waste tailings are transferred from the panel conveyor to the mine waste tailings face conveyor and thence along the length of the excavated area. The mine waste tailings face conveyor delivers the tailings to an off-loading device and feeds them to a placement subsystem.

The placement subsystem adds energy to the mine waste tailings resulting in velocities and trajectories that lead to their deposition and packing, on the side of the excavated area opposite to the panel being cut, with such integrity that they support the mine roof.

It is an object of the invention to provide a mining system which avoids the need to utilize mineral bearing material for support of the mine roof.

It is a more specific object of the invention to provide a coordinated transport system for a mine by means of which ore is transported to the surface for processing and mine waste tailings are returned to the mine and deposited in the excavated area for roof support.

In accordance with one aspect of the invention there is provided an optimum mineral extraction system comprising:

ore extraction means for removing ore by successive cuts along a predetermined length of rock face in a mine;

first means for conveying the ore removed from said rock face continuously to a mineral-processing site;

second means for conveying the waste material of the mineral-processing operation from said mineral-processing site to the excavated region on the side of said extraction means remote from said rock face, the operation of said first and second conveying means being coordinated;

back-filling means receiving the waste material from said second conveying means and ejecting said waste material with suitable trajectory and velocity to fill therewith a portion of said excavated region remote from the rock face from which ore is being removed and to deposit said waste material with such integrity as to support said mine roof and to prevent catastrophic failure thereof by controlling rate of subsidence.

In accordance with another aspect of the invention there is provided a method of underground mining comprising:

removing ore by successive cuts along a predetermined length of rock face in a mine;

conveying the ore removed from the rock face continuously to a mineral-processing site;

conveying waste material of the mineral-processing operation from the mineral-processing site to the excavated region;

imparting to said waste material suitable trajectory and velocity so as to fill therewith a portion of the excavated region remote from the rock face from which ore is being removed so as to support said mine roof and prevent catastrophic failure thereof by controlling rate of subsidence.

An embodiment of the invention will now be described which is to be read in conjunction with the accompanying drawings in which:

Figure 1 is a diagrammatic view of underground excavation equipment and a conveyor system in accordance with the invention;

Figure 2 is a diagrammatic view showing a drop pipe system in accordance with the invention located in a mine shaft;

Figure 3 shows diagrammatically a surface conveyor system in accordance with the invention.

DESCRIPTION OF PREFERRED EMBODIMENT

In Figure 1 there is illustrated a panel 4 of mineral-bearing rock which lies adjacent a main roadway 1. Extending from the main roadway on either side of panel 4 are side roadways 2 and 3. An excavated area 5 extends between roadways 2 and 3.

A mine excavator or mining machine 7 removes material from the work face. An ore face conveyor 9 extends along the face of panel 4 adjacent the work face from roadway 3 and extending into roadway 2 at its other end. Mining machine 7 feeds ore to cross-conveyor 18 which delivers it to face conveyor 9. From the loading point face conveyor 9 transports the ore to roadway 2 where it is loaded onto panel conveyor 10. Panel conveyor 10 carries the ore to main roadway 1 where it is transferred to main line conveyor 11. The ore is carried by the main line conveyor along main roadway 1 to ore chute conveyor 12 which feeds it into the underground storage bin 13. From this point on the ore is handled by standard mining methods as feed to the mill or refinery where the ore is processed into product and waste tailings.

The mining machine is of known type. It may suitably be a Goodman or Marietta rotor mining machine or any other machine appropriate to the use.

The cross-feed conveyor is of a special type designed to move with the mining machine in both directions along the length of the panel being cut. It can be of variable

length and is capable of slewing so that when the mining machine changes direction the cross feed conveyor also changes operating position. The cross feed conveyor is arranged to be moved laterally toward the face of the panel as the mining machine removes material. In this way the appropriate position of the conveyor with respect to the mining machine is retained.

The underground portion of the waste tailings return system at the mining level is also shown in Figure 1. The waste tailings descend from the ground level via a down pipe which will be described hereinafter, and are deposited in underground surge bin 21 located at the bottom of the mine shaft 24 within which the down pipe is located.

The tailings are fed by vibrating feeder 20 or other suitable means to feeder conveyor 10, thence to feeder-to-mainline conveyor 11 from which they are transferred to tailings mainline conveyor 12 which carries them along the main roadway to roadway 2.

At roadway 2 the tailings are loaded onto the tailings panel conveyor and transported to the excavated area 5 adjacent the area to be backfilled on the opposite side of the excavated area from the panel being cut away. The tailings are then transferred to the tailings face conveyor 14 which carries them along the length of the area to be backfilled to the placement subsystem 15.

The ore face transport system and the tailings face transport system share a sectionalized modular chassis (not shown) which is capable of moving the total system sideways and providing self-alignment over its full length. In this way the tailings face conveyor 14 and placement subsystem 15 are properly located with respect to the area being backfilled while at the same time the ore face conveyor 9 is properly located with respect to the face being mined. Electro-hydraulic jacks, wheels or other moveover devices may be used for the sideways movement of the face conveyor system, the choice being specific to the site. The sectionalized chassis is equipped with a curtain 22, as shown in Figure 1, which is used to separate the environments of the ore out and waste tailings in. Seals are provided to secure this separation at the top and bottom of the curtain. Also mounted on the chassis are support peripherals for electrical services, mine drainage, communications, moveover systems, instrumentation and controls.

The ore and tailings panel conveyors may be a single endless belt conveyor the top strand of which carries the ore from the excavated area and the lower strand of which carries the tailings from the mainline conveyor to the tailings face conveyor. In such an arrangement the support for the belt may be suspended from the mine roof.

It is to be understood that while the mainline roadway is shown in Figure 1 adjacent to the panel being mined the mainline roadway may in fact be some distance from the panel, in which case the panel conveyors extend beyond the panel to the mainline roadway. Also, there may be several panels rather than a single one. Moreover, the panel may be cut away on the side thereof near to the mainline roadway so that the mining operation proceeds in the direction away from the main roadway rather than toward it as in Figure 1. Mine specific rock mechanics will dictate panel design.

It is also to be understood that the ore may be drawn off and the tailings returned at opposite ends of the panel being mined. However, it is preferred that both these operations be done at the same end of the panel as illustrated in Figure 1. This permits the same panel conveyor to be used for both ore and tailings and also provides an equipment layout which is more easily accessed. Moreover, the equipment can more easily be protected against groundfall if the conveyors are all in the same panel entry.

In any case a roadway is required at each end of the panel to provide space for manoeuvring the mining equipment.

The placement subsystem 15 moves successively along the length of the area to be backfilled taking the tailings from the tailings face conveyor and ejecting them with sufficient force to backfill so as to provide placement and adequate support for the roof. The subsystem consists of travelling tripper 25, accelerating conveyor 26

and flinger 27. For proper placement of the tailings it is necessary that they be ejected from the flinger with relatively high velocity and in a low trajectory owing to the very limited height of the mine roof. The purpose of the accelerating conveyor 26 is to receive the tailings from tripper 25 and to add sufficient energy to them that the required exit trajectory from the flinger is achieved.

Figure 2 shows a drop pipe 36 located in a mine shaft 34 extending from the ground level 30 to the mining level 32 and with a transition piece 40 located at the top thereof. The waste material or tailings are fed to the drop pipe via transition piece 40 by means of a feed auger 42 or other suitable means. The drop pipe extends in a substantially vertical direction within the mine shaft except that a curved elbow is attached to the lower end of the pipe to direct the tailings into underground surge bin 21.

The drop pipe is fully automated with feed-forward transducers 44, 46, 48 and 50 linked to the material flow control and to air flow control 49 so as to adjust the material flow and ingress of air to the drop pipe to avoid plugging.

The surface conveyor system as shown in Figure 3 comprises a conveyor 64 which transports the tailings from mill 60 to the site adjacent to the down pipe 26, a cross conveyor filter 62 which feeds the tailings from the mill to conveyor 64, and dewatering conveyor 66. The dewatering conveyor reduces the water

content of the tailings, conditioning them so that they are suitable for transport and backfilling. The conditioning is determined by the support properties required and the process flow control needs.

The tailings are then deposited in surface surge bin or hopper 68. From hopper 68 the tailings are fed to drop pipe 26 by means of feed auger 70 or other suitable means which is driven (not shown), the rate of feed being controlled as explained in the foregoing, to avoid plugging of the drop pipe. However, should any part of the underground conveyor system fail or should the drop pipe become plugged emergency bypass flight conveyor 72 is actuated to dump the tailings from hopper 68.

An important feature of the invention is the automation and interlocking of controls for the various parts of the overall system. The automation and interlocking of controls includes the mill, the surface conveyor system including filter 62, the drop pipe 36, the underground ore and tailings conveyor systems including the face conveyors, the mining machine and the placement subsystem. The placement subsystem 15, including flinger 27, is automated and is run by the mining machine operator. Moreover, it is envisaged that the mining machine can be linked to back-up equipment and that it can have the capability of being automated. All the conveyors have zero speed switches and are interlocked so that the failure of one causes the others to stop when appropriate. The drop pipe off-loading is tied into the rest of the

underground system so that the drop pipe feed is automatically stopped in case of conveyor failure. Also, the surface materials handling system and mill draw point are tied directly to the drop pipe in-feed for automatic operation. The system is controlled so that back filling proceeds at a rate consistent with the removal of ore so that the dimensions of the unsupported portion of the mine roof are kept within safe limits.

With materials handling and mining systems optimized to provide the maximum economic benefit mining panel face lengths of 200 feet to 6,000 feet or more may be employed using the equipment and method of this invention.

If necessary provision can be made to transfer material cut from the panel which is unsuitable for refining directly from the ore face conveyor to the tailings face conveyor to be used for back filling.

The described embodiment of the invention is exemplary only. Many variations of the structure as described will be apparent to those skilled in the art. The invention includes all such variations and is delineated not by the preceding exemplary embodiment but rather solely by the appended claims.

CLAIMS

1. An optimized mineral extraction system comprising:

ore extraction means for removing ore by successive cuts along a predetermined length of rock face in a mine;

first means for conveying the ore removed from said rock face continuously to a mineral-processing site;

second means for conveying the waste material of the mineral-processing operation from said mineral-processing site to the excavated region on the side of said extraction means remote from said rock face; the operation of said first and second conveying means being coordinated;

back-filling means receiving the waste material from said second conveying means and ejecting said waste material with suitable trajectory and velocity to fill therewith a portion of said excavated region remote from the rock face from which ore is being removed and to deposit said waste material with such integrity as to support said mine roof and to prevent catastrophic failure thereof by controlling rate at subsidence.

2. An optimized mineral extraction system as claimed in claim 1 wherein said first conveying means comprises an ore face conveyor; an ore panel conveyor

and a mainline conveyor, said extraction means feeding the ore to the face conveyor, said face conveyor conveying the ore to a location adjacent one end of said rock face and transferring said ore to said panel conveyor, said panel conveyor extending transverse to said rock face and feeding said ore to said mainline conveyor, said mainline conveyor transferring said ore to a storage area from which it is transported to the mineral-processing site.

3. An optimized mineral extraction system as claimed in claim 2 wherein said mineral-processing site is above ground and said second conveying means comprises a drop pipe, a tails mainline conveyor, a tails panel conveyor and a tails face conveyor, said drop pipe extending downward from adjacent ground level, receiving said waste material at the top end thereof and feeding said waste material to said tails mainline conveyor, said tails mainline conveyor feeding said waste material to said tails panel conveyor and said tails panel conveyor feeding said waste material to said tails face conveyor, said tails face conveyor feeding said waste material to said back-filling means.

4. An optimized mineral extraction system as claimed in claim 3 wherein said ore panel conveyor and said tails panel conveyor are a single endless

conveyor with upper and lower levels serving as the ore panel conveyor and the tails panel conveyor respectively.

5. An optimized mineral extraction system as claimed in claim 1 wherein said back-filling means comprises an accelerating conveyor and a flinger, said accelerating conveyor receiving and accelerating said waste material from said second conveying means and feeding said waste material to said flinger, said flinger ejecting said waste material.

6. An optimized mineral separation system as claimed in claim 1 wherein said extraction means comprises a mining machine and a cross conveyor, said cross conveyor feeding the ore to said first conveying means.

7. An optimized mineral extraction system as claimed in claim 1 wherein said second conveying means includes a downwardly directed drop pipe and means to control the feed of waste material to said pipe to avoid plugging thereof.

8. An optimized mineral separation system as claimed in claim 7 further comprising waste material processing means, said waste material being conditioned and fed to said drop pipe by said waste material processing means.

9. An optimized mineral extraction system comprising:

a mining machine for extracting ore;

a first conveying means comprising a first plurality of conveyors for transferring said ore from said mine;

a second conveying means comprising a second plurality of conveyors for conveying waste material to said mine for backfilling excavated space therein; and

interlock means actuated upon break-down of any one of said belt conveyors to stop all other conveyors of said first and second pluralities as appropriate.

10. An optimized mineral separation system as claimed in claim 9 wherein one of said conveyors is an endless belt conveyor having upper and lower strands, one of said strands conveying ore in a first direction and the other of said strands simultaneously conveying ore in a second direction opposite to the first direction.

11. An optimized mineral separation system as claimed in claim 9 wherein said second conveying means further comprises a down pipe, means to feed waste material to said down pipe, and means to control the rate of feed of said waste material to avoid plugging of said down pipe.

12. An optimized mineral separation system as claimed in claim 9 wherein said second conveying means comprises a down pipe, means operative to feed waste material to said down pipe, and

interlock means actuated upon break-down of any one of said conveyors to stop feed of waste material to said down pipe.

13. A method of underground mining comprising: removing ore by successive cuts along a

predetermined length of rock face in a mine;

conveying the ore removed from the rock face continuously to a mineral-processing site;

conveying waste material of the mineral-processing operation from the mineral-processing site to the excavated region;

imparting to said waste material suitable trajectory and velocity so as to fill therewith a portion of the excavated region remote from the rock face from which ore is being removed so as to support said mine roof and prevent failure thereof by controlling rate of subsidence.

14. A method of underground mining as claimed in claim 13 wherein said ore is removed by a mining machine by successive cuts in opposite directions from one end to the other of said length of rock face.

15. A method of underground mining as claimed in claim 14 wherein said ore is transferred from said mining machine by an ore face conveyor which extends adjacent to and along said rock face.

16. A method of underground mining as claimed in claim 15 wherein the ore is loaded onto said ore face conveyor from said mining machine by a cross conveyor.

17. A method of underground mining as claimed in claim 16 wherein the waste material is conveyed along said portion of said excavated region by a waste material face conveyor and wherein said ore face conveyor and said waste

material face conveyor are commonly mounted and are moved as a unit toward said rock face and away from said portion of said excavated region as the mining operation proceeds.

18. A method of underground mining as claimed in claim 13 wherein first and second pluralities of conveyors convey said ore from the rock face to the mineral-processing site and from the mineral-processing site to the excavated region respectively and wherein all said conveyors are interlocked so that they are caused to cease operating as appropriate when one of the belt conveyors becomes inoperative.

19. A method of underground mining as claimed in claim 18 wherein the waste material is conveyed from the ground surface to the underground mining level by a gravity-flow down pipe and wherein said down pipe is interlocked with said first and second pluralities of conveyors that the flow of waste material to said down pipe is halted when any one of said conveyors becomes inoperative.

20. A method of underground mining as claimed in claim 18 wherein one of said conveyors is an endless belt conveyor common to said first and second pluralities and said endless belt conveyor is caused to convey ore in one direction and simultaneously to convey waste material in the opposite direction.

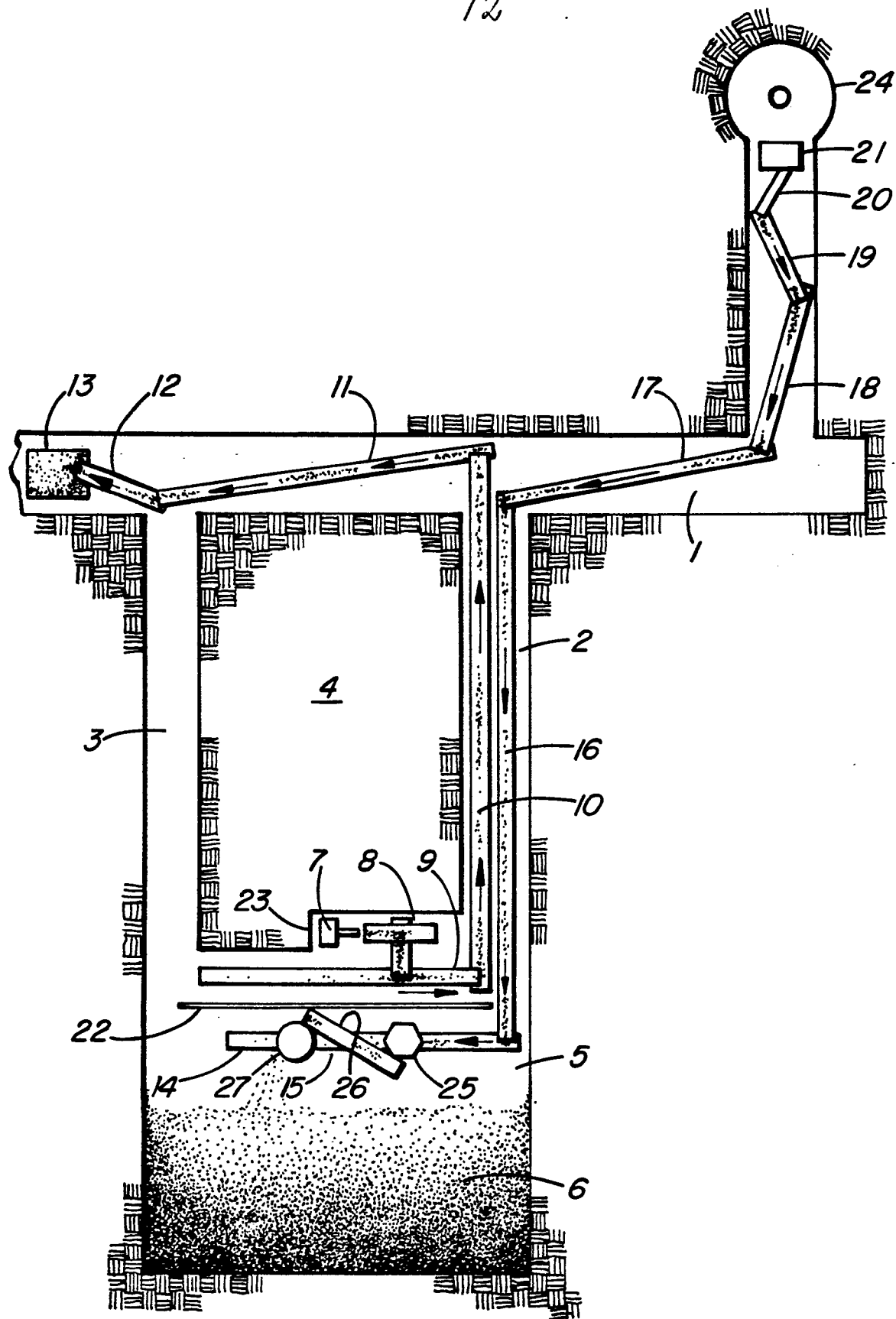


FIG. 1

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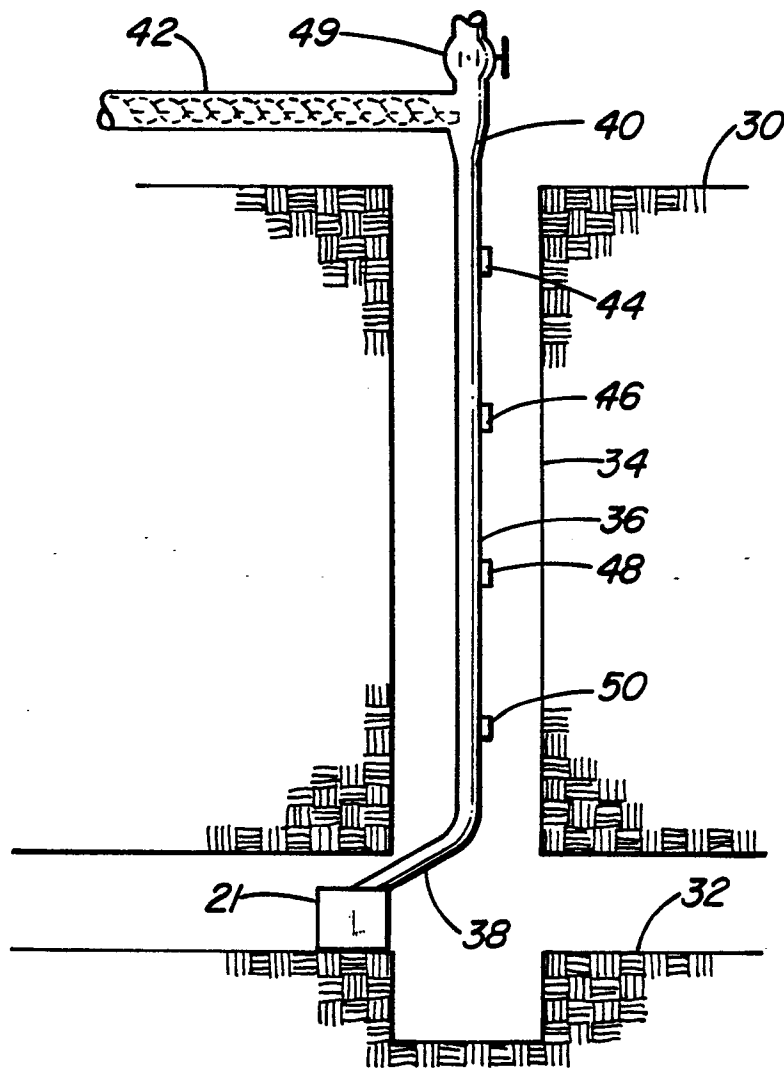


FIG. 2

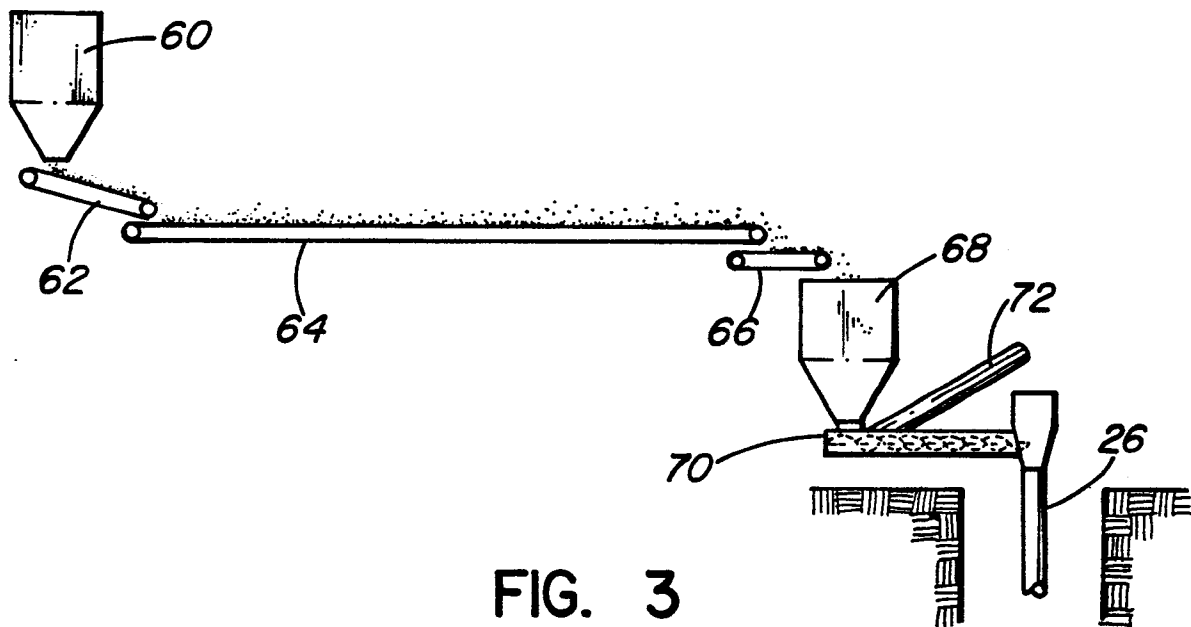


FIG. 3



DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	DE-B-1 241 395 (SALZGITTER) * Column 3, lines 16-25; column 4, lines 10-19; figures 1,2 *	1,5,13 -15	E 21 C 41/06 E 21 F 15/00
A	---	9,17	
A	DE-B-1 007 275 (DEMAG) * Column 3, line 61 - column 4, line 3; figures 1,2 *	3,9,13	
A	FR-A-1 192 384 (REUSS) * Page 3, column 1, paragraph 4; figure 4 *	3,7,11 ,12,19	
A	FR-A- 632 104 (LEROUX) * Page 3, lines 12-17; figures *	1,6,9, 13,16	TECHNICAL FIELDS SEARCHED (Int. Cl.4)
A	DE-C- 612 921 (WESTFALIA) * Claim 1; figures *	5	E 21 C E 21 F
A	FR-A-1 056 939 (GREBE)		
A	GB-A-1 136 233 (COAL INDUSTRY)		
	--- -/-		
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 03-03-1986	Examiner RAMPELMANN J.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			



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Application number

EP 85 11 5057

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 4)
A	GB-A-1 123 008 (JOY)		
A	GB-A- 682 981 (MARKHAM)		
A	DE-C- 220 761 (BERGS)		
			TECHNICAL FIELDS SEARCHED (Int. Cl. 4)
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 03-03-1986	Examiner RAMPELMANN J.
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone		T : theory or principle underlying the invention	
Y : particularly relevant if combined with another document of the same category		E : earlier patent document, but published on, or after the filing date	
A : technological background		D : document cited in the application	
O : non-written disclosure		L : document cited for other reasons	
P : intermediate document		& : member of the same patent family, corresponding document	