May 15, 1962 H. R. LEGATSKI 3,034,773

MINING AND EXTRACTION OF ORES

Filed March 24, 1958 3 Sheets-Sheet 1

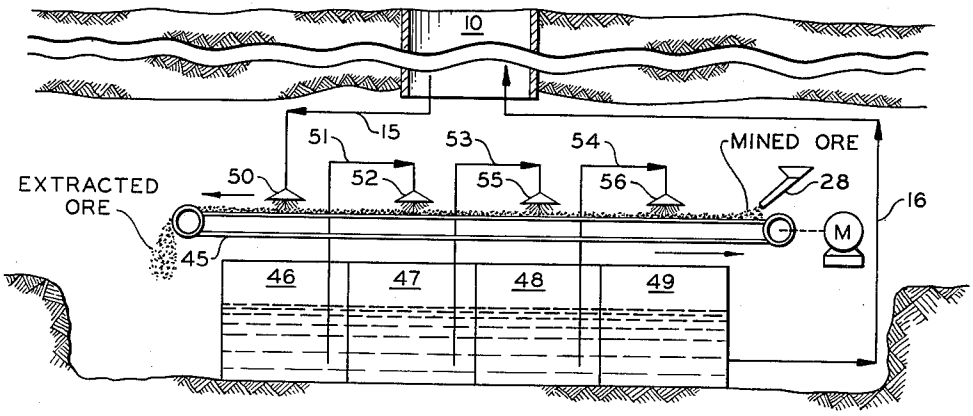

FIG. 6

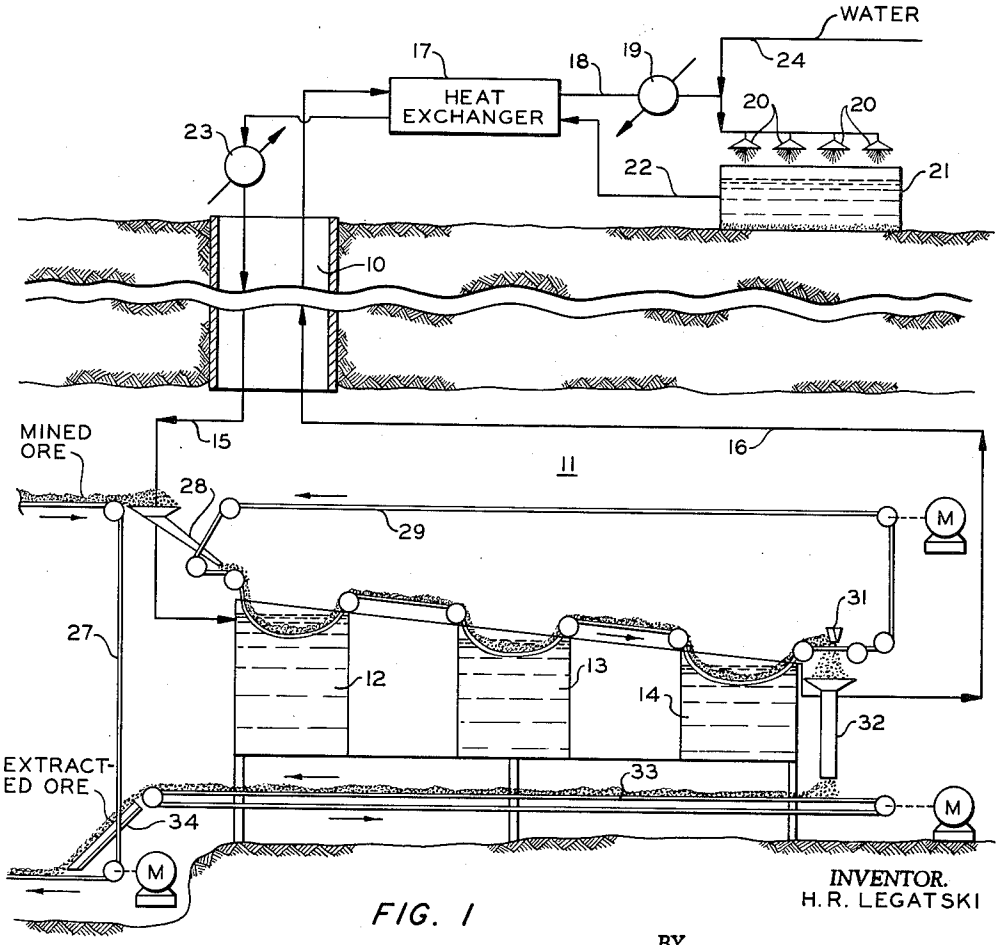

FIG. 1

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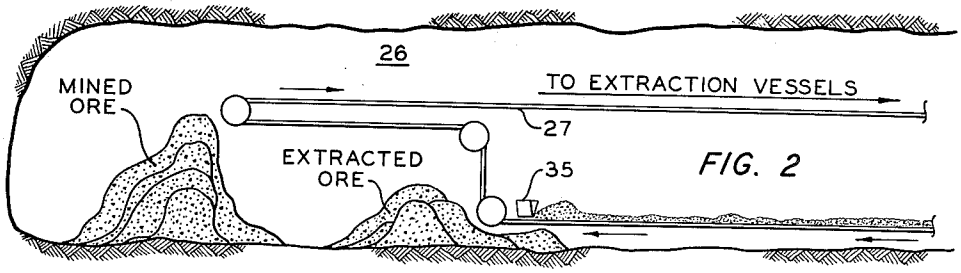

FIG. 2

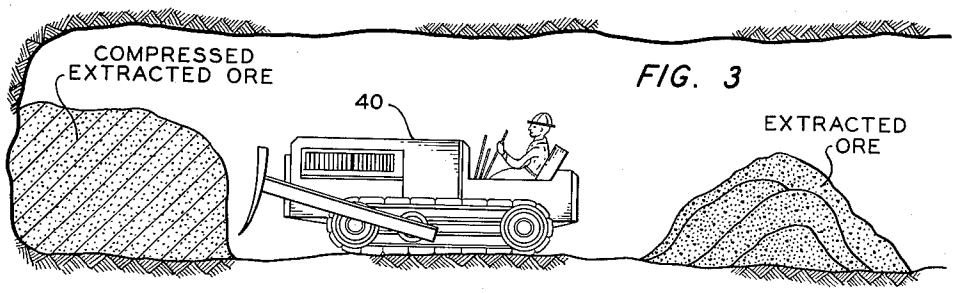

FIG. 3

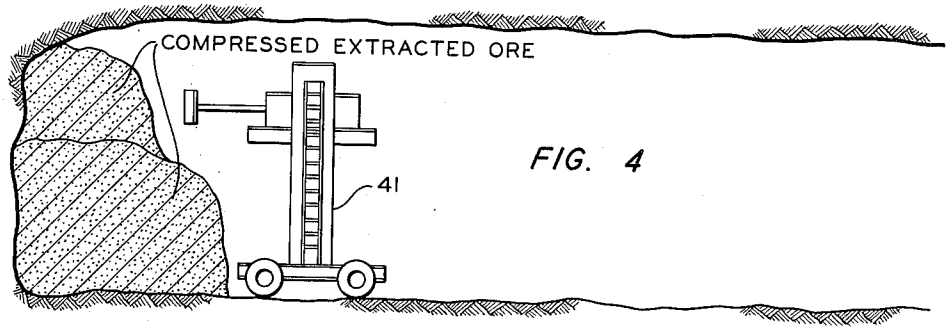

FIG. 4

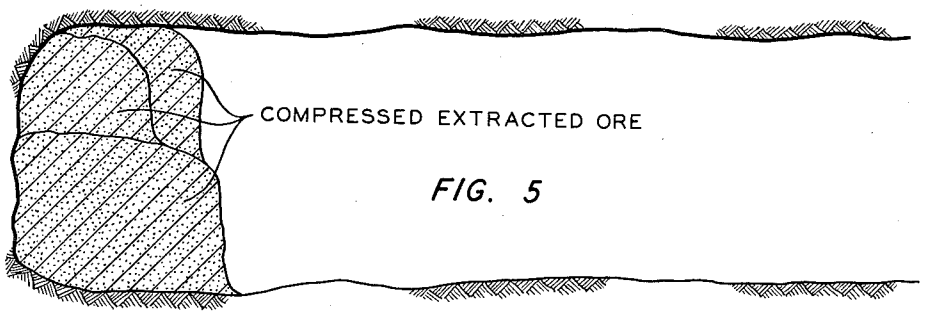

FIG. 5

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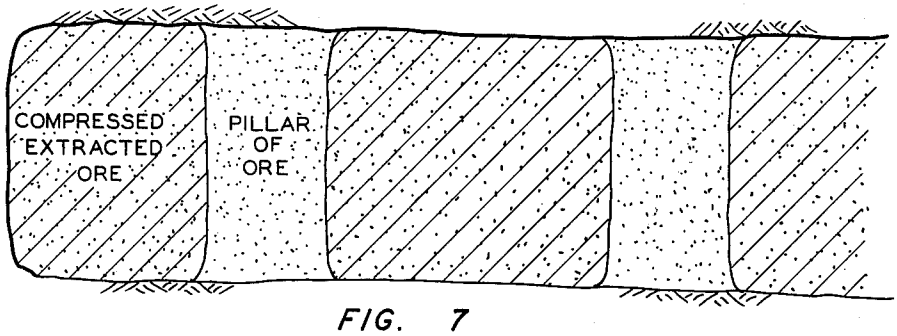

FIG. 7

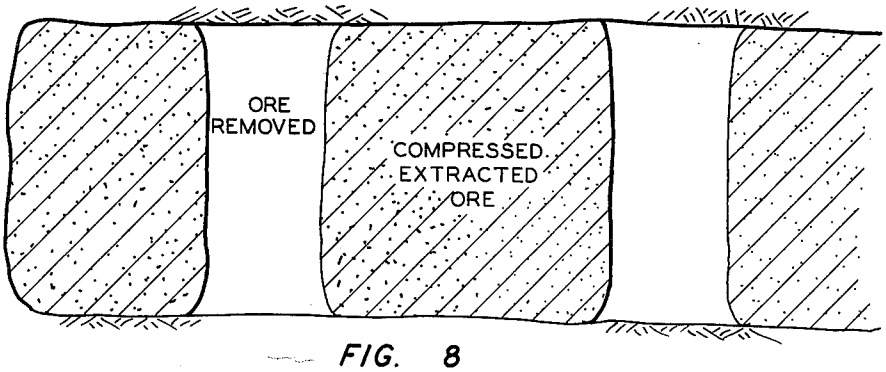

FIG. 8

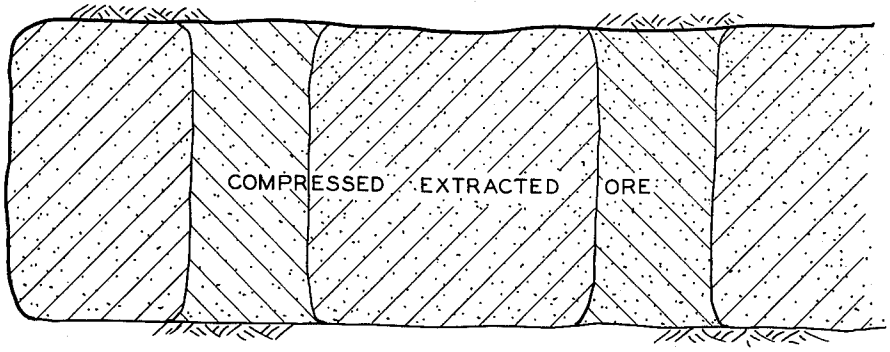

FIG. 9

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MINING AND EXTRACTION OF ORES

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10 Claims. (Cl. 262—2)

This invention relates to a method of and apparatus for mining and extracting ores underground.

In many parts of western Texas and New Mexico there exist relatively large subterranean beds of saline minerals which include potassium salts. One procedure which has been employed in the mining and refining of these ores comprises hoisting the ore to the surface and extracting the potassium salts. However, this procedure is relatively expensive due to the fact that large quantities of ore must be lifted to the surface in order to recover the desired salts. Furthermore, it is generally necessary to retain approximately 25 to 40% of the ore in the drifts to prevent the mine ceiling from collapsing. Another procedure which has been suggested involves solution mining of the ore beds. However, conventional solution mining has a number of drawbacks. It is difficult to control the direction of mining and the cavern ceiling may collapse and block off large bodies of ore deposits.

In accordance with the present invention, a novel procedure is provided for underground mining of ore and the subsequent extraction of the ore at underground caverns adjacent to the mined areas. The extracted ore is subsequently returned to the mined areas and compressed in place to support the ceilings. This procedure has a decided economical advantage over conventional mining procedures because it is not necessary to lift large quantities of ore to the surface. Furthermore, the procedure of this invention permits the mine drifts to be formed in any desired direction to recover maximum quantities of ore.

Accordingly, it is an object of this invention to provide an improved method of mining and extracting ores underground.

A further object is to provide a novel procedure for mining ores, extracting the desired minerals, and returning the extracted ore to the formations from which the ore originally was mined.

A further object is to provide an economical procedure for recovering potassium salts from underground formations.

Other objects, advantages and features of this invention should become apparent from the following detailed description, taken in conjunction with the accompanying drawing in which:

FIGURE 1 is a schematic representation of apparatus employed to carry out the ore extraction procedure of this invention.

FIGURE 2 is a schematic representation of the mining procedure of this invention.

FIGURE 3 is a schematic representation of the first step of a procedure for returning the extracted ore to the original formation.

FIGURE 4 illustrates a second step in returning the extracted ore to the formation.

FIGURE 5 illustrates the extracted ore which has been returned to the formation.

FIGURE 6 is a schematic representation of a second embodiment of the ore extraction procedure of this invention.

FIGURE 7 is a vertical cross-section of a mine shaft showing pillars of ore and compressed extracted ore.

FIGURE 8 shows the section of mine shaft of FIGURE 7 from which ore forming pillars has been removed.

FIGURE 9 shows the section of mine shaft of FIGURE 7 in which there is now compressed into place extracted ore in lieu of the original pillars.

Referring now to the drawing in detail and to FIGURE 1 in particular, there is shown a shaft 10 which extends from the surface of the earth to an underground cavern 11 that represents a part of a mine formed in a potash ore bed. Shaft 10 is of suitable size to permit workers and equipment to be lowered into the cavern. A series of leaching tanks 12, 13 and 14 are positioned within cavern 11. A conduit 15 extends from the surface of the earth downwardly through shaft 10 and communicates with leaching vessel 12. The vessels are arranged so that liquid in vessel 12 overflows into vessel 13 and liquid in vessel 13 overflows into vessel 14. The overflow from vessel 14 is returned to the surface through a conduit 16. The liquid removed from the mine through conduit 16 is directed to the first inlet of a heat exchanger 17. The corresponding first outlet of heat exchanger 17 is connected by a conduit 18, which has a cooler 19 therein, to a plurality of spray nozzles 20 which are disposed over a tank 21. Liquid is removed from tank 21 through a conduit 22 which communicates with the second inlet of heat exchanger 17. The corresponding second outlet of heat exchanger 17 is connected to conduit 15, which has a heater 23 therein. A conduit 24 communicates with conduit 18 to introduce water or other liquid into the system as required to make up for losses. If desired, this water can be added by being sprayed over belt 29 adjacent tank 14 to extract further any potassium salts.

At the beginning of the mining operation, a drift 26, see FIGURE 2, is drilled outwardly from cavern 11. This drift is drilled to the greatest distance from cavern 11 that it is desired to mine ore. The ore recovered during the drilling of this drift is deposited on a conveyor belt 27 which extends through drift 26 to cavern 11. This mined ore is crushed, either during the mining operation or at cavern 11, and is passed from conveyor belt 27 through a funnel 28 to the underside of a second conveyor belt 29. Belt 29 is suspended within leaching vessels 12, 13 and 14 so that the mined ore is slowly passed through the liquid in these leaching vessels. The resulting extracted ore is subsequently removed from belt 29 by a scraper arm 31 and directed through a funnel 32 to a third conveyor belt 33. The extracted ore passes from belt 33 down an incline 34 to the underside of belt 27 and is returned to drift 26, as illustrated in FIGURE 2, where it is removed by means of a scraper arm 35. It should be evident that side drifts can be drilled from drift 26 for the mining of additional ore.

Water preferably is employed initially as the extracting liquid. This water is heated by heater 23 to a temperature in the range of 100 to 212° F., for example, and circulated through vessels 12, 13 and 14. The water dissolves the potassium salts and other soluble salts, such as sodium chloride, which normally are present in the ore. The resulting solution is passed to the surface through conduit 16, cooled by heat exchanger 17 and cooler 19, and sprayed into tank 21 at a temperature in the range of 50 to 90° F.,

for example. The spray results in further cooling by evaporation so that the potassium salts are selectively precipitated out as crystals in tank 21. The sodium chloride tends to remain in solution and is recirculated back to the extraction vessels through conduits 22 and 15. The resulting heated solution is capable of extracting additional potassium salts from the mined ore. This extraction process can proceed continuously. Additional water is added to the system as needed by means of conduit 24.

In the original mining operation, some of the ore normally is left in the drift in the form of pillars to support the ceiling. As previously described, the extracted ore is returned to the drift by conveyor belt 27. This wet extracted ore is then forced back into the formation from which the ore originally was mined. As illustrated in FIGURE 3, this operation can conveniently be performed by means of a bulldozer 40. The extracted ore can further be compressed into the formation by means of a hydraulic ram 41, such as shown in FIGURE 4. This operation results in the ore being forced rigidly into the formation so as to fill portions of the shaft, as shown in FIGURE 5. After drying, the resulting crystallized extracted ore has sufficient strength to support the ceiling of the shaft. The ore originally left in the drift to form pillars can then be mined and extracted by the procedure described. It can thus be seen that substantially all of the ore can be removed from the mine shaft. Referring now to FIGURES 7, 8 and 9, it can be seen that ore originally left in the drift as pillars of support is now surrounded by compressed extracted ore. Referring to FIGURE 8, the ore content of the pillars has been removed and the compressed extracted ore supports the overburden. In FIGURE 9, extracted ore has been compressed into place in lieu of the pillars so that the entire drift is now substantially completely filled with compressed extracted ore. In some instances, the wet extracted ore can merely be "thrown" against the sides of the formations.

In FIGURE 6 there is shown a second embodiment of extraction apparatus which can be employed to perform the mining procedure of this invention. The mined ore is delivered through funnel 28 to a conveyor belt 45 which is directed over a series of leaching vessels 46, 47, 48 and 49. The heated solvent from conduit 15 is directed to a first spray head 50 which is positioned above conveyor belt 45 adjacent leaching vessel 46. The solvent sprayed from head 50 dissolves potassium salts from the ore on conveyor belt 45 and the resulting solution falls into vessel 46. The solution in vessel 46 is directed through a conduit 51 to a second spray head 52 which is similarly positioned over vessel 47. The solution in vessels 47 and 48 is passed by respective conduits 53 and 54 to respective spray heads 55 and 56 which are positioned over respective vessels 48 and 49. The solution in vessel 49 is returned to the surface through conduit 16. The mined ore is thus contacted by the solvent in a series of spraying steps over vessels 46, 47, 48 and 49. The equipment employed at the surface is identical to that illustrated in FIGURE 1. Other extraction procedures, such as the use of closed agitated tanks, can also be employed to dissolve the potassium salts.

From the foregoing description it should be evident that there is provided in accordance with this invention a novel procedure for mining and extracting ores underground. This procedure results in a more economical operation because it is not necessary to elevate the ore to the surface of the mine. Furthermore, it is possible to remove substantially all of the available ore from a given mine.

While the invention has been described in conjunction with the extraction of potassium salts from potash ores, it should be evident that the procedure of this invention is applicable to any ores which can conveniently be extracted by solvents within the mine cavern.

While the invention has been described in conjunction with present preferred embodiments, it should be evident that it is not limited thereto.

What is claimed is:

1. The method of recovering potassium salts from underground potash beds which comprises forming a cavern adjacent the potash bed to be mined, removing ore from said bed, passing said ore through a series of leaching zones within said cavern, passing a solvent for the potassium salts through said leaching zones in series to contact ore therein, passing the resulting solution to the surface, removing said potassium salts from said solution at the surface, returning the solvent having the salts removed therefrom to said cavern to contact additional ore, and returning the extracted ore to a potash bed from which it originally was mined.

2. The method of claim 1 wherein said potassium salts are removed from said solution by lowering the temperature of said solution.

3. The method of claim 2 wherein said solvent is heated prior to being returned to said cavern, the heating being accomplished at least in part by passing said solvent in heat exchange relationship with said solution prior to said solution being cooled.

4. The method of claim 1 wherein said solvent comprises water.

5. The method of claim 1 wherein said extracted ore is compressed into the bed to which it is returned to support the ceiling thereof.

6. The method of recovering potassium salts from underground potash beds which comprises forming a cavern adjacent the potash bed to be mined, removing ore from said bed, passing said ore above a plurality of tanks in series within said cavern, spraying a solvent for the potassium salts into the first of said tanks through the ore above said first tank, removing the resulting solution from said first tank and spraying same through the ore above said second tank and through said second tank, and repeating this operation for any remaining tanks, passing the resulting solution from the last of said tanks to the surface, removing said potassium salts from said solution at the surface, returning the solvent having the salts removed therefrom to said cavern to contact additional ore, returning the extracted ore to a region from which is originally was mined, and compressing the extracted ore into the formations to support the ceiling of the cavern.

7. The method of recovering potassium salts from underground potash beds which comprises forming a cavern adjacent the potash bed to be mined, removing ore from said bed, passing a solvent for the potassium salts in series through a plurality of leaching tanks within said cavern, passing said ore through said leaching tanks in series in contact with solvent therein, passing the resulting solution from the last of said tanks to the surface, removing said potassium salts from said solution at the surface, returning the solvent having the salts removed therefrom to said cavern to contact additional ore, returning the extracted ore to a region from which it originally was mined, and compressing the extracted ore into the formations to support the ceiling of the cavern.

8. The method of recovering minerals from an underground ore bed which comprises forming a cavern adjacent the bed to be mined, removing ore from said bed forming a cavity, passing said removed ore into said cavern, in said cavern extracting materials to be recovered from said ore, passing the recovered minerals from said cavern to the surface, returning the ore having minerals removed therefrom from said cavern to a region from which ore has been mined, and compressing the extracted ore into said region to fill up the cavity at said region thereby to support the ceiling of the cavity.

9. A method according to claim 8 wherein during the formation of the cavity, there are left remaining pillars to support the ceiling of the cavity, the ore which has been treated, as stated, is compressed into the cavity to fill up the cavity at said region, thereby to support the

ceiling of the cavity, and wherein the pillars are then mined and treated as was the ore originally taken from said cavity.

10. A method according to claim 9 wherein when the ore content of the pillars has been treated, it is returned to the cavity to substantially fill up the same, thus having substantially filled the cavity while at the same time having mined the entire volume defined by the external limits of said cavity.

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