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(54) **Hydrocarbon fuel extraction system.**

(57) A system for the extraction of a hydrocarbon fuel from a hydrocarbon fuel-bearing ore, such as shale or coal, comprises means (10) for mining the ore, and a plurality of portative retorts (24) for processing the mined ore to produce a hydrocarbon fuel. Means (28) is provided for transporting the mined ore to each of the retorts (24), means (32) coupled to the transport means (28) regulating the amount of ore transported to a respective retort (24). At least one storage device is coupled to the retorts (24) for collecting and storing the hydrocarbon fuel. The retorts (24) are moved in consonance with movement of the mining of the ore.

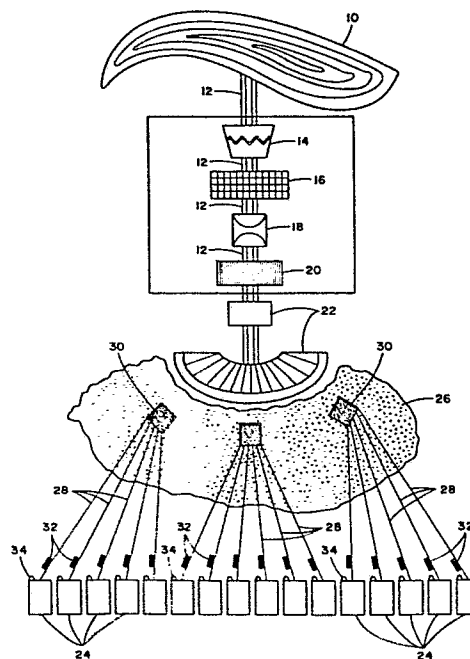


FIG 1

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HYDROCARBON FUEL EXTRACTION SYSTEM

This invention relates to a system and method for recovering hydrocarbon fuel from hydrocarbon fuel bearing ores; for example gasification recovery of oil from oil-bearing shale and coal gasification.

5 As the energy situation becomes more and more critical, it is important not only to conserve energy, but also to find every possible means of recovering energy from all sources available as economically and as efficiently as possible. In this regard, it is
10 well-known that oil shales exist in large deposits which can be readily mined and pyrolyzed to produce shale oil and that there are similarly large coal reserves.

The term "oil shale" refers to marlstone, a
15 limestone-like carbonaceous rock that can produce oil when heated to pyrolysis temperatures of about 800⁰-1000⁰F (427-538⁰C). The oil precursor in the shale is an organic polymer substance of high molecular weight referred to as "kerogen". Oil shale is found all over
20 the world and estimates of the amount of oil locked in those formations runs into trillions of barrels. In addition, a large amount of these oil shale formations can only be recovered by underground mining techniques.

Present techniques for producing oil from shale
25 require large capital investment, pollution control,

handling of raw and spent shale, and the need in some cases for large amounts of water to cool the hot kerogen vapours from the retort or kiln and to slurry and compact the spent shale back into the deposit.

5 In a modification of retorting applicable to underground mining referred to as in situ mining, a small portion of the rock is removed and the rest is reduced to small particles by explosives and then the particles are burned in place. The oil is collected
10 at the bottom of the natural retort and pumped to the surface.

 Regardless of the specific technique employed, in order to produce shale oil in large quantities, enormous expenditures are required with present state of the art
15 techniques. One company estimates that it will have spent more than US \$100,000,000 by the time its first 9,500 barrel a day retort begins operating. Another company indicates that to produce 48,000 barrels of oil a day, it would need six storey tall retorts, each
20 capable of processing 11,000 tons of shale a day. The company officials estimate that it will cost \$1.3 billion to \$1.5 billion for that operation. Still another company states that it has spent over US \$100,000,000 developing modified in situ technology for use at shale
25 sites and has been testing underground retorting for a number of years. The last three retorts built by this company were big enough for commercial production and were 160 feet square and almost 300 feet high. One collapsed. This company states that to scale operations
30 up to commercial production, it would require 40 underground in situ retorts to produce the 50,000 barrels a day which was set as a goal.

 There are at least six significant contributory factors to the continuing lack of economic feasibility
35 for recovery of shale oil. These are high fixed costs

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of on-site construction of the necessary recovery plants (retorts and the like); the high carrying cost of the land necessary to support the large recovery plants; the uncertainties as to the technological feasibility of large plants due to problems arising from scaling up from small, successful pilot plants; the logistics of handling vast quantities of materials; the high risk premium on the cost of capital to carry out the recovery; and the environmental problems. These same factors have inhibited and largely prevented commercially-successful coal gasification.

Thus, it can be understood why no one in the last century has produced shale oil in other than small quantities, even though efforts to effect commercial production have been going on since the 1920's and particularly since the early 1970's.

As previously noted, the greatest available source of richest deposits of shale requires underground mining where it is expected that the usual mining techniques such as large room and pillar mining techniques will have to be used. This necessitates the dual problem of working to recover the shale and, further recovering the oil from the shale.

Another major problem with regard to extracting kerogen from shale is the problem of disposing of the spent shale. Having been exposed to the high temperatures in order to extract the oil, the shale expands in volume by a factor of as much as 150% and the original area mined cannot accomodate all of the expanded spent shale. Attempts to handle the shale by leaving them in dumps has not proven satisfactory. Aside from the unsightliness of such dumps, there is the problem of pollution due to the fact that rains on such dumps can produce a highly alkaline run-off. This necessitates the development of containment

devices to prevent any such run-off. There is also the problem of landscaping and revegetation.

The same problem of massive capital expenditure also applies to efforts to make coal gasification a
5 viable commercial reality even though the underlying technology exists.

In accordance with the present invention, a system for extraction of a hydrocarbon fuel from a hydrocarbon fuel-bearing ore comprises means for mining
10 the ore; a plurality of portative retorts, as hereinafter defined, for processing the ore to extract a hydrocarbon fuel; means for transporting the mined ore to each of the retorts; means coupled to the transport means for regulating the amount of ore transported to
15 a respective retort; and at least one storage device coupled to the retorts for collecting and storing the hydrocarbon fuel.

By "retort" I include retorts, kilns and other recovery plant.

Also in accordance with the present a method of
20 extracting a hydrocarbon fuel from hydrocarbon-fuel bearing ore comprises the steps of mining the ore; transporting the ore to a plurality of portative retorts, as hereinafter defined, in which the ore is
25 processed to produce a hydrocarbon fuel fluid; and moving the retorts in consonance with movement of the mining of the ore.

Means may be coupled to each retort for processing and purifying gaseous wastes generated during extraction
30 of the hydrocarbon fuel. Furthermore, the system may further include heat exchanger means coupled to each retort to remove heat therefrom; and means coupled to each of the heat exchangers and the fuel storage and collecting device for transferring heat from the heat
35 exchanger to the at least one storage and collecting

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device for maintaining the hydrocarbon fuel in a fluid state.

5 A feature of the system is the ability to utilize proven portative retorts of a size that they can be placed in and operate in, underground mines of the room and pillar type and to move as the mining operation moves. This has significant advantages in both underground as well as surface mining which are described in detail below. As used herein, the term "portative" means portable or movable either by means on the unit itself, or by means of a vehicle, such as a tractor, without any extensive disassembly, but in all cases portative shall mean non-permanent.

15 First, the ability to process the ore underground is a tremendous advantage in that it eliminates the need to carry all of the ore to the surface to be retorted and then have to return ore back into the mine for disposal. The only remaining problem in underground mining is disposal of the volume of spent ore that cannot be accomodated by the previously mined area. Thus, the problem of surface containment of spent ore is, in addition, greatly minimized.

25 Secondly, the problem of emissions is made simpler in that the retorts, being placed in the mine, and there being limited ways in which the gases can rise therefrom to the surface, the emissions can be more readily treated to prevent pollution. Also, by having the retorts in the mine, the natural beauty of the areas where mining occurs is largely preserved. In effect, one is able to recover the fuel without any of the emission problems resulting from surface retorting.

30 Portability; i.e., mobility, is also of importance in surface mining in that smaller, mobile units make commercial recovery possible by requiring less land, less reclamation, market entry by moderation,

35

optimization of materials handling, and ability to mix different retort systems to obtain a desired by-product mix.

5 In addition, the portative retorts are of a size such that they can be produced in a factory and transported as self-contained units or in a few readily assembleable parts to the mining site. This avoids the much larger cost of on-site construction required of large retorts in remote mining areas. The savings
10 in cost are substantial.

While underground in situ mining by the use of creating a rubble in the ground and then using the rubbleized formation for a natural retort has been attempted, it is not successful in that the recoveries
15 are low, and of course, a great deal of the fuel is lost. It is known also that with room and pillar mining techniques, up to as much as 50 to 60% of ore is left in pillars and hence fuel cannot be recovered therefrom. This, of course, results in higher costs and lower
20 production. However, with the proposed method it is contemplated that as certain areas are mined, after movement of the retorts to another area for continuous recovery of additional ore, the sections serving as pillars can be collapsed and the remaining material mined
25 by the pulverized or rubbleized in situ techniques discussed above. This minimizes, again, the cost of the process and the loss in production. Further, the spent ore can be used as a structural support to eliminate the problems of surface subsidence or mine collapse as
30 experienced by conventional in situ processing.

Thus, the economies of large scale mining operations and the economies of small scale already proven retorts known to be successful are combined. Furthermore, the combination of the large mine and
35 crushing operation with a series of small, proven

retorts which have been made portative avoids the costs, uncertainties, and sub-optimization of scale-up to large size retorts.

5 More particularly, the retorts can be constructed in a factory and driven to the site, avoiding on-site construction and effecting a large reduction (up to 85%) in fixed costs. Small retorts have already been tested and found successful the use of smaller portative retorts reducing the necessary amount of land needed
10 for economic feasibility; while materials handling is largely obviated in the case of underground mines by placing the retorts down in the mine. The environmental advantages and cost savings are numerous, particularly with underground mining; and by utilizing
15 smaller, proven retorts and the above economies associated therewith, there is a much lower cost-of-capital to effect recovery of shale oil.

The system and method are particularly applicable to extraction of oil from oil shale and coal gasification
20 and will be particularly described in connection with the former.

An example of a system and method in accordance with the present invention is illustrated in the accompanying drawings, in which:-

25 Figure 1 is a schematic representation of the over-all mining operation;

Figure 2 is a general schematic representation of a shale oil collection operation;

30 Figure 3 is a more detailed schematic representation of an individual retort and its associated inputs and outputs; and

Figure 4 is a cross-sectional schematic representation of a room and pillar mining system.

35 Figure 5 is a cross-sectional schematic representation similar to Figure 4 but showing a conventional

mining system.

The invention will be described in connection with the recovery of oil from oil shale and particularly in connection with underground mining systems, it being understood that if desired, it can also be used with respect to surface mining, such as strip mining techniques.

The shale oil recovery operation shown schematically in Figure 1 enables recovery of shale oil through a plurality of individual retort operational units, each of which, if desired, can be owned by an individual operator thus eliminating the requirement that the entire capital outlay be produced by one company. Further, each of the retorts is portable (mobile) in nature and can be quickly connected to or disconnected from the system or moved as the mining operation is moved.

As can be seen in Figure 1, the oil-bearing shale is removed by a quarrying operation 10 in any well-known manner. The quarrying operation may be a strip mining operation or it may be an underground mining operation. Both methods are old and well-known and the shale produced thereby is placed on a conveyer belt 12 which carries the shale to a primary crusher 14 which has jaws or other means for reducing the size of the shale in a well-known manner. The output from crusher 14 is carried by the conveyer belt 12 to a coarse screen 16 which separates lumps in excess of the maximum allowable size. The screened shale is then carried by the conveyor belt 12 to a secondary crusher 18 where the large pieces of shale are further reduced in size. The crushed shale is carried by the conveyer belt 12 from the secondary crusher 18 to a fine screen 20 which extracts shale which is less than a minimum allowable size. The

residue is carried by conveyer belt 12 to a radial stacking unit (or stacker) 22. The radial stacker 22 can be any of the commercially available types and stockpiles the oil-bearing shale over a large area 26 covered by movement of the stacker in a semi-circular pattern.

A plurality of individual retorts 24 receive oil-bearing shale from stockpile 26 by means of individual conveyer belts 28. Automatic feeders 30 in stockpile 26 constantly supply the oil-bearing shale to conveyer belts 28.

Each retort 24 has an individual control 32 which is used to adjust its speed and hence the feed rate of the conveyer belt 28 coupled to that particular retort 24. Thus, the amount of shale delivered to each retort can be controlled by means of individual manual control 32. Further, each individual retort 24 has its own monitor 34 which calculates the total volume of raw shale, either in linear feet or gross weight, which is fed to the particular retort and calculates the shale fed to that particular retort. Thus, the shale is delivered in quantities as required by the individual retort and the amount of such shale delivered is measured. For each retort owned by different operators, the amount to charge can be calculated according to the amount of shale received.

The oil-bearing shale is fed into the individual retort 24 in the usual manner where it is heated to a temperature (about 800° - 1000°F (427-538°C)) which releases the shale oil. The residue from the burning shale is removed as an ash and sold or otherwise discarded. The shale oil is fed into a collection system and the gaseous waste by-products are also coupled to a cleansing system where they are precipitated, filtered and/or detoxified before the final wastes are released

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into the free atmosphere. All of the individual retorts 24 are shown as coupled into a common collection system and by-products cleansing system, but alternatively each retort 24 could have its own pollution control system. It is also contemplated that different retorts 24 can be utilized to form hybrid systems that can obtain a variety of by-products dependent upon the retort used.

As can be seen in Figures 2 and 3, the oil-bearing shale in stockpile 26 is coupled by means of individual conveyer belts 28 to the respective retorts 24. Each of the retorts 24 is coupled to a power line 36 through an electrical plug to provide the electrical power necessary to operate the hydraulics, suction blower, gear motors, and other electrical devices. A conventional meter unit, not shown, such as a watt-meter, at each retort 24 monitors the total power consumed by the retort. If owned by different operators, they can be charged accordingly.

The kerogen released by the heated shale flows from each retort's individual product line 38 to a common product line 40 which transfers the kerogen to a storage tank 42. The line 38 may be connected to the respective retort 24 by a quick release coupling. As the kerogen enters the individual product line 38 from a particular retort 24, it flows past a volume monitor 44 which measures and records the quantity of kerogen produced and contributed by each individual retort. If individually owned, the individual retort operator is paid according to this volume figure. Further, the meter reading from this volume monitor 44 may also be used, as necessary, for computing any royalties which may be owed to the land owner and/or lease payments owed to the land owner and/or lease payments owed to the retort lessor.

The gaseous wastes from each retort 24 are collected in parallel through a gaseous waste line 46 which leads to conventional environmental cleansing/by-product extraction hardware 48. (The line 46 may be connected to the respective retort by a quick release coupling.) Here the gaseous wastes are precipitated, filtered, and/or detoxified before the final wastes, in the form of carbon dioxide and water, are released into the free atmosphere. As previously noted, each retort can have its own environmental cleansing/by-product extraction hardware and controls. It is also possible to entrain the wastes in the kerogen and permit waste removal at the refinery where waste treatment facilities already exist.

Since kerogen tends to become "jello-like" in consistency when its temperature drops below 85°F (29.4°C) individual product lines 38 and site product line 40 as well as storage tank 42 may be heated, for example by being wrapped by a tubing loop.

A heat exchanger 50 has coupled thereto an outlet line 52 for carrying heat away from the retort 24 and an inlet line 54 for providing a return flow to retort 24. Line 52 may be used to wrap line 38 and site product line 40 as well as the kerogen storage tank 42. The heat exchanger 50 would recover the convected heat from the retorts, resulting from on-going combustion and conduct the heat by suitable means to heat the individual product lines, the site product line, as well as the kerogen storage tank. The heat of the on-going combustion in each retort 24 is utilized to maintain the kerogen in a fluid state. Heat can also be recovered from the spent shale clinker and if desired the recovered heat can be used to distill off certain fractions of the kerogen after it has been recovered from the oil shale.

Not depicted is the skid-mounting for the retorts 24. This is conventional in nature and tractors or other similar movers can be attached to the skid-mounting to move the individual retorts to any site
5 desired. It will be evident that other means equivalent to skid mounts can be used to make the retorts portable or, if desired, motor means on the retort itself operatively connected to motive means; i.e., wheels, continuous track, and the like, mounted on the bottom
10 of the retorts can be used to move the retorts when desired.

The retorts 24 can be any one of the successfully used retorts such as the Union Oil rock pump retorts (Types A and B), the Cameron and Jones kiln, or the
15 retorts used in the Paraho, Superior, and Tosco oil shale processes as described on pages 263 to 270 of the text "The Energy Source Book", edited by McRae et al. Certain of these and other retorts are disclosed in U.S. Patent Specifications Nos 2,875,137, 3,162,583,
20 and 3,980,865. These retorts must, however, be made of a size to be portative and provided with means to make them portative.

Figure 4 illustrated a conventional room and pillar mine having sufficient pillars 71 to support the
25 mine. Conventional mining equipment (not shown) is used to mine the shale from the mine face and the shale is conveyed, as by front-end loaders 72, to conventional crushers 73. The crushed shale is moved by conveyers 74 to a screen 99, then through a second crusher 75
30 (if necessary), and then the crushed ore is placed into feeder piles 76 by a radial stacker 95. A plurality of conveyors 77 carry the crushed shale from piles 76 to retorts 78. The kerogen is conveyed by pipes 79 to storage tank 80 located on the surface. The other by-
35 products are conveyed to recovery tank 90 by pipes 91.

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The spent shale is moved by means of conveyors 85 to a portion of the mine already mined where it is disposed of and the excess spent shale is moved by means of conveyors (not shown) to spent shale storage tank 81 where the excess spent shale is carried to the surface by suitable elevator means, such as the continuous bucket system 82, and onto surface conveyor 83 for transport to a suitable surface dump site. If desired, the spent shale can be treated with a suitable aqueous solution in tank 81 to dissolve and remove the alkaline cations therefrom. These alkaline materials can then be disposed of in the mine thereby eliminating a major problem with respect to surface deposit of the excess spent shale.

The system shown in Figure 5, for comparison purposes, combines, again, room and pillar mining, but with conventional surface retorting and stationary retorts. It is not as economically suitable in that all the oil shale must be conveyed to the surface, not just the excess shale as with the system shown in Figure 4. In the Figure 5 system, the shale mined in mine 80 is conveyed by loader 72 to crusher 73, screened, lifted to the surface in buckets 100, and there secondarily crushed. The crushed shale is then fed to non-mobile retorts 78 and the kerogen conveyed to storage tank 80 and other recoverable by-products to recovery tank 90. If the spent shale is to be placed back into the already mined area of the mine, it can be lowered by means of buckets 103 into the mine and conveyed by means of conveyors 104 to the area where it is to be dumped. Such a system is significantly less economic than that shown in Figure 4. In addition, the reduced distances over which the spent shale must be transported is, by virtue of the retort mobility, greatly minimized and avoids the requirement of slurrying the shale residue as foreseen necessary in the large immobile facilities thereby avoiding the necessity of large water usage.

The use of small portative retorts is advantageous over large retorts even in surface mining in that much less land is required for economic mining as the retorts can be readily moved from place to place over the mining area.

Thus, there has been disclosed an oil recovery system in which kerogen is recovered from oil-bearing shale which permits economic recovery and in a manner which allows, if desired, individual operators to share the enormous costs that are involved in the production of such shale oil and yet which allows each operator to set up a portable retort on the site of the oil-bearing shale or to purchase from the land owner or other individual the amount of shale necessary for continually operating the retort as many hours a day as necessary and to supply the recovered shale oil to a common collection system and to have the gaseous waste supplied to a common collection system for purification. The costs thus become managable and allows a shale oil recovery operation which could not be effectively handled by one operator.

While the system has been described in detail with respect to recovery of oil from oil shale, it is also applicable to recovery of oil from tar sand, and coal gasification. The applicability arises from the fact that in these other energy recovery efforts, large scale mining of the sands and coal is well-known and efficient, but the recovery of the oil from the sand and gasification of the coal have been hampered by the cost of scaling up the recovery devices; i.e., retorts, kilns, and the like. As with shale oil recovery, this problem can be overcome by using a sufficient number of the already proven pilot scale recovery units which are made portative and which avoid the problems, economic and mechanical, of scaling up. Thus, the system of

mating large scale mining techniques with small scale portative retorts to provide economic and efficient recovery of oil from oil shale can be applied to recovery of oil from tar sands and to coal gasification.

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CLAIMS

1. A system for extraction of a hydrocarbon fuel
from a hydrocarbon fuel-bearing ore, the system
comprising means for mining the ore; a plurality of
portative retorts (24), as hereinbefore defined, for
5 processing the ore to extract a hydrocarbon fuel;
means (28,77) for transporting the mined ore to each of
the retorts; means (32) coupled to the transport means
(28,77) for regulating the amount of ore transported to
a respective retort (24); and at least one storage
10 device (42,80) coupled to the retorts (24) for
collecting and storing the hydrocarbon fuel.
2. A system according to claim 1, further including
means (48) coupled to each retort (24) for processing
and purifying gaseous wastes generated during extraction
15 of the hydrocarbon fuel.
3. A system according to claim 1 or claim 2, further
including heat exchanger means (50) coupled to each
retort (24) to remove heat therefrom; and means (52,54)
coupled to each of the heat exchangers (50) and the
20 fuel storage and collecting device (42,80) for
transferring heat from the heat exchanger to the at
least one storage and collecting device for maintaining
the hydrocarbon fuel in a fluid state.
4. An underground mining system according to any of
25 claims 1 to 3 for extraction of a hydrocarbon fuel from

an underground hydrocarbon fuel-bearing ore, further comprising means for forming an underground chamber and to mine the ore, and wherein the plurality of portative retorts (24) are located in the chamber, the means (28,77) for transporting the mined ore to each of the retorts (24) are located underground, and the at least one storage device is located either in the chamber or above ground.

5. A system according to any of claims 1 to 4, further comprising means for conveying spent ore to areas already mined.

6. A method of extracting a hydrocarbon fuel from a hydrocarbon fuel-bearing ore, the method comprising the steps of mining the ore; transporting the ore to a plurality of portative retorts (24), as hereinbefore defined, in which the ore is processed to produce a hydrocarbon fuel fluid; and moving the retorts (24) in consonance with movement of the mining of the ore.

7. A method according to claim 6, including the step of disposing of spent ore in areas already mined.

8. A method according to claim 6 or claim 7 of extracting a hydrocarbon fuel from oil-bearing shale or coal.

9. A method according to claim 8 of extracting oil from oil-bearing shale, the method comprising the steps of forming an underground chamber in a vein of oil-bearing shale; mining the shale in the vein; conveying the mined shale to the plurality of portative retorts (24) located in the chamber; processing the shale in the retorts (24) to extract an oil-bearing fluid; and moving the retorts (24) in consonance with movement of mining of the shale.

10. A method according to claim 9, wherein the chamber includes supporting pillars (71) comprising oil-bearing shale, the method comprising the further step of subsequently pulverizing the pillars (71) and subjecting them in situ processing to recover the oil-bearing fluid therefrom.

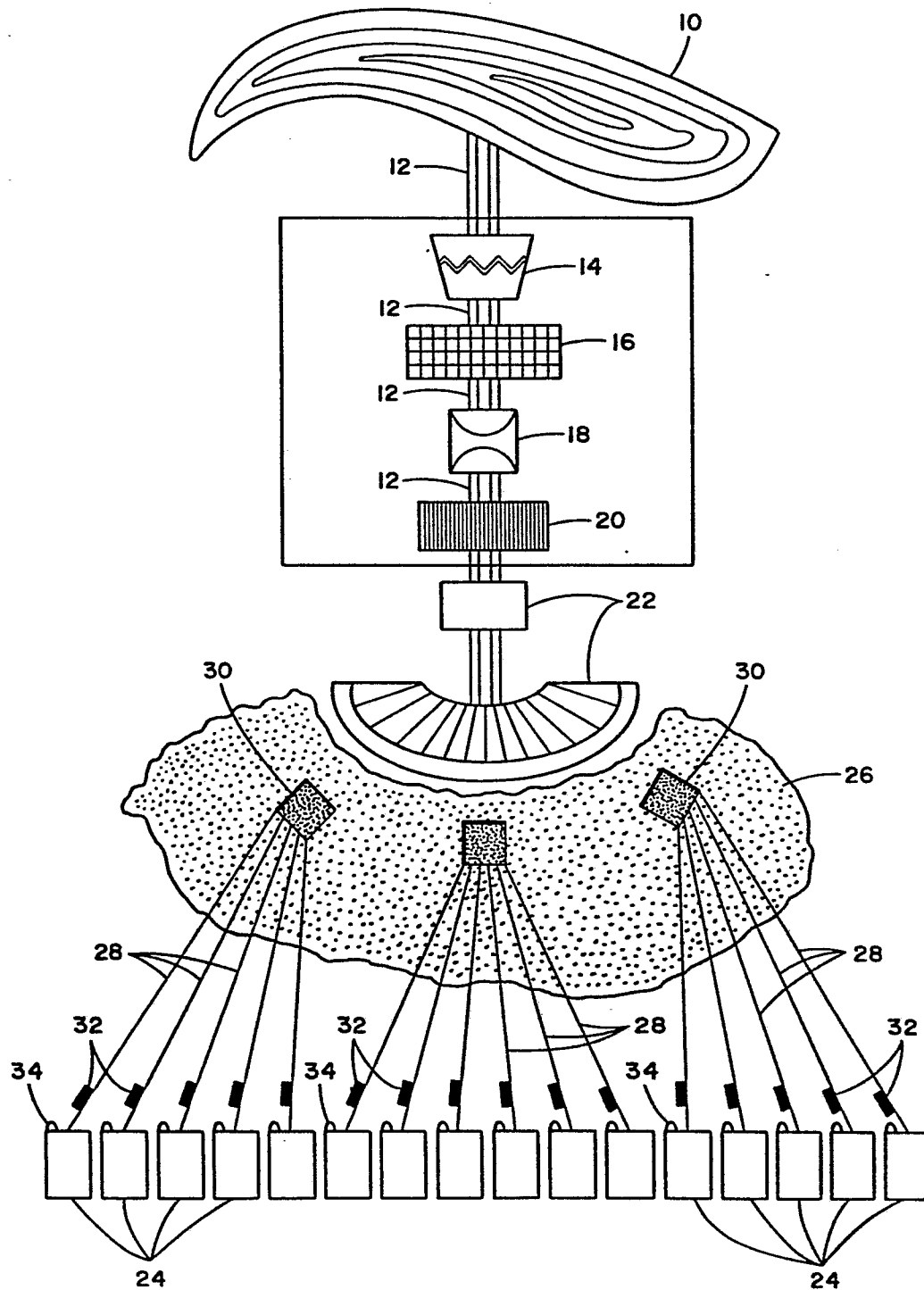


FIG 1

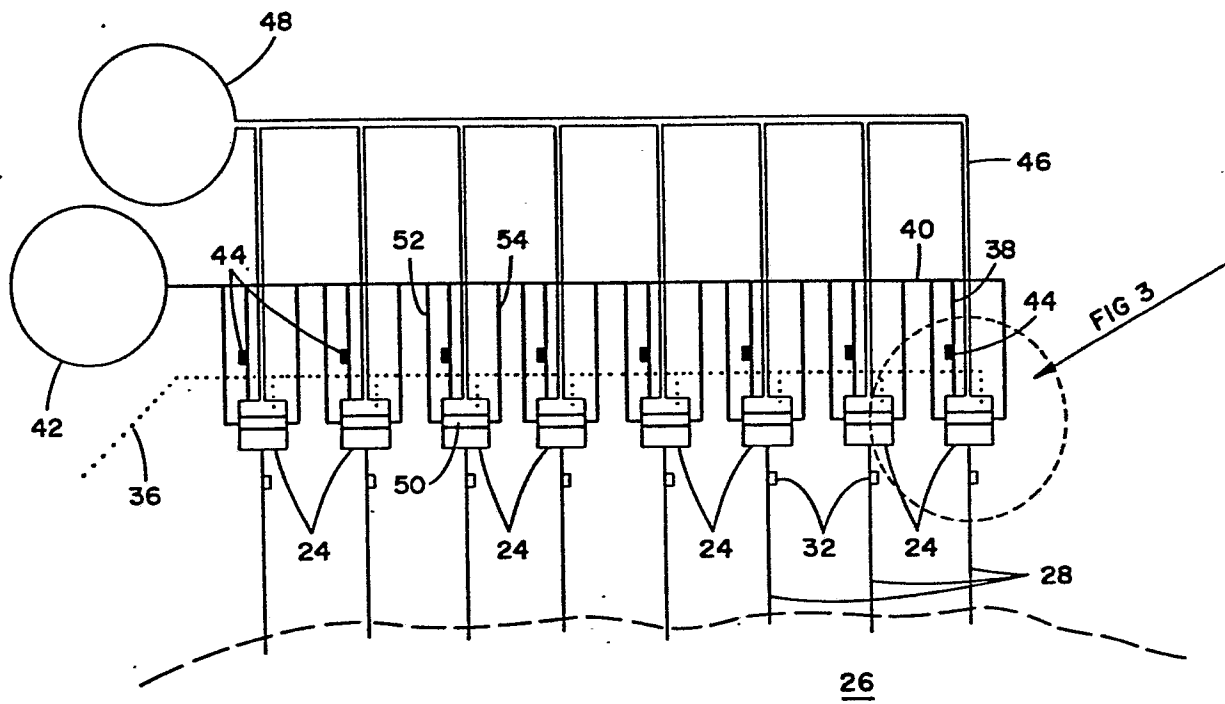


FIG 2

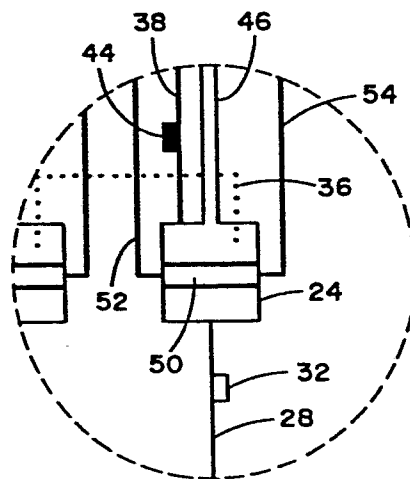
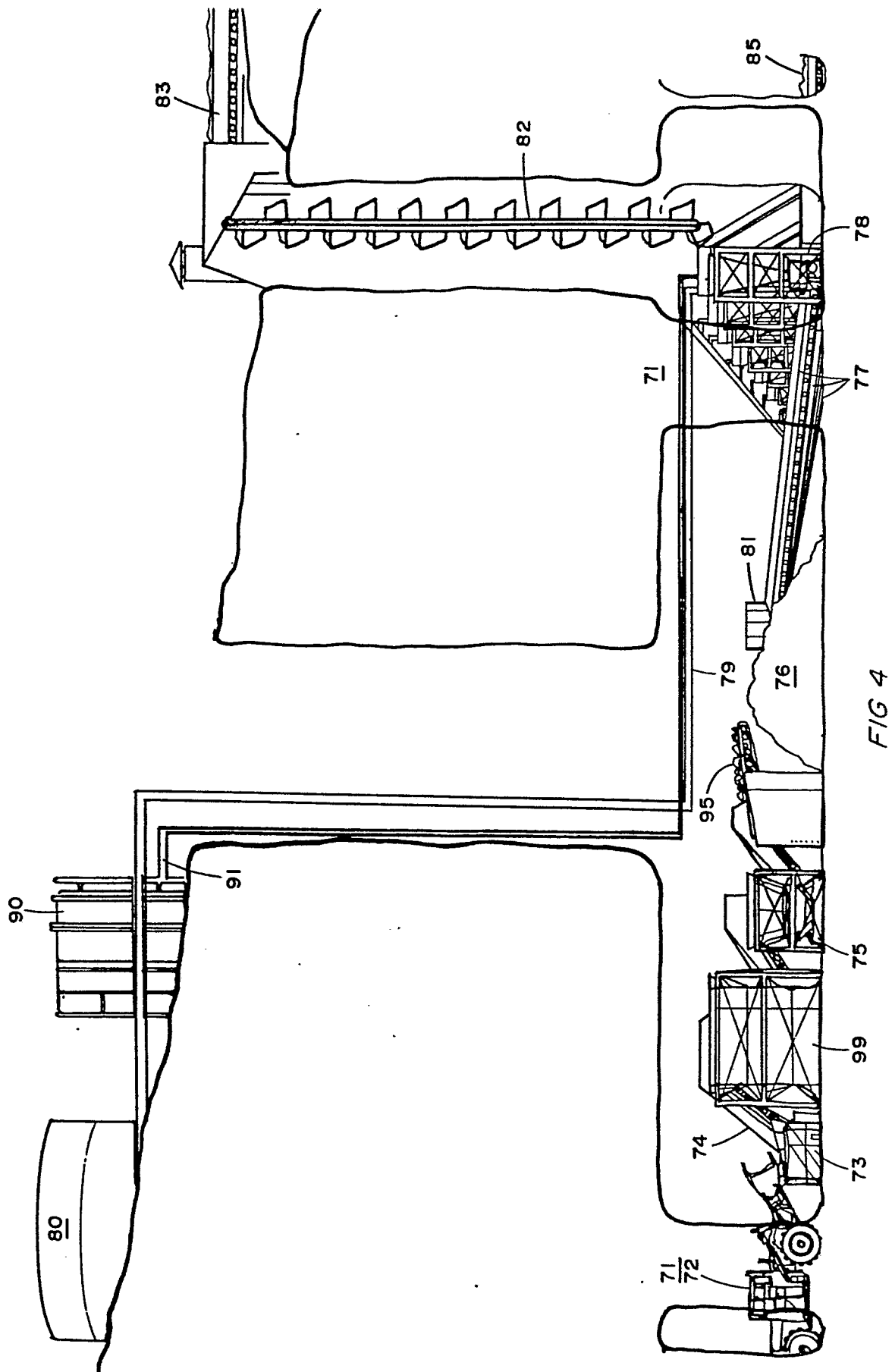
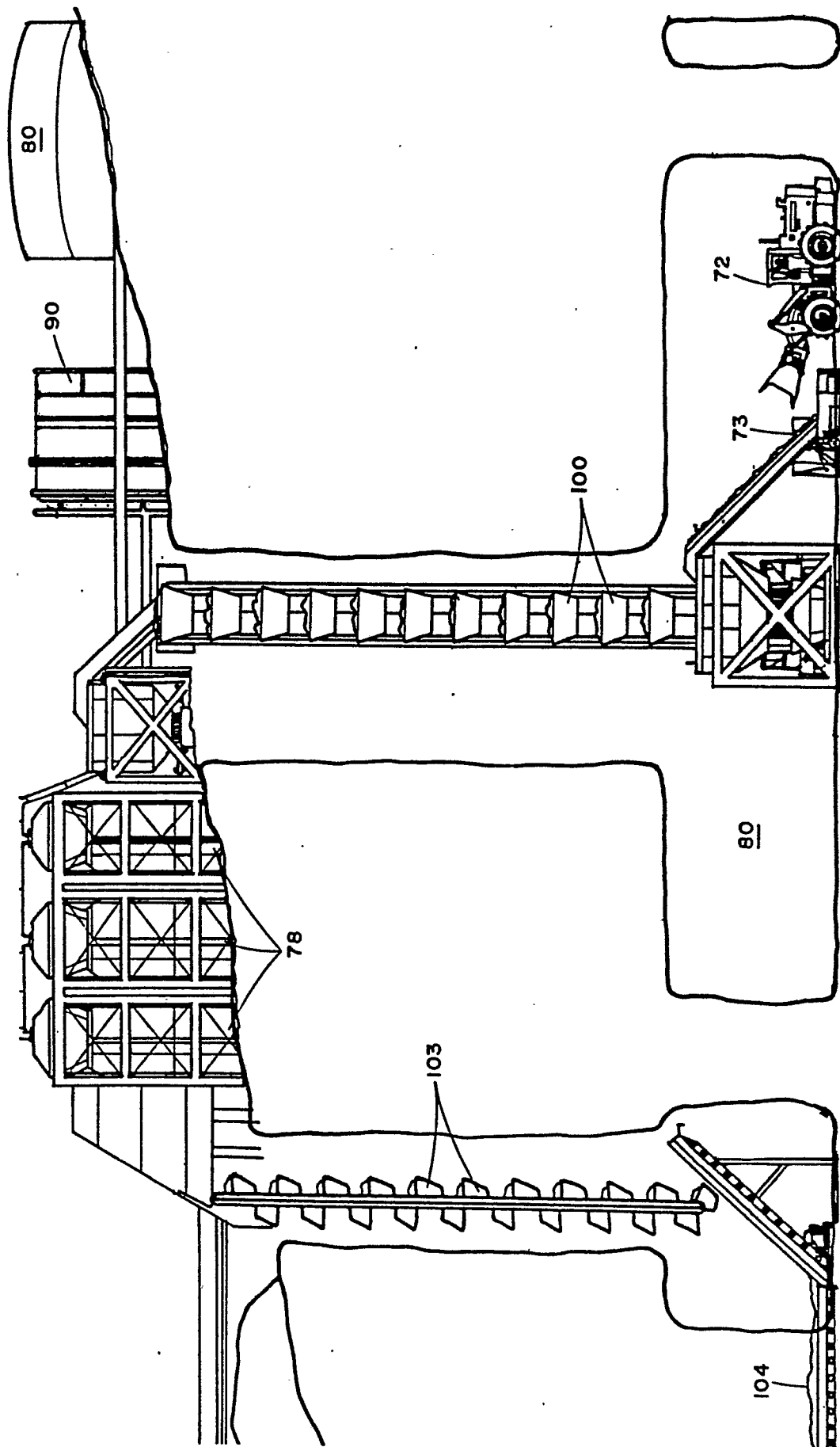


FIG 3







European Patent
Office

EUROPEAN SEARCH REPORT

0044700
Application number

EP 81303245.5

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl.)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
A	<u>GB - A - 1 154 108</u> (MC DOWELL-WELLMAN ENGINEERING COMPANY) * Claim 1 *	1,6,8	C 10 G 1/00 C 10 B 57/20 C 10 J 5/00
A	<u>GB - A - 1 122 091</u> (EQUITY OIL COMPANY) * Claims 1,2,6,11 *	1,6,8	
A	<u>US - A - 4 160 479</u> (REGINALD D. RICHARDSON AND ROBERT H. SHANNON) * Claim 1 *	1,6	TECHNICAL FIELDS SEARCHED (Int. Cl.)
A	<u>US - A - 4 125 453</u> (PAUL W. TAMM AND CHRISTOPHER W. KUEHLER) * Claim 1 *	1,6,8	C 10 G C 10 B C 10 J
A	<u>US - A - 4 090 945</u> (ADAM A. REEVES) * Claim 1 *	1,6,8	CATEGORY OF CITED DOCUMENTS X: particularly relevant A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: conflicting application D: document cited in the application L: citation for other reasons
X	The present search report has been drawn up for all claims		&: member of the same patent family, corresponding document
Place of search VIENNA		Date of completion of the search 30-09-1981	Examiner STÖCKLMAYER