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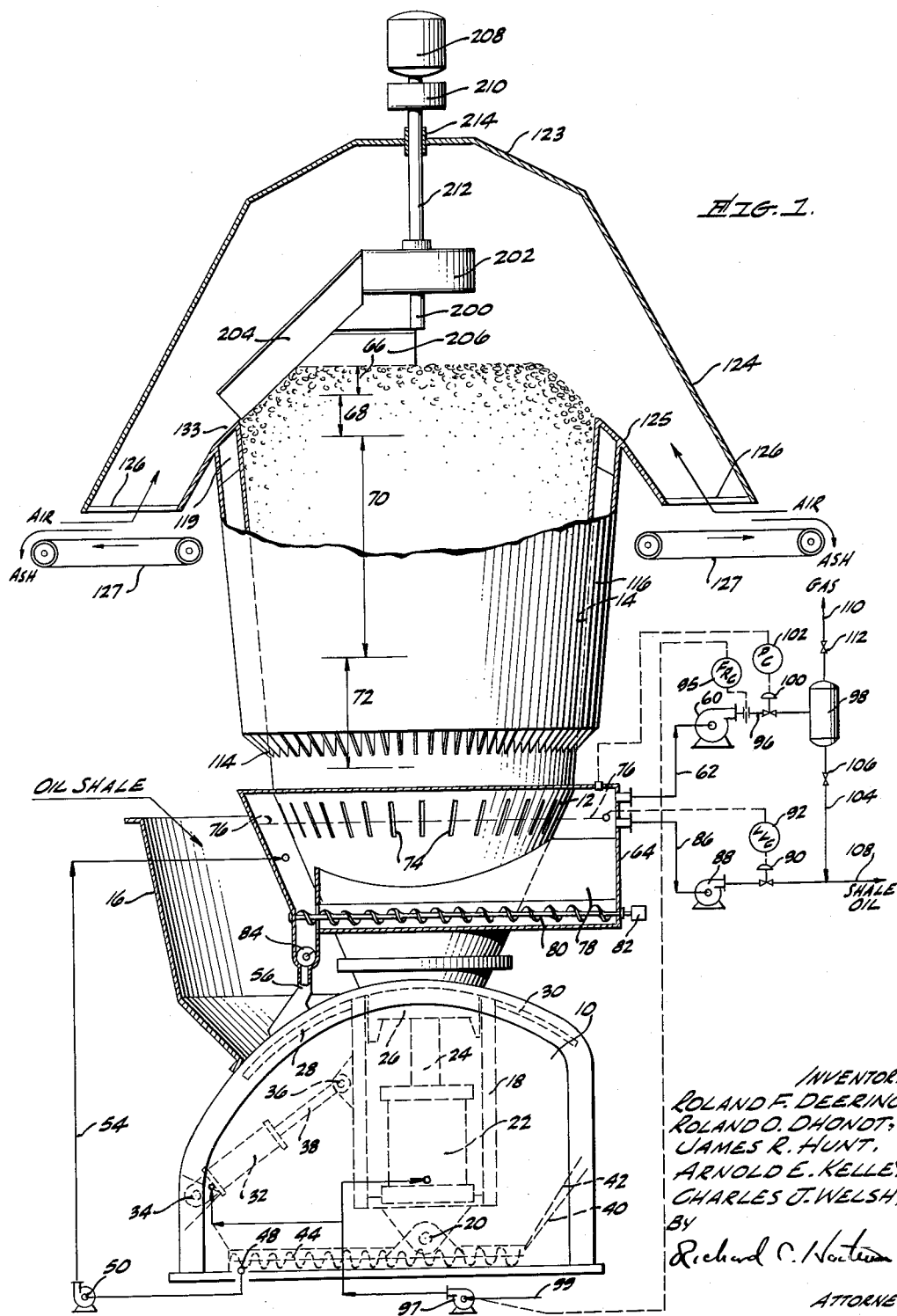
R. F. DEERING ET AL

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RETORTING PROCESS AND APPARATUS

Filed June 19, 1958

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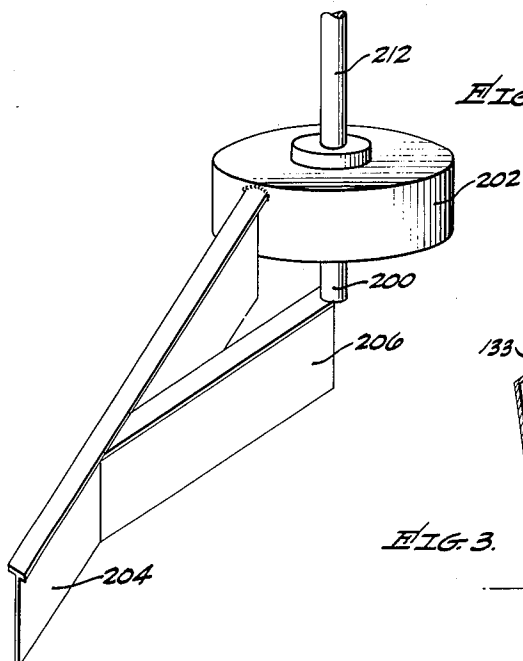


FIG. 2.

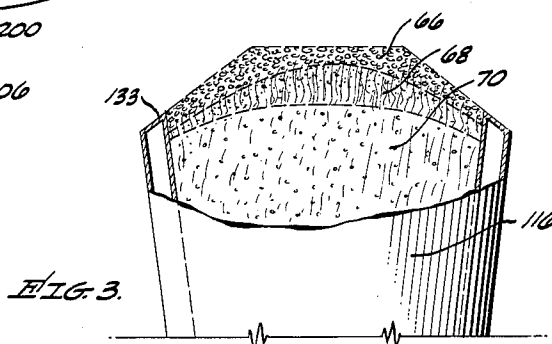
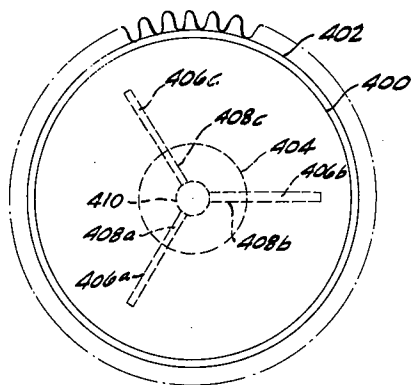


FIG. 3.

FIG. 4.



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RETORTING PROCESS AND APPARATUS

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This invention relates in general to improvements in solids-fluid contacting, and particularly to an improved process and apparatus for the production of hydrogen gases and oils from solids by thermal means. Applicable solids include such oil-producing and oil-containing materials as oil shale, tar and oil sands, oil-saturated diatomite, bituminous and sub-bituminous coals, and the like. For the sake of simplicity, the description will be conducted in terms of the eduction of shale oil and gas from oil shale, but it is to be understood that the process and apparatus are applicable in general to other processes in which oils and gases are produced by solids-fluid contact at elevated temperatures.

Of the various oil shale eduction processes which have been proposed, one of the more successful has been one in which the oil shale is passed upwardly countercurrently to a downflow of eduction fluid, an example of which is in U.S. Patent No. 2,640,019. This is used in combination with the present invention. The shale is fed upwardly and successively through a product fluid-shale rock disengaging zone, an eduction zone, a combustion zone and an ash cooling zone, while air or other oxygen-containing gas is introduced at the top of the ash cooling zone and passes downwardly through the aforesaid zones in reverse order. During such passage, the air is first preheated by cooling the hot shale ash in the ash cooling zone, and then burns the carbonaceous residue from the spent shale in the combustion zone, thereby forming hot flue gases and hot shale ash. The hot flue gases, which constitute the eduction fluid, continue downwardly to heat the shale rock to eduction temperatures in the eduction zone. Within the latter, hydrocarbon oils and gases are educted from the shale, forming spent carbonaceous shale and a mixed fluid phase containing flue gas and oil vapors and liquids. The fluid phase is cooled and passes downwardly in direct contact with the cool raw shale, thereby condensing the hydrocarbon oil and pre-heating the raw shale. The liquid and gaseous products are drawn off at the disengaging zone and are thus separated from the upwardly moving shale rock. A solids feeder passes the shale rock upwardly through the disengaging and eduction zones, and displaces the shale ash out the top of the unit. The process thus supplies its own fuel in the form of carbonaceous spent shale, and cools and partially condenses its own product by preheating the cool raw shale.

Despite its superiority over the other oil shale eduction methods, the above process does present certain difficulties which are believed to be due to the presence of fines in the burning zone of such an upwardly moving bed. Fines in the burning zone increase the tendency toward sintering or slagging, resulting in the formation of large clinkers which prevent even distribution of air

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within said burning zone, and which cause poor temperature control and poor distribution of eduction fluid in the eduction zone. Fines in the burning zone which did not enter with the raw shale feed are generally produced by undue agitation of ash during removal from the top of the bed, which ash fines then fall back into the burning zone.

An outwardly tapered retort from bottom to top such as is generally used in a solids upflow process is also limited in oil shale throughput capacity by the burning zone area. Thus a burning zone contained within such a retort at a lower level results in a more limited retort capacity than if the burning zone were at a higher level. Furthermore, a burning zone within a retort shell produces greater shell distortion due to high temperatures encountered. Shell distortion is undesirable because of mechanical difficulties present when operating with a distorted shell, and because the shell distortion if excessive may result in shell failure.

It is, accordingly, a primary object of the present invention to provide an improved process and apparatus for the production of oil and gas from hydrocarbonaceous minerals such as oil shale, tar sands, bituminous deposits, and the like.

Another object is to provide an improved autothermic or self-heating process for the production of oil and gas from such hydrocarbonaceous solids.

A further object is to provide a process and apparatus of the aforesaid type which avoids the difficulties attributed to the presence of fines in the solids treated.

A still further object is to provide, in an oil shale eduction process of the upflow solids type, means for improving the ease of temperature control and uniform distribution of the air and/or the eduction fluid.

We have now found that the foregoing objects and attendant advantages may be realized in a process and apparatus in which the ash cooling (and air preheating) zone and the combustion zone are maintained primarily above the top level of the retort shell, and the bed of solids above the retort shell is maintained in the shape of a truncated cone by means of a moving scraper or the like which is hereinafter more fully described. By the foregoing means, the combustion zone area and retort capacity are increased, and uniformity of the rising solids mass above the retort shell is maintained. This has an effect of tempering slagging conditions in the combustion zone, reduces the production of fines, and reduces the ash content of the product fluids. Furthermore, the maintaining of a uniform periphery of rising solids mass above the retort shell results in improved control over the temperature in the combustion zone, gives uniform distribution of the air passed into the rising solids mass, and gives a more uniform distribution of the eduction fluid throughout the rising solids bed.

The present invention is therefore directed to an improved upflow solids retorting process and apparatus in which the solids pass upwardly countercurrent to a downflow of eduction fluid, and in which the burning of residual carbon on the educted solids and cooling of the resulting ash to a large extent occurs above the top edge of the retort while maintaining the shape of the bed above the retort in the general shape of a truncated cone.

In the accompanying drawings which form a part of this application:

Fig. 1 is an elevation view, in partial cross-section, of a complete upflow solids-fluid contacting apparatus embodying the principle of the invention as applied to the retorting of oil shale, and indicates at the upper end

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thereof the rotary equipment employed to maintain a shaped bed of solids substantially above the retort shell as previously mentioned.

Fig. 2 is an isometric view of the rotating scraper assembly shown in Fig. 1.

Fig. 3 diagrammatically illustrates the configuration of the bed of rising solids adjacent the top of the retort, and

Fig. 4 is a top plan view of an alternative form of scraper assembly.

Referring now to Fig. 1, the retort itself consists essentially of a feeder case 10, a perforate solids-fluid disengaging section 12, and an eduction section 14 superimposed one above the other in the manner shown. A rotating scraper assembly is mounted above eduction section 14, and serves to maintain that portion of the bed which extends above the top edge 133 of the retort in the general shape of a truncated cone.

Oil shale is introduced into feed hopper 16 and is fed by means of a solids feeder assembly upwardly successively through disengaging section 12 and eduction section 14. The solids feeder assembly comprises a solids feeder cylinder 18 disposed within feeder case 10 and supported by trunnion 20 which permits it to be oscillated in a vertical plane so that the upper opening of the cylinder is aligned alternately with the bottom of hopper 16 and the solids inlet to disengaging section 12. A hydraulic feeder cylinder 22, provided with piston rod 24 and feeder piston 26, is disposed within solids feeder cylinder 18 and oscillates with it. Guards or shoes 28 and 30 curve away from the sides of the upper opening of feeder cylinder 18 and serve to close the lower outlet of hopper 16 when feeder cylinder 18 is in the position shown, and also to close the solids inlet to disengaging section 12 when the feeder cylinder is oscillated to the left in registry with hopper 16. The oscillatory motion of feeder cylinder 18 is provided by means of oscillating hydraulic cylinder 32 connected at pivot 34 to the inside of feeder case 10, and also connected at pivot 36 by means of piston rod 38 to the side of feeder cylinder 18.

The cyclic action of hydraulic cylinders 22 and 32 achieves removal of fresh solids from hopper 16 and the introduction thereof upwardly from below in a vertical path through disengaging section 12 and eduction section 14 in a sequence of four repeated steps. First, the oscillating hydraulic cylinder 32 retracts and pulls solids feeder cylinder 18 and hydraulic feeder cylinder 22 out of the position shown and to the left into alignment with shale hopper 16. Second, hydraulic feeder cylinder 22 retracts feeder piston 26 downwardly toward trunnion 20, drawing a charge of fresh shale into the top of feeder cylinder 18. During this time guard 30 seals the solids inlet to disengaging section 12. Third, hydraulic oscillating cylinder 32 extends, moving solids feeder cylinder 18 back into the vertical position shown, but with feeder piston 26 at its lowest position, not shown. Fourth, feeder cylinder 22 extends moving feeder piston 26 upwardly forcing the charge of raw shale upwardly into the lower part of disengaging section 12. The entire mass of solids moves upwardly through sections 12 and 14 and educted solids discharge from the top of eduction section 14. During this time guard 28 is in the position shown, closing the lower outlet of feed hopper 16. These four steps are repeated in sequence to maintain a substantially continuous upward flow of solids.

A pair of inclined sloping baffles 40 and 42 are provided along the bottom of feeder case 10 extending in the general direction of the plane of oscillation and closely beside trunnion 20, thus providing feeder case 10 with a V-shaped bottom. Along the lower line of intersection of the trough is extended screw conveyor 44, driven by conventional rotary means not shown. Conveyor 44 moves solids fines which leak past guards 28 and 30 and accumulate in the feeder case to feeder case outlet 48. Then fines, plus some product oil are removed

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in the form of a slurry from outlet 48 and pumped by means of pump 50 through line 54 into the product separator chamber 64. From here, as described below, the fines are recycled to the shale feeder.

As indicated previously, the solids move successively in an upward direction as a dense, fluid-permeable, continuous mass through the perforated fluid disengaging section 12 and through eduction section 14. The downward countercurrent flow of air and eduction fluid is maintained by means of blower 60 which takes suction through line 62 at the upper end of product separator chamber 64 surrounding the perforated disengaging section 12. Air therefore enters the open top of eduction section 14 through the ash discharge apparatus 126 as described below, and passes downwardly through ash cooling and air preheating zone 66 into educted shale combustion zone 68. The flue gases which are formed in combustion zone 68 and which constitute the eduction fluid are drawn successively through retorting or eduction zone 70 and raw shale preheating and product fluid cooling and condensing zone 72, into disengaging section 12, and thence through perforations 74 into separator chamber 64. The fluid products produced in the eduction zone are also drawn with the eduction fluid by blower 60, through preheating zone 72 and perforations 74 into product separator chamber 64. The condensed shale oil accumulates in the lower portion of product separator chamber 64 providing a liquid level at the approximate position indicated at 76. The feeder case 10 is also filled with this product oil.

Product separator chamber 64 is provided with a V-shaped bottom comprising two pairs of inclined baffles, one of which is indicated at 78 and the intersection lines of which run generally parallel to the plane of Fig. 1. The baffles are inclined with respect to one another at angles of about 45° when viewed in a plane at 90° from the plan of Fig. 1. Along the bottom of each V-shaped pair of baffles is extended a primary screw conveyor, one of which is indicated at 80. Conveyor 80 is driven by rotary drive means 82, and delivers any solid shale fines which fall through slots 74 and settle in chamber 64, into transverse secondary conveyor 84. The fines are here accumulated from both primary conveyors and discharged by means of conveyor 84 into fines distributor 56. The latter is designed to discharge the fines centrally at the bottom of shale hopper 16 so that the fines are concentrated in the interior of the charge of larger sized shale particles into which they are introduced. This reduces subsequent fall-through of these same fines into product separator chamber 64 and insures that they be carried upwardly with the raw shale feed and treated therewith in eduction section 14. Note also that the fines withdrawn from feeder case outlet 48 and discharged into separator chamber 64 mingle with the fines passing out of slots 74 and are likewise recycled to the central portion of the feed hopper 16.

As indicated previously, the liquid and gaseous components of the eduction product are separated from each other in separator chamber 64. The liquid shale oil flows from separator chamber 64 through line 86 under the influence of product oil pump 88 at a rate controlled by valve 90 and liquid level controller 92.

Blower 60, previously described, draws non-condensed gases through line 62 from the upper portion of separator chamber 64 and passes them through line 96 into mist separator 98 at a rate controlled by valve 100. Pressure controller 102 may serve to control valve 100 in order to maintain a predetermined subatmospheric pressure in separator chamber 64, or it may, if desired, serve to maintain a predetermined differential pressure between the top and the bottom of eduction section 14. The flow rate of gas through line 96 in turn regulates shale feed rate which then controls bed pressure differential and gas rate in the following manner. Flow recorder controller 95 operates in response to gas flow rate in line 96. With too high a

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gas rate through line 96, as a result of the high burning zone and less bed fusion, flow recorder controller 95 controls pump 97 to reduce the rate at which hydraulic fluid is supplied from source 99 to the hydraulic cylinders 22 and 32, thereby reducing the shale feed rate. This tends to reduce the bed pressure differential and gas rate through line 96. Too low a gas rate through line 96, as a result of too low burning zone and bed fusion, operates by control of fluid supply pump 97 to increase both shale feed rate and bed pressure differential with an attendant elevation of the burning zone and fusion reduction thus increasing gas rate through line 96.

Any conventional pneumatic recorder controller system elements may be used to accomplish the various control methods used above when the measured indicating variable is pressure or fluid flow.

In mist separator 98, residual traces of entrained liquids are separated from the gas stream and are passed through line 104 controlled by valve 106 into combination with the shale oil product produced through line 108. The non-condensed gases flow through line 110 provided with valve 112. These gases comprises essentially carbon monoxide, nitrogen and carbon dioxide with relatively small amounts of hydrocarbon gases sufficient to give the gas a heating value of about 90-100 B.t.u per cubic foot. Accordingly, it may be used as fuel or, if desired, part or all of it may be reintroduced as recycle gas into the top of eduction section 14 to dilute the incoming air in order to moderate combustion temperatures and the conditions of eduction.

Eduction sectional 14 is conical in shape, as is disengaging section 12. The eduction section 14 is provided on its outer surface with a plurality of vertically extending radial fins 114, the outer edges of which are enclosed in jacket 116. Said fins and jacket thus form a series of vertical passageways which are open at their lower ends to flow of air by natural convection; such flow of air serves to cool the metal walls of eduction section 14. The upper ends of the vertical passageways terminate in a manifold 119 which serves to collect the stream of warm air which flows upwardly through the passageways and to discharge said streams to the atmosphere through one or more stacks not shown.

Hood 123, having outwardly flaring sidewalls 124, is supported above the retort by means of a V-shaped mounting ring 125 which is rigidly affixed to the lower edge of sidewalls 124 and retort jacket 116 as shown. The horizontally disposed portion of mounting ring 125 is provided with two relatively large apertures 126, spaced 180° apart, and a rotary belt ash conveyor 127 is mounted immediately below each of said apertures. Sidewalls 124 and mounting ring 125 extend to below the top edge 133 of the retort, and form an annular chute through which the shale ash, which spills over the top edge of the retort, falls and passes through apertures 126 to ash conveyor 127. Rotary scrapers, not shown, may be mounted within said chute to scrape the ash into apertures 126.

The eduction air, preferably at atmospheric pressure, is drawn upwardly through apertures 126 by blower 60, reverses its direction within hood 123, and passes downwardly through the rising bed of solids as previously explained. The air thus passes countercurrent to the hot shale ash sliding down through the chute, and is thereby preheated while cooling the ash. Such arrangement utilizes the heat of the ash and increases the overall thermal efficiency of the unit.

The foregoing description indicates the general scheme of the upflow solids-fluid contacting process and apparatus. The following description, made with reference to Fig. 2 as well as Fig. 1 relates more particularly to the operation and design of the scraper assembly which serves to maintain the rising mass of solids which protrudes above top edge 133 of the retort in the general shape of a truncated cone.

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The scraper assembly consist of a vertically disposed central shaft 200 having a horizontal platform 202 rigidly affixed to its upper end. A sloping scraper bar or leg 204 is rigidly affixed as by welding to the periphery of platform 202, and extends downwardly and outwardly therefrom so that its lower end lies closely adjacent to the top edge 133 of the retort. The angle which scraper bar 204 makes with the horizontal corresponds approximately to at least as great as the natural angle of repose of the ash. By "natural angle of repose" is meant the angle from the horizontal which would be assumed by size of the original shale. For Colorado shale ash this relatively cool, dry ash broken up to about the particle is about 35-45°.

A more nearly horizontal scraper bar 206, hereafter referred to generally as a horizontal scraper bar, is rigidly affixed to the lower end of shaft 200 and extends radially outwardly therefrom to join sloping scraper bar 204 at a point substantially above the lower end of the latter. The vertical distance between the plane of horizontal scraper bar 206 and the top edge 133 of the retort determines the height to which the bed of shale ash protrudes above the edge of the retort, and such height is suitably of the order of $\frac{1}{2}$ the diameter of the bed. Platform 202, shaft 200, and the two scraper bars are caused to rotate by motor 208 mounted above hood 123 and connected to platform 202 via a reduction-gear unit 210 and shaft 212 which passes through the walls of hood 123 via bearing 214. As is readily apparent, rotation of the scraper assembly maintains the protruding bed of ash in the shape of a truncated cone. The speed of rotation will of course depend upon the rate at which the solids are passed upwardly through the retort, but under ordinary conditions of operation is of the order of 1-11 revolutions per hour for a single blade 204. Scraping preferably is an infrequent as practical in order to reduce ash agitation. A multiple blade arrangement, of course, may be rotated more slowly to accomplish the same number of scraper contacts.

Referring now to Fig. 3, there is shown a diagrammatic representation of the rising bed of solids in the upper part of the retort. As previously stated, an important feature of the process of the invention lies in maintaining a substantial part of the combustion and cooling zones above the top edge 133 of the retort. Thus, as shown in Fig. 3, the eduction zone 70 extends up to a level approaching that of top edge 133, and burning or combustion zone 68 is of somewhat concave-convex extending substantially above top edge 133. Ash cooling zone 66 lies substantially entirely above the edge of the retort. This configuration of the various zones within the rising solids bed results in greatly improved operation. A large part of the combustion occurs beyond the walls of the retort, and as a result such walls are not subjected to the relatively high temperatures previously encountered. Typically, the wall temperature is of the order of 800° F. or even less. The walls are thus subjected to less thermal stress, and their tendency to warp out of shape is minimized. Also, it has been found that the formation of fines within the retort itself by attrition of the peripheral particles of the bed against the walls of the retort is considerably decreased when such walls are maintained at a relatively low temperature.

The position, and to some extent the shape, of the combustion zone within the shale bed is determined by the air-to-shale ratio. At a given rate of shale feed, an increase in the rate at which the air is drawn downwardly through the bed will cause the combustion zone to move downwardly and its thickness to be increased. Conversely, by decreasing the rate of air feed, the combustion zone can be caused to become thinner and to move upwardly until it is positioned largely above the level of the retort walls. Accordingly, it is an important feature of the present process to control the air-to-

shale ratio in such manner that a substantial portion of the combustion zone lies above the edge of the retort. Typically, with a Colorado oil shale of 30 gal./ton Fischer assay, such air-to-shale ratio is of the order of 12,000 s.c.f./ton.

Referring now to Fig. 4, the alternative form of the scraper assembly there shown consists of a circular supporting plate 400, having a ring gear or a sprocket 402 affixed at its periphery. A coaxial mounting plate 404 is affixed to the underside of supporting plate 400. Three sloping scraper bars 406a, 406b and 406c are rigidly affixed 120° apart to the periphery of mounting plate 404. Three more nearly horizontal outward sloping scraper bars 408a, 408b and 408c extend between central shaft 410 and sloping scraper bars 406a, 406b and 406c, respectively. The disposition of the sloping and horizontal scraper bars, and the manner in which they are affixed to their supporting structure is essentially the same as that shown in Fig. 2. The assembly of Fig. 4 is rotated by a driven pinion engaging the gear ring, or by a driven chain engaging the sprocket.

As will be apparent to those skilled in the art, the scraper assembly may take various forms other than those described above, and the best manner for supporting the scraper bars and causing them to rotate will be dictated by the usual engineering considerations based on the details of the retort construction, the physical characteristics of the solids being retorted, the ash, the temperature of the hot ash in which the scrapers operate, and similar operating variables. Essentially, the scraper assembly comprises one or more scraper bars disposed at an angle corresponding to an angle at least as great as the angle of repose of the ash, one or more horizontal scraper bars, means for rotating said scraper bars, and supporting means maintaining said scraper bars in such position that upon being rotated they trim the mass of rising solids above the top edge of the retort into the shape of a truncated cone.

A typical example of a retorting operation on Colorado oil shale assaying 30 gallons/ton with the process and apparatus of the invention is as follows:

Raw oil shale:	
Fischer assay, gal./ton	30
Particle size, inches	½ to 3
Mineral, CO ₂ , wt. percent	18
Crude shale oil:	
Gravity, ° API	21
Yield, vol. percent F.A.	80
Retort make gas:	
Quantity, s.c.f./ton	18,000
Cross heating value, B.t.u./s.c.f.	98
Design factors:	
Retorting rate, lb./(hr.) (sq. ft.)	300
Air, s.c.f./ton	12,000
Gas and oil outlet temperature, ° F.	125
Ash chute outlet temperature, ° F.	900
Scraper slope—	
Lower scraper (three blades)	40°
Upper scraper (three blades)	Horizontal
Scraper rotational rate, r.p.h.	2

Use of the process and apparatus of the invention effects a number of improvements in the retorting operation. For a shell of given maximum diameter at its upper periphery there is a greater burning area and a resultant greater throughput with the foregoing process and apparatus. That is, this is true when the comparison is made with a similar shell having a lower burning zone. Thus, the economic advantage over heretofore-known commercially practical process and apparatus is greatly increased because of increased throughput rate.

The ash is more gently handled than permitted by a flat type bed scraping at the kiln top level. The ash for the most part doesn't have to be dragged as far across the ash bed. This substantially avoids stirring up of the

ash bed and production of fines by attrition of ash dragged against ash for extensive distances. Such production of fines having been substantially avoided thus reduces resultant clinkering in the burning zone. Clinkering when present to a greater extent results in a decrease in retorting capacity and an increase in requirements on the main blower, such as 60. There are thus appreciable economic savings on main blower requirements as well as further increased throughput for a given retort apparatus.

The power requirements to operate the foregoing scraper apparatus for forming the truncated cone shaped ash bed is appreciably less than for flat scraping systems generally used, since gravity aids more in ash movement. Furthermore, required structural strength of the scraper apparatus may be less than for flat scraping systems ordinarily used, which either reduces original cost of scraper apparatus, or in some instances permits scraping in hot ash beds where almost any scraper of other forms which are of convenient structural strength would ordinarily fail.

Continual movement in rotary motion over the central areas of the ash bed prevents a "dead zone" which in such an upward solids flow retort frequently develops. Such a "dead zone" is a bed area in which solids dwell an undesirable length of time, which because of the heat of the burning zone below, then forms clinkers in the "dead zone," or within the burning zone below it. Also, the continual movement over the bed by the scraper apparatus of the invention does not in any way restrict upward movement of the upwardly moving solids and ash bed from below because of the small contacting surface area of the scraper with the ash bed over any particular bed area for any great length of time.

With the process and scraping apparatus of the present invention, lower bed pressure differentials are required at comparable throughput rates than for any type retorting unit not employing such. A lower bed pressure differential results in appreciable savings in blower horse power requirements for creating the pressure differential, which lowers considerably initial cost of the gas blower. Particular embodiments of the present invention have been described above in considerable detail by way of illustration. It should be understood that various other modifications and adaptations thereof may be made by those skilled in the art without departing from the spirit and scope of the invention as set forth in the appended claims which define the limits of the present invention.

We claim:

1. In an apparatus for passing solids upwardly through a kiln and removing ash from the top thereof, the improvement which, comprises a scraper bar inclined at an angle from horizontal, and extending from a point adjacent the upper peripheral limit of said kiln upwardly toward the upward extension of the center line of said kiln, a more nearly horizontal scraper bar extending from said inclined scraper bar to said upward extension of the centerline of said kiln, a rotatable supporting means positioned above said kiln and supporting said inclined scraper bar and said more nearly horizontal scraper bar in respective positions above said contacting apparatus and motive means for horizontally rotating said rotatable supporting means.
2. Apparatus according to claim 1 in which said rotatable supporting means comprises a dependent rotatable shaft coincident with said upward extension of the centerline of said kiln and engaged with said motive means.
3. Apparatus according to claim 1 in which said rotatable supporting means comprises a rotatable circular supporting plate provided with means for engaging said motive means for rotating said rotatable supporting means.
4. Apparatus according to claim 1 in which said inclined scraper bar is inclined at an angle of at least 35° but less than 60° from horizontal.

5. Apparatus according to claim 1 in which said inclined scraper bar is inclined at an angle of at least 35° but less than 45° from horizontal.

6. In an apparatus for the contacting of fluids and shale solids which comprises a contacting vessel having an imaginary center line, a perforate fluid disengaging vessel, and a solids feeder case disposed at successively lower levels in a column, a shale inlet hopper opening downwardly into the top of said feeder case, an oscillating vertically-acting piston solids feeder disposed in said feeder case, means for oscillating and reciprocating said piston feeder so as to receive a mass of shale solids from said hopper and force it upwardly into and successively through said disengaging and contacting sections, a closed separator vessel surrounding said disengaging vessel, and means for removing fluids therefrom to maintain flow of fluid downwardly through the rising mass of shale solids, the improvement in combination therewith of means for scraping the solid mass which rises above said contacting vessel, which comprises a scraper bar inclined at an angle from horizontal, said inclined scraper bar being so disposed as to extend from adjacent upper peripheral limits of said contacting vessel at a lower elevation toward a position which is on a point of an upward extended center line of said contacting vessel at a higher elevation, and which also comprises a more nearly horizontal scraper bar so disposed in positions as to extend from said inclined scraper bar to said upward extended center line of said contacting vessel, a rotatable supporting means supported above said contacting vessel for supporting said inclined scraper bar and said more nearly horizontal scraper bar in positions above said contacting vessel, and motive means for rotating said rotatable supporting means, whereby rotation of said rotatable supporting means rotates said scrapers and scrapes off said rising mass of solids above said contacting vessel in the form of a uniformly truncated conical shaped mass having a minimum diameter at a central higher elevation and having a maximum diameter at a lower elevation at the upper periphery of said contacting vessel.

7. In an apparatus for the contacting of fluids and solids which comprises a contacting vessel, a perforate fluid disengaging vessel, and a solids feeder case disposed at successively lower levels in a column, an inclined solids inlet hopper opening downwardly into the side of said feeder case, an oscillating vertically-acting piston solids feeder disposed in said feeder case, means for oscillating and reciprocating said piston feeder so as to receive a mass of solids from said hopper and force it upwardly into and successively through said disengaging and contacting sections, a closed separator vessel surrounding said disengaging vessel, and means for removing fluids therefrom to maintain flow of fluid downwardly through the rising mass of solids, the improvement in combination therewith of means for scraping the solids mass which rises above said contacting vessel which comprises a first scraper bar inclined at an angle from horizontal and positioned to extend from the upper peripheral limits of said contacting vessel at a lower elevation toward an extended center line of said contacting vessel at a higher elevation, a second scraper bar substantially horizontal in position extending from said first scraper bar to said extended center line of said contacting vessel, means of support for said first and second scraper bars in said positions, rotatable means for rotating said first and second scraper bars and their means of support concentrically with respect to said extended center line of said contacting vessel, and motive means for rotating said rotatable means and two related scraper bars, whereby movement of said first scraper bar scrapes off said rising mass of solids at an angle from horizontal at the elevational periphery of said rising solids mass thereby releasing the scraped off portion of said peripheral solids for removal by gravity from the vicinity of the apparatus,

and movement of said second scraper bar levels the central topmost area of said rising mass of solids to move solids from the central topmost area to the elevational periphery of the rising solids mass where said first scraper bar operates.

8. A scraper assembly mounted on and positioned above a kiln and adapted for scraping a mass of rising solids above the top edge of said kiln comprising: at least one inclined scraper bar extending inwardly and upwardly from the kiln upper edge at an angle from the horizontal at least as great as the angle of repose of said solids; a substantially horizontal scraper bar extending from said inclined scraper bar to a position above the center of said kiln; means for supporting and means for rotating said scraper bars in said positions whereby a truncated conical mass of rising solids is shaped above the upper edge of said kiln.

9. Apparatus according to claim 8 in which said kiln is adapted for contacting of fluids and shale solids, said kiln assembly comprising: an upper contacting vessel, an intermediate perforate fluid disengaging vessel, and a lower solids feeder case, an inclined shale inlet hopper opening downwardly into the side of said feeder case, an oscillating vertically acting piston solids feeder disposed in said feeder case, means for oscillating and reciprocating said piston feeder so as to receive a mass of shale solids from said hopper and force it upwardly into and successively through said disengaging and contacting sections, a closed separator vessel surrounding said disengaging vessel, and means for removing fluids therefrom to maintain a flow of fluid downwardly through the rising mass of solids.

10. Apparatus according to claim 8 in which said scraper bar supporting means comprises a moveable circumferential ring support situated and supported about the upper periphery of said kiln.

11. Apparatus according to claim 8 in which said scraper bar supporting and rotating means comprises: motive means, a central rotatable shaft operatively connected to said motive means and positioned above and on an extended centerline of said kiln and means for joining said scrapers to said central shaft.

12. In a method for continuously processing solids, wherein said solids are passed upwardly through a solids bed containing a processing zone to which heat is supplied by direct contact with a downwardly flowing stream of combustion gas from a combustion zone maintained at a higher zone within said bed of solids, the improved method of maximizing vessel capacity and minimizing thermal stress of said vessel walls, which comprises permitting said bed of solids to rise above the upper edge of the vessel, supplying combustion supporting fluid downwardly through the upper surface of said rising mass, and continuously scraping the upper surface of said rising mass to shape said mass into a form which will permit the downwardly introduced combustion supporting fluid to be uniformly distributed over the cross sectional area of said bed of solids and maintaining a substantial portion of said combustion zone above said upper vessel edge and within said rising mass of solids.

13. A method according to claim 12 in which the solids processed are shale and the combustion supporting fluid is air.

14. A method according to claim 12 in which the rising mass of solids is scraped into a truncated conical shape.

15. A method according to claim 14 in which the elevation of said truncated cone above said vessel is at least 10% of said kiln diameter but not more than 45% of said kiln diameter.

16. A method according to claim 14 in which said combustion-supporting fluid is air at atmospheric pressure and is uniformly drawn into said truncated cone at selected rates of volume by providing selected subatmos-

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pheric pressures at a lower elevation of said rising mass of solids.

17. A method according to claim 14 in which the elevation of said truncated cone above said vessel is at least 5% of said kiln diameter but not more than 45% of said kiln diameter. 5

18. A method according to claim 17 in which the maximum elevation of said truncated cone is not more than 30% of said kiln diameter.

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