

Sept. 27, 1960

R. O. DHONDT ET AL
EDUCATION APPARATUS

2,954,329

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3 Sheets-Sheet 1

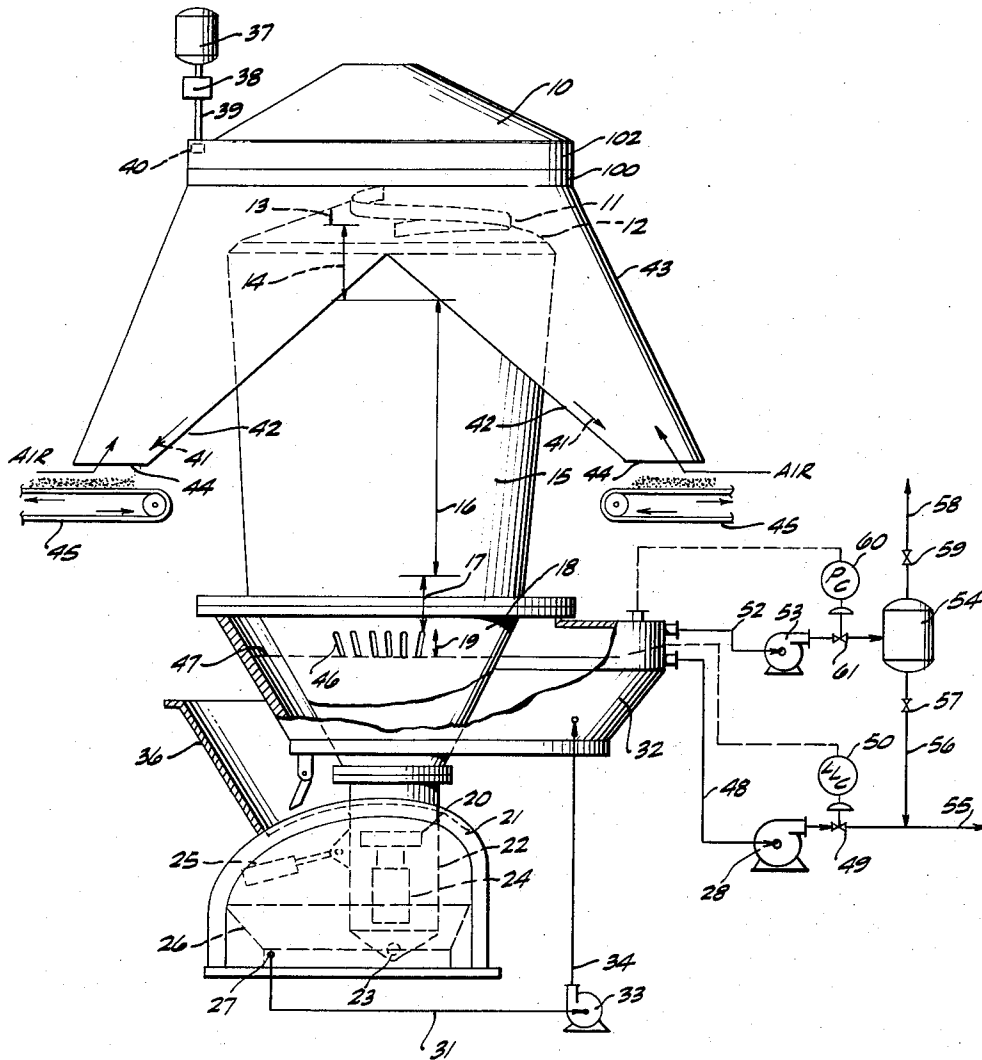


FIG. 1.

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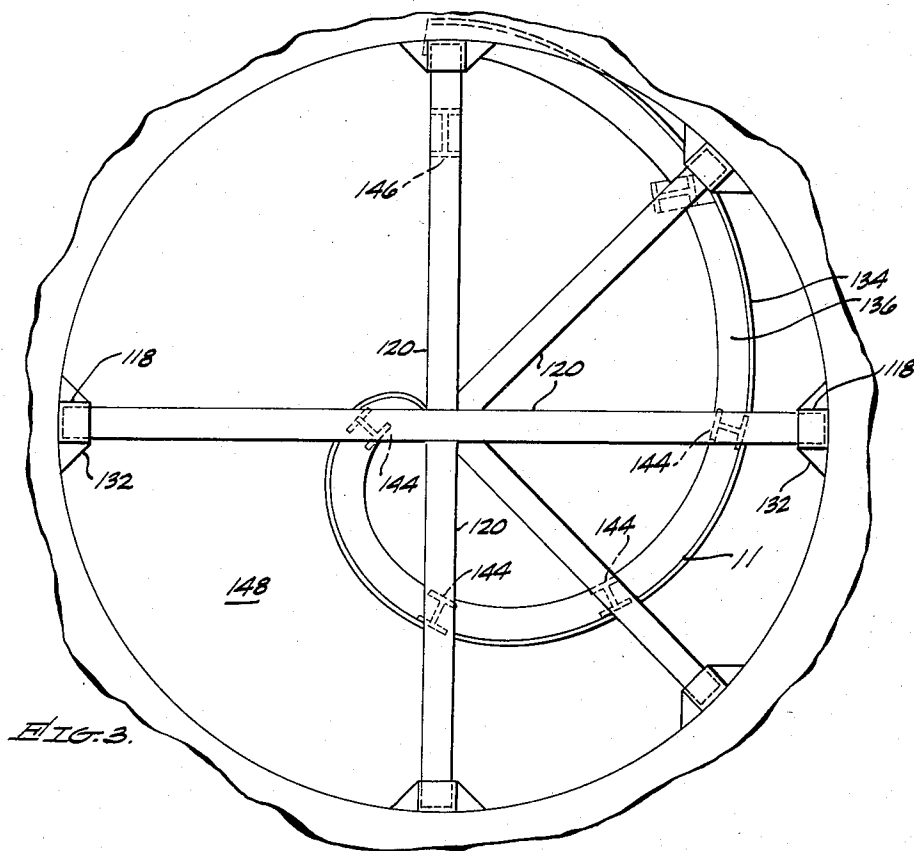


FIG. 3.

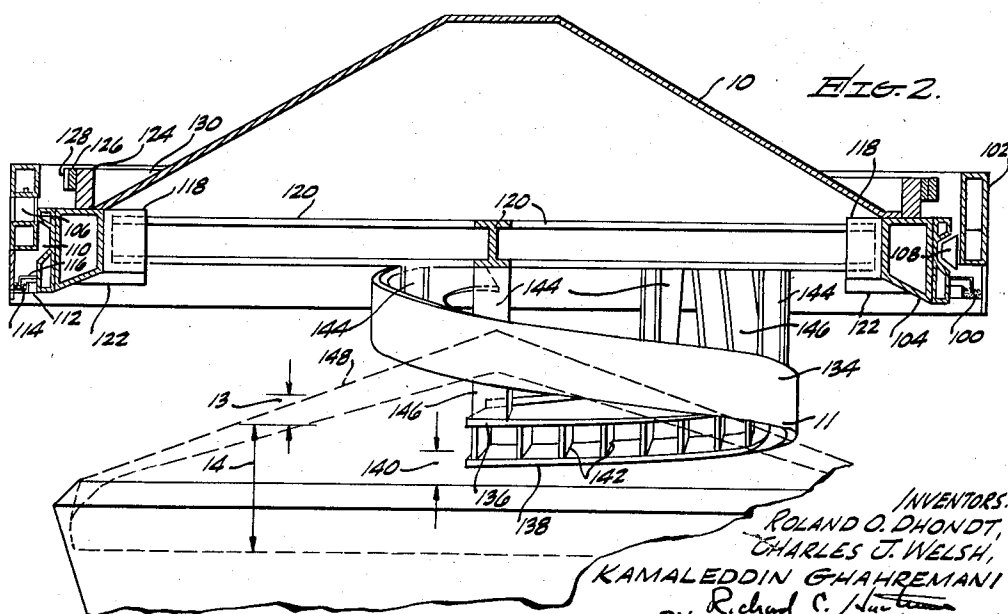


FIG. 2.

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3 Sheets-Sheet 3

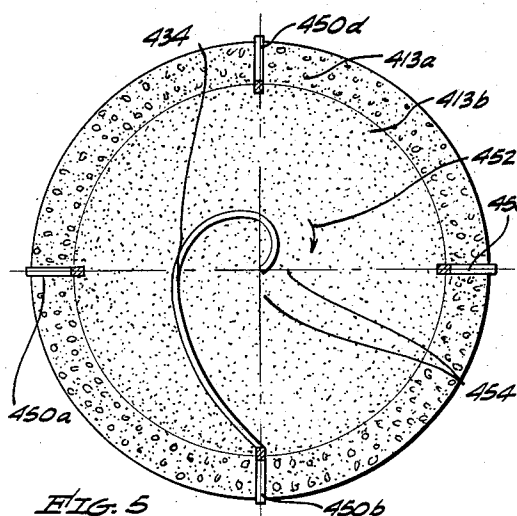


FIG. 5

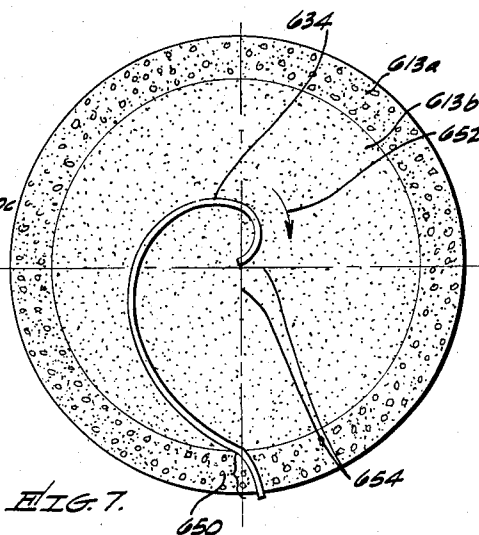


FIG. 7

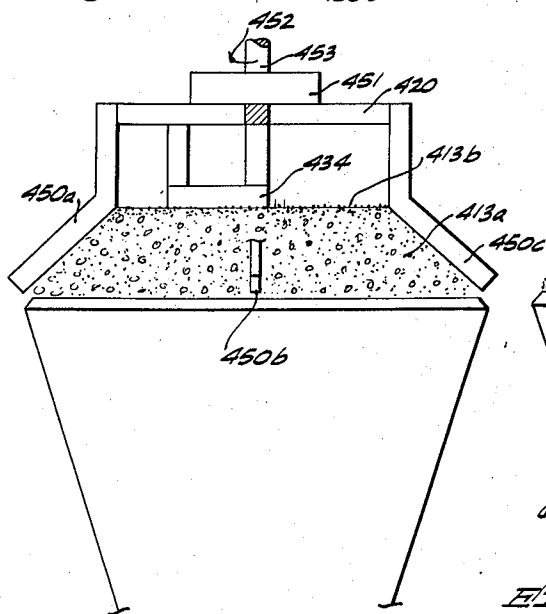


FIG. 4

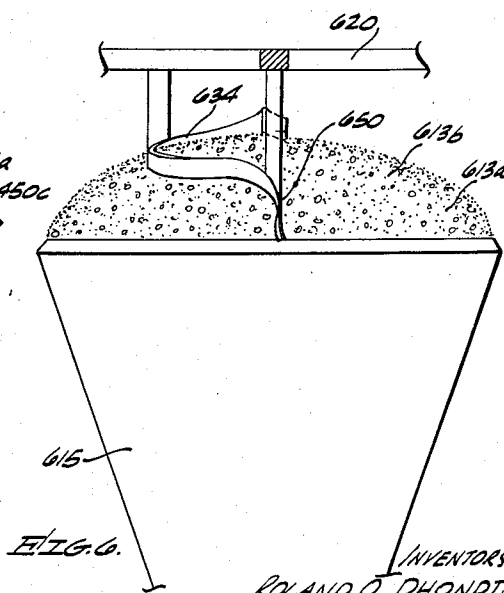


FIG. 6

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2,954,329

EDUCTION APPARATUS

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18 Claims. (Cl. 202—93)

This invention relates to a method and apparatus for solids-fluid contacting and particularly it relates to the retorting of oil-containing or oil-producing shale solids to educt hydrocarbon oils and gases therefrom.

A solids upflow type retort, such as described, for example, in U.S. Patent No. 2,501,153, uses a solids upflow eduction process which is also used in this invention. This eduction process utilizes an upflow of oil shale and a downflow of hot gas used therein to obtain eduction temperature levels of oil shale. Oil shale is fed upwardly in sequence through a perforated disengaging section and a kiln section, while air or other oxygen-containing gas enters the top and moves downwardly into the kiln section. The air is preheated by cooling the hot shale ash at the kiln top, then the air supports combustion of carbonaceous residue remaining on educted shale from a lower level or zone, and then continues downward changed to flue gases to lower levels within the kiln section where shale rock is heated and hydrocarbon oils and gases are educted therefrom. In such an upflow process of oil shale, the vapor phase of educted oil and gases passes downward in direct contact with the cooler raw shale which condenses the hydrocarbon vapors and preheats the raw shale near the bottom of the kiln. Liquid and gaseous products of the process are drawn off at the apparatus disengaging section and are there separated from the upwardly moving shale rock. A solids feeder situated below the kiln and disengaging sections pass the oil shale upwardly through the disengaging and eduction zones of the retort and pushes the shale ash out the top of the unit.

Although the foregoing solids upflow process has been found to be superior in this respect to other processes, there is inevitably some degree of sintering or slagging within the combustion zone, and this is aggravated by the presence of shale or ash fines. Such formation of slag adversely affects the uniform distribution of the eduction fluid throughout the shale bed and makes it difficult to control the temperature within the eduction zone and elsewhere in the unit.

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

A further object is to provide a method and apparatus of the aforesaid type which in a substantial degree avoids difficulties attributed to the presence of ash fines in the solids bed.

A still further object is to provide, in an oil shale eduction apparatus of the upflow type, means comprising an improved ash scraping apparatus for improving the ease of temperature control and uniform distribution of eduction fluid.

It is also an object of this invention to provide such apparatus for carrying out the foregoing objects, which apparatus is economical in power requirements and adaptable to varied process temperature conditions.

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We have found that the foregoing objects and attendant advantages may be realized by an apparatus in which ash pushed upward by solids fed from below is removed with only slight agitation from the ash bed surface. Such minimum of ash agitation in ash removal has been accomplished by scraping the ash bed with a positive radially-acting force mechanically applied. Preferably, the ash bed is scraped to form a convex upper surface so that the force of gravity somewhat aids the radial ash movement. This combination method for ash movement also has the effect of minimizing the frequency of mechanical scraper passes. Reduction of scraping frequency and provision for more positively applied radially-acting mechanical force has resulted in a minimum of ash attrition. Such ash attrition has also been reduced by reducing the distance over which ash particles are in contact with the scraper from the time of particle engagement with the scraper to the time at which the same particle is discharged at the upper periphery of the retort.

Gravity aid has been accomplished by provision for a peaked center area of ash surface above the retort. Reduction of frequency of scraping and reduction of scraper contact distances has been made practical by providing for a substantial radial component of force with the scraping method and apparatus of this invention. For aid of gravity, the scraping apparatus provided therefore descends from retort center to retort periphery. An appreciable radial force component, and a reduced scraping contact distance before ash discharge, has been provided by giving the descending scraper apparatus a spiral form and making it rotatable about the retort center.

The improved ash scraping apparatus may also involve a combination of a radially-acting scraper over the central area and a circumferentially-acting or radially-disposed scraper over the circumferential area. Preferably also, the scraper assembly is provided with expansible support means to accommodate the vast temperature changes involved.

Figure 1 is an elevation view in partial cross-section of a complete solids-fluid contacting apparatus embodying the principle of the invention as applied to the retorting of oil shale, and indicates at the upper end thereof the rotary equipment employed to scrape the bed of ash solids above the retort shell as previously mentioned,

Figure 2 is an enlarged view in cross section of the rotary equipment shown in Figure 1,

Figure 3 is a plan view of a fragmentary portion of the apparatus taken within diameter 3—3 in Figure 2,

Figure 4 is an elevation view of an alternative form of scraper apparatus provided with an alternative central drive,

Figure 5 is a plan view of a main portion of the apparatus shown in Figure 4,

Figure 6 is an elevation view of a third alternative form of scraper apparatus, and

Figure 7 is a plan view of a main portion of the apparatus shown in Figure 6.

Referring now to Figure 1, the apparatus shown comprises essentially four parts, first, an upper assembly 10 for directing air flow and ash discharge, and also having a rotatable ash scraper 11 (indicated by dotted lines) mounted therein for scraping the surface of the upper solids bed 12 within the assembly 10. The upper solids bed 12 has an air preheating ash zone 13 at its outer layer for the preheating of air passing therethrough, and just below said layer a burning zone 14 for the combustion of residue of carbonaceous material remaining on oil-free shale within this zone. Second, a kiln 15 having therein at successively lower levels an eduction zone 16 in which shale oil is educted from oil shale by downward moving flue gas at a suitable temperature obtained from the burning zone above, and a raw shale preheating zone

17. Third, the apparatus comprises a perforate disengaging section 18 having within a fluid disengaging zone 19, and, fourth, a lower reciprocating shale feeder piston 20 within a liquid filled feeder case, or housing 21.

Shale feeder housing contains vertically reciprocating feed piston 20 within a feed cylinder 22. Cylinder 22 oscillates about a trunnion 23. A hydraulic actuating cylinder 24 disposed within cylinder 22 reciprocates feeder piston 20 in cylinder 22 vertically. A second hydraulic cylinder 25 contained within feeder case 21 oscillates feeder cylinder 22 between a slanted filling position and a vertical feeding position. A V-shaped trough 26 runs along the bottom of the feeder case and has a screw conveyor at its lower apex to move settled fines toward outlet 27. Fines and product oil, which enter case 21 by leakage past the moving cylinder 22 as it oscillates, is flushed in a fines slurry by way of outlet 27 through line 31. This slurry is returned to settler 32 by pump 33 and line 34 for the purpose of settling the recycled fines and further treatment.

Raw shale is introduced into shale feed hopper 36, then with feeder piston 20 disposed at its upper extremity immediately after its upstroke, cylinder 22 is moved to a point for communicating relationship with feed hopper 36. Cylinder 24 retracts piston 20, drawing a charge of shale rock into the upper part of feeder cylinder 22. Hydraulic cylinder 25 is then extended returning feeder cylinder 22 to the vertical position shown. Then hydraulic cylinder 24 is extended, forcing piston 20 upwardly thereby moving the charge of shale rock into disengaging section 18 and displacing the shale therein and in kiln 15 upwardly. This cycle is repeated thereby continuously feeding fresh shale at the bottom of the structure and displacing hot spent shale ash from the top.

The shale ash from the surface of zone 13 is displaced downward and outward and over the side of the top of kiln 15 by means of rotatable ash scraper 11 driven so as to rotate about the central axis of kiln 15 by motive means 37. A gear reduction unit 38 and shaft 39 transmit power from motive means 37 to a driving gear 40 operated at a suitable speed of rotation.

Shale ash displaced from ash zone 13 falls by gravity through the paths indicated by the arrows 41 downwardly onto the inside bottom 42 of housing 43 which may be rigidly attached to the kiln 15. The ash then discharges through outlets 44 to ash conveyors 45 for carrying ash away from the vicinity of the kiln to an ash waste pile. Air for supporting the combustion in the burning zone 14 enters through ash outlets 44 and is thereby pre-heated before use in the process by the hot discharging ash with which air comes in contact. The gas mixture formed in the burning zone 14, where all the oxygen is used for burning, moves downwardly and comprises the hot flue gas mixture for eduction which heats the upwardly-moving shale and educts the oil and gas therefrom in the eduction zone 16. The spent shale is expelled from the upper surface of zone 13 by scraper 11 which is provided to maintain a shaped surface at the top of kiln 15 and to maintain a relatively even rate of discharge of spent shale ash to ash conveyors 45.

The hot eduction gases produced in burning zone 14 pass downwardly first through the preheated shale eduction zone 16 and then through the fresh shale preheating zone 17, where product cooling and condensing take place. This mixture of eduction gases and educted fluids passes downwardly to apparatus section 18 having disengaging zone 19 which is surrounded by an integrally attached product settler 32 having an internal volume which comprises a product settling and separator zone. Section 18 is provided with a plurality of apertures 46 opening into separator settler 32. Through these apertures the condensed liquid product overflows forming a body of liquid having a level 47. The gas flows there-through into the top part of the separator settler 32

above the liquid level. The liquid product is removed by means of line 48 at a rate controlled by valve 49 in accordance with liquid level controller 50, and is passed as a product of the process through line 55 to further processing or storage facilities not shown.

The gas phase is withdrawn from settler 32 through line 52 under the influence of gas blower 53 and is directed through one or more mist separators such as the one indicated as 54. This separator may comprise a cyclone separator, an oil wash such as an oil absorber, or an electrostatic precipitator, or any other suitable separators or combinations thereof for removing finely divided liquid particles from a gas stream. Any recovered liquid is combined with the product liquid flowing through line 55 by means of a line 56, at a rate controlled by valve 57. The remaining gas stream is forced by blower 53 through line 58 at a rate controlled by valve 59. Valve 61 in fluid connecting relationship between blower 53 and separator 54 responds to pressure recorder controller 60 which is provided so that valve 61 is controlled to maintain a predetermined sub-atmospheric pressure in settler 32, or it may, if desired, serve to maintain a predetermined differential pressure between the top and the bottom of the eduction zone 16. With air entering ash chute 44 at atmospheric pressure the pressure recorder controller 60, in response to a sub-atmospheric pressure in settler 32 which happens to become lower than a selected optimum, closes to some extent the valve 61 to reduce rate of removal of gas from settler 32. With gas removal reduced in rate the burning zone 14 then raises in the kiln 15 which increases the pressure in settler 32 due to less slag blocking gas flow through the solids with such a higher burning zone.

Control of the shale feed rate may, if desired, be used in the process by control of shale feed rate with a flow rate controller (not shown) responsive to gas flow rate in line 52 which is made to control fluid supply rate to hydraulic cylinders 24 and 25. Decrease in gas rate through line 52, for example, would then increase the shale feed rate which in turn would raise the burning zone 14 and increase the gas rate in line 52. Other controls or combinations of controls will suggest themselves from the foregoing control methods disclosed.

The gas product is taken off through line 58 and directed toward any suitable use or treatment, or may be burned if desired. The gas product will contain a heating value of about 100 B.t.u. per cubic foot and may be used to dilute incoming air at the top of the kiln to moderate combustion temperatures and conditions of eduction.

The previous description indicates generally the up-flow solids-fluid contacting process and apparatus. Referring now to Figures 2 and 3, the following description points out in particular the improved scraper 11 and apparatus closely associated therewith. A ring girder side frame 100 is a heavy cylindrical element disposed vertically with its axis substantially coincident with the vertical axis of disengaging section 18 and kiln 15. Said ring girder side frame 100 is supported by housing 43 (see Figure 1) which in turn is attached to the kiln. A ring girder 102 is disposed around the upper end of side frame 100 and serves to strengthen the upper edge of the side frame. A drive ring 104 is disposed within the ring girder 102. A plurality of horizontal thrust rollers 106 with their axes vertical are supported at uniformly spaced locations around ring girder 102. A plurality of vertical thrust rollers 108 disposed with their axes horizontal are also uniformly spaced around ring girder 102. These roller bearings operate to resist any horizontal and vertical thrusts of the rotary apparatus attached to the rotatable drive ring 104. Vertical thrust rollers 108 thus ride in peripheral track 110 disposed around the outer surface of drive ring 104.

Disposed around the inner surface of ring girder side frame 100 and just below ring girder 102 is a stationary

L-shaped cross section circular channel 112 containing a bed 114 of fine solids such as sand. Supported from the lower outer surface of the drive ring 104 is rotating circular seal element 116 having an inverted L-shaped cross section which extends entirely around the drive ring and also extends downwardly into seal solids bed 114. This seal prevents entry of atmospheric air into the kiln under the influence of the gas blower 53 around the periphery of the drive ring and requires the air flow to enter via the ash discharge outlets 44. In so flowing in through the ash outlets, the air entering is counter-currently contacted by the discharging ash thereby effecting a significant degree of ash cooling and air preheating.

As shown in Figure 2, the drive ring 104 has attached to it on its inner side a plurality of expansion boxes 118 adapted to receive ends of horizontal H-beams 120 used to support the ash scraper 11 in a central position above kiln 15. Pairs of gusset plates 122 are welded under each of the expansion boxes 118 to provide support of these boxes which support H-beams within. Above the drive ring and attached thereto is a coaxial supporting plate 124 having a ring gear 126 affixed at its periphery. Gear teeth such as 128 are engaged by pinion gear 40 (shown in Figure 1), for purposes of drive. A sprocket and chain drive, or other common drive, may be substituted for this driving assembly if desired. The rotating driving force from the motive means is applied continuously, sufficient to rotate the ring gear 126 at a velocity between about 1 and about 6 revolutions per hour. A plurality of plates 130 are used to position mounting plate 124 with respect to upper assembly 10, so that the mounting plate will be supported in a coaxial position with respect to the central axis of kiln 15 and the axis of rotation of the ash scraper 11. Expansion boxes 118 are provided with one or more horizontally disposed reinforcing plates 132 on each side of an expansion box. The expansion boxes are deeper than required for a snug fit by the H-beams extending into them. This permits lengthening of the H-beam supports due to temperature increase, without physical distortion of the drive ring 104 due to H-beam lengthening. The peripheral track 110 on the drive ring is thus not distorted.

The ash scraper 11 comprises a vertically disposed outer peripheral plate 134 which is preferably in the form of a spiral of 360° or less uniformly increasing in radius from a spiral center, as shown in Figure 3. As shown in Figure 2, the specific spiral scraper illustrated is slanted downward in a helix form at about 20 degrees. The center of the spiral is at its higher elevation under the central intersecting position of the horizontal H-beams 120, and at its lowest elevation it is at its greatest radius. The spiral peripheral plate 134 is reinforced on its inner side along its length by two generally upward slanting facing plates 136 and 138 slanted at the same downward angle of the spiral plate 134 and positioned a distance from the top and bottom, respectively, thereof. The spiral plate 134 at its greatest radius terminates just above the upper edge of the kiln 15, separated from the kiln by the dimension indicated as 140. With a kiln having an upper diameter of 16 feet, or more, the dimension 140 will preferably be of the order of a 4-6 inch separation. Disposed between the reinforcing plates 136 and 138 are gusset plates 142 welded in and forming reinforcing ribs which may be spaced, for example, about one foot apart for use with a 16-foot diameter kiln. The horizontal H-beam supports 120 are preferably spaced every 90°. However, there are two additional of such H-beam supports dividing the quadrants between adjacent H-beams having the spiral plate 134 situated therein at greater radii. At the lesser radii of the spiral plate 134, four vertically extending H-beams 144 support the plate 136 from the horizontal H-beams above. At greater radii of the spiral plate 134 two additional

downwardly extending H-beams 146 are disposed at an angle from vertical and support the plate 136 from above. The angular H-beams 146 are disposed at an angle from the vertical in such a manner as to avoid interference with the adjacent expansion boxes.

Rotation of drive ring 104, horizontal H-beam supports 120 and spiral plate 134, at 1 to 6 revolutions per hour clockwise as viewed in Figure 3, gently moves upper peripheral portions of the ash bed. Ash on the ash bed surface, represented by the dotted line 148, is moved radially downward and outward from ash zone center to the upper edge of the kiln where ash moves by aid of gravity downward and through ash outlets 44 (see Figure 1). The upper surface 148 of the ash zone 13 is, of course, shaped to a 20° cone for a spiral plate 134 with a uniform 20 degree descent.

Figures 4 and 5 show an alternative form of scraper according to the invention in which there is provided a central horizontal spiral scraper plate 434 rotatable about a centrally positioned mounting shaft 453 above the kiln 415. Circumferentially-acting radially-disposed, relatively steeply sloping outer edge scrapers 450a, 450b, 450c, and 450d are supported from a mounting platform 451 and horizontal beams 420 above the kiln. These outer scrapers, when rotated serve to cut loose sticky molten shale ash from the outer circumferential area 413a of the shale ash surface, and since these scrapers are at an angle with the horizontal greater than the normal angle of repose, e.g., 35° to 85°, the dislodged ash falls away from the kiln largely by gravity. The central surface 413b, at the same time, has shale ash removed therefrom to the outer circumferential disposal area 413a by the correct rotary motion of the spiral plate 434 indicated by the direction of the curved arrow 452. When such radially disposed outer scrapers are used, the circumferential area which they scrape should not extend inward more than about 75 percent of the radius, and preferably not more than 50 percent of the radius, i.e., the central area covered by radially-acting scrapers should cover at least 25 percent and preferably 50 percent of the radius of the kiln.

It is to be understood that outer scrapers may also be disposed at an angle from the radial position so as to impart a radial thrust, in which case the angle may be less than 35°. Of course, one or several of such outer scrapers may be used as desired. The imaginary quadrant lines 454 in Figure 5 indicate the plan view positions at which the horizontal support beams 420 would ordinarily be disposed if they were shown in this figure.

Figures 6 and 7 show another alternative form of a scraper according to the invention in which the horizontal support beams 620 are driven at their outer ends in a manner as shown in detail in the embodiment of Figures 1, 2 and 3. The alternative form of Figures 6 and 7 is numbered corresponding to the form of Figures 4 and 5. This includes a central spiral scraper plate 634 having a varied rate of gradual descent above the kiln 615, an attached outer spiral edge scraper 650 at the end of the spiral plate 634, an outer circumferential area 613a of the shale ash surface, a central surface 613b of shale ash, a curved rotation directional arrow 652 and the quadrant lines 654. It is to be realized that descending spiral scrapers with changing rates of descent at various ash surface diameters are provided for by the alternative scraper form shown in Figures 6 and 7. The specific rate of the descent of the spiral shown at various kiln diameters in Figures 6 and 7 is illustrative only.

For the scraping apparatus of the foregoing embodiments, the separation distance of the kiln top edge and scraper is preferably made at least equal to or greater than the maximum particle size of shale solids fed upwardly into the kiln so as to aid the discharge of particles below the scraper.

If the central area of shale ash is to be maintained at a substantially higher elevation than the kiln top, as pre-

ferred, the maximum elevation of the shale solids above the top edge of the kiln, preferably is from 5 percent to 45 percent of the kiln diameter to provide the elevational distance for the descending scrapers of the invention.

The concentric uniformity of shape at various levels of the solids bed in the ash zone and in the upper part of the burning zone, in combination with the gentle continuous movement of a central spiral plate across the upper surface of the ash zone, provide especially desired results. The ash will be handled gently without undue ash agitation for a retort having a relatively large upper surface area. The upper surface of the ash bed need not be restricted to a form having relatively steep conical surfaces. This is because the helix type scraper and method of ash-moving force application provides more positive mechanical force and to some extent, gravitational force application which is gentle in its ash moving action in a radial direction. An advantage in gentleness of ash handling is therefore gained over angularly descending straight scrapers and also over radially acting rotary horizontal ash scrapers. The scraper apparatus and method disclosed herein will provide similar results of gentle and positive radial ash movement for larger retort upper surfaces than presently known ash scrapers. This positive movement factor permits building of larger capacity retorts without being limited by more troublesome ash removal difficulties from such larger retorts. The helix form of scraper is thus adaptable to different ash bed requirements for different ash solids which may require different forms for best process control.

With less ash agitation with a spiral form scraper than normally expected in rotary scraping operations, production of ash fines is reduced. This reduces clinker or slag formation in the burning zone which results in improved control of air distribution therein and lower bed pressure differential requirements. Lower bed pressure differential in turn effects appreciable savings in gas blower H.P., both as to installation capacity and operating cost.

The continuous movement of this type of descending helix scraper also in no way blocks normal upward movement of the solids bed. The upward thrust of the solids bed is less of a problem because of the following: The curved form of the scraper provides continuous substantial displacement of all points of the rotating scraper except immediately at the retort center, and in most instances the angular disposition of a portion of the scraper from horizontal.

The above specific embodiment is intended to be illustrative only since persons skilled in the art may devise other embodiments still within the spirit and scope of the following claims which define the limits of the invention.

We claim:

1. In an apparatus comprising a kiln, means for passing solids upwardly through said kiln while maintaining combustion therein and means for removing hot ash from the top of said kiln, the improvement in said latter means which comprises a continuous solids scraper blade of helical form operative on ash solids from an elevated central area of said retort top to a circumferential area of said retort top, said scraper blade pivoted from a point on the extended centerline of said kiln at a substantial distance above the upper edge of said kiln and motive means for operating said blade.

2. In an apparatus comprising a kiln, means for passing solids upwardly through said kiln and means for removing hot ash from the top of said kiln, the improvement in said latter means which comprises a continuous solids scraper blade of helical form which descends from an upper central area over said solids surface to a lower circumferential area of said solids surface, and means for rotating said blade, whereby rotation of said solids scraper blade provides in combination with gravitational force a positive downward and outward acting radial force component to upwardly fed hot ash solids pushed to said surface, said hot ash solids being thereby removed from

said ash surface by application of said radial force component.

3. Apparatus according to claim 2 in which the lower end of said scraper blade of helical form terminates above the top edge of said kiln at a distance separated vertically therefrom at least equal to the maximum size of particles of said solids passed upwardly through said kiln.

4. Apparatus according to claim 2 in which the circumferential portion of said scraper blade descends at an angle at least equal to the normal angle of repose of the solids.

5. Apparatus according to claim 2 in which said means for rotating said ash scraper blade comprises: radial blade supports disposed horizontally above and attached to said blade; a rotatable drive ring, said rotatable drive ring being attached to, and in supporting relation to said radially disposed supports; means for support of said rotatable drive ring, said means for support of said rotatable drive ring being stationary relative to said kiln; and motive means for rotating said rotatable drive ring upon its means for support.

6. Apparatus according to claim 5 in which said rotatable drive ring is provided with radially disposed support boxes, each of said support boxes having an open end facing inward for receiving one end of said radially disposed blade supports, said support boxes having provision for excess space therein, thereby providing for heat expansion of said supports which are held therein.

7. Apparatus according to claim 5 in which said means for supporting said rotatable drive ring is provided with vertically disposed rollers for receiving radial thrust and with horizontally disposed rollers for receiving vertical thrust, whereby radial thrust and horizontal thrust respectively, of said scraper blade of helical form, is absorbed by said means for supporting said rotatable drive ring.

8. Apparatus according to claim 5 in which said means for support of said rotatable drive is provided with an air sealing means and said rotatable drive ring is provided with a cooperating air sealing means, whereby said rotatable drive ring and its means for support are maintained in movable air-sealed relation with respect to each other, thereby restricting air entry path to ash discharge path.

9. In an apparatus comprising a kiln, means for passing solids upwardly through said kiln and means for removing hot ash from the top of said kiln, the improvement in said latter means which comprises a horizontal scraper blade of continuous spiral form rotatable over an elevated central area of said kiln, said central area vertically positioned a substantial distance above the top of the kiln; outer edge scraper means rotatable over the circumferential area of said kiln, said outer scraper descending from the periphery of said elevated central area to the outer edge of said kiln and means for rotating said horizontal scraper blade and said descending scraper means, said horizontal scraper blade rotation thereby moving centrally rising ash solids to said circumferential area and said outer edge scraper means thus scraping loose solids from said circumferential area, said loosened solids thereby falling away from said rising solids above said kiln top due to the effect of gravity acting on said loosened solids.

10. Apparatus as defined in claim 9 wherein said means for rotating comprises an upper support structure and means for rotating said support structure above the outer edges of said kiln top.

11. Apparatus as defined in claim 9 wherein said means for rotating comprises an upper support structure and means for centrally rotating said support structure at the center of said kiln top.

12. An apparatus according to claim 9 in which the descending outer edge scraper means is substantially radially disposed and descends at an angle at least equal to the normal angle of repose of said solids.

13. An apparatus according to claim 9 in which the descending outer edge scraper means operates over a circumferential area within outer radial kiln distances greater

than 0% of the kiln radius and less than 75% of the kiln radius.

14. An apparatus according to claim 9 in which the descending outer edge scraper means operates over a circumferential area within outer radial kiln distances greater than 25% of the kiln radius and less than 50% of the kiln radius.

15. In an apparatus comprising a kiln, means for passing solids upwardly through said kiln and means for removing hot ash from the top of said kiln, the improvement in said latter means which comprises: a descending continuous helix scraper blade rotatable over an elevated central area of said kiln, said central area vertically positioned a substantial distance above the top of the kiln; an outer rotatable edge scraper blade descending at a greater rate of descent from the periphery of said elevated central area to the outer edge of said kiln; and means for rotating said continuous helix scraper blade and said outer edge scraper blade, said continuous helix scraper blade thereby moving centrally rising ash solids to the circumferential area and said outer edge scraper blade thereby scraping loose solids from said circumferential area, said loosened solids thereby falling away from said rising solids above said kiln top due to the effect of gravity

acting on said loosened solids moved to the edge of said kiln.

16. A descending helix scraper blade as defined in claim 15 which descends at increasingly greater angles of descent at increasingly greater distances from the center of said kiln top.

17. Apparatus as defined in claim 15 wherein said means for rotating comprises an upper support structure and means for rotating said support structure above the outer edges of said kiln top.

18. Apparatus as defined in claim 15 wherein said means for rotating comprises an upper support structure and means for centrally rotating said support structure at the center of said kiln top.

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