June 17, 1941. W. F. COURT 2,245,554

HYDRAULIC DISRUPTION OF SOLIDS

Filed Feb. 21, 1938 2 Sheets-Sheet 1

FIG. 3

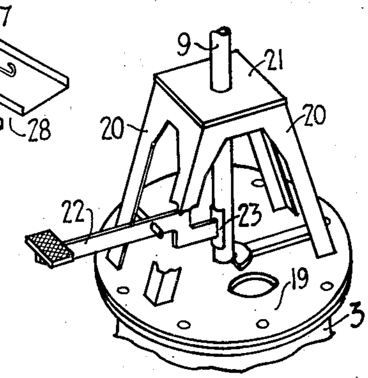
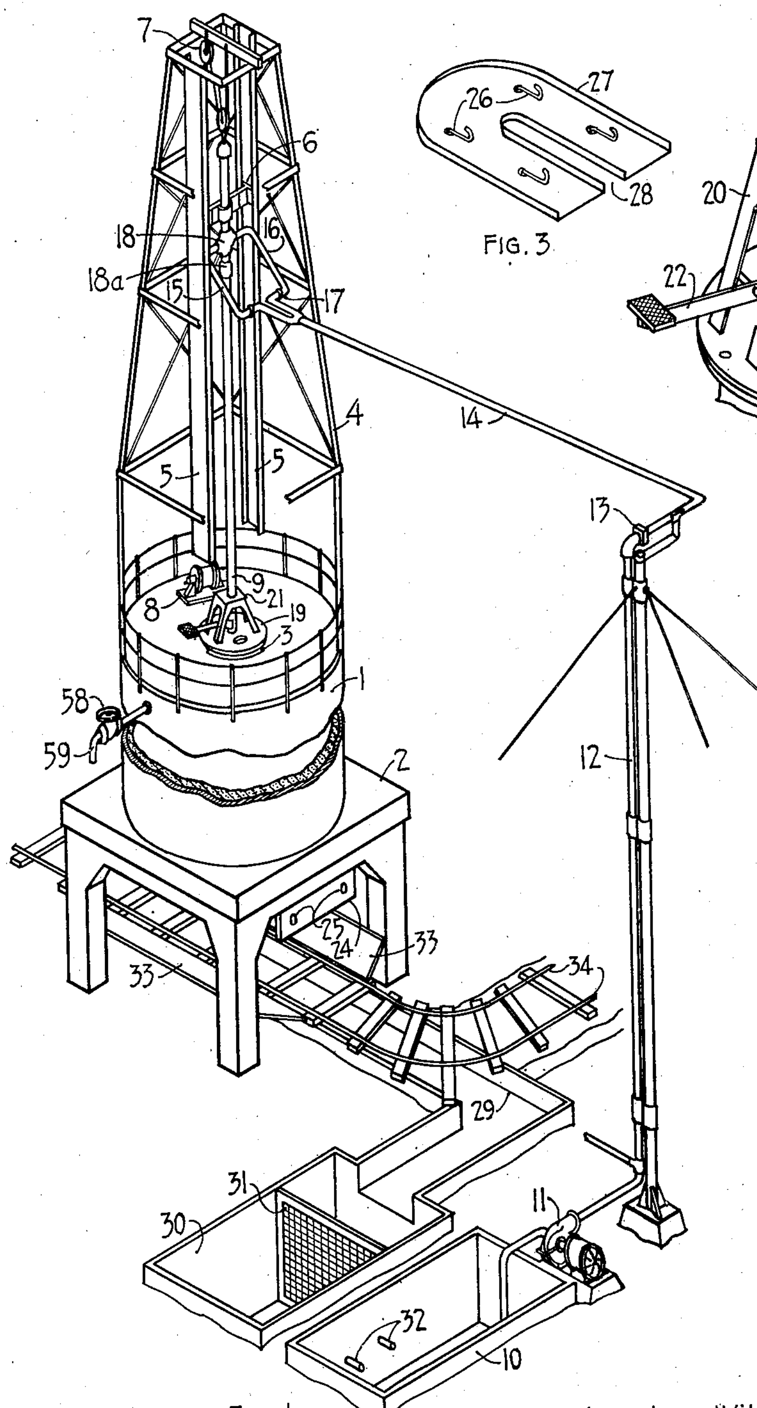


FIG. 2



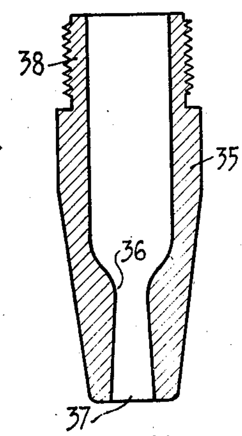


FIG. 7

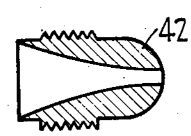


FIG. 9

FIG. 1

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By his Attorney: [signature]

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HYDRAULIC DISRUPTION OF SOLIDS

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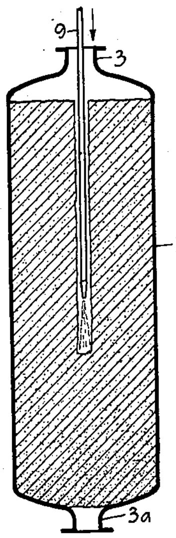

FIG.-4

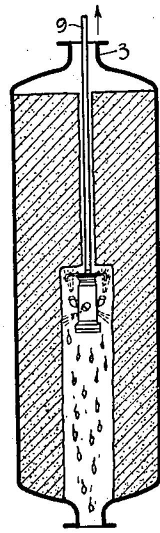

FIG.-5

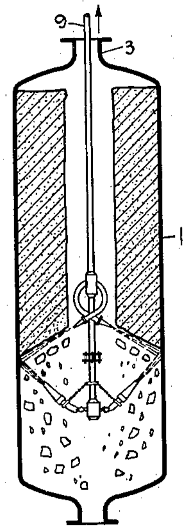

FIG.-6

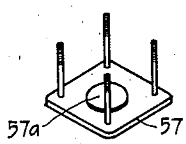

FIG.-12

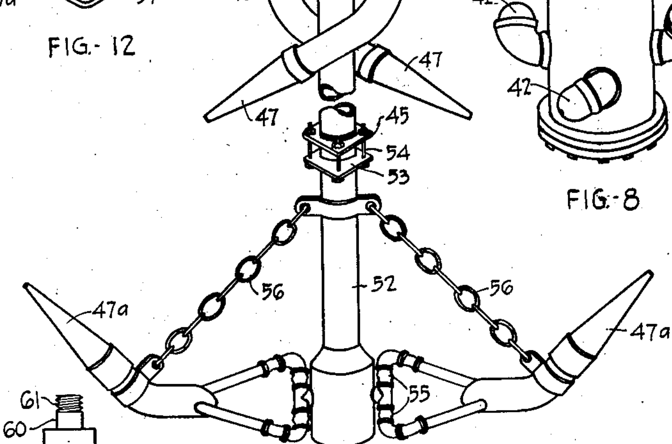

FIG.-10

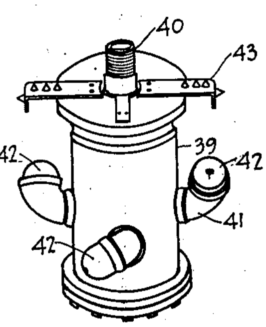

FIG.-8

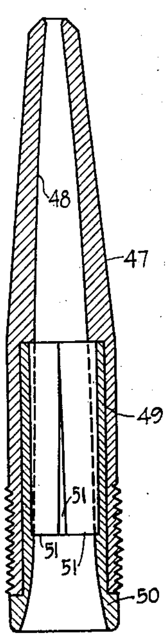

FIG.-11

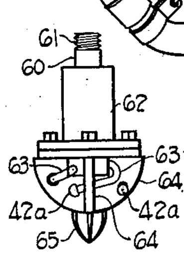

FIG.-13

Inventor: William F. Court

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UNITED STATES PATENT OFFICE

2,245,554

HYDRAULIC DISRUPTION OF SOLIDS

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Application February 21, 1938, Serial No. 191,685

5 Claims. (Cl. 141—1)

This invention relates to the cleaning of vessels which contain solids, like carbonaceous material, particularly deposits of coke produced by the carbonization of hydrocarbon oils, such as reaction and coking chambers employed in petroleum cracking plants and the like and asphaltic material, especially the solid, brittle kind. While the process may be applied to the removal of various types of carbonaceous material from diverse forms of apparatus, it is particularly useful for the removal of porous coke of the type produced by heat contained within the body of the oil. For convenience, in the following description the application of the process to the cleaning of a vertical reaction or coking chamber of the type used in connection with a Dubbs cracking unit will be described, it being understood that the process may be applied as well to a horizontal reaction chamber, and to containers of other shapes, as well as to the removal of similar types of porous coke or asphaltic materials from containers or conduits in which coke has been deposited due to the carbonization of oil by external as well as internal heat.

The conventional method of removing petroleum coke from cracking plant reaction or coking chambers involves hanging a steel cable in a series of spirals inside the chamber before the unit is placed in operation, and the withdrawal of the cable after the termination of a run by means of a steam hoist. The withdrawal of the cable breaks up the body of coke, discharging the same through a manhole. Following this, several men enter the chamber and remove the coke adhering to the chamber walls with pickaxes. Such a method is objectionable in that it is time consuming, since the chamber must be cooled to a point at which men can work within it; it is hazardous to workmen; and iron wire used to suspend the steel cable is withdrawn together with the coke, rendering it useless for many purposes without subsequent operations for separating pieces of metal.

It is the purpose of the present invention to provide an improved method and apparatus for removing carbonaceous materials, such as coke and the like from containers, which is less laborious than those heretofore employed, consumes less time, is more economical and is less hazardous than methods now employed.

It is a further object to provide a hydraulic method of removing coke and the like in which the coke will be free from metallic bodies. Still another object is to provide a novel apparatus for carrying out the process herein described. Other objects of the invention will become apparent from the following specification, taken together with the drawings forming a part thereof, in which a representative embodiment of the process is illustrated, it being understood that the process is not limited to the specific steps illustrated, nor to the cleaning of chambers of the particular type or shape shown.

In the drawings, Figure 1 is a perspective view of a cylindrical reaction chamber showing the general layout of the de-coking system; Figure 2 is an enlarged perspective view of the water feed pipe guide; Figure 3 is a perspective view of the water shed shield; Figures 4, 5 and 6 are vertical sectional views of the reaction chamber illustrating successive stages or steps according to one embodiment of the process; Figure 7 is a vertical sectional view of the spear jet nozzle; Figure 8 is a perspective view of the reaming nozzle head; Figure 9 is a longitudinal sectional view of a nozzle tip used on the nozzle head of Figure 8; Figure 10 is a perspective view of the main nozzle head; Figure 11 is a longitudinal sectional view of the nozzle employed with the nozzle head according to Figure 10; Figure 12 is a perspective view of the blind flange adapted to be bolted to the upper section of the nozzle head of Figure 10; and Figure 13 is an elevation view of a modified form of nozzle head suitable for effecting the first two steps of the process.

The present process is based on the discovery that carbonaceous materials of the type described above can be efficaciously broken up and removed from containers by the action of a jet of water directed so as to have a cutting action on the deposit of carbonaceous material. This is effected by directing the water by means of a suitably designed nozzle so as to cause a great impact or reaction on the body of the solid to be removed over as small an area as possible. In this manner the primary action of the water is to cut the solid material into lumps, and erosion is minimized. For the main cutting or disrupting operation, I prefer to employ water jets which have velocities of more than about 200 feet per second, best results being obtained with velocities of about 300 to 500 feet per second and higher, and which are confined. By "confined" jets, I mean jets which do not substantially break up or spread prior to impact. It is, moreover, desirable to employ jets of sufficient size to cause an impact of more than 100 lbs., best results being obtained with jets having impacts of between 200 and 300 lbs. or greater. When lower velocities are employed, or when the design of the nozzle is such as to cause the jet to break up the cutting action is materially reduced and erosion is increased. This materially increases the time required for the removal of the solid and is, moreover, often undesirable, since it is frequently advantageous to produce maxium lump and egg size coke. As an example, I may employ a jet of water from a ⅜ inch in diameter nozzle, with a velocity of 380 feet per second. Such a jet will cause an impact of about 212 lbs. over an area only slightly larger than 0.11 sq. in., the opening of the nozzle. I am, however, not restricted to the specific examples herein disclosed.

The method according to the present invention, according to the preferred mode of operation, comprises the steps of cannulating the body of the material to be removed, either by means of a jet of water or of a drill to provide a well or tubular opening, and disrupting the material by a radially outwardly directed cutting jet of the type described above from the opening. To permit the apparatus required to direct the cutting jets to be introduced into the opening, the cannulating operation may be carried out in two steps, a small opening being made in the first step, and the opening being enlarged or reamed in the second step.

The process may be applied to any solid material (not soluble in water) which can be disrupted or cut by a jet of water producing impacts up to 250 pounds against the solid, and is not restricted to the cutting of carbonaceous deposits. The invention may be better understood from the following detailed description.

Referring to the drawings, 1 represents a coke chamber of an usual cracking installation, supported by a foundation or pedestal 2 and provided with an upper chamber head manhole 3 and a lower manhole 3*a* (see Figure 4). The tower 4 is mounted on top of the coke chamber and is provided with a pair of vertical tracks 5 in the form of channel bars. A pipe guide 6 is mounted to have a vertical sliding movement along the tracks, supported by a cable passing through a block 7, and wound about a drum 8 operable by a suitable source of power. The pipe guide 6 carries a vertical water feed pipe 9 concentrically with respect to the coke chamber. The water may be supplied thereto from surge tank 10, via pump 11, riser pipe 12, hinged connection 13, pipe 14, and a pair of pipes 15 and 16. The pipes 15 and 16 are hinged about a horizontal axis with respect to the pipe 14, as shown at 17, and are similarly hinged with respect to the cross fitting 18. This permits the pipes 15 and 16 to swing towards and away from the pipe 9 when the pipe guide 6 is moved vertically, allowing the pipe 14 to swing about its hinged connection 13. A swivel connection 18*a* permits the pipe 9 to rotate about its own axis.

For removing coke from the chamber the upper manhole cover is removed and replaced by a water feed pipe guide comprising a plate 19 adapted to be bolted to the chamber head manhole. Plate 19 is apertured to avoid pressure, and carries brackets 20 supporting a guide plate 21. Plates 19 and 21 are centrally perforated to permit the water feed pipe 9 to extend downwardly into the chamber, and to guide the pipe in its vertical movement. A foot brake lever 22 carrying a brakeshoe 23, engageable with the water feed pipe 9 is attached to the brackets 20.

The pedestal 2 carries an angle bar 24 having holes 25 to receive pipe guides (not shown) for guiding an upwardly convex apron used as a connecting piece between coke cars to prevent spillage of coke on the tracks during loading operations, when the cars move into position. A water shedding shield 27 (see Figure 3) is adapted to be fastened to the bottom of the lower chamber manhole 3*a* by hooks 26; it has a medial slot 28, adapted to permit the water feed pipe to extend below it, as described below, and upturned flanges at its periphery and along the slot 28.

A trough 29 located below the pedestal 2 is provided to lead off water into a settling basin 30. A screen 31 is located across the settling basin 30 which is connected to the surge tank 10 via conduits 32. A pair of concrete aprons 33 direct water into the trough 29. Rails 34 for the side dump coke cars pass beneath the coke chamber 1.

A piercing or spear nozzle 35 (see Figure 7) provided with a constricted throat 36 and a flaring orifice 37 is adapted to be secured to the water feed pipe by means of an externally threaded boss 38, and is shaped to have a small external diameter, co-extensive with the exterior of the water feed pipe 9.

The reaming nozzle head (see Figures 8 and 9) comprises a hollow body portion 39 rotatably mounted by means of roller bearings, on a central pipe having a threaded boss 40 adapted for connection to the water feed pipe. A plurality of elbows 41 are attached to the body 39 in communication therewith and with the feed pipe 9, and carry nozzle tips 42 directed so as to cause water issuing therefrom to rotate the nozzle head by the reaction of the water on the elbows. One pair of oppositely disposed nozzles is directed downwardly at an angle of about 30° with the horizontal and of the other pair is directed upwardly at an angle of about 45° horizontal. A pair of scrapers 43 provided with sharp points is secured to the top of the body 39.

The main nozzle head which carries the cutting nozzles (see Figures 10 to 12) comprises an upper and a lower section and is preferably non-rotatably connected to the feed pipe 9. The upper section comprises a pipe 44, adapted to be threadedly connected at its upper end to the water feed pipe 9, and carries a flange plate 45, threadedly secured at its lower end. Two curved pipes 46, in communication with the interior thereof, carry nozzles 47, and are shaped to direct a stream of water downwardly therefrom at an angle of about 30° with the horizontal, nozzle axes being skew with respect to the axis of the pipe 44, whereby the reaction of the water imparts a turning force to the nozzle head. The nozzle 47 as shown in Figure 11, comprises a tapering body portion 48 and an externally threaded coupling portion rearwardly thereof, having a cylindrical recess 49 shaped to retain a bushing 50 carrying axially extending straightening vanes 51. It is important to design these nozzles and the nozzles 47*a* so as to produce a jet which will not substantially break up before striking the body of the coke, whereby the cutting action will be at a maximum, since my process is essentially one of cutting the coke, as distinguished from erosion. It is also desirable to design the nozzle tips 42 and the nozzle 35 to avoid breaking up and scattering of the jet as much as possible.

The lower section comprises the vertical pipe 52 surmounted by a flange plate 53 provided with bolts 54 for attachment to the flange plate 45. A pair of nozzles 47*a*, constructed like nozzles 47, is connected to the lower end of the pipe 52 so as to swing upwardly about swivels 55. Chains 56 normally support the nozzles 47a at an angle of about 45° above the horizontal.

A blind flange 57, having a sealing gasket 57a, is adapted to be connected to the open section 44 when the lower section and the flange 53 are removed therefrom.

If desired, an overflow outlet pipe 59, provided with a gate valve 58, may be connected to the coke chamber near the top.

The nozzles, particularly the spear nozzle 35, are preferably made of case hardened steel since they are subjected to considerable handling abuse.

Referring to Figure 13, a modified form of nozzle head suitable for combining the piercing and reaming operations is shown. It comprises a central pipe 60, provided with a threaded boss 61 adapted for attachment to the water feed pipe 9. An annular rotating head 62 is secured to the pipe 60 by means of roller bearings, and carries a plurality of nozzle tips 42a, similar to the tip 42 shown in Figure 9. The nozzle tips are inclined downwardly about 30° below the horizontal, and supplied with water from the pipe 9 and through curved conduits 63, supported by cross flanges 64 which are attached to and rotatable with the head 62. A drill 65 is mounted beneath the cross flange 64. The cross flanges 64 are downwardly convex and their outer edges are shaped as cutting edges, preferably made of stellite alloy and ground.

The operation of removing coke according to this invention proceeds as follows:

The coke chamber is first cooled in any suitable manner, as by the introduction of steam for a period of from 15 to 30 minutes followed by the introduction of water over a period of 30 minutes to two hours. This may be introduced through the regular connection or pressure conduits provided for this purpose. It is not necessary in this process to cool the coke chamber to the extent necessary in the cable method. The method of operation according to the preferred embodiment then comprises the following three steps:

First step (illustrated in Figure 4)

The chamber is unheaded at the top and bottom and the water feed pipe guide secured to the upper manhole head 3. The pipe guide 6 is raised to the top of the tower and the spear nozzle 35 attached to the lower end of the pipe 9. This assembly is then lowered into the chamber and water under high pressure such as, for example, 1200 lbs. gauge measured at the pump, supplied thereto, causing a high velocity jet of water to be directed downwardly. The rate of discharge may, for example, be 400 to 750 gallons per minute or higher, using a spear nozzle 8 inches long with a ¾ or ⅞ inch throat and a ⅞ or one inch orifice. The water pierces a vertical hole through the coke of sufficient diameter to permit free movement of the feed pipe. During this operation the pipe is gradually lowered, being guided by plates 19 and 21. In most cases, although the hole is pierced through from the top, the water escapes through the lower manhole without flooding the chamber. The fine particles of coke displaced by this operation are diffused into the main body of the coke bed. When extremely hard or asphaltic layers of coke are encountered and the flow of water therethrough is insufficient the overflow pipe 59 may be used to carry off the water. In most cases, however, by shutting off the water supply momentarily the chamber may be drained out through the bottom. When such abnormal strata of asphaltic or extremely hard coke are encountered it also may be necessary to raise the assembly a foot or two above the obstruction and permit it to drop, repeating this operation until the strata have been broken through, using the hoist cable and power driven drum 8, or an auxiliary hand operated hoist for this purpose.

To reduce the required height of the tower 4 the feed pipe 9 may comprise two or more sections, successive sections being added when the pipe line 6 has reached its lowermost position at the bottom of the tracks 5.

The first step may also be effected by drilling, water being preferably introduced to wash out the loosened material. Alternatively, a hollow pipe may be mounted in the coke chamber prior to coking, and this may be withdrawn by means of a hoist, leaving a central hole.

Second step (illustrated in Figure 5)

The object of the second step, which may sometimes be omitted, is to increase the size of the initial hole to about 18 to 24 inches in diameter in order that the nozzle head may be used in the last step without fouling the coke bed and may be regarded as a continuation of the cannulating operation described in the first step. Following the completion of the first step, the nozzle 35 extends through the lower manhole 3a and below the coke chamber. The water shedding shield 27 is placed beneath the coke chamber so as to cause the pipe 9 to extend through the slot 28 and the reaming nozzle head is attached in place of the nozzle 35. The shield 27 is removed, and the pipe and nozzle are then raised through the chamber and full water pressure is applied, causing the nozzle head to rotate at a high speed, such as 1000 revolutions per minute. The rate of water discharge may, for example, be 400 to 750 gallons per minute, or higher, using two or more nozzles 42 with ⅜ inch diameter outlets. The pipe and nozzle head are then raised steadily to the top of the chamber and upon reaching the top the water is turned off. The scrapers 43 are provided primarily for the purpose of preventing coke bridging on the head and stopping the rotation, since the main cutting action is effected by the water.

The second step may be carried out simultaneously with the first step, as by mounting the piercing nozzle on the reaming nozzle head to discharge in the direction of the scrapers 43, the water feed pipe 9 being in this arrangement attached to the opposite end of the body 39. Alternatively, the nozzle head shown in Figure 13 may be mounted on the feed pipe 9 from a position above the coke bed, and the water turned on. The reaction of the water on the nozzle tips 42a will cause the head 62 to rotate at a high velocity, thereby causing the drill 65 and the edges of the flanges 64 to cut the coke. The water will wash away the disintegrated coke, as described above. Since the flanges 64 extend radially beyond the termini of the nozzle tips 42a, the latter will move downwardly into the hole, and enlarge it to the dimension required for the third step.

Third step (illustrated in Figure 6)

This is the final step during which the main body of coke is disrupted and completely removed from the chamber. It is preferably carried out following the completion of the first and second steps, but may be carried out simultaneously with either or both, as by attaching the main nozzle head to the bottom of the reaming nozzle head. In the preferred mode of operation, following the completion of the second step the reaming nozzle head is lowered to extend beneath the coke chamber, and the water shedding shield 27 is reattached. The main nozzle head is then attached to the water feed pipe in place of the reaming nozzle head. For the initial cutting, the lower section of the main nozzle head is disconnected and the blind flange 57 is attached to the flange plate 45, thereby closing the lower end of the pipe 44. The shield 27 is removed, the upper half of the assembly is raised into the chamber and jetting is started immediately after the nozzle is in position above the manhole neck. Due to the angular disposition of the nozzle, the assembly, including the water feed pipe, rotates under its own power, the rate of turning being preferably regulated by means of the foot brake 22—23 not to exceed about 2–4 revolutions per minute, whereby the jets assume a plurality of successive orientations. The rate of turning, however, depends upon the size of the chamber being cleaned, it being desirable to regulate the rotation so that one rotation will make a complete circular cut into the coke body. With the water pressure still on, the assembly is raised about 6 or 7 inches and rotation continues. This procedure is followed until approximately 5 feet of coke have been removed from the bottom of the chamber. The water is then shut off, the assembly is lowered, water shedding shield reattached, the blind flange 57 is disconnected, and the lower section of the main nozzle head is coupled to the vertical pipe 44 by means of bolts 54. The shield 27 is removed, and complete assembly is then raised into the bottom of the coke body, the nozzle 47a being folded upwardly to permit passage through the manhole neck, and assuming the position shown in Figure 10 after having entered the coke chamber. The complete assembly is raised into the coke chamber to a position at which the frustro-conical surface of revolution defined by the axes of the nozzle 47 is just below the frusto-conical bottom of the coke body, as shown in Figure 6, full water pressure is applied and jetting restarted. The rate of water discharge may, for example, be 450 to 750 gallons per minute using nozzles 47 and 47a having ⅜ inch orifices. The nozzles 47a direct jets of water upwardly to impact on the chamber wall at the same height and preferably at 90° from the points of impact of the downwardly directed jets from the nozzles 47, although the jets from the nozzles 47a may be directed somewhat lower and to different orientations. The procedure from this point on is similar to that described in the second step, the water feed pipe and nozzle head being procedure raised until all coke has been completely removed from the coke chamber, and the rate of turning being regulated to about 2 to 4 revolutions per minute.

By way of example, it may be stated that the total pumping time for the three steps in removing coke from a chamber forty feet high and ten feet in diameter, using the rates of flow and nozzle sizes given above, is usually between one and two and a half hours.

During the jetting operations, a dump car is placed beneath the coke chamber to receive the mixture of water and coke. It was found that most of the coke settles to the bottom of the car and only the extremely fine mixture is washed over the side or through the perforation of the car.

The water, directed by aprons 33, flows into the trough 29, carrying the coke with it. Any number of suitable settling basins such as the basins 30 may be provided. After the heavier particles of the coke have been settled the partially clarified water passes through a screen 31 which retains the finer particles of coke.

The nozzles disclosed in this specification are claimed in my continuation-in-part application Serial No. 208,711, filed May 18, 1938, now Patent No. 2,217,360.

I claim as my invention:

1. A method of removing a body of coke from a vertical cylindrical reaction chamber which is open at the top and at the bottom, comprising the steps of cannulating the body of the coke substantially at the center thereof, enlarging the opening thus formed by means of a jet of water directed outwardly therefrom in a plurality of successive orientations and at progressively different levels and disrupting the body of the coke by directing a substantially confined jet outwardly and a second jet upwardly and outwardly from an origin which is below the origin of the first jet, said disrupting jets having a velocity sufficient to cut the body of coke to produce lumps, said jets being directed in a plurality of successive orientations and at progressively higher levels.

2. A method for removing a body of solid carbonaceous material from a reaction chamber comprising the steps of cannulating the body of said material, enlarging the opening thus formed and thereafter conducting a substantially confined stream of water outwardly from said enlarged opening against said body, said stream striking said body at a velocity sufficient to effect cutting the body to lumps, and removing said lumps.

3. A method for removing a body of solid carbonaceous material from a reaction chamber comprising cannulating the body of said material, conducting a first substantially confined stream of liquid outwardly from a source within said cannular opening and conducting a second stream of liquid from a second source within said cannular opening and spaced from said first source, said streams converging and striking said body with a velocity sufficient to effect cutting the body into lumps, and removing said lumps.

4. A method for removing a body of solid carbonaceous material from a reaction chamber comprising conducting at least two converging streams of liquid against said body, said streams striking said body at velocities sufficient to effect cutting said body to lumps, and the direction of said streams relative to each other being such that upon removal of said body from said chamber they meet on the chamber wall.

5. The method of claim 4 in which the direction of said streams is such that they meet on the chamber wall at an angle of about 90°.

WILLIAM FREDERICK COURT.