United States Patent [19]

Novy

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[45] **Apr. 29, 1975**

[54] **APPARATUS FOR DECOKING A DELAYED COKER**

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[73] Assignee: **Great Lakes Carbon Corporation**, New York, N.Y.

[22] Filed: **Apr. 24, 1974**

[21] Appl. No.: **463,581**

Related U.S. Application Data

[62] Division of Ser. No. 238,304, March 27, 1972, Pat. No. 3,836,434.

[52] **U.S. Cl.** ..... **239/565**; 239/587; 201/2; 202/241; 134/24; 134/39; 134/168 R

[51] **Int. Cl.**..... **C10c 3/18**; B05b 1/14; B05b 15/08

[58] **Field of Search**..... 239/227, 243–245, 239/565, 587, 588; 201/2; 202/241; 134/24, 8, 39, 167 R, 168 R; 15/104.1 C; 208/48, 131

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Primary Examiner—Robert S. Ward, Jr.
Attorney, Agent, or Firm—Wallace F. Neyerlin

[57] **ABSTRACT**

Coke is removed from the delayed coker or container by hydraulically cutting a substantial portion or all of it in a substantially vertical direction with water jet streams emanating from nozzles operatively mounted and coupled to a central drill stem which is provided with water under pressure and which is capable of rotation and vertical movement within the container. The coupling is by mechanical and hydraulic linking means permitting the movement of the nozzles in a radial direction from the axis of the central drill stem. After the cutting of the pilot hole with a conventional cutting head designed for that purpose, a substantial portion or all of the remainder of the coke in the container is removed by hydraulically cutting the coke in a substantially vertical direction by directing the water jet streams from the nozzles in a substantially vertical and downward direction against the horizontal surface of the coke in a series of radial incremental distances (which may be variable) substantially circumferentially across the surface of the coke. After each radial incremental cut, the drill stem is raised in the container, the nozzles are extended radially and the nozzles are then moved vertically from the top of the coke to the bottom thereof by lowering the drill stem as the coke is removed by the action of the water, thereby forming a varying, increasing diameter, cylindrical void in the container through which passes the remainder of the coke that is removed in this manner.

3 Claims, 12 Drawing Figures

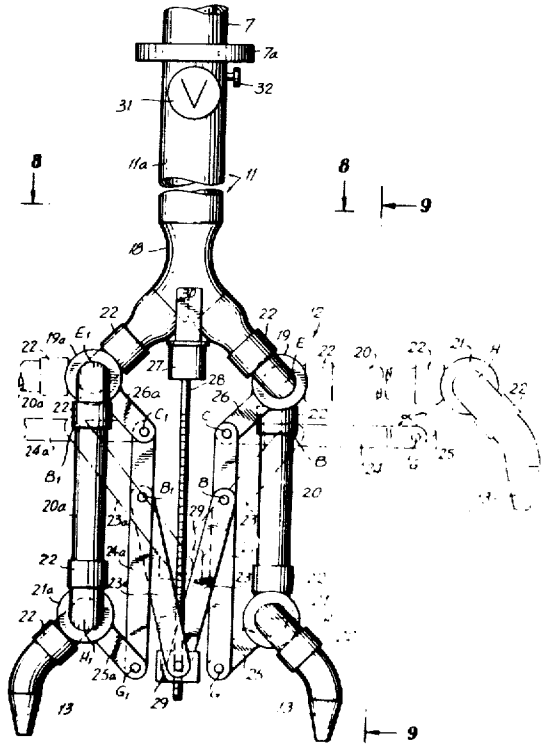


FIG.1

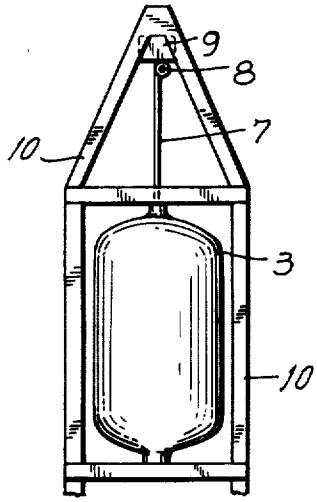


FIG.2

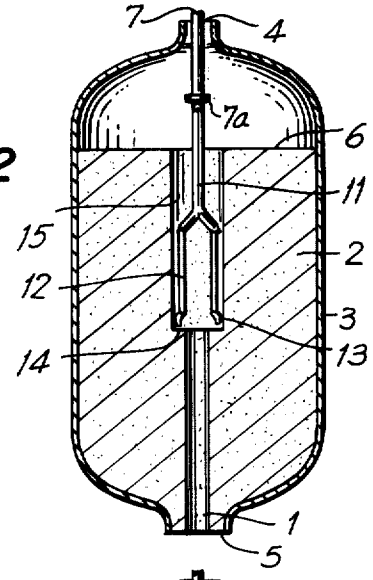


FIG.3

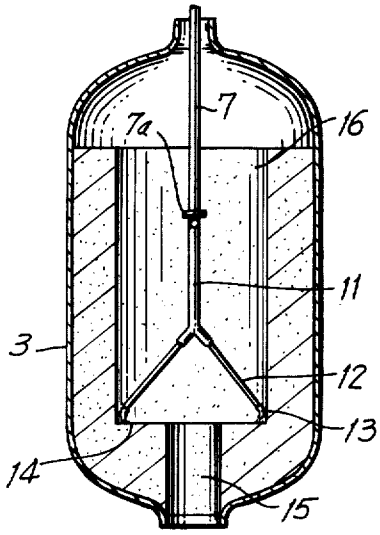


FIG.4

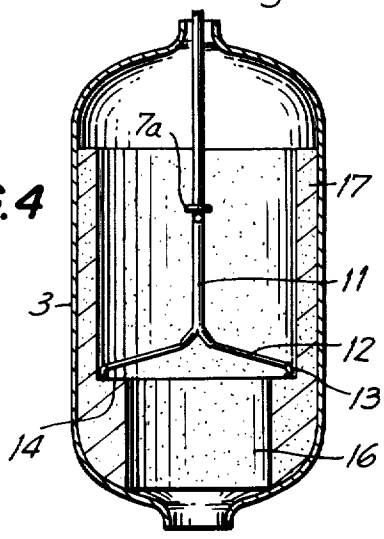


FIG.5

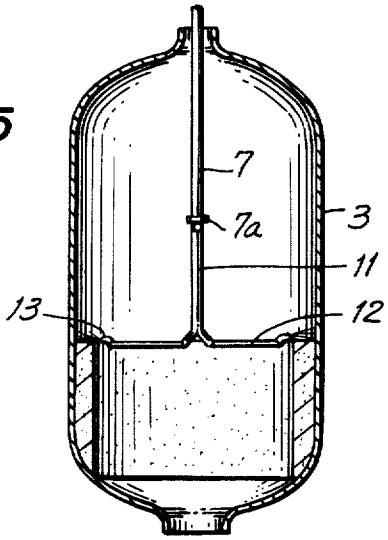


FIG.6

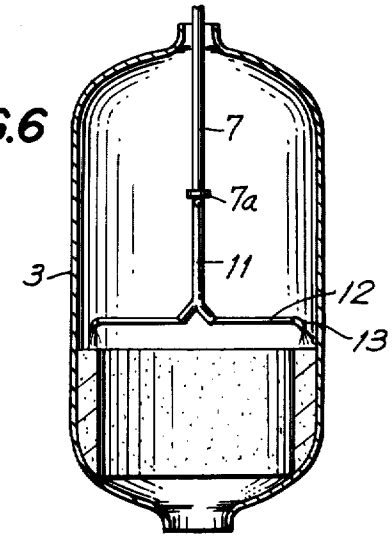
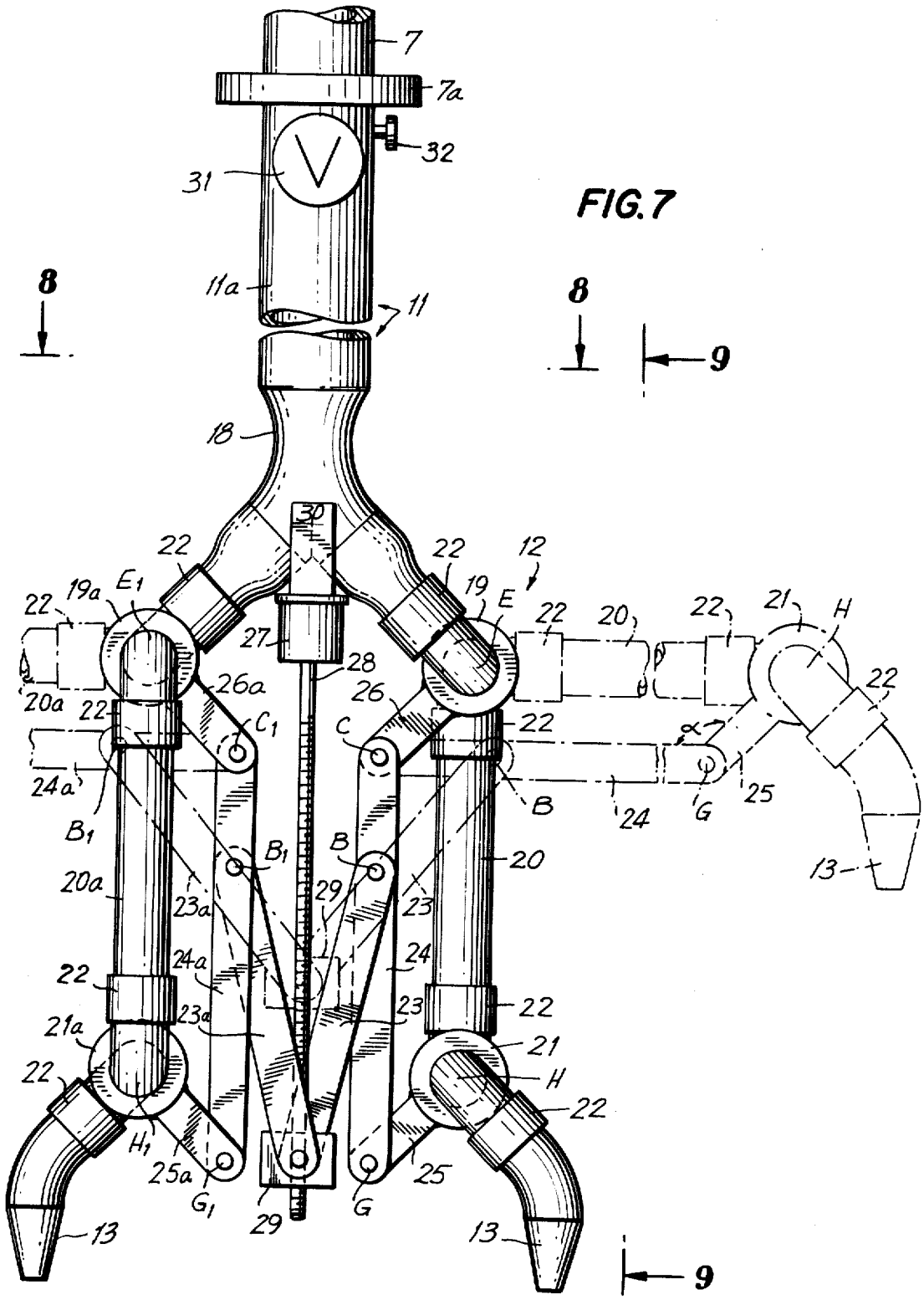


FIG. 7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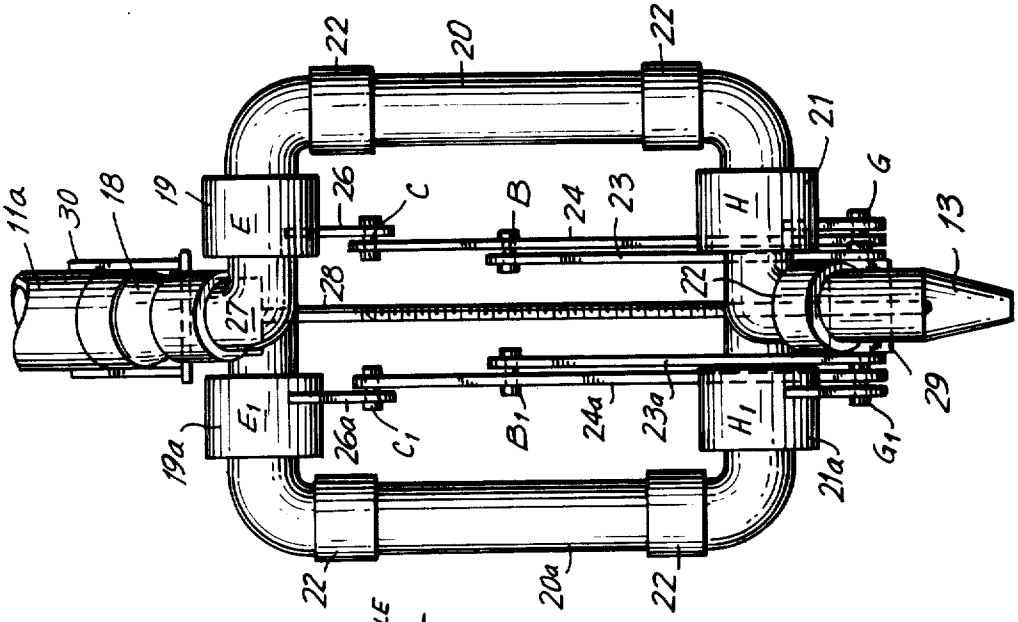
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FIG. 9

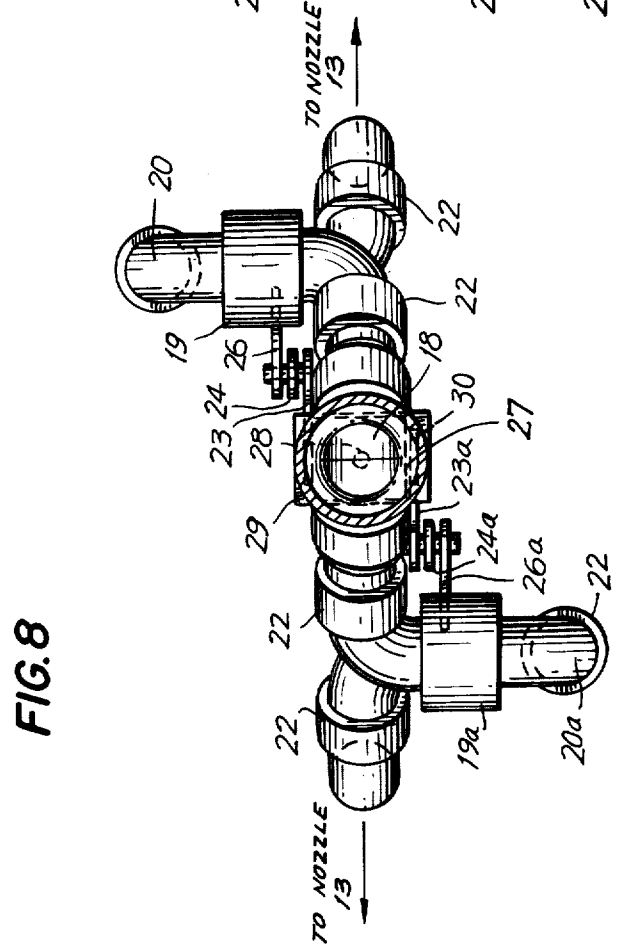
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FIG. 8

FIG.10

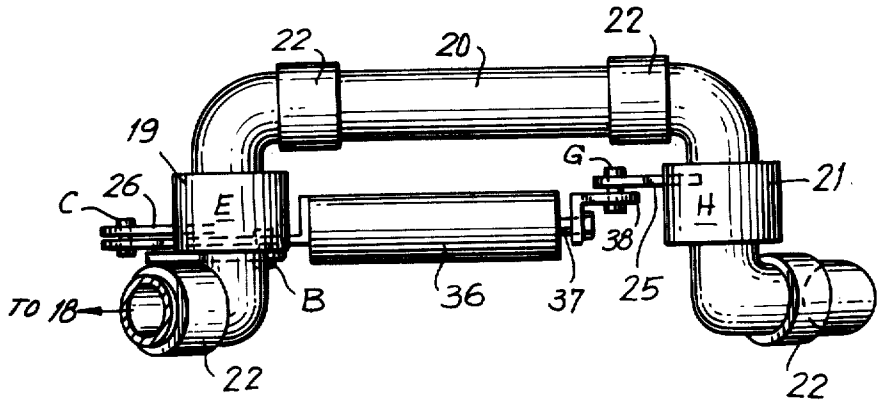


FIG.11

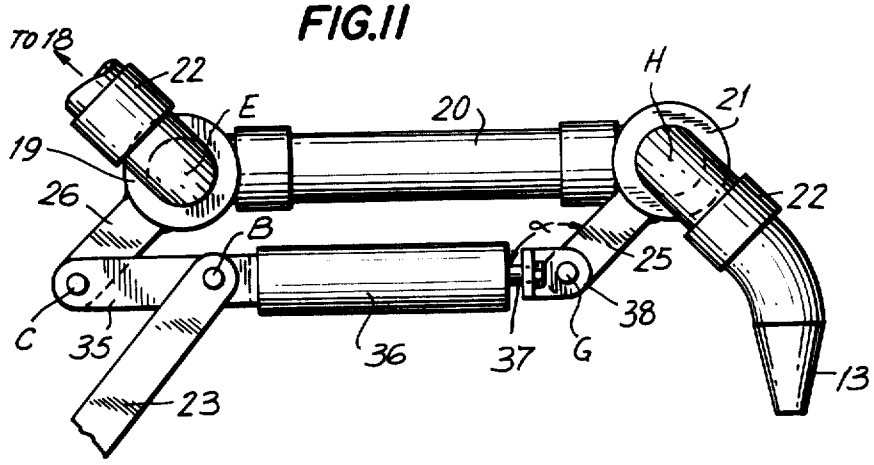
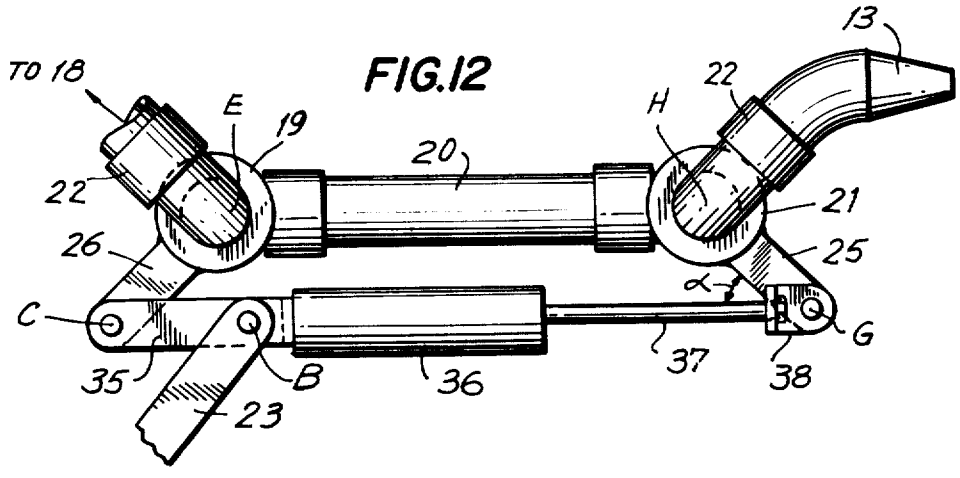


FIG.12



APPARATUS FOR DECOKING A DELAYED COKER

This application is a Divisional application of Application Ser. No. 238,304 filed Mar. 27, 1972 now Pat. No. 3,836,434.

BACKGROUND OF THE INVENTION

Field of the Invention and Description of the Prior Art

This invention relates to a process and apparatus for removing coke which has been formed in coke drums or containers by a delayed coking process.

The production of coke by the delayed coking process involves the heating of a petroleum residual oil or pitch (or coal tar pitch) to a high temperature, and permitting the residual heat of the coker feed to convert it to coke in a generally cylindrically shaped drum or container from which the coke is removed by mechanical and hydraulic decoking tools. In the removal of the coke, the coke is initially cooled with steam, followed by a mixture of steam and water until the coke temperature is below 212°F, after which the coke and drum are flooded with water to complete the cooling.

After the water is drained from the drum, a central pilot is then bored in the coke by lowering a drill stem which is provided with a conventional cutting head designed for boring the pilot hole with high pressure water. The initial cutting head is replaced by another cutting head and the drill stem is then inserted into and along the axis of the pilot hole. High pressure water jetting from the second cutting head breaks up and cuts the coke from the drum by being directed at it in a series of horizontal cutting intervals going progressively from the top to the bottom of the coke in the drum, during which the coke is removed from the bottom of the drum.

The solid coke product removed from the drum is typically referred to as "raw" coke because it still contains a substantial percentage of organic volatile matter. The raw coke is then typically "calcined" to enhance its usefulness during which it is heated to a substantially higher temperature (e.g. about 1,300°C) than it was subjected to in the delayed coking drum and in which step its volatile matter content is substantially reduced.

It is desirable that coke to be calcined have a minimum of fines and the lowest possible volatile matter. The fines create dusting problems in handling, storage and calcination of the coke and are of lower value than lump coke, and the volatile matter content is usually largely responsible for and inversely proportional to the calcined particle density of the coke. (A high particle density is generally desired by the ultimate user of the coke). In contrast, the coke producer is mainly interested in decoking the drum as rapidly as possible. Since a "soft" (high volatile) coke is easiest to cut, the coke producer is reluctant to reduce the volatile content to the levels desired by the calciners and ultimate users of the coke.

As indicated, at the present time the most commonly used decoking tools consist of two hydraulic cutting heads used in succession. (In any case, the decoking tool used is operatively connected to a central drill stem which can be lowered through the coking drum and by means of which the decoking tool is supplied with water under pressure). The first head possesses a series of nozzles which are placed or directed in an essentially vertical manner and is used to cut the initial

or pilot hole in the bed of coke. This head is then removed from the drill stem and replaced by a cutting head which uses two or four nozzles which direct water jets in an essentially horizontal manner. The drill stem is then progressively lowered in the drum a number of cutting intervals, during which intervals approximately horizontal layers of coke are cut from the coke bed.

It is apparent that this technique of coke removal is relatively inefficient since substantially every lump of coke dislodged from the bed must be washed over the edge of the coke bed into the pilot hole. The nozzle cutting stream operates in the opposite direction tending to drive the dislodged lumps away from the pilot hole toward the wall of the coking drum. This also results in an undesirable grinding action which results in an excess of fines.

At the present time, also, a modified cutter head using nozzles placed at a 20° to 30° angle above horizontal has been described and is being considered as a replacement for the conventional head. This should improve the operation of the nozzle by providing a downward sloping surface toward the pilot hole on the coke bed to accelerate the movement of the lumps toward the discharge, but also suffers from other disadvantages, which will become apparent hereinafter, as compared to the decoking technique of the present invention.

A tend in the delayed coking industry is toward larger diameter drums. The largest in operation today are 26 feet in diameter. Drums up to 40 feet in diameter are being discussed. As the diameter increases, the effectiveness of the cutting stream is reduced when employing coke removal techniques of current practice. This loss is presently being overcome by the use of high pressures and larger water flows. The following table, based upon data contained in a paper presented at the Petroleum Mechanical Engineering and Pressure Vessels and Piping Conference, Denver, Colorado, U.S.A. Sept. 13–17, 1970, by R. Jagodzinski; R. W. Piazza; and R. L. Bodin and entitled "Hydraulic Decoking-Design Versus Cutting Time" shows typical flows and pressures used today in drums of different sizes:

Drum Diameter, feet	Pressure, psi	Water Flow Gallons per Minute (GPM)
19 to 22	2200 - 2500	750 - 800
23 to 24	2500 - 3000	800 - 1000
26	3000 - 3500	1000- 1200

This same paper also describes typical techniques and apparatus for decoking a delayed coker such as have already been referred to or briefly described herein. Other techniques and/or apparatuses employed to decoke a delayed coker are described in U.S. Pat. Nos. 2,245,575 and 3,412,012.

All such techniques, however, as have been described or referred to suffer from the disadvantage of requiring significantly higher pressures and volumes of water as the diameter of the coke drum increases and also from other disadvantages as compared to the technique of the present invention.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a process and apparatus for decoking a delayed coker wherein there is no real limit imposed to the coking

drum diameter by the decoking tool; wherein significantly fewer fines are produced since little or no grinding of dislodged lumps occurs; and wherein significantly lower pressures and water volumes are required to achieve the cutting rates attained by present cutting systems, or wherein, for the same pressures and volumes, significantly shorter decoking times are achieved.

It is another object of the present invention to carry out the decoking of a delayed coker by means capable of providing rapid cutting of relatively hard, low volatile coke because the cutting operation tends to automatically compensate for the hardness of the coke. For any given rate of downward motion of the cutting head, the distance between the nozzles and the cutting surface will tend to become relatively large in soft coke. As the coke becomes harder and because of the features of the technique and decoking tool of the present invention, this distance will become shorter and thus the greater cutting energy close to the nozzles can be brought to bear on the coke.

The decoking tool of the present invention is just as efficient in a 40 foot diameter drum as in a 20 foot drum. In addition, its efficiency is significantly greater than designs of the prior art because the decoking is accomplished with significantly lower water pressures and volumes since, as aforesaid, the cutting can be done at a short, relatively constant distance from the nozzles and in any event, at a more constant distance than when employing decoking techniques of the prior art. The operation involves a minimum of grinding and a maximum of cutting and the dislodged lumps are dropped directly into the pilot or central hole rather than being driven toward the wall of the coking drum.

Other objects, and coincident advantages, and a complete understanding of the invention will be apparent to those skilled in the art after a study of the drawings, and a reading of the specification and claims.

The tool or apparatus used in the technique of the present invention consists of or includes, in combination:

- Water nozzles capable of directing water in jet streams in a substantially vertical and downward direction against the coke;
- a central drill stem, which can be provided with water under pressure, capable of rotation and vertical movement within the coking container or drum, to which stem the jet nozzles are operatively mounted and coupled; and
- mechanical and hydraulic linking means between the water nozzles and the central drill stem for radially extending the cutting action of the jet streams while simultaneously maintaining the jet nozzles in the same substantially vertical direction, thus enabling a series of substantially cylindrical and vertical, hydraulic cuttings, and thus also enabling each subsequent cylinder hydraulic cutting in the series to enlarge the diameter of the central hole in the container by the total radial movement of the linking means between each respective cutting in the series.

The inclusion of specific apparatus parts (described hereinafter) which actuate the linking means, and which thus cause the enlarged diameter cutting action of the jet streams, comprise another novel apparatus combination of the present invention.

The sub-combination of water nozzles and linking means is also considered a novel and patentable embodiment of the present invention.

Because of the foregoing features of the apparatus of the present invention, the nozzles thus are also mounted on the drill stem by an arrangement which is capable of maintaining a constant nozzle distance from the surface of the coke while each vertical hole of progressively greater diameter is serially cut.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing objects are achievable by removing the coke from the drum in a manner as illustrated schematically in FIGS. **2–6.** Apparatus which makes possible the coke removal as indicated in these figures is illustrated primarily in FIGS. **7–12** and also in FIG. **1** which merely shows schematically some equipment features of the present invention.

FIG. **7** is a front view of the mechanical and hydraulic valve cutter assembly and linking means mechanism which can be employed in the present invention and which make possible coke removal techniques such as have just been briefly described.

FIG. **8** is a top plan view of the apparatus taken along line **8—8** of FIG. **7.**

FIG. **9** is a side or end view of the apparatus taken along line **9—9** of FIG. **7** (with the nozzle arms retracted).

FIG. **10** is a top plan view (with the nozzle arms extended, or in horizontal position) of an alternate form of nozzle arrangement which can be employed in the present invention to carry out the variation illustrated in FIG. **5.**

FIG. **11** is a front view of the nozzle arrangement of FIG. **10.**

FIG. **12** is a view similar to FIG. **11** but wherein the linkage means to the nozzles are in the extended position, thereby rotating the nozzles into substantially horizontal direction so as to carry out the process variation of FIG. **5.**

DETAILED DESCRIPTION OF THE DRAWINGS

In FIG. **1** there is schematically shown a typical environment or construction in which the device and/or process of the present invention are employed. The coking container **3** is surrounded by a construction of framework **10,** similar to an oil well derrick, which is suitable for lowering drill stem **7** entirely through the container. This lowering can be accomplished through the use of a hydraulic or mechanical motor **8** suitably connected to the framework by support brackets **9.** In other words, conventional equipment or means may be employed to raise and lower the drill stem, to rotate it at a suitable speed, and to supply water thereto.

In FIGS. **2–6** various coke removal steps of the process of the present invention are illustrated schematically, it being appreciated that the steps illustrated are representative, and that more steps may be employed than are actually illustrated.

In FIG. **2,** a substantially vertical and central pilot hole **1** has already been cut through the entire height of the coke **2** in the container **3** according to a procedure standard in the art. Container or drum **3** is about 80 feet in length between upper opening **4** and lower opening **5.** The opening **4** of the drum at the top is about 3 feet in diameter and the opening **5** of the drum at the bottom is about 5–6 feet in diameter. The initial

distance between top opening 4 and the top surface 6 of the coke in the container, which is referred to as "outage," is generally at least 10 or more feet. In cutting the central pilot hole, a drill stem 7, which typically possesses a diameter between about 4 and 6 inches, was lowered through the top opening of the container after an initial cutting nozzle assembly had been coupled to same. The drill stem was provided with water under pressure and this water was directed against the top surface of the coke through the cutting nozzle assembly. The initial cutter which was employed to cut the pilot hole through the coke is about 15–18 inches in diameter and results in a pilot hole 1 about 30 inches in diameter. (It should be appreciated that the openings and container dimensions, etc. of the figures are not scale drawings but are for purposes of explanation only). The drill stem, driven either hydraulically or mechanically, was caused to rotate slowly such as at a speed of 2 to 4 revolutions per minute. The drill stem is typically about 100 feet long, or about 20 feet longer than the container, in order to provide for connection to the drive means above the container and so that its lower end may extend to the bottom of the container. The drill stem is periodically lowered as the coke surface, against which the jet streams from the nozzles are directed, becomes progressively lower, until eventually the central pilot hole is cut through the entire height of the coke in the container. The coke removed from the container is typically cut either into a dewatering pit or directly into a railroad car for shipment to subsequent place of usage. What has been described thus far is a standard step or procedure in the art.

After the cutting of the pilot hole, the drill stem is raised until the initial cutter attached to same is above the top opening of the container or drum so that the initial cutter can be removed and a different jet nozzle assembly can be attached in its place. This change of "cutting heads" is conveniently accomplished through the use of a steel coupling or quick release joint 7*a* well known in the art. Standard in the art type quick release joint, final cutting nozzle assembly and coke removal technique are illustrated in FIGS. 6 and 7 of the aforementioned "Hydraulic Decoking . . . " paper by Jagodzinski et al. In such standard in the art nozzle arrangement and/or removal technique using same, the jet nozzles must of necessity always be located very close to the drill stem for accomodation in the pilot hole with the consequence that, for any given horizontal layer of coke removed, the distance between the coke being acted upon and the ends of the jet nozzles changes as the coke is progressively removed radially commencing at the perimeter of the pilot hole and proceeding toward the container wall.

In the present invention, rather than proceeding in the foregoing manner to remove the main body of the coke after first cutting the central pilot hole, instead a special final cutter assembly 11, illustrated schematically in FIGS. 2–6, and in detail in FIGS. 7-12, is then employed in the next sequence of steps. As is the case with final cutting nozzles as employed in the prior art, cutter assembly 11 is operatively mounted and coupled to a drill stem 7 but in the present invention this is accomplished by novel mechanical and hydraulic linking means, indicated schematically at 12, between water nozzles 13 and the central drill stem 7.

FIG. 2 illustrates the cutter assembly mechanism of the present invention in a position in the coke container approximately midway during the first vertical cutting after the cutting of the pilot hole. The nozzles 13 are about halfway down the container. This typifies their position when the cutting action has taken place for some time and after the central drill stem 7 has been periodically lowered several feet in the container. It will be noted that the jet nozzles 13 are maintained in a substantially, but not exactly, vertical direction so that the jet streams from same are also directed in a substantially vertical direction against the coke, starting at the top surface of the coke in the container and finishing at the bottom thereof. The distance of the jet stream between the nozzles 13 and the surface 14 of the coke being cut may vary depending on the hardness of the coke and the rate of lowering the drill stem but will be substantially constant for a given set of conditions as the drill stem is lowered in the container. The jet nozzles are directed at an angle slightly outward (radially) against the surface of the coke in order to provide a positive working clearance for the cutter assembly in the hole generated by the cutting action. It is thus seen that, when the step illustrated in FIG. 2 is completed, the diameter of the central hole in the container is substantially increased or enlarged as compared to the diameter of the initial pilot hole 1. For preferred results in the present invention, the diameter of the central hole is progressively changed by about 2 to about 4 feet for each complete vertical cutting employed in the removal of the coke. (In the step illustrated in FIG. 2, the central pilot hole 1 was 2½ feet in diameter and the enlarged hole 15 was 5½ feet in diameter).

Upon completion of the step of FIG. 2, the drill stem 7 was raised in the container and the setting of the cutter assembly 11 was changed by adjusting or altering the positioning of the linking means 12 in order to increase the diameter of the hole being cut in the container, as illustrated in FIG. 3. More will be said later on when describing FIGS. 7–12 so as to what was done in order to make this change, it sufficing for the present to state that the change can be effected from outside the container and that after the change, the water nozzles 13 are still in a substantially vertical direction. It was thus possible to carry out the cutting step illustrated schematically in FIG. 3 in substantially the same manner as the cutting step of FIG. 2, with the jet nozzles 13 and jet streams directed in a substantially vertical direction, but with the cutting step substantially enlarging the diameter of the central hole in the container changing it from the diameter of hole 15 to the diameter of hole 16. It will be noted, however, that despite the increased diameter of the hole and thus the increased distance of the inner wall of the coke being acted upon from the central drill stem, the distance from the jet nozzles 13 to the coke ledge 14 being acted upon is substantially the same in the step of FIG. 3 as it was the step of FIG. 2. Because of this, the efficiencies of the water quantities and water pressures used were maximized, it being appreciated that the nearer the nozzles 13 are to the coke ledge, the less the water quantities and pressures required are in the order to effect equivalent coke removal results as compared to the technique of the prior art. Also such reduced water quantities and pressures result in process economies because of less water usage, increased nozzle and pump life and reduced pump maintenance. It will also be noted that in both the steps of FIGS. 2 and 3 the distance that the coke "eroded" from the ledge 14 has to

travel in order to reach the central pilot hole is relatively minimal. In the step of FIG. **3**, the diameter of the central hole was changed from 5½ feet at **15** to a diameter of 9½ feet at **16**. The removal step such as illustrated in FIG. **3** is repeated any desired number of times, each time resulting in an increasing diameter cylindrical void as shown in FIG. **4**, the number of times typically depending upon the size coke desired and also the diameter of the container being emptied, the diameter of the central hole in the container each time typically increasing by from about 2 to about 4 feet.

Typically and preferably the least vertical cutting will be carried out in such a manner as illustrated in FIG. **4** leaving a "tube" **17** of the coke around the wall of the container, which tube is then removed in a manner as illustrated in FIG. **5**. In a less preferred embodiment the last such vertical cutting may also remove the tube of coke from the wall of the container, as illustrated in FIG. **6**.

Eventually, the diameter of the central hole is increased to a point where the coke remaining in the container is substantially in the shape of a hollow tube or annulus **17** with a wall thickness which typically may be from 2 to 3 feet. Because this wall thickness is around the circumference of the container, the volume of the coke remaining in the container is still very substantial. Because it is difficult to remove this coke in a controllable manner (huge portions or sections of the coke may fall away from the container wall at once) and also because of possible damage to the bottom of the container and/or to railroad cars beneath the container, and/or of overloading of same, it is preferable to carry out the final cutting in a manner as illustrated in FIG. **5** rather than in the manner as illustrated in FIG. **6**. (This decision is also affected by the final wall thickness of the coke remaining in the container). In the removal step illustrated in FIG. **5**, the coke is removed by directing the water nozzles **13** in a substantially horizontal direction, (apparatus features which make this possible are described hereinafter) whereas in the step illustrated in FIG. **6**, the coke is removed by directing the water nozzles at the coke in a substantially vertical direction just as it is in the steps illustrated in FIGS. **2**, **3** and **4**.

It will be noted from the foregoing, however, that if and when a horizontal cutting of the coke is resorted to in the present invention as in FIG. **5**, the nozzles **13** are quite distant from the axis of the drill stem **7** and close to the surface of the coke being acted upon. It will also be noted that the distance that the removed coke has to travel in order to reach the removal hole in the container is minimal. Therefore, if this variation of the invention is resorted to, the advantages of efficient utilization of water pressure and water flows and minimum grinding of the coke are still obtained, despite the fact that the jet streams are in a substantially horizontal condition rather than in a substantially vertical condition.

Referring now to FIG. **7**, the drill stem is shown at **7**. The final cutter assembly, indicated generally at **11**, includes drill stem extension **11***a*, linking means indicated generally at **12**, nozzles **13** and such other features as are necessary to carry out the present invention. The cutter assembly is connected or operatively mounted and coupled, mechanically and hydraulically, to the drill stem at the quick release joint or quick disconnect coupling **7***a*. The cutter assembly is made up of several parts both mechanical and hydraulic, which are operatively linked to the drill stem so that the jet nozzles **13** of the valve assembly can be provided with water and also so that the jet nozzles can be lowered in the container and also extended radially to carry out the hydraulic cuttings of the coke in the manner previously described. These include a branched swivel connector **18** connected to drill stem extension **11***a*, which swivel connector is capable of mechanically supporting the remaining parts of the cutting apparatus and of also serving as a part of the conduit system for the water from **11**a to the nozzles **13**. The remainder of the water conduit system is made up of swivel joint **19**, water line **20** and swivel joint **21** on the righy side of FIG. **7** and their counterparts **19***a*, **20***a* and **21***a* on the left side of FIG. **7**. The high-pressure swivel joints **19**, **19***a*, **21** and **21***a* are well known in the hydraulics art. For example, swivel joints which will satisfactorily carry out the desired functions in the present invention are commercially provided by the FMC Corporation, Chiksan Division, Brea, Calif., Joint Style No. 40 being particularly suitable. Conventional couplings **22** are used throughout the system to connect the various swivel joints, water lines and nozzles.

Lever arms **23, 24, 25** and **26** provide part of the mechanical means for controlling the radial positioning of the nozzle **13** on one side of the cutter and lever arms **23***a*, **24***a*, **25***a* and **26***a* do the same on the other side of the cutter. The radial positioning of these arms is controlled by moter **27**, drive screw **28** and drive nut **29**. Motor **27** is typically of the hydraulic or pneumatic type and is illustrated as being attached to connector **18** by mechanical support means **30**. The positioning of this support means **30** may be varied which in turn can be used as a control for the vertical positioning of the hydraulic motor and consequently, to some degree, the radial extension of the nozzles **13**. The dimensions or lengths of the various lever arms and water lines can be varied in order to provide for the desired amount of the radial extension of the nozzles. The amount of radial extension of the nozzles required or desired will, of course, depend upon the diameter of the container which is to be decoked. Control **31** (e.g. a valve) is operatively connected to motor **27**. Opening and closing this valve thus controls the running of motor **27** which in turn determines the turning and adjustment of drive screw **28** in drive nut **29**. The threading of drive screw **28** into and through nut **29** causes the vertical raising of the drive nut and the radial extending of the lever arms and consequently of the nozzles **13**. Maximum lifting of drive nut **29** results in maximum radial extension of the cutter system, during which the angle at which lever arms **23** and **23**a intersect at the drive nut **29** increases substantially and causes lever arms **24** and **24***a* to go from a vertical position to a horizontal position. (This final positioning of the rigid arms is shown in FIG. **7** by the use of the dotted lines). In this transition the drive nut **29** acts on the links or lever arms **23** and **23***a* which because of their linkage to arms **24** and **24***a* at points B and B_1 cause arms **24** and **24a** to rotate about movable pivot points B and B_1, and fixed pivot points C and C_1, respectively, in turn causing the nozzles **13** to swing radially outward. When arms **24** and **24***a* thus rotate about points C and C_1, the water lines **20** and **20***a* rotate about pivot points E and E_1 at the swivel joints **19** and **19***a*. Lever arms **25** and **25***a* complete the forming of parallelograms C E H G and C_1 E_1

H_1G_1, the line C E always remaining parallel to the line G H, as is true also of the line C_1E_1 to the line G_1H_1. Thus at any angle of rotation of the arm **24** about the pivot C or of the arm **24***a* about C_1, the direction of the jet nozzles **13** relative to the axis of the drill stem remains constant.

Valve **32** is used in the operation of hydraulic cylinders used in connection with control arms employed in the embodiment of the invention described in connection with FIG. **5**, which embodiment is also described in more detail hereinafter in connection with FIGS. **10–12.**

Drill stem extension **11***a*, shown in cut-away view in, FIG. **7**, may be of variable length, but must be long enough so that when drill stem **7** is raised after a complete vertical cutting, the valve **31** will be above container opening **4** so that it may be opened and closed to operate the motor, so that the next desired radial positioning of the nozzles can be effectuated. The same consideration applies to the placement and operation of valve **32** is the embodiment of FIGS. **10–12** is to be employed. Also, preferably the drive nut **29** will be coupled to an indicator device so that when the drill stem is raised a reading or observation coordinated to the extent of vertical movement of the drive nut will inform the operator of the amount of radial extension of the nozzles **13.** He will thus be able to accurately adjust the cutting diameter for each vertical pass up to and including the final cut.

FIGS. **8** and **9**, which are top and side views of the apparatus, are set forth in order to complete the illustration from different perspective of how the various parts of the apparatus are assembled. The description and function of the various numbered parts of these figures are clear from the detailed description of these same parts and their functions in connection with the earlier discussion of FIG. **7.**

FIGS. **10–12** also illustrate several parts of the apparatus which have already been previously described and, therefore, such correspondingly numbered parts require no further discussion. However, in these figures, lever arm **24** has been partially replaced by parts numbered **35, 36, 37** and **38.** In FIGS. **7, 8** and **9**, lever arm **24** is fixed in its length throughout the entire decoking operation, with the result that lever arm **25** stays at the same relative angle α (with respect to horizontal) throughout the various decoking steps. However, in FIGS. **10–12**, lever arm **24** is partially replaced by hydraulic cylinder **36**, hydraulically actuated push-rod **37**, connecting arm **35** and coupling means **38.** The opening and closing of valve **32** actuates hydraulic cylinder **36** with the result that the cylinder piston (not shown) controllably extends push-rod **37** from said cylinder. Thus, fixed-in-length lever arm **24** is partially replaced by a variable length linkage which can be employed to controllably change the angle (α) which lever arm **25** makes with horizontal (changing from obtuse to acute), thus also changing the angle of the nozzle **13** from a substantially vertical direction to a substantially horizontal direction in order to carry out the removal step as illustrated in FIG. **5.**

While the foregoing figures show one type of mechanical and hydraulic linkage means for extending the cutting nozzles, and also altering their direction for the final cut, it should be readily appreciated that many other mechanisms can be used to accomplish these same purposes.

It should also be appreciated that since many coke drums have projecting thermocouple wells in the drum, the extension equipment will be so designed as to prevent mechanical contact of the cutters with such equipment.

The modification of the mechanism illustrated in FIGS. **10-12** permits rotation of the cutter head and elevation of the nozzles to the horizontal or near horizontal to make a final cleaning of the coke drum walls. Since the extension means prevents raising the cutting head to the very top of the drum, occasionally or each time the drill stem is raised upon the completion of a cylindrical cutting, the heads can at that moment be temporarily rotated to horizontal (or even above horizontal) by operating valve **32** to clean the upper part of the drum before returning the nozzles to their substantially vertical and downward direction and carrying out the next vertical cylindrical cutting.

From the foregoing description, it is thus readily apparent that the process and apparatus of the present invention result in several advantages including the following chief advantages:

a. Significantly fewer coke fines are produced since little or no grinding of dislodged lumps occurs in the cutting operation;
b. No real limit is imposed on the drum diameter by the cutting operation;
c. Significantly lower water pressures and volumes may be used in order to achieve the cutting rates attained by present or prior art cutting systems;
d. With the same water flow rates and pressures as employed in the prior art, the rate of coke removal is substantially increased;
e. The total volume of water handled is substantially decreased and there is, therefore, increased nozzle and pump life and reduced pump maintenance;
f. All dislodged coke is immediately dropped out of the drum and does not interfere with the cutting process. This is a most important factor in increasing the speed at which the drum is decoked; and
g. Because of reduced decoking time, the system is much better able than prior art systems to guard or insure against exceeding the maximum time allowed for the hydraulic decoking operation. (As pointed out in the Jagodzinski et al article, extension of this time beyond the customary **4-5** hours allotted for same upsets the operating cycle and can cause reduction of the feedstock charge rates into the coker and consequent loss of productivity and can even lead to shutdowns).

It is to be understood that the invention is not limited to the specific details which have been offered merely for illustrative purposes and that modifications may be made within the scope of the appended claims without departing from the spirit of the invention.

I claim:

1. An apparatus used for removing coke from a delayed coking container by a series of substantially cylindrical and vertical hydraulic cuttings of the coke after a substantially vertical and central pilot hole is first cut through the entire height of the coke in the container, said removal means including:

Water nozzles capable of directing water in jet streams in a substantially vertical and downward direction against the top surface of the coke;

a central drill stem, which can be provided with water under pressure, capable of rotation and vertical

movement within the container, to which stem the jet nozzles are operatively mounted and coupled; and

mechanical and hydraulic linking means between the water nozzles and the central drill stem for radially extending the cutting action of the jet streams while simultaneously maintaining the jet nozzles in about the same substantially vertical direction, thus enabling each subsequent cylindrical hydraulic cutting in the series to enlarge the diameter of the central hole in the container by the total radial movement of the nozzles between each respective cutting in the series;

the vertical and rotary movement of the drill stem, the radial extension of the linking means, and the hydraulic action of the jet streams all thus coacting in the removal of the coke.

2. An apparatus according to claim 1 wherein the linking means for radially extending the cutting action of the jet streams are actuated to a change of position by a motor, a screw driven by said motor, and a drive nut into which said screw is threaded, said drive nut being mechanically coupled to lever arms of said linking means and causing said lever arms to radially extend when said drive screw is further threaded into or through said nut, the operation of said motor being capable of being controlled from outside the coking container whenever one of the vertical cuttings in the series is ready to be commenced.

3. In an apparatus used for removing coke from a delayed coking container after a substantially vertical and central pilot hole is first cut through the entire height of the coke in the container, which apparatus includes a drill stem which can be provided with water under pressure and which drill stem is capable of rotation and vertical movement within the container and to which drill stem water nozzles capable of directing water in jet streams are operatively mounted and coupled, the improved removal means which include:

Water nozzles capable of directing water in jet streams in a substantially vertical and downward direction against the top surface of the coke; and

mechanical and hydraulic linking means between the water nozzles and the central drill stem for radially extending the cutting action of the jet streams while simultaneously maintaining the jet nozzles in about the same substantially vertical direction, thus enabling removal of coke from the container by a series of substantially cylindrical and vertical, hydraulic cuttings, and thus also enabling each subsequent cylindrical hydraulic cutting in the series to enlarge the diameter of the central hole in the container by the total radial movement of the nozzles between each respective cutting in the series.

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