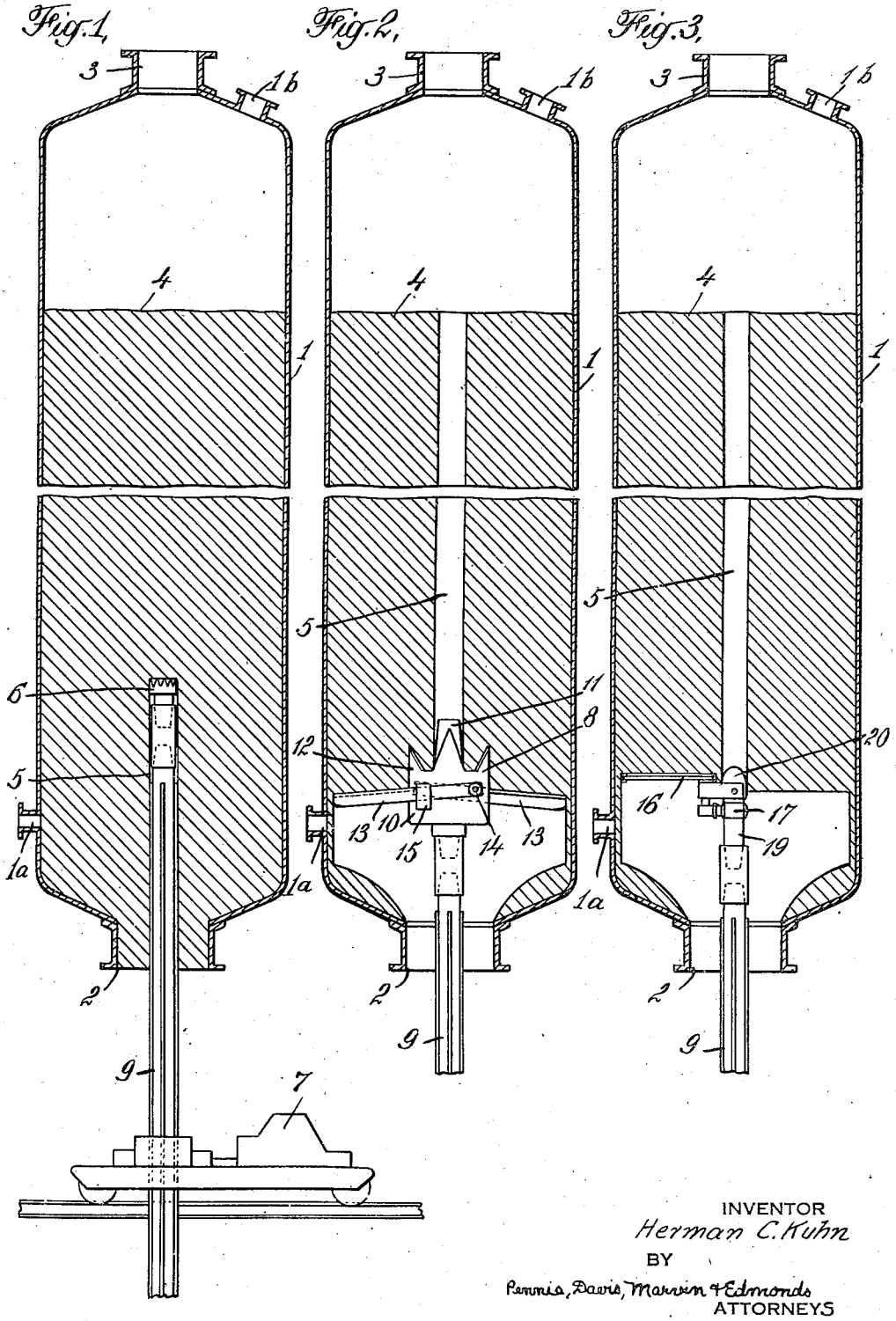
June 15, 1943. H. C. KUHN 2,322,146

METHOD AND APPARATUS FOR REMOVING COKE FROM COKING CHAMBERS

Filed Aug. 16, 1941 4 Sheets-Sheet 1



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Fig. 4,

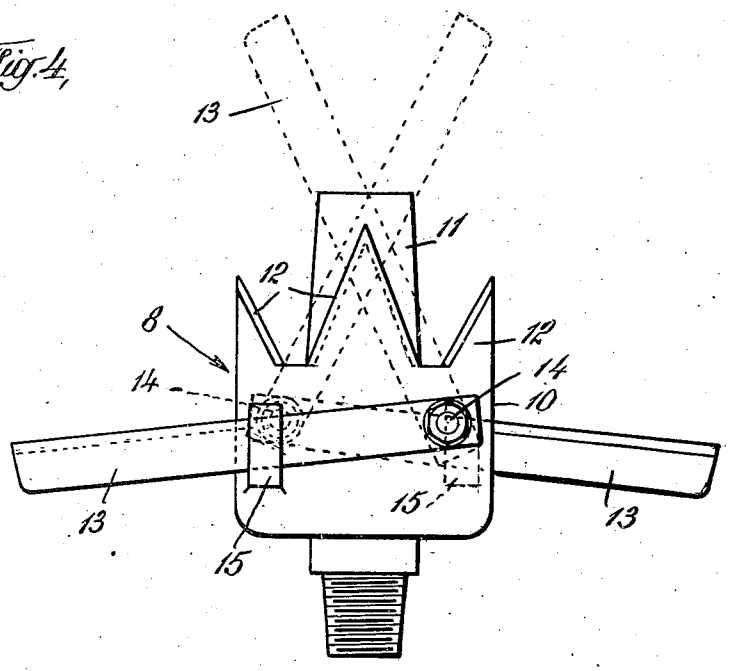
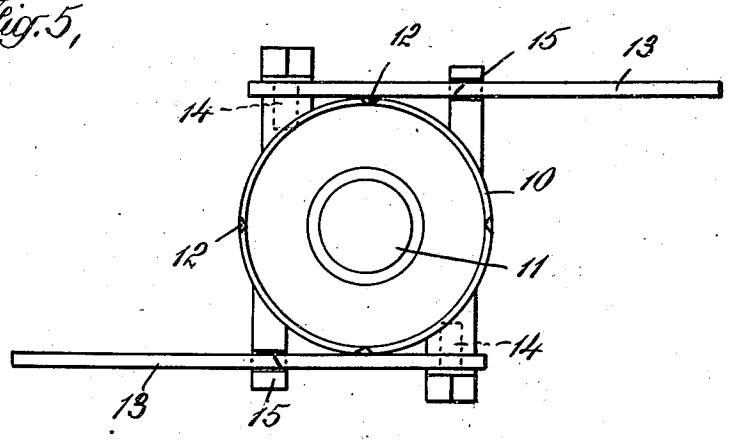


Fig. 5,



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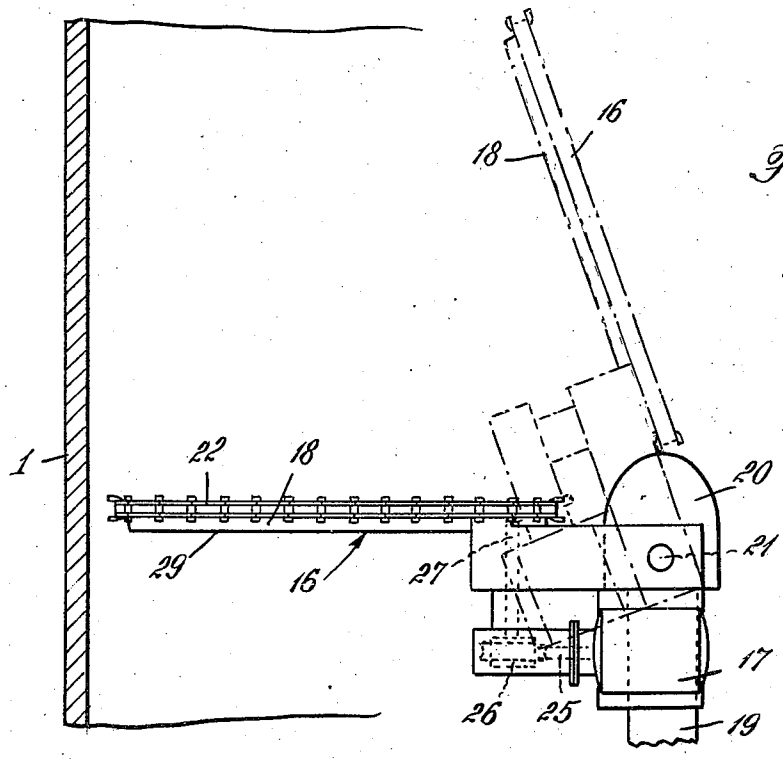


Fig. 6,

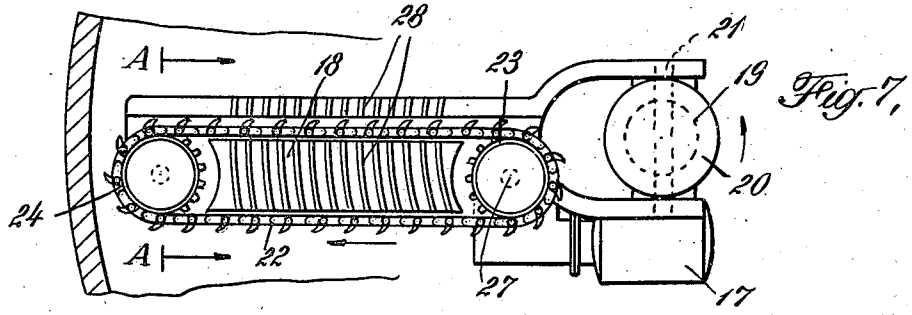


Fig. 7,

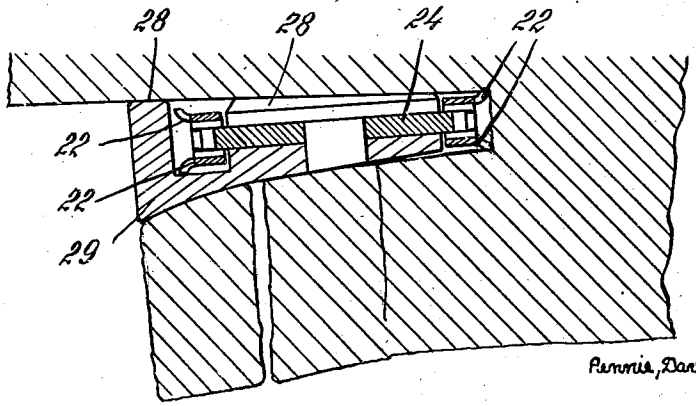


Fig. 8

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Fig. 9.

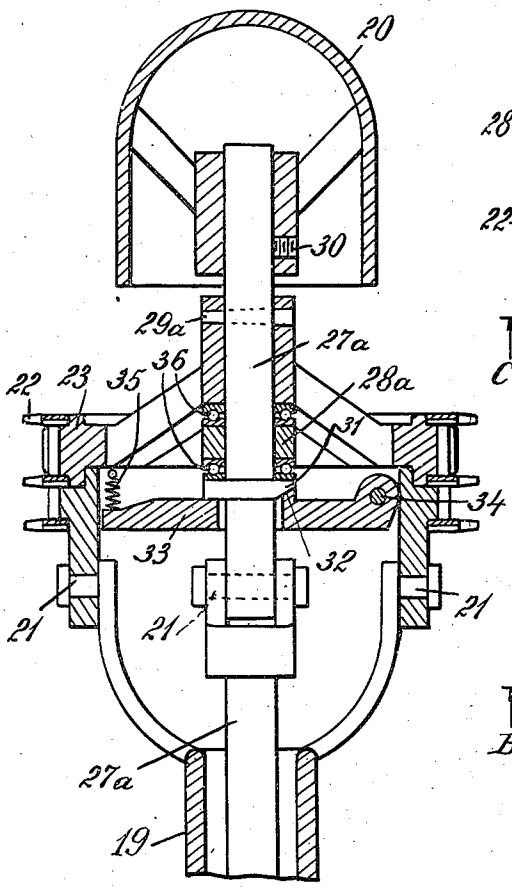


Fig. 10

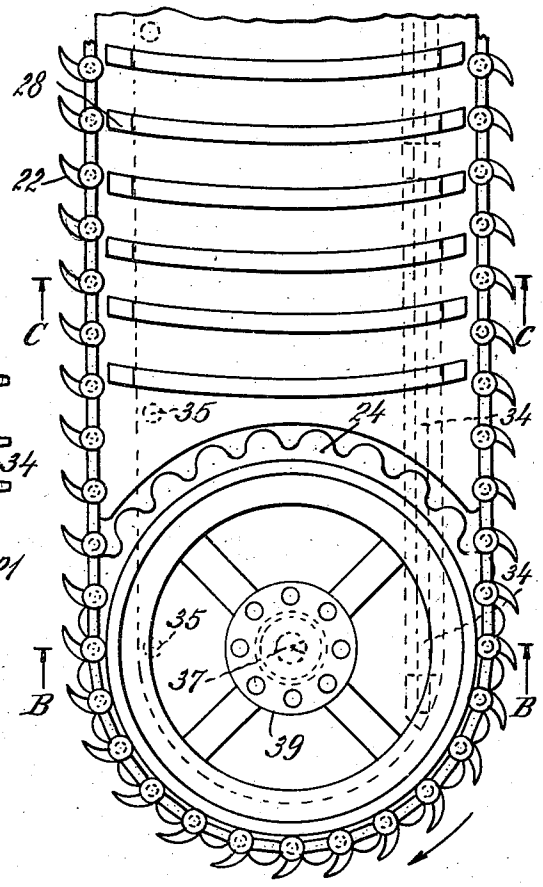


Fig. 11

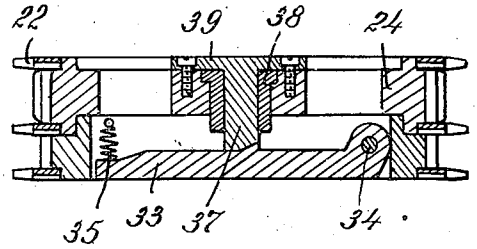
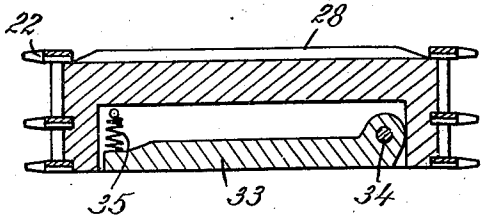


Fig. 12.



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UNITED STATES PATENT OFFICE

2,322,146

METHOD AND APPARATUS FOR REMOVING COKE FROM COKING CHAMBERS

Herman C. Kuhn, Hammond, Ind., assignor to Sinclair Refining Company, New York, N. Y., a corporation of Maine

Application August 16, 1941, Serial No. 407,233

8 Claims. (Cl. 83—6)

This invention relates to the removal of coke or coke-like material from the chambers in which it is deposited during the high temperature processing of hydrocarbon oils or the like, for instance in the pyrolytic decomposition or cracking of such oils. It relates more particularly to an improved method of removing such cokey material with a relatively large percentage of the coke in lump form and a minimum of fines or dust. The invention also includes novel apparatus adapted to this purpose.

Though the invention has utility with respect to other industrial operations, it is particularly applicable to the removal of coke deposits from the coking chambers of apparatus used in the processing of hydrocarbon oils.

In the vapor phase cracking of hydrocarbon oils, for example, very large quantities of coke are produced. This coke is a valuable by-product of the cracking operation. Its potential commercial value as a fuel has, however, not been fully realized because of the difficulty of recovering the coke from the coking chambers in a condition best suited to compete with other types of solid fuel.

Previous attempts to recover the coke in lump form have met with only partial success for the reason that the proportion of fines to lumps has been excessively high.

The difficulty of recovering the coke in lump form as opposed to fines has been aggravated by the type of chamber in which the bed of coke is usually deposited. These chambers are customarily vertically elongated, cylindrical chambers of relatively small horizontal cross-section with respect to their height. At the period in the operation when the removal of the coke becomes practical from the point of view of the cracking schedule, these chambers are substantially filled with a relatively firm bed of coke. Access to the chambers for the purpose of removing the coke is difficult and the method customarily used has consisted, in part at least, of a haphazard breaking of the coke, frequently by hand, into particles of such size as would pass through the manhole. Such methods have been expensive and time-consuming and also have resulted in the reduction of a large percentage of the coke to fines.

Not only is the commercial value of the fines materially less than the coke in lump form but a considerable amount of the coke has been lost during the coke-cleaning operation. Further, the fines being very light weight, readily become suspended in the atmosphere and cause discomfort to the workmen and others in the vicinity. Also, the handling of the finely divided coke is more difficult and expensive than the handling of the coke in lump form.

These coke deposits may readily be removed, in accordance with my invention, in predominantly lump form and with a minimum of cleaning time, labor and physical discomfort to the workmen. Further, the resulting lumps of coke are of more uniform size than have previously been directly obtainable.

My improved method of removing coke consists primarily in moving a cutting member radially and helically upwardly through the coke deposit to progressively form a helical cut extending into the coke deposit a material distance, and a distance sufficient that when the coke behind the forward edge of the cut is broken from the body of coke, the major portion will be in relatively large pieces, rather than in fines, and, as the cutting progresses through the coke bed, systematically breaking off the coke underlying the cut by the downward application of pressure thereon independently of the cutting action at a predetermined distance to the rear of the forward edge of the cut. The helical cut formed as just described, preferably extends from approximately the center of the bed outwardly to a point just short of the inner surface of the walls of the chamber.

The means for systematically breaking off the coke underlying the cut may take various forms, and although independent of the cutter may be carried by, or form a part of the support for the cutter. Preferably the coke is broken off by mechanically forcing the upper and lower surfaces of the cut apart either continuously, as by means of a wedging action, or by periodic expansion at a point along the helical cut a predetermined distance back of the cutting edge. The cutting and breaking operations may with advantage be effected by means of the novel apparatus presently to be described.

Usually the only means of access to these coking chambers for the purpose of removing the coke deposits is through the manways in the upper and lower ends of the chamber. These manways are ordinarily of considerably smaller diameter than that of the chamber itself. Therefore, in order to make a helical cut upwardly through the coke deposit of substantially the inner diameter of the chamber, certain preliminary operations are usually necessary before the helical cutter can be brought into operating position.

For example, in the removal of coke deposits, in accordance with my invention, from a coking chamber such as previously described, the chamber is first cut off from the processing operation by means of valves or the like in the connecting lines and the chamber is freed of inflammable or combustible material such as oil or oil vapors in the customary manner. The manway covers are then removed from the top and bottom of the chamber.

A bed of relatively firm coke is ordinarily found to extend downwardly from the bottom of the chamber into the space surrounded by the flange of the bottom manway. As previously noted, the manway is customarily of considerably smaller diameter than the chamber itself and, for this reason, a unique problem is presented with respect to ways and means of making such a helical cut upwardly through the bed of coke.

My invention includes a combination of operations especially designed to cooperate in overcoming the difficulties presented by such chamber arrangement. It includes also a novel combination of apparatus adapted to be inserted into the chamber through the restricted area of the manway and to cooperate in the carrying out of the several operations.

To avoid the necessity of using excessively heavy and rigid driving shafts for the operation of the helical cutting tool, to be presently described, it is necessary to provide means for centering and supporting the upper end of the cutting tool. In accordance with my invention, such guidance and support may be provided by first drilling a centering hole along the central axis of the coke bed and providing a pilot on the upper end of the cutting tool adapted to be continuously wedged into this centering hole as the cutting tool is forced upwardly.

Also, before the helical cutting tool can be brought into position in the chamber, it is necessary to remove the coke from the manway and from the bottom of the chamber to substantially the full diameter of the chamber and for a sufficient distance upwardly to permit the insertion of the helical cutter. This second operation may be readily accomplished in accordance with my invention by means of a novel device to be presently described designed to cooperate with the apparatus used in carrying out the other steps of the process and herein designated "expanding reamer." This reamer is adapted to be operated by the rotary driving shaft used in the drilling and cutting operations and is preferably likewise surmounted by a protrusion or pilot adapted to be wedged into the centering hole as the reamer is advanced so as to guide and support the upper end of the apparatus.

My invention will be further described with reference to the accompanying drawings, in which

Figure 1 of the drawings represents a vertical cross-sectional view of a conventional coking chamber from which the manway covers have been removed and containing a bed of coke through which the preliminary boring of the centering hole has been only partially completed;

Figure 2 represents a similar view of the chamber and coke bed with the boring of the centering hole and the reaming operation completed and with the expanding reamer in position;

Figure 3 represents a similar view of the chamber and coke bed with the combination helical cutting and breaking tool in position and after the cutting of the spiral has been started;

Figures 4 and 5 represent, respectively, an elevation and a plan view of the expanding reamer tool;

Figures 6 and 7 represent, respectively, in greater detail, an elevation and a plan view of one form of a combination helical cutting and breaking tool in position in the coking chamber;

Figure 8 represents a sectional view at AA of Figure 7;

Figure 9 is a cross-sectional elevational view showing details of the driving mechanism of an alternate form of helical cutting and breaking tool;

Figure 10 represents a plan view of the outer end of the arm of the tool shown in Figure 9;

Figure 11 represents a cross-sectional view of Figure 10 along the lines BB; and

Figure 12 represents a cross-sectional view of Figure 10 along lines CC.

Referring particularly to Figures 1, 2 and 3, the numeral 1 indicates a conventional vertically elongated, cylindrical coking chamber equipped with connecting flanges 1*a* and 1*b*, lower manway 2 and upper manway 3.

When the coke-removal operation is started, the coking chamber is usually filled with coke from the bottom thereof up to a level approximating that indicated in the drawings at 4. The centering hole, when completed, extends entirely through the coke bed as shown at 5 of Figures 2 and 3 of the drawings.

In the boring of this centering hole a conventional type rotary drill bit such as represented at 6 may be used. The drill bit is advantageously adapted to be mounted on a vertically positioned rotary driving shaft 9 also used in the reaming and helical cutting and breaking operations and which is adapted to be centrally positioned beneath the manway 2. The drive shaft 9 is adapted to be rotated and fed upwardly by conventional means such as diagrammatically represented at 7 on Figure 1 of the drawings and is preferably mounted on a track running beneath a plurality of coking chambers so as to be readily available for the alternate cleaning of a number of chambers.

In the cleaning of a coking chamber, such as that shown in the drawings, having a diameter of 8 to 9 feet and an overall height of approximately 45–50 feet, the centering hole may advantageously be 8 to 10 inches in diameter.

After the centering hole 5 has been completed, the driving shaft is withdrawn and the rotary drill bit is replaced by an expanding reamer such, for example, as shown in Figure 2 at 8 and in greater detail in Figures 4 and 5 of the drawings. This expanding reamer is adapted to be inserted through the manway 2 and to be attached to and rotated and fed upwardly by means of the driving shaft 9 used in the preceding operation.

The expanding reamer shown consists of a cutting head 10 provided with a centrally positioned, upwardly projecting pilot or guide such as the frustro-conical protrusion 11, the upper base of which is of smaller and the lower base of larger diameter than the diameter of the centering hole bored by the preceding operation so that it is wedged into the centering hole as the tool is advanced, thus centering and guiding the reamer and supporting the upper end of the rotary shaft 9.

The upper surface of the reamer head is also provided as shown with a plurality of cutting teeth 12 spaced around the periphery of the

reamer head and projecting upwardly therefrom, but of insufficient height to interfere with the operation of the pilot 11.

Cutting arms 13, as shown in greater detail in Figures 4 and 5 of the drawings, are pivotally attached at one end to opposite sides of the reamer head 10 at 14 so as to permit the swinging of the arms in an upward-over-and-downward direction. The immediately downward swing of the arms 13 is arrested by means of lugs 15 which are shown in the drawing as slotted so as to afford lateral support to the arms. By this arrangement the cutting arms may be collapsed while being inserted through the restricted area of the manway 2 and extended to substantially the diameter of the chamber as the reaming operation progresses. The length of the arms will, of course, be governed by the diameter of the coking chambers with which the reamer is to be employed.

Before starting the reaming operation, the coke is removed from the lower part of the manway flange. This may be accomplished either by hand or by the reamer head with the arms hanging in a vertical position.

The arms 13 of the reamer are then raised to a position as indicated by the dotted lines on Figure 4 of the drawings such that the distance between the upward tips of the respective arms permits their insertion into that portion of the manway from which the coke has been removed. The reamer is then advanced upwardly to the lower surface of the coke and the rotation and upward advance begun.

As the reamer is advanced upwardly against the coke there is a tendency for the arms to be forced outwardly. However, until the arms have progressed past the manway flange their outward movement is restrained by the metal walls thereof. After passing the manway flange the arms 13 are forced outwardly as shown in Figure 2 of the drawings and the coke in the lower part of the chamber is cut away by the reamer as there indicated to provide space for the insertion of the helical cutter.

During this reaming operation the reamer is centered and supported at its upper end by the pilot 11 extending into the centering hole 5, as shown in the drawing.

When the reaming operation has progressed to approximately the extent indicated on Figure 2 of the drawings, the reamer is withdrawn from the chamber, this being possible by reason of the collapsible arrangement of the arms 13, disconnected from the shaft 9 and replaced by the combination helical cutting and breaking tool, generally referred to herein as "helical cutter."

The cutting mechanism of the spiral cutter is advantageously of the chain type, diagrammatically represented at 16 in Figure 3 of the drawings, similar to that of the chain cutters used in coal mining. This helical cutter, as shown, is adapted to be threaded or otherwise securely fastened to the rotary driving shaft 9 used in the preceding boring and reaming operations. The cutting mechanism may, however, be driven independently in any conventional manner such as by a rigid or flexible shaft or cable connected to a suitable source of power or may be conveniently operated by means of an air motor or the like forming an integral part of the helical cutter such as shown diagrammatically on Figure 3 at 17.

Details of two specific types of spiral cutters found to be particularly suitable for the purposes of the present invention are shown by Figures 6 to 12, inclusive, of the drawings.

Each type of the helical cutter is provided with a cutting arm frame structure 18 so connected to the main body or shank 19 of the tool as to allow the arm to swing upwardly from the horizontal to a position such as indicated by dotted lines on Figure 6 of the drawings to permit the insertion through the manway 2, but to arrest its downward swing at approximately the horizontal plane. After the cutter has been brought into the enlarged portion of the chamber from which the coke has been cut by the preceding reaming operation, the cutting arm is returned to the approximate horizontal position and the helical cut may be started.

The main body or shank 19 of the helical cutter is surmounted by a pilot or guide 20 adapted to project into the centering hole 5, as previously described with reference to the reamer, to guide and support the cutter.

A cutting chain 22 is carried by the driving sprocket 23 and the driven sprocket 24 which are rotatably mounted at opposite ends of the cutting arm. The driving sprocket is shown in Figures 6 and 7 as being driven by means of the air motor 17 to which it is connected by a shaft 25, gearing 26 and shaft 27.

In operation the cutter arm is caused to rotate, for instance, in a counterclockwise direction, as indicated on Figure 7 of the drawings, by means of the rotary drive shaft 9, while the cutting chain is operated in a clockwise direction. Simultaneously, the cutter is forced upwardly and by synchronizing the rotary and upward movement of the cutting unit a helical cut is effected.

To facilitate the upward progress of the cut, the plane within which the cutting chain lies is preferably slightly inclined upwardly from the horizontal in the direction in which the cutting arm rotates. The angle of this inclination may be varied somewhat, depending upon the hardness of the coke or the like and the desired angle of inclination of the helix cut. For cutting a spiral such as indicated above with an advance of approximately 8 inches per revolution of the arm, an inclination of the plane of the cutting chain may advantageously be approximately 5 degrees from the horizontal.

As previously stated, simultaneously with the helical cutting operation of my invention the layer of coke intermediate the convolutions of the helix is systematically broken off, for instance by forcing apart the upper and lower surfaces of the cut. This breaking may be accomplished either by the continuous application of pressure, as by wedging action or by the intermittent application of pressure by a periodic expanding action at a predetermined distance back of the forward edge of the cutting arm.

One method of breaking off the coke by wedging action and effective means for accomplishing the same is illustrated by Figures 6, 7 and 8 of the drawings, Figure 8 being a cross-sectional elevation view of the cutting arm shown in Figures 7 and 8 at section AA.

In Figure 8 the cutting arm is shown as increasing in thickness from the front toward the rear so that as the cutting arm advances the wedging action thereof exerts an increasing pressure on the underlying layer of coke, causing it to fracture and drop to the lower portion of the chamber 1 from whence it is removed through the manway 2.

The upper surface of the cutting arm may with

advantage be provided with bearing guides 28 to form a bearing surface between the top surface of the arm and the newly cut coke, as more clearly shown in Figure 8 of the drawings. These bearing guides serve to maintain the cutting edge at the desired angle of inclination from the horizontal and their shape will be governed by the particular angle of inclination chosen. The bearing guides may be of uniform thickness extending from the outer to the inner end of the cutting arm. However, to reduce the friction between the cutting arm and the newly cut coke, I prefer to provide guides composed of ribs projecting upwardly from the frame of the arm, as shown at 28 on Figure 7 of the drawings, conforming in shape to the arc of a circle, the center of which coincides with the center of rotation of the cutting arm.

The flaring lower surface 29 of the cutting arm which exerts pressure on the underlying layer of coke may likewise be of uniform thickness, extending from end to end over the cutting arm, as shown in Figure 6 of the drawings. However, I prefer for this purpose the ribbed arrangement just described with reference to the bearing guides.

A variation in the cutting arm design embodying an alternate means of breaking off the coke, i. e. by the intermittent application of pressure, is shown by Figures 9 to 12, inclusive, of the drawings.

In this modified arrangement, as appears in Figure 9, the driving sprocket 23 of the cutting arm is actuated by shaft 27*a* extending upwardly through the rotary drive shaft 9, which shaft 27*a* may be driven by any convenient source of power, not shown. Pivotal connections 21 are provided in the shaft 27*a* as well as for the cutter arm mounting to permit the tilting of the cutter arm, as previously described. Above the pivotal connection 21 the shaft 27*a* is supported by the bushing 28*a* mounted in the inner end of the frame of the cutter arm. The sprocket 23 is mounted on the shaft 27*a* at a point above the bushing 28*a* and is secured to the shaft by means of the pin 29*a*. The shaft 27*a* is surmounted by the guide or pilot 20 such as previously described and which may be held in position thereon by any suitable means such as the set-screw 30 or may be rotatably mounted on the shaft 27*a*.

Also mounted on shaft 27*a* at a point below the bushing 28*a* is a cam 31 adapted to cooperate with the cam surface 32 of the coke-breaking plate 33. The coke-breaking plate is pivotally connected to the frame of the cutter arm at 34 and is forced upwardly against the cam 31 by flexible means such as the springs 35. As shown in the drawings, the breaking plate 33 is provided with an opening through which the shaft 27*a* extends with sufficient clearance to permit the breaking plate to swing downwardly, as will be presently described. Between the lower surface of the bushing 28*a* and the upper plane surface of the cam 31, and also between the upper surface of said bushing and the lower surface of the hub of sprocket 23, thrust bearings 36 are provided.

By the cam arrangement shown, the breaker plate 33 is periodically forced downwardly as the shaft 27*a* rotates. The cam arrangement may be varied to some extent, depending upon the particular breaking requirement. Such cams are well known and need not be here described in detail. However, a particular cam design which may be used with advantage is one which forces the breaker plate downwardly once for each revolution of the shaft 27*a*. For instance, while passing through an angle of 45 degrees, the breaker plate may be forced uniformly downwardly and during the following 45 degrees may be permitted to uniformly rise. For the remaining 270 degrees the breaker plate may remain at rest in the upper position.

The breaker plate advantageously extends substantially the entire length of the cutter arm and may be ribbed, as previously described with reference to the friction guides, or may be of uniform thickness throughout. In Figures 10, 11 and 12, the breaker plate is shown as having a plane lower surface.

A cam arrangement similar to that just described is also provided at the outer end of the cutting arm and is actuated by the rotation of the driven sprocket 24, as shown more particularly in Figure 11 of the drawings. In the arrangement there shown, the rotating cam surface is at the lower end of the stud 37, projecting downwardly through the center of the hollow bearing 38 about which sprocket 24 rotates, the stud being an integral part of the plate 39 which is rigidly fastened to the sprocket 24 and rotates therewith.

In Figure 10 of the drawings, which is a plan view of the outer end of the cutting arm, the breaker plate is shown as extending substantially the entire length of the arm and pivotally supported substantially throughout its length. A plurality of springs 35 are provided for pulling the plate upwardly against the cam surface. This modified form of cutting arm may also be provided with friction ribs 28, as described with reference to Figures 6, 7 and 8.

The specific apparatus herein described is particularly adapted to the removal of coke from chambers provided with manways of considerably smaller diameter than the diameter of the chamber itself. It will be understood that my invention is also applicable to the removal of coke from chambers of different sizes and designs. Where the diameter of the lower end manway approximates that of the chamber, the second step of the process, i. e. the reaming operation, becomes unnecessary. Likewise, where rigid support and guidance of the spiral cutter is otherwise provided, for instance by the use of a larger, more rigid drive shaft 9, the boring of the centering hole may be omitted.

An alternate method of guiding and supporting the upper end of the reamer or of the spiral cutter, not specifically shown in the drawings but which may be employed with advantage, is the extension of the rotary drive shaft up through the upper manway 3 and the provision of a bearing in the upper manway for securing and supporting the upper end of the shaft. This extension may be inserted from the top of the chamber through the centering hole and fastened on to the upper part of the reamer or helical cutter by conventional means.

The size of the rotary drill, reamer and helical cutter will, of course, depend somewhat upon the diameter of the chamber to be cleaned and the depth of the coke bed. It is necessary that the drive shaft used in the boring be sufficiently rigid to bore a true centering hole through the coke bed or otherwise the arms of the reamer or helical cutter might strike the metal walls of the chamber.

In removing coke from coking chambers of the size normally used commercially in the vapor

phase cracking of petroleum oil, it is desirable to provide sufficient clearance to allow for slight deviations of the centering hole from the true center of the chamber. For example, with a coking chamber approximately 8 to 9 feet in diameter and approximately 45 to 50 feet overall height, the coke bed is usually approximately 35 to 45 feet deep. In the reaming and cutting operations in chambers of this size, it is advisable that the arms of the reamer and the arm of the helical cutter be of such length as to provide a clearance of about an inch between the outer ends thereof and the walls of the chamber. This will leave a layer of coke about 1 inch thick around the walls of the chamber. This layer of coke and also that along the lower walls of the chamber which is not removed by the reamer may subsequently be removed by hand tools.

In removing coke from a coking chamber of approximately the size described above containing a coke deposit 30 feet in depth where the helical cutter is operated at approximately one rotation of the cutter arm per minute and an upward advance of 8 inches per revolution, the cutting and breaking operations may be completed in less than one-half hour. The proportion of the coke obtained therefrom in lump form by my improved method and apparatus is approximately 65% as indicated by the following tabulation based on a coke density of 52.5 pounds per cubic foot:

	Fines	Lumps
Drilling operation ..... pounds..	750	.....
Reaming operation ..... do....	13,400	.....
Cutting operation ..... do....	22,500	67,500
Total coke ..... do....	36,650	67,500
Per cent total ..... per cent..	35	65

Where the size of the manway will permit, the coke-breaking mechanism may be carried by a second arm extending outwardly from the rotary driving shaft instead of being combined directly with the cutting arm, as previously described. Where a second arm is provided for carrying the breaking mechanism, it may advantageously be positioned at an angle of 180 degrees from the cutting arm. By this arrangement, the center of gravity of the revolving mechanism can be made to coincide with or at least approximate the axis of rotation thereof, thereby reducing shaft stresses.

Preference for the wedging type of breaking mechanism over the periodically expanding type, or vice versa, depends to a considerable extent upon the character of the coke deposit. Where the periodically expanding arm is used, additional power must be supplied for its operation but relatively less force is required to rotate the arm. Where the coke deposit is of such character that it is easily broken off, the wedging type of arm may be satisfactorily used but, where the coke deposit is of such nature as to be broken off only with difficulty, the periodically expanding type of arm is preferred because of the possibility of excessively straining the rotary driving shaft in forcing the wedge into the cut.

I claim:

1. An improved method of removing coke deposits in relatively large pieces from vertically-elongated cylindrical chambers which comprises moving a cutting member radially and helically upwardly through the coke deposit to progressively form a helical cut extending into the coke deposit a material distance and a distance sufficient that when the coke behind the forward edge of the cut is broken from the body of coke, the major portion thereof will be in relatively large pieces rather than in fines, and systematically breaking off the coke underlying the cut by the downward application of pressure thereon independently of the cutting action at a predetermined distance to the rear of the forward edge of the cut.

2. An improved method of removing coke deposits in relatively large pieces from vertically-elongated cylindrical chambers which comprises moving a cutting member radially and helically upwardly through the coke deposit to progressively form a helical cut extending into the coke deposit a material distance and a distance sufficient that when the coke behind the forward edge of the cut is broken from the body of coke the major portion thereof will be in relatively large pieces rather than fines, and systematically and simultaneously breaking off the coke underlying the cut as the cutting progresses by the downward application of pressure thereon independently of the cutting action at a predetermined distance to the rear of the forward edge of the cut.

3. An improved method of removing coke deposits in relatively large pieces from vertically-elongated cylindrical chambers which comprises moving a cutting member radially and helically upwardly through the coke deposit to progressively form a helical cut extending into the coke deposit a material distance and a distance sufficient that when the coke behind the forward edge of the cut is broken from the body of coke the major portion thereof will be in relatively large pieces rather than in fines, and systematically breaking off the coke underlying the cut independently of the cutting action by automatically forcing the walls of the cut apart at a predetermined distance to the rear of the forward edge of the cut.

4. An improved method of removing coke deposits in relatively large pieces from vertically-elongated cylindrical chambers which comprises moving a cutting member radially and helically upwardly through the coke deposit to progressively form a helical cut extending into the coke deposit a material distance and a distance sufficient that when the coke behind the forward edge of the cut is broken from the body of coke the major portion thereof will be in relatively large pieces rather than in fines, and systematically breaking off the coke underlying the cut independently of the cutting action by automatically forcing a wedge-shaped device into the spiral cut at a predetermined distance to the rear of the forward edge of the cut.

5. An improved method of removing coke deposits in relatively large pieces from a vertically-elongated cylindrical chamber through a manway located in the bottom end of the chamber and of smaller diameter than the diameter of the chamber which comprises boring a hole through the coke deposit along its central vertical axis, reaming out the coke from the lower end of the chamber to a diameter slightly less than the inner diameter of the chamber to permit the insertion of a radially moving helical cutting tool, moving a cutting member radially and helically upwardly through the coke deposit to progressively form a helical cut extending into the coke deposit a material distance and a distance sufficient that when the coke behind the

forward edge of the cut is broken from the body of coke the major portion thereof will be in relatively large pieces rather than in fines, and systematically breaking off the coke underlying the cut by the downward application of pressure thereon independently of the cutting action at a predetermined distance to the rear of the forward edge of the cut.

6. Apparatus for removing coke deposits from a vertically elongated, cylindrical chamber comprising a vertical shaft adapted to be rotated and simultaneously advanced upwardly and to be centrally positioned beneath a central lower opening in the chamber, a combined helical cutting and coke-breaking tool adapted to be securely fastened to the upper end of said shaft and comprising an outwardly extending arm pivotally connected to the shank of said tool and adapted to be swung upwardly to a position approaching the vertical but having its downward swing arrested at approximately the horizontal position, a cutting chain supported by said arm having its cutting teeth projecting from the forward edge thereof and extending substantially throughout the length of the arm, said cutting chain being supported in a plane inclining upwardly from the horizontal toward its forward end, a driving mechanism for motivating said cutting chain and an expanding device to the rear of the forward edge of the arm adapted to force apart the surfaces of the cut made by the cutting teeth at a predetermined distance to the rear of the forward edge of the arm.

7. Apparatus for removing coke deposits from a vertically elongated, cylindrical chamber comprising a vertical shaft adapted to be rotated and simultaneously advanced upwardly and to be centrally positioned beneath a central lower opening in the chamber, a combined helical-cutting and coke-breaking tool adapted to be securely fastened to the upper end of said shaft and comprising an outwardly extending arm pivotally connected to the shank of said tool and adapted to be swung upwardly to a position approaching the vertical but having its downward swing arrested at approximately the horizontal position, a cutting chain supported by said arm having its cutting teeth projecting from the forward edge thereof and extending substantially throughout the length of the arm, said cutting chain being supported in a plane inclining upwardly from the horizontal toward its forward end and a driving mechanism for motivating said cutting chain, the rear edge of said arm being of greater thickness than the forward cutting edge.

8. Apparatus for removing coke deposits from a vertically elongated, cylindrical chamber comprising a vertical shaft adapted to be rotated and simultaneously advanced upwardly and to be centrally positioned beneath a central lower opening in the chamber, a combined helical-cutting and coke-breaking tool adapted to be securely fastened to the upper end of said shaft and comprising an outwardly extending arm pivotally connected to the shank of said tool and adapted to be swung upwardly to a position approaching the vertical but having its downward swing arrested at approximately the horizontal position, a cutting chain supported by said arm having its cutting teeth projecting from the forward edge thereof and extending substantially throughout the length of the arm, said cutting chain being supported in a plane inclining upwardly from the horizontal toward its forward end, the lower surface of said arm comprising a rigid plate extending substantially the entire length of the arm and pivotally supported by the arm at its forward edge, a cam mechanism adapted periodically to force the rearward edge of the plate downwardly and a driving mechanism for motivating said cutting chain and the cam.

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