ROTARY WELL BORE CLEANER

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Filed Apr. 7, 1958, Ser. No. 726,930
12 Claims. (Cl. 166—173)

This invention relates to the cementing of a casing in a well bore, and more particularly to the surface condition-
ing of a bore wall portion by cleaning or removing the crust or cake of drilling mud deposited during the well drilling operation and preparing the wall surface for a subsequent cementing operation. The invention is of the type wherein a rotating and upwardly reciprocating cutter is employed to engage with the wall surface and to abrade it to a condition suitable for cementing. A semieliptical spring is provided which is arranged to engage a portion of the casing wall in the direction of rotation of the cutter and to impart a longitudinal movement thereto to facilitate the abrading action of the cutter. The present invention is particularly directed to a method and means for cleaning the wall of a drilled well in the area just adjacent to a casing being cemented in the well.

A further object of this invention is to provide a casing cleaner in which the casing is cleaned by a cutter which is rotated in a direction opposite to the direction of drilling the well and which is reciprocated axially in an upwardly directed path along the well wall.

A still further object of the invention is to provide a method of cleaning the bore wall of a well which includes the cleaning of a casing in the well bore using a reciprocating cutter which is provided with an upper and a lower semielliptical spring arrangement which engages the casing and provides a mechanical advantage for the cleaning operation.

The method and means of the present invention provide for a casing cleaner which is rotated in a direction opposite to that of the drilling operation and which is axially reciprocated in a path adjacent to the well bore. The cutter is provided with semieliptical springs which engage the casing and provide a mechanical advantage for the cleaning operation. The method and means of the present invention provide for a casing cleaner which is rotated in a direction opposite to the direction of drilling the well and which is reciprocated axially in a path adjacent to the well bore. The cutter is provided with semieliptical springs which engage the casing and provide a mechanical advantage for the cleaning operation.

In the drawings, the dotted lines shown in different positions in the figures illustrate the manner in which the cutter is rotated in dragging engagement with the bore wall; Fig. 2 is a fragmentary front elevation of a casing mounted cutter locating strap as viewed in the direction of the arrows 2-2 in Fig. 1 but with the semieliptical cutter straps swung back against the mounting strap in preparation for descent into the well bore. In the figures, the following designations are used: Figs. 1 and 2 are transverse sections of the mounting strap for the device as shown in Fig. 1; Figs. 4, 5, 6, and 7 are transverse sections on lines 4—4 and 5—5 respectively of Fig. 2 and show the cutter arm fully retracted as would be the case during longitudinal travel of the casing in a well bore by casing rotation; and Figs. 6 and 7 are transverse sections similar to Fig. 4 but illustrating the rockimg action of the cutter bar, Fig. 6 showing the position of the cutter bar immediately upon start of casing rotation and Fig. 7 showing the cutter bar in the fully outwardly projected cutting relation in which the cutter drags on and abrarrassively scrapes over the exposed face of the bore wall throughout continued casing rotation.

In the drawings the hole or well bore through the earth formation 1 is shown as being lined by a thickness of mud cake 2 at the end of the drilling operation and it is this cake which must be removed at one or more vertical depths where a cementing operation is to be made for filling the annular space which occurs between the bore wall and the wall 3 of the sectional casing inserted for lining the bore in the usual manner. The casing is first suspended in the well bore by the drilling derrick and is lowered in increments as casing sections are added and after the installation of the casing has been completed the rig mechanism is employed to impart continuous rotation to the casing for effecting the cleaning operation with the cutter of this invention. For the relation of parts as shown in the drawing, casing rotation can be considered as occurring in a clockwise direction, as indicated by the arrows in Figs. 6 and 7. To maintain the wall 3 of the casing in substantially concentric relation with the well bore, the casing will have fitted to it one or more conventional centralizers and such centralizers may be of the type which are provided with a number of radial spring arms fixed to the casing to project into elastic bearing with the bore wall.

As shown in the drawings, the improved cake cutter involves as a single assembled unit a vertical pintle pin 4 hingedly connecting a mounting strap 5 and one or monoroped strips, each comprising a length of steel wire of the type known in the trade as piano grade wire and preformed to comprise an outwardly bowed portion or cutter loop 6 throughout its major longitudinal extent and terminated at opposite ends in convolutions or portions 7 and 8 wrapped in coiled form to provide pivot mounting eyes brazed on the pintle pin 4. When so hinged on the mounting strap 5, the flexible cutter loop 6 is free to swing or rock about the pintle pin 4 toward and away from the face of the mounting strap and is illustrated in Figs. 1, 6 and 7 in positions projected outwardly and in Figs. 2, 4 and 5 in positions seated backwardly against the strap 5. In the initial preformed shape the spring wire loop follows a substantially semieliptical form in the manner shown in full lines in Fig. 1, which is the shape of the wire bow prior to being placed under stress. In this initial bow shape, the center portion of the longitudinal extent of the bow is spaced from its pivot axis a distance greater than the radial space which will exist between the sip pintle pin 4 and the formation face of the well bore to which the casing is to be fitted. Thus the loop shape is predetermined for any particular hole bore and casing to be fitted therein. As a matter of choice, the ends of the semieliptical bow may terminate immediately adjacent to and merge with the coil eyes 7 and 8 or they may...

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include short arm portions for producing a more shallow bow or U-shape, as shown in the drawing. Between the longitudinally spaced apart hinges 7 and 8, the unstressed and outwardly bowed wire loop normally lies in a plane substantially radially related to the hinge axis. The bottom terminal of the spring wire extends laterally outwardly for a short distance from the lowermost coil 7 and is given angular relation such as an angle of approximately ninety degrees to the vertical plane of the bow 6, to provide a short length leg 9 arranged to have stop abutment (see broken line position, Fig. 2) with the mounting strip 5 at the outwardly projected limit of oscillation of the cutter arm or bow 6. Above the upper end of the U-shaped stop 10, the wire is again coiled upon itself as a pivot pin attachment eye 11 and beyond the coil 11 the wire projects as an integral tang or lever arm extension 12 and is inclined upwardly and outwardly to the pivot axis from a terminal tip which is spaced from the pivot axis a radial dimension predetermined in relation to a given installation and in any event slightly in excess of the radial dimension between the casing 3 and the interior surface of the bore whereby to contact the bore surface in use and in the manner later referred to in connection with Figs. 4 and 6. The upwardly and outwardly extending terminal tang or lever arm 12 also is angularly related to the vertical plane of the bowed cutting arm 6 and the divergence of these two lever arms 12 and 6 as illustrated is on the order of about ninety degrees. Such spaced relation can be varied so long as an operative co-operation of the arms with the well bore wall is maintained throughout installation of the casing and which contemplates that during casing descent in the well the cutter arm 6 will be held at its retracted limit of oscillation and away from the bore wall by reason of the frictional drag engagement with the wall by the position control arm 12, as is seen in Fig. 4, and that during subsequent casing rotation with the cutting arm 12 swung out into wiping relation with the wall and at its outwardly projected limit of oscillation, the control arm 12 will be out of action and clear of the wall, as seen in Fig. 7, but that during a short increment of initial casing rotation and while the hinged wire is been rocked through an intermediate portion of its oscillation range bow arm 12 will be momentarily in engagement with the wall to insure operative positioning of the cutter arm 6 before frictional contact of the control arm 12 is broken.

The mounting strip 5, as best seen in Fig. 3, can be easily formed of a narrow sheet metal strip bent along a longitudinal line with the opposite sides diverging to bear at their ends on the outside surface of the casing wall 3 while the apex is away from the casing. At longitudinally spaced intervals, pairs of transverse slits are cut through the apex and for a short distance into each of the legs and the material between each pair of slits is pressed inwardly, as at 13, to provide a keeper bearing wall for co-operation with the apex portion of the strip in receiving and locating the pin 4. The pin ends may be headed over, as shown in Fig. 1, for retention with the mounting strip 5.

In fastening the mounting strip 5 to a well casing, the side edges of the angular legs may be spot welded at several points to the casing. Alternately, the strip may be clamped to the casing as by means of two or more flexible wires or banding cables 14, each of a length to fit around the casing and the mounting strip 5 and to be secured at opposite ends by suitable fastenings, such as terminal mounting heads 15—15 for a threaded tensioning stud 16.

In the region where the lower spring wire coil 7 embraces the pivot pin 4, the central area of the strip 5 has a coil passing cutout or window 17 which in the axial direction of the pivot pin is of a length only slightly greater than the length of the coiled eye 7. By opposite coil end abutment with the window top and bottom edge the coil is axially located within the narrow confines of the window 17. The upper pivot eye, comprising the coils 8 and 11, similarly extends through an opening or window 18 which is of relatively great axial extent to permit the eye to slide on the pin and accommodate axial elongation and shortening of the bowed portion 6 for its radial expansion and contraction. Thus in Fig. 1 illustrating the parts prior to placement of the assembly within a well hole but with the cutter arms rocked toward but not necessarily at the outermost limit established by the abutment stops 9 and 10, the upper hinged eye of each bowed strip is illustrated in full lines as approximately centered within the window space 18 and the bowed portion 6—6 is shown by solid lines in an unstressed and preformed normal loop shape and in which it projects from the hinge pin a distance greater than annulus space in which the loop is to be received between the walls of the bore and casing. It will be apparent, therefore, that after the casing has been lowered into a well and the bow is brought into working contact with a wall surface being cleaned, it will tend to conform to the wall and contact radially and may flatten out in the fashion indicated by broken lines in the upper portion of Fig. 1, in which case the upper pivot eye will have shifted upwardly with the tang or control arm 12 in the dotted line position shown. On the other hand, relative downward pressure on the tang 12 will contract the length of the loop whereby, as shown by the broken lines in the lower half of Fig. 1, the upper spring eye will have moved downwardly in the window 18 and the bowed portion 6 will have increased its radial projection, as indicated by the broken lines. This illustration in Fig. 1 comparatively demonstrates the result of downward pressure on the tang 12 prior to entry of the casing in the hole and with the bowed portion 6 in an outwardly rocked position. However, when the bow portion is rocked back away from the bore wall and is within the bore space, as shown in Fig. 4, its longitudinal shortening will increase its curvature projection in the same manner. Such bow increase will occur in advance of outward swinging of the bow, as will later be referred to, and is for the purpose of insuring bore wall contact by the bow upon its eventual swing out and in prior to completion of the concurrent swing back of the control arm 12, as explained in connection with the Fig. 6 illustration.

When the axial length of the bore surface to be cleaned in preparation for cementing is greater than a single bowed strip can effectively work, it will be desirable to hinge on a common pin a vertical succession of identical bowed wires and arrange them so that adjacent ends of succeeding wires overlap one another, as illustrated in Fig. 1. By way of illustration, an axial length of about five feet to be cleaned can be effectively worked with a succession of five bowed strips, each having the overlapping relation indicated in Fig. 1 for motion transmitting contact with an adjoining strip, so that the succeeding strips tend in a measure to co-operate with one another in unisonal oscillation between inactive and active positions.

In the use of the wall cleaner constructed as heretofore described, the casing section with a single one of the units mounted thereon is introduced into the well hole with the bowed cutter arm as in Fig. 4 swung inwardly about its pivot pin 4 to extend forward therefrom in the direction of eventual casing rotation. Accordingly the upwardly and outwardly extending control
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5 arm 12 will project radially outwardly and be under elastic bending stress, inasmuch as its length is selected that with the arm free of bending strain, its terminal tip is farther from the pivot pin than the width of the annulus space, and the free end of the radially disposed spring arm 12 will ride on and be in longitudinal slide bearing relation with the inner surface of the well bore, or, more particularly, with the inner surface of the mud cake. During the lowering in operation with the casing maintained nonrotatable, the terminal tip of the control arm 12 will draw downwardly on the bore wall with a one-way slipping clutch type of action. The elastic bearing and the terminal tip will be offset toward the cutter arm 6 from the vertical plane containing the axis of the hinge pin 4. By reason thereof, the control arm 12 will be held under elastic stress to resist oscillation and retain the bowed cutter arm 6 in stop abutment with the mounting strap 5.

After descent of the casing has ended and placed the cutter at a desired cleaning depth, the rig suspension mechanism will be operated to retract or raise the casing a short distance. Because of the upward and outward extent of the control arm 12, its tip will have a braking action with and tend to dig into the wall and resist upward movement of the slidable hinge eye afforded by the coils 8 and 11 at the upper end of the bowed portion. Length shortening and radial expansion of the bowed portion 6 in readiness for being rocked toward contact with the wall to be cleaned. Through the usual rotary machine, the raised well casing 3 can now be turned clockwise, whereupon the pivot pin 4 will be carried forward in the direction of rotation and away from the wall. The bowed tip of the control arm 12 as to oscillate or rock the previously expanded bow 6 outwardly toward the wall. Fig. 6 shows by full lines the start and by broken lines an intermediate part of the range of swing with the bow coming into wall contact just before control arm 12 stops. As this initial increment of rotation proceeds, the oscillation of the wire assembly about its axis in spaced parallelism with the axis of rotation will bring the control arm 12 into trailing relation with the circularly travelling pivot pin 4 and establishment of bore wall contact by the bow 6 swings the control arm inwardly toward the casing. That is, in advance of rotation of the control arm 12, the angularly spaced and radially expanded bowed portion 6 will have swung out and into contact with the wall (see Fig. 6) and once that contact is established, the bowed portion will hug the wall surface as the hinge pin 4 advances. During such advance, the bow will be squeezed between its hinge and the bore wall and placed under radial stress. Its curve decreases to a flattened shape in elastic conformity with the wall surface and its length elongates as permitted by wire yieldability and ensuing complete disengagement of the wall clutching tip with back swing of the control arm 12.

During continued rotation, the swing of the cutting bow will be stopped by the limit stops 9 and 10 in bearing with the mounting strip 5 and the expansible spring wire bow 6 will trail the pivot pin 4 and continuously exert outward force on the mud film cake for thinning it down by both cutting into and abrading its surface.

Casing rotation may be continued for as long as an hour or more, depending on the thickness and hardness of the mud cake to be scraped off, and after the cleaning operation has been satisfactorily completed, to expose the face of the formation, a cement slurry is introduced through the casing for controlled flow into the annular space surrounding the casing in the usual way and casing and cutter rotation is continued, whereby the parts of the cutting unit move together and keep the cement slurry stirred for working out air pockets and for troweling the wet cement into the surface of the formation as an aid to a firm cement bond. After the cement flow has completely shut down further rotation disturbance is discontinued to enable the cement to set up.

Various modifications of the structure may be made without departing from the invention as set out in the attached claims.

What is claimed is:

1. In a well bore cleaner assembly to be mounted on and rotated by a casing, a pintle pin mounting member, a series of scraper loops, means pivotally joining the loops at their opposite ends on said mounting member for swinging travel from a retracted position to an outwardly projected position and each loop arranged in a vertically spaced succession with a portion of each loop vertically overlapping a portion of the next adjoining loop, said loops each having an upwardly and outwardly projected extension angularly related to the loop and in trailing relation thereto with respect to the direction of casing rotation, each extension being arranged to project outwardly for bore wall contact to maintain the loops retracted during casing descent and to respond to casing rotation by swinging backwardly and thereby causing the loops to swing outwardly for rotational drag engagement with the bore wall.

2. In a cleaner as in claim 1 wherein the means pivotally joining the loops to the mounting member includes axially slidable fitted parts and enables relative movement of the loop ends toward and from one another to accommodate change in loop length with loop expansion and contraction and wherein the loops are spring strips for elastic conformation to the bore wall surface.

3. In combination with a well casing to be cemented in a well bore, of an outwardly bowed spring strip having its opposite ends vertically spaced apart, means pivotally mounting on said ends on the casing for swing travel of the bowed spring strip from a retracted position adjacent the casing to an outwardly projected position and a control arm carried by the strip and provided with a terminal tip portion angularly spaced from said bowed strip, said tip portion being engageable with the bore wall for holding the bowed strip in its retracted position during lowering of the casing in the bore and for compelling backward swing of the control arm upon casing rotation to thereby swing the bowed strip outwardly into drag cleaning engagement with the bore wall as casing rotation continues.

4. In combination, a well casing to be lowered and then rotated in a well bore, a vertical succession of spring loops, means pivotally mounting these in the same at vertically spaced apart points on the casing with end portions of adjoining loops overlapping one another, the pivotal mounting of said loops accommodating their movement from a retracted position adjacent the casing and forward of their pivotal mountings in relation to casing rotation and to an outwardly projected bore wall engageable position and a control arm carried by each loop and projected upwardly and outwardly in angular trailing relation with the loop with respect to the direction of casing rotation, said arm being of a length to be engageable with the bore wall for holding the loop in retracted position during lowering of the casing and for compelling said loop to swing outwardly into wall engagement upon casing rotation.

5. A cement conditioning wall cleaner to be rotated with a well casing and thereby dragged on the surface of a well bore wall, comprising a length of spring steel wire bowed throughout its major portions at opposite ends of the wire bow constituting pivot mounting eyes, pintle pin means to be carried by the casing and projecting through the coiled portions on a substantially vertical axis and locating the wire bow for swinging movement between a retracted position and a portion of said pintle pin means in rotation of the direction of casing rotation and a bore wall engageable and outwardly projected position, a short wire extension projecting laterally from each coiled portion in a common vertical
plane angularly spaced from the vertical plane of the wire bow and constituting abutment stops at said outwardly projected position of the wire bow, a wire continuation projecting beyond one of said abutment stops and extending outwardly from the pintle pin means for a distance greater than the radial width of the casing annulus space and terminating in a bore wall engageable portion in spaced relation with the wire bow in the direction of the arcuate swing path of said bow.

6. The cleaner of claim 5 wherein one of the pivot mounting eyes is axially slidable relative to the pintle pin received thereby and accommodates relative axial movement of said end collars upon elongation of the wire bow in compensation for a flattening thereof to bore wall conformation in the outwardly projected position of the wire bow.

7. A well bore cleaner of the character described, mounting means for attachment to a casing, a bore wall engageable scraper, a pivotal connection joining said scraper with the mounting means on a pivot axis to extend in the longitudinal direction of the casing and accommodate the swinging of the scraper between positions inwardly retracted toward and outwardly projected from said mounting means and a position control arm fixedly joined to the pivoted scraper and provided with a bore wall engageable portion angularly outwardly extending from the scraper and swingable therewith to an outwardly projected position coincident with scraper retraction and to an angularly retracted position coincident with scraper projection.

8. A well bore wall scraper assembly to be mounted on a casing and to partake of longitudinal and rotary travel with the casing during installation thereof in a well bore, said assembly including a mounting member for attachment to a casing, pivot pin connection means carried by said member on a pivot axis to extend longitudinally of the casing, a rockable spring strip having a pivot portion fulcrumed by said pivot pin connection means and a pair of divergently related arms joined to and projected outwardly from said pivot portion, one of said arms including a bore wall scraper portion extending in the longitudinal direction of and laterally spaced from said pivot axis and being rockable about said axis between angularly spaced positions, one of which is an active scraping position for co-operation of the scraper portion with the bore wall during use and the other of which is a nonactive position in advance of said pivot axis with respect to the travel direction in which the casing is to be rotated and the other of said arms including a bore wall engageable portion rockable with said scraper portion and between angularly spaced positions which, with respect to casing rotary travel, are respectively slightly in advance of and in trailing relation to said pivot axis.

9. A well bore wall scraper assembly to be mounted on a casing for sequential longitudinal and rotary movement with the casing, said assembly including a mounting member to be fastened to a casing, a longitudinally extending scraper having a bore wall engageable position outwardly spaced from said mounting member, means pivotally connecting said scraper with the mounting member on a longitudinal axis for swinging movement between said wall engageable position and a disengageable position and means fixed to said scraper for swinging movement therewith and terminated in a wall engageable tip portion angularly spaced about said axis of the scraper to a distance to be positioned for wall co-operative engagement outwardly from said mounting member when the scraper is in its disengaged position and to swing back from its position of wall co-operative engagement and thereby compel scraper movement to wall engageable position upon forward rotary movement of said mounting member.

10. In combination, a well casing having longitudinal and rotary travel within a well bore and a rotary well bore wall scraper comprising a mounting member attached exteriorly of the casing, a longitudinally extending bore wall scraper, means pivotally joining said scraper to the mounting member on a longitudinal axis for swinging travel of the scraper toward and outwardly from the casing and interengageable seat surfaces carried by the scraper and by said mounting member and engageable to limit swinging travel of the scraper away from an inward position adjacent the casing and forward of said pivot axis in the rotational travel of the casing and to a bore wall scraping position in which the scraper projects radially outwardly from the casing.

11. In combination, a casing having longitudinal and rotary movement in a well bore and a bore wall cleaner comprising an expandable bowed strip having its opposite ends vertically spaced apart, means pivotally connecting said opposite ends to the casing on a vertical axis and accommodating swinging of the strip between relative positions disposed inwardly toward and outwardly from the casing, said means being closely fitted to and restricting axial movement of one of said ends and engaging the other end with axial clearance to permit axial movement thereof in compensation for increased expansion of the bowed strip and a control arm fixed to and projected outwardly and upwardly from the axially movable end and terminated in angularly spaced relation to the strip, said control arm being of a length for well bore contact when the strip is inwardly disposed to thereby resist outward swinging of the strip during downward casing travel in the well bore and resist upward movement of the axially movable end with upward casing travel to thereby forcibly expand the strip and additionally causing outward swinging of the expanded strip when said axis is carried forward with casing rotation.

12. The combination as in claim 3 wherein said bowed strip is expandable upon relative movement of its opposite ends one toward the other in response to upward casing travel when said terminal tip is in bore wall engaging relation and the pivotal mounting means co-operates with the ends to accommodate such movement.

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