

June 17, 1969

H. HÜGEL ETAL

3,450,216

CORE ORIENTING APPARATUS AND METHOD

Filed May 21, 1965

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FIG. 1a.

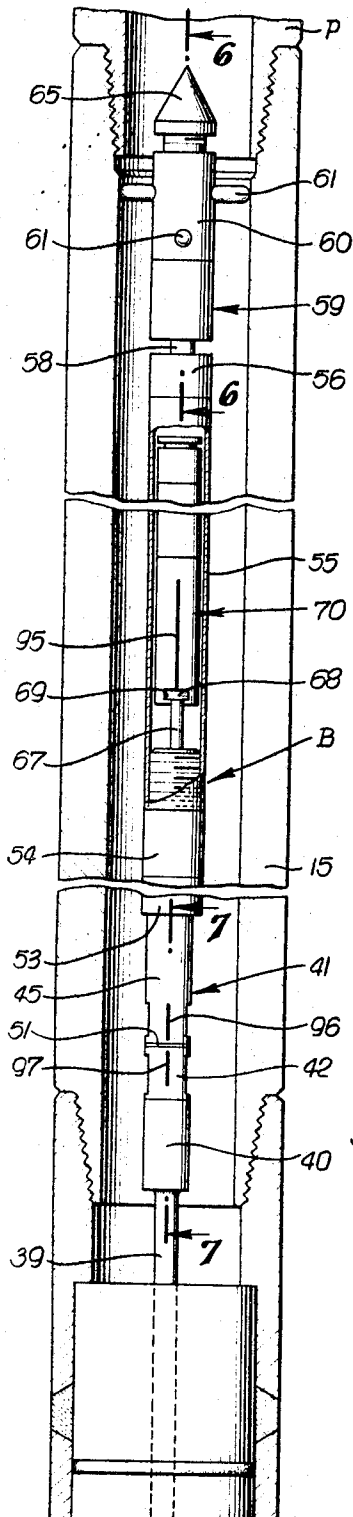


FIG. 1b.

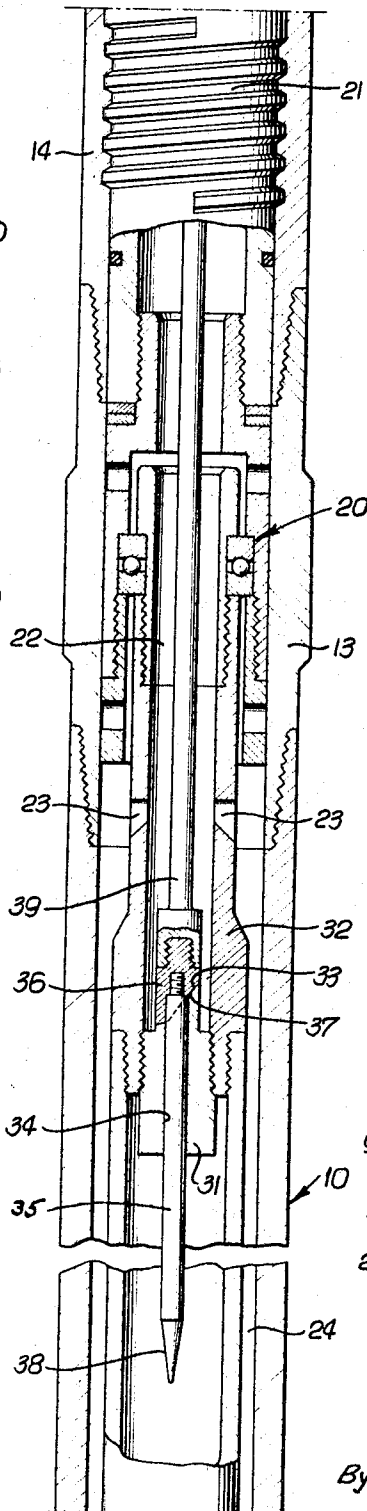
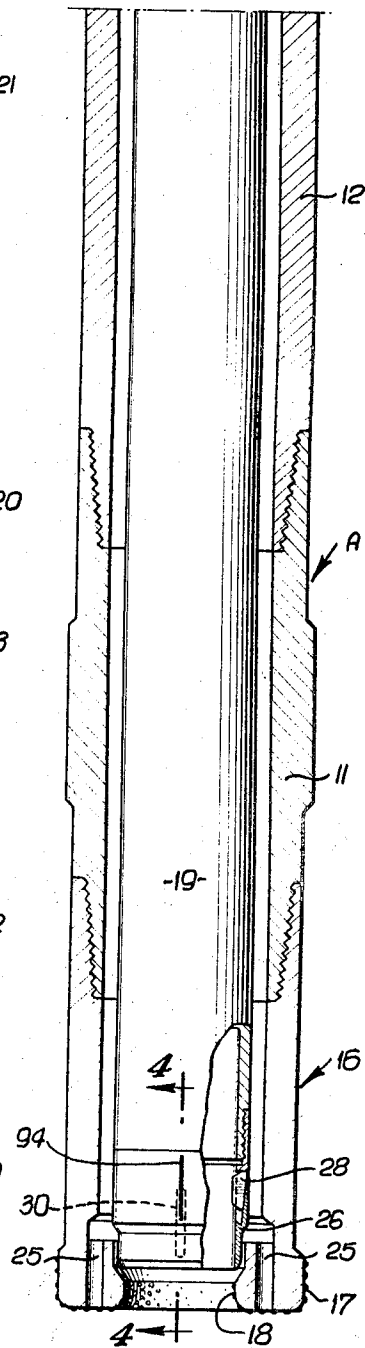


FIG. 1c.



INVENTORS.
HELMUT HÜGEL
TOM MANUEL
 By *Bernard Kriegel*
 ATTORNEY.

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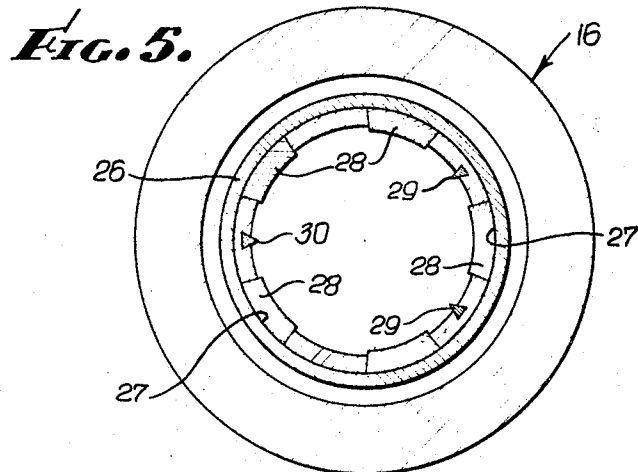
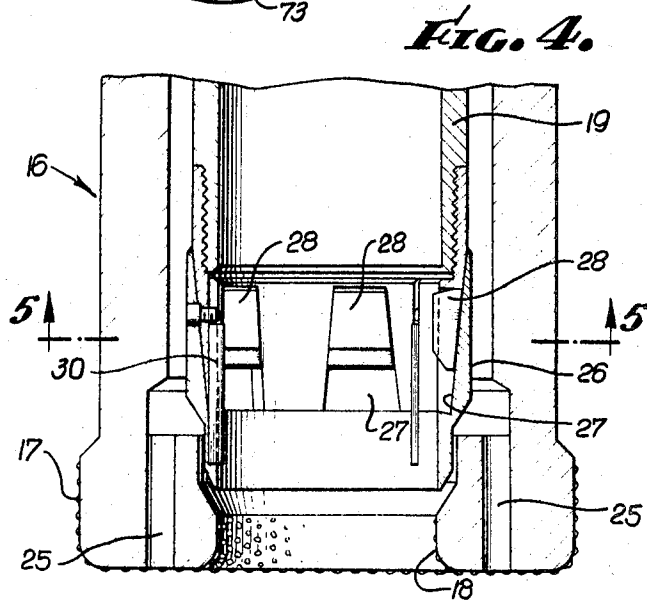
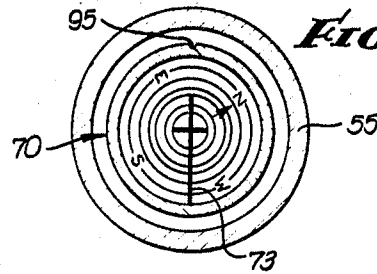
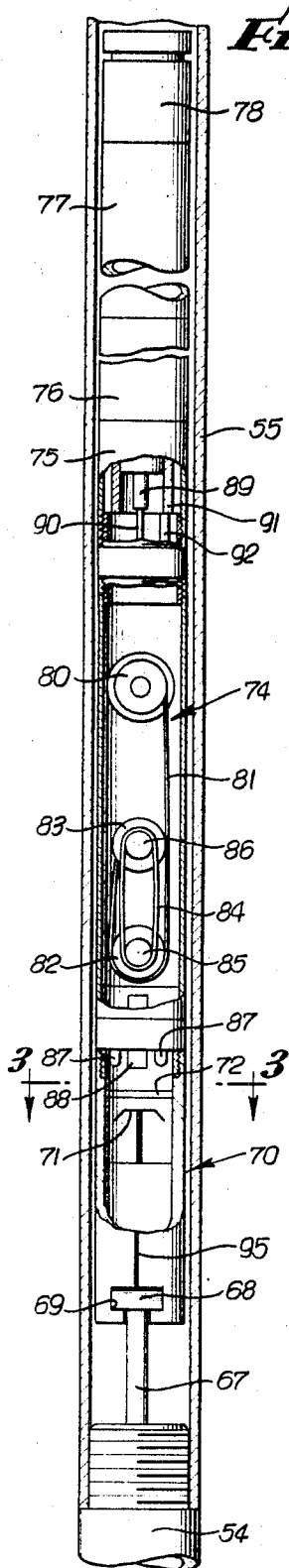
H. HÜGEL ET AL

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INVENTORS.
HELMUT HÜGEL
TOM MANUEL
By *Bernard Kriegel*
ATTORNEY.

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FIG. 6.

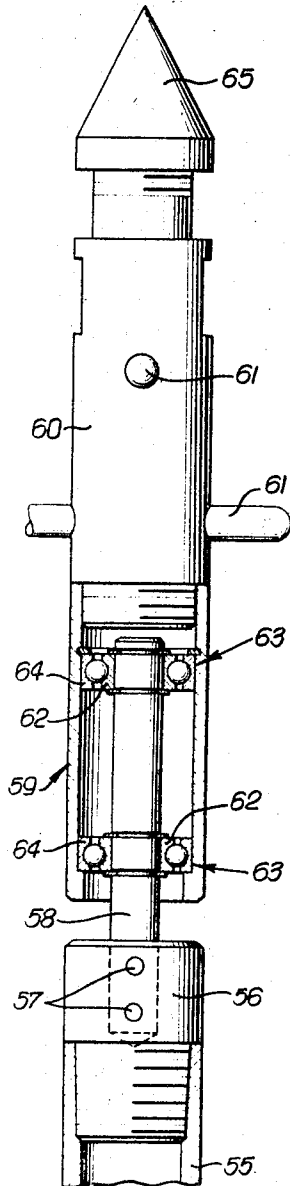


FIG. 7.

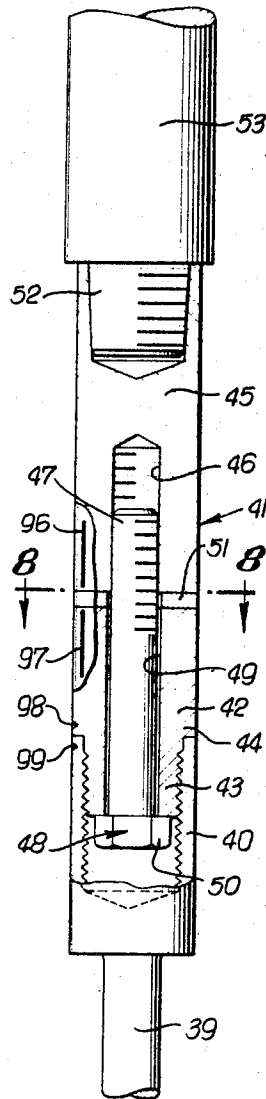


FIG. 9.

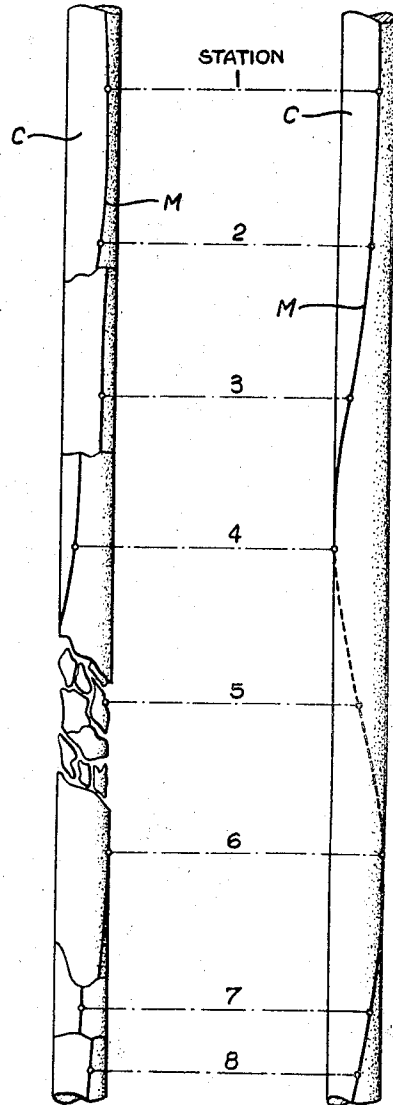
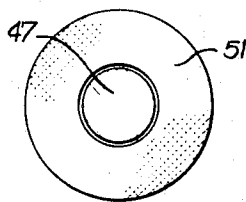


FIG. 10.

FIG. 8.



INVENTORS.
HELMUT HÜGEL
TOM MANUEL
By *Bernard Kriegel*
ATTORNEY.

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CORE ORIENTING APPARATUS AND METHOD
 Helmut Hügel, Salvador-Bahia, Brazil, and Tom Manuel,
 Stanmore, New South Wales, Australia, assignors to
 Christensen Diamond Products Company, Salt Lake
 City, Utah, a corporation of Utah

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U.S. Cl. 175—44

10 Claims

ABSTRACT OF THE DISCLOSURE

Method and apparatus for cutting and orienting cores in a bore hole, in which a knife or the like marks a groove in the core substantially along its entire length during the coring operation, and a multiple shot camera, at desired intervals during the coring operation, photographs a reference mark with respect to a magnetic compass, the reference mark being in a known relation to the marking knife, thereby producing a series of photographs giving the magnetic bearings of the groove marked in the core at a plurality of stations along its length.

The present invention relates to apparatus and methods for cutting cores in oil, gas, mineral, construction, and similar bore holes, and to the directional orienting of the cores which are obtained.

The invention is directed to a method and apparatus for determining the orientation of a bore hole core at a plurality of intervals along its length by placing a continuous reference mark on the core as it is being cut, the marking instrument being appropriately related to a compass instrument that has a reference member in a known angular relation to the device forming the reference mark, a multiple shot camera mechanism embodied in the apparatus photographing the compass instrument at known times and at known depths of the bore hole to provide a plurality of photographs, each of which can be related to a particular point or station on the reference mark in the core, which enables the drift angle and drift magnetic direction of the core at each station to be determined accurately following withdrawal of the apparatus and the core disposed in its inner barrel to the top of the bore hole.

An object of the invention is to provide a method and apparatus for cutting a length of core and for accurately directionally orienting different portions of the core at desired stations or points along its length, as, for example, at intervals of one inch, one foot, three feet, five feet, etc.

Another object of the invention is to provide a method and apparatus for directionally orienting cores, in which orienting can be made across an interruption in the core, such as a fracture or discontinuity.

A further object of the invention is to provide a method and apparatus for orienting cores capable of effecting continuous orientation along the length of the core.

An additional object of the invention is to provide a method and apparatus for orienting cores at any desired number of stations along the length of the core that utilizes standard oil field coring and other equipment without major change or modification, thereby effecting substantial economies.

This invention possesses many other advantages and has other objects which may be made more clearly apparent from a consideration of a form and method embodying the invention. This form and method are shown and described in the present specification and in the drawings accompanying and constituting a part thereof. They will now be described in detail, for the purpose of illustrating

the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

FIGURES 1a, 1b and 1c together constitute a longitudinal section through a core orienting apparatus embodying the invention, with parts shown in side elevation, FIGS. 1b and 1c being lower continuations of FIGS. 1a and 1b, respectively;

FIG. 2 is a longitudinal section, on an enlarged scale, through the survey instrument portion of the apparatus, parts being shown in side elevation;

FIG. 3 is an enlarged cross-section taken along the line 3—3 on FIG. 2;

FIG. 4 is an enlarged longitudinal section taken along the line 4—4 on FIG. 1c;

FIG. 5 is a cross-section taken along the line 5—5 on FIG. 4;

FIG. 6 is a combined side elevational view and longitudinal section through an upper swivel and stabilizer portion of the apparatus, taken along the line 6—6 of FIG. 1a;

FIG. 7 is an enlarged section, with parts shown in side elevation, taken along the line 7—7 on FIG. 1a;

FIG. 8 is a cross-section taken along the line 8—8 on FIG. 7;

FIG. 9 is a side elevational view of a portion of one type of core recovered with the apparatus;

FIG. 10 is a side elevational view of another type of core recovered with the apparatus.

The apparatus illustrated in the drawings is capable of providing a reference mark M along the entire length of a core C being cut, and to give a directional orientation of such reference mark at any desired number of stations along the length of the core. As shown, the apparatus includes a core barrel section A for cutting, marking, receiving and retaining the core and an instrument section for recording orientation of the core at intervals along its length.

The apparatus includes an outer core barrel 10 composed of several sections 11, 12, 13, 14, 15 threadably secured together, the core barrel terminating in a core bit 16 which may be of the type embodying diamond cutting elements 17. The core being cut in the bottom of the hole can pass upwardly through a central opening 18 in the core bit and into an inner barrel 19 supported non-rotatably within the outer barrel. The inner barrel may be of any suitable length, as, for example, 20, 30 or 60 feet, and terminates at its upper portion in a suitable bearing assembly or swivel 20 extending between it and the outer barrel 10 so that the outer barrel can rotate in cutting the core without rotating the inner barrel. The outer barrel may include a safety joint 21 of any known type, its upper portion 15 being a non-magnetic drill collar containing the survey instrument assembly B.

The upper end of the non-magnetic drill collar 15 is secured to the lower end of drill pipe P extending to the top of the bore hole. Fluid pumped down through the drill pipe will pass into the non-magnetic drill collar section 15 and safety joint 21, passing therefrom into a fluid passage 22 in the upper portion of the inner barrel 19 and through lateral side ports 23 of the latter into an annular space 24 between the inner and outer barrels, fluid moving downwardly through such annular space or passage and discharging through longitudinal passages 25 in the core bit into the bottom of the hole, carrying the cuttings outwardly around the exterior of the outer barrel and drill pipe to the top of the hole, as well as cleaning the core bit 16 and maintaining its diamond cutting elements 17 and other portions in a cool condition.

The lower end of the inner core barrel 19 is constituted as a shoe 26 having an internal tapered surface 27 against which tapered slips or core catcher elements 28 bear (FIG. 4). These slips are movable upwardly along the tapered surface to permit ready entry of the core into the inner barrel 19, but in the event the core tends to move downwardly and drop from the barrel, the slips moving downwardly along the tapered surface 27 and inwardly into firm gripping engagement with the exterior of the core to retain it in the barrel 19.

The shoe 26 also carries a marking device for forming the continuous reference mark or line M in the exterior of the core C as it passes upwardly into the inner barrel. As shown, three longitudinally extending knives 29, 29, 30 are suitably secured in the shoe, one of the knives 30 being a reference knife, and the other two knives 29 being back-up knives. The longitudinally extending knife edges will cut shallow longitudinal grooves M in the exterior of the core C as it moves relatively upwardly into the inner barrel 19. In addition, the three knives, in effect, become slidably splined to the core and tend to prevent the inner barrel from turning relative to the core and to the formation being cut by the bit 16. The knives 29, 30 are not spaced equidistant from one another. Instead, one of the knives 30, which is a reference knife, is spaced a much greater distance from each of the other two knives 29 than such back-up knives 29 are spaced from one another. As an example, the reference knife 30 may be spaced about 144° from each of the back-up knives 29, the back-up knives being spaced 72° from one another (FIG. 5). Accordingly, a definite reference mark or longitudinal groove M is cut in the core C by the reference knife 30, in view of the spacing of such groove or mark with respect to longitudinal grooves (not shown) cut in the core by the back-up knives 29. It is this reference knife 30 which is oriented with respect to the survey instrument B within the non-magnetic drill collar 15, so that the records produced by such survey instrument are appropriately coordinated with the reference groove M cut by the knife 30 in the exterior of the core.

The mechanism for orienting the survey instrument with respect to the reference or marking knife 30 includes a female mule shoe 31 threadedly secured in the lower portion of the upper section 32 of the inner barrel 19, the upper end of this mule shoe terminating in a helix 33, and this shoe having a central bore 34 therethrough adapted to receive a mule shoe probe 35 secured to and depending from a male mule shoe 36 having a tapered helix portion 37 adapted to mate against the helix 33 of the female mule shoe. The probe has a lower tapered point 38 to guide it into the central passage 34 of the female mule shoe.

The upper portion of the male mule shoe 36 is threadedly secured to an extension rod 39 extending upwardly through the fluid passage 22 in the upper portion of the inner barrel and upwardly through the safety joint 21 and into the lower portion of the non-magnetic drill collar 15, this extension rod terminating in an upper threaded box 40 threadedly secured to the lower end of an adjustable connector assembly 41 (FIG. 7). This assembly includes a lower connector member 42 having a pin 43 threaded within the box, a downwardly facing shoulder 44 on this connector member engaging the upper end of the box 40. The adjustable connector assembly further includes an upper connector member 45 having a central threaded bore 46 threadedly receiving the shank portion 47 of a connector bolt 48 extending upwardly through a central passage 49 of the lower connector member, the head 50 of the bolt bearing against the lower end of the latter. By tightening the bolt 48, the upper connector member 45 and lower connector member 42 can be moved toward one another to clamp a friction washer 51 therebetween, which will retain the upper and lower connector members 45, 42 in a desired angular position with respect to one another, as described herein-

below. The friction washer 51 may have hard-facing material on each side to insure its friction gripping against the upper and lower connector members.

The upper connector member 45 is secured to the lower pin end 52 of a non-magnetic extension rod 53, the upper end of which is threadedly attached to an instrument connector sub 54 which is, in turn, threadedly secured to the lower end of an instrument protector barrel or housing 55 made of non-magnetic material. The upper end of the housing is closed by a head 56 threaded thereto which is secured by suitable pins 57, or the like, to the spindle 58 of a swivel and stabilizing device 59 for supporting the survey instrument assembly B centrally within the non-magnetic drill collar 15 (FIG. 6). Actually, the spindle projects upwardly within a casing 60 having a plurality of radial pins 61, which may be made of rubber or the like, extending therefrom and terminating closely adjacent to the inner wall of the non-magnetic drill collar 15, to center the apparatus therewithin. The spindle 58 has a swivel connection with the casing 60 by suitably securing inner races 62 of ball bearings 63 to the spindle, the outer races 64 bearing against the casing. A head or spear 65 is secured to the upper end of the casing 60 in the event retrieval of the survey instrument assembly is desired.

The upper end of the connector sub 54 is constituted as a rod 67 having a connector lug 68 adapted to be received in a transverse slot 69 in the lower end of an angle unit 70 embodying the magnetic compass device. This angle unit has a compass card 71 pivoted therein which seeks the magnetic north and also has a reference plate 72 fixed therein above the compass card that has a reference lug 73 (FIG. 3) extending across the compass card, which is photographed at intervals, together with the compass card therebelow, by a multiple shot camera mechanism 74, or other recording mechanism, secured to and extending upwardly from the angle unit 70. Secured to the upper end of the camera device is a solenoid 75, which is, in turn, attached to a battery section 76 attached to an instrument clock 77, the clock housing being enclosed by a suitable end member or cap 78. The angle unit 70, camera 74, solenoid 75, battery section 76 and instrument clock 77 are all enclosed within the protective barrel or housing 55, the lower end of which is threadedly secured to the connector sub 54, and the upper end of which is secured to the head 56 to which is attached the spindle 58 of the swivel and stabilizer unit 59, described above.

The instrument clock, battery section, solenoid and camera may be of a known type used in surveying well bores and other bore holes. One specific mechanism is obtainable from Eastman Oil Well Survey Company, and another from Sperry-Sun Well Survey Company. The specific mechanism per se forms no part of the present invention, and for that reason only a portion is illustrated and described herein. The camera 74 (FIG. 2) includes a film supply reel 80 from which a film strip 81 extends and passes downwardly over a film drive sprocket 82 from where the film passes on to a film take-up reel 83, the film drive sprocket and the take-up reel being suitably interconnected by a drive spring or belt 84 passing around a sprocket pulley 85 and a film take-up pulley 86.

The instrument clock 77 is a spring-driven mechanism which turns a drive cam (not shown) that operates switches (not shown) which alternately turn on a light source 87 provided beneath the film drive sprocket 82 and sealed therefrom, this light source being adapted to cast light upon the reference plate 72 and the compass card 71 therebelow. The image of the reference lug 73 of the reference plate and the compass card passes through a camera lens 88 onto the film 81 passing over the film drive sprocket.

The battery section 76 contains the power source required to operate the film advancing solenoid plunger 89 and the light source 87. The solenoid plunger operates the film advance lever 90 on receipt of an impulse from the

clock 77. A spring loaded electrical contact ring 91 makes a positive contact with the electric contact 92 of the camera.

The camera contains no shutter arrangement, and its lens 88 is directly open to the film. The film exposure is controlled entirely by the operation of the light source 87, which is switched on and off at predescribed intervals by the clock 77, this clock actuating the plunger 89 to advance the film 81 step-by-step, and to turn on and off the light source 87 at selected intervals, which may, for example, be every 15 seconds, one minute, two minutes or four minutes.

The reference lug 73 of the angle unit 70 is oriented or aligned with the reference knife 30. As shown, the orienting shoe 26 has a scribe line 94 on its exterior aligned with the reference knife 30 and this scribe line is aligned with a scribe mark 95 on the exterior of the angle unit which bears a definite relation to the reference lug 73. As shown in the drawings, it is located 180° from the reference lug, the directional indications on the compass card being 180° from the normal concept so that a direct reading of the reference lug on the compass card can be taken, which will give the orientation of the scribe line 94 on the shoe and, consequently, of the reference knife 30, and of the mark or longitudinal groove M formed in the core C by the reference knife.

The scribe mark 95 on the angle unit is brought into angular alignment with the scribe line 94 on the orienting shoe. This can be done by removing the non-magnetic drill collar 15 from the safety joint 21 and by then assembling the male mule shoe 36, the steel extension rod 39, the adjustable connector assembly 41, the non-magnetic extension rod 53 and the instrument connector sub 54. This assembly is inserted into the box of the safety joint 21 until the mule shoe probe 35 enters the female mule shoe 31 and the male mule shoe helix 37 seats and matches the helix 33 of the female mule shoe. If the scribe line 94 is not present on the orienting shoe, it can be marked on its exterior to exactly match the reference knife 30 on the inside of the shoe. The angle unit 70 is then attached to the instrument connector sub 54 by sliding it transversely onto the connector lug 68.

By using suitable leveling devices, the scribe mark 95 on the angle unit 70 is brought into exact alignment with the scribe mark 94 on the orienting shoe by turning the adjustable connector device 41, which may at that point be in a loose condition in that the friction washer 51 is not clamped between the upper and lower connector members 45, 42. When the scribe line 95 on the angle unit is precisely aligned with the scribe line 94 on the orienting shoe, a pencil reference mark 96 is made on the upper connector member 45 and a corresponding pencil reference mark 97 in alignment therewith is made on the lower connector member 42. Permanent punch marks 98, 99 in alignment with an adjacent to one another are made on the lower connector member 42 and on the box 40 of the extension rod.

The lower connector member 42 is then unthreaded from the extension rod 39 and the penciled reference marks 96, 97 are aligned, whereupon the connector bolt 48 is tightened to firmly clamp the friction washer 51 between the upper and lower connector members 45, 42 and securely hold the latter together and prevent their inadvertent angular shifting. The lower connector member 42 is then reattached to the steel extension rod 39 with the punch marks 98, 99 being aligned. Thus, the instrument lug 68 and the reference knife 30 on the scribe shoe 26 are fixed in an aligned position, so that when the angle unit 70 is moved transversely over and connected to the rectangular connector lug 68, the scribe mark 95 will be precisely aligned with the scribe mark 94 on the shoe and with the reference knife 30 on the interior of the shoe.

The instrument connector sub 54, adjustable connector assembly 41, extension rod 39 and male mule shoe 36 can then be removed from the apparatus and the angle

unit 70 slipped off the lug 68 to assemble the survey instrument device thereto.

In assembling the instrument mechanism B, the batteries are loaded into the battery section 76, and the instrument clock 77 is attached to the top of the battery section and the latter to the solenoid section 75. The film loaded camera 74 is attached to the bottom of the solenoid section and to the angle unit 70, whereupon the entire instrument assembly is slipped into the instrument protective barrel 55, but not to a full extent. The connector lug 68 of the connector sub is then fitted into the transverse slot 69 of the angle unit 70 and this whole assembly then shifted fully into the protective barrel 55, the connector sub 54 then being threadably secured to the bottom of the latter.

The entire coring apparatus can now be fully assembled. The inner barrel 19 is lowered into the outer barrel 10 and the safety joint connection 21 made between these parts so that the inner barrel is supported longitudinally by the outer barrel through the agency of the bearing assembly or swivel 20. The entire instrument string is then inserted into the inner barrel once again, the male shoe probe 35 moving into the passage 34 of the female mule shoe 31 and the male shoe helix 37 mating with the female shoe helix 33, which will result in the scribe line 95 of the angle unit being aligned with the scribe line 94 and reference knife 30 of the inner barrel shoe. The non-magnetic drill collar 15 is then lowered over the survey instrument and attached to the adjacent section 14 of the outer barrel, the rubber stabilizing pins 61 contacting the inner wall of the non-magnetic drill collar to stabilize the instrument string, while assuring that the instrument mechanism B will not rotate with the drill collar 15, because of the swivel connection 59 between the spindle 58 and casing 60. Thus, assurance is had that the inner barrel 19 will not rotate with the outer barrel 10.

As soon as the instrument is assembled, it begins taking pictures at the prescribed time interval because of the intermittent operation of the mechanism by the clock 77. The core barrel mechanism is attached to the drill pipe P and is lowered in the bore hole until its bottom is reached, at which point coring can commence. The drill pipe is rotated to turn the outer barrel 10 and the drill bit 16 to cut away the annular portion of the formation and produce a core that will pass relatively upwardly into the inner barrel 19. As the core is forced through the knives 29, 30, longitudinal grooves are formed in its exterior which will provide a reference mark M by the reference knife 30 on the exterior of the core, and which will also assist in insuring that the inner barrel 19 and the instruments B are maintained in a stationary condition.

During the coring operation, pictures are taken at the prescribed intervals by the filming of the reference lug 73 and the compass card 71 therebelow, but such pictures will be blurred during the drilling operation because of vibration of the drill string and vibration of the drilling fluid caused by the pumps at the top of the bore hole pumping fluid down the drill string P and through the apparatus for discharge from the drill bit 16 onto the bottom of the well bore. A clear picture will only be secured after rotation has ceased and the pumps have either been disengaged or are idling so as to eliminate all vibrations in the drill string. When such cessation of drilling and of the pumping of liquid into the drill string occurs, the time is noted at the top of the well bore, such time being synchronized with the instrument clock 77. The depth of the bit 16 at that time is also noted. Accordingly, the picture taken will be related to a section of the core C at that depth. The data recorded on the film 81 for a particular station stop includes the elapsed time as recorded on the surface watch which is synchronized with the instrument clock 77. This determines the picture number. As was stated above, also recorded in the depth or footage of the core, which locates the station on the

core at the reference knife 30 when the clear picture was taken.

The frequency of station stops during the coring operation is determined by the operator, based on experience in the formation. Stations may be taken as frequently as desired, limited only by the clock interval. As an example, the apparatus may be stopped to obtain a clear picture, as the core C is cut, at one to five foot intervals. If the core apparatus is to be picked up and the core broken at any time, the apparatus is stopped and a station taken before the break is made. Following any interruption or breaking of the core, one foot is cut before a clear picture at another station is taken. This provides orienting information on both sides of a break and, therefore, allows continuous orientation of the final core.

Through use of the multiple shot or picture magnetic survey instrument B, in combination with the scribing of the reference mark M on the exterior of the core by the reference knife, a photographic record of the reference scribe direction at frequent time intervals is obtained throughout the coring operation. The magnetic survey instrument takes a clear picture when the mechanism is stopped of the direction that the reference knife 30 has cut a groove or mark M in the core at as many points or station stops as is desired which, as indicated above by way of example, can be every foot or every five feet or, for that matter, every inch. Thus, regardless of fractures that might occur in the core, or other discontinuity, a record is made at a station on both sides of the fracture which allows directional orienting of the core below the fracture to be made, as well as orientation above the fracture or point of interruption. Such an arrangement is illustrated in FIG. 9 in which the numbers 1 through 8 indicate the station stops at which pictures have been taken and in which the longitudinal line M indicates the groove cut by the reference knife 30 in the exterior of the core C. Despite the fact that a fracture has occurred at several stations, such as between stations 2 and 3, 3 and 4, 6 and 7, and 7 and 8, the taking of a picture at each station provides a definite orientation of a definite magnetic bearing of the groove M at any desired interval along the length of the core. The discontinuity noted at station 5 in FIG. 9 cannot be directionally oriented but the remainder of the core, both above and below the discontinuity, can be properly oriented at each station.

Even where solid cores are obtained, orientation through use of applicants' method or system can be made accurately along the length of the core. Experience has shown that the drilling fluid pumped downwardly through the annular space 24 between the inner and outer barrels 19, 10 applies a torque on the inner barrel and this torque causes the scribing knives 29, 30 to spiral around the core, so as to produce a spiral reference line or groove M in the exterior of the core by the knife 30, as shown in FIG. 10. By the taking of pictures with the survey instrument at suitable lengths along the core, the appropriate directional orientation of the mark M at each station can be determined.

Thus, it is apparent that the apparatus and orienting system described are capable of continuous orientation because the scribe line M is continuous along the core. The actual orientation of such scribe line with respect to magnetic or true north is achieved periodically at specific combinations of time and depth. The core can be continuously oriented by extrapolation working up or down the continuous scribe from the periodically oriented depth locations or stations. At each "station," the time and depth is noted and the clear picture or photograph taken. The period between orienting stations can be varied, as desired. The minimum period depends upon the particular survey instrument assembly being used. By way of example, a minimum period can be obtained by using a camera which is actuated every 15 seconds. Other cameras can be provided to give other minimum intervals of actuation of the mechanism, that is, energizing of the light

source 87 and advancing of the film 81, of one minute, two minutes or four minutes. The time interval at which stations are taken is determined by the coring rate of penetration.

In the apparatus illustrated, a comparatively standard oil field core barrel without major change or modification is used. Similarly, the magnetic photo survey instrument is available from manufacturers, which will actuate and advance the film 81 and energize the light source 87 at desired intervals, to obtain a pictorial record of the magnetic bearing of the reference lug 73, which is definitely related to the reference knife 30. As a result the apparatus is comparatively simple and relatively inexpensive.

We claim:

1. In apparatus for orienting a core cut in a bore hole: an outer barrel; a core bit secured to the lower end of said outer barrel; an inner barrel in said outer barrel; a reference knife secured to said inner barrel to cut a reference mark in the core as it passes into said inner barrel; an angle device including a compass and reference means extending across said compass; means interconnecting said angle device and said inner barrel for placing said reference means in a predetermined angular position relative to said reference knife; said interconnecting means comprising a first shoe secured to said inner barrel and having a tapered surface, a second shoe having a tapered surface mating with said other tapered surface, elongate means secured to said second shoe and including an adjustable connection for enabling said angle unit to be turned relative to said reference knife; and a camera mechanism for photographing said reference means and compass at a plurality of predetermined time intervals during the coring operation to provide a record of the orientation of the reference mark in the core at selected points along the length of the core.

2. In apparatus for orienting a core cut in a bore hole: an outer barrel; a core bit secured to the lower end of said outer barrel; an inner barrel in said outer barrel; a reference knife secured to said inner barrel to cut a reference mark in the core as it passes into said inner barrel; an angle device including a compass and reference means extending across said compass; means interconnecting said angle device and said inner barrel for placing said reference means in a predetermined angular position relative to said reference knife; said interconnecting means comprising a transverse slot in said angle device and a lug slidable in said transverse slot to prevent relative turning between said angle device and interconnecting means while permitting disconnection of said angle device from said interconnecting means; and a camera mechanism for photographing said reference means and compass at a plurality of predetermined depth intervals during the coring operation to provide a record of the orientation of the reference mark in the core at selected points along the length of the core.

3. In apparatus for orienting a core cut in a bore hole: an outer barrel; a core bit secured to the lower end of said outer barrel; an inner barrel in said outer barrel; a reference knife secured to said inner barrel to cut a reference mark in the core as it passes into said inner barrel; an angle device including a compass and reference means extending across said compass; means interconnecting said angle device and said inner barrel for placing said reference means in a predetermined angular position relative to said reference knife; said interconnecting means comprising a transverse slot in said angle device and a lug slidable in said transverse slot to prevent relative turning between said angle device and interconnecting means while permitting disconnection of said angle device from said interconnecting means; said interconnecting means further comprising a first shoe secured to said inner barrel and having a tapered surface, a second shoe having a tapered surface mating with said other tapered surface, elongate means secured to said second shoe and including an adjustable connection for enabling said angle unit

to be turned relative to said reference knife; and a camera mechanism for photographing said reference means and compass at a plurality of predetermined depth intervals during the coring operation to provide a record of the orientation of the reference mark in the core at selected points along the length of the core.

4. In apparatus for orienting a core cut in a bore hole: an outer barrel; a core bit secured to the lower end of said outer barrel; an inner barrel in said outer barrel; reference marking means secured to said inner barrel to place a reference mark on the core as it passes into said inner barrel; an angle device including a compass and reference means disposed across said compass; means interconnecting said angle device and said inner barrel for placing said reference means at a predetermined angular position relative to said reference marking means; said interconnecting means comprising a first shoe secured to said inner barrel and having a tapered surface, a second shoe having a tapered surface mating with said other tapered surface, elongate means secured to said second shoe and including an adjustable connection for enabling said angle device to be turned relative to said reference marking means; and a camera mechanism for photographing said reference means and compass at a plurality of predetermined depth intervals during the coring operation to provide a record of the orientation of the reference mark on the core at selected points along the length of the core.

5. In apparatus for orienting a core cut in a bore hole: an outer barrel; a core bit secured to the lower end of said outer barrel; an inner barrel in said outer barrel; reference marking means secured to said inner barrel to place a reference mark on the core as it passes into said inner barrel; an angle device including a compass and reference means disposed across said compass; means interconnecting said angle device and said inner barrel for placing said reference means at a predetermined angular position relative to said reference marking means; said interconnecting means comprising a first shoe secured to said inner barrel and having a tapered surface, a second shoe having a tapered surface mating with said other tapered surface, elongate means secured to said second shoe and including an adjustable connection for enabling said angle device to be turned relative to said reference marking means; said interconnecting means further comprising a transverse slot in said angle device and a lug slidable in said transverse slot to prevent relative turning between said angle device and interconnecting means while permitting disconnection of said angle device from said interconnecting means; and a camera mechanism for photographing said reference means and compass at a plurality of predetermined depth intervals during the coring operation to provide a record of the orientation of the reference mark on the core at selected points along the length of the core.

6. In apparatus for orienting a core cut in a bore hole: an outer barrel; a core bit secured to the lower end of said outer barrel; an inner barrel in said outer barrel; a reference knife secured to said inner barrel to cut a reference mark in the core as it passes into said inner barrel; an angle device including a compass and reference means extending across said compass; means interconnecting said angle device and said inner barrel for placing said reference means in a predetermined angular position relative to said reference knife, said means including an adjustable connection for enabling said angle device to be turned relative to said reference knife; and a camera mechanism for photographing said reference means and compass at a plurality of predetermined time intervals during the coring operation, while said camera mechanism remains in the apparatus, to provide a record of the orientation of the reference mark in the core at selected points along the length of the core.

7. In apparatus for orienting a core cut in a bore hole: an outer barrel; a core bit secured to the lower end of said outer barrel; an inner barrel in said outer barrel; a

reference knife secured to said inner barrel to cut a reference mark in the core as it passes into said inner barrel; scribe knives secured to said inner barrel to cut scribe marks in the core as it passes into said inner barrel; said scribe knives being spaced arcuately from said reference knife to a substantially different degree than from each other; an angle device including a magnetic compass and reference means disposed across said compass; means interconnecting said angle device and said inner barrel for placing said reference means in a predetermined angular position relative to said reference knife, said means including an adjustable connection for enabling said angle device to be turned relative to said reference knife; and a camera mechanism for photographing said reference means and compass at a plurality of predetermined depth intervals during the coring operation to provide a record of the orientation of the reference mark in the core at selected points along the length of the core.

8. In apparatus for orienting a core cut in a bore hole: an outer barrel; a core bit secured to the lower end of said outer barrel; an inner barrel in said outer barrel; reference marking means secured to said inner barrel to place a reference mark on the core as it passes into said inner barrel; an angle device including a compass and reference means disposed across said compass; means interconnecting said angle device and said inner barrel for placing said reference means at a predetermined angular position relative to said reference means; said interconnecting means including an adjustable connection for enabling said angle device to be turned relative to said reference marking means; and a camera mechanism for photographing said reference means and compass at a plurality of predetermined depth intervals during the coring operation, while said camera mechanism remains in the apparatus, to provide a record of the orientation of the reference mark on the core at selected points along the length of the core.

9. In apparatus for orienting a core cut in a bore hole: an outer barrel; a core bit secured to the lower end of said outer barrel; an inner barrel in said outer barrel; reference marking means secured to said inner barrel to place a reference mark on the core as it passes into said inner barrel; an angle device including a compass and reference means disposed across said compass; means interconnecting said angle device and said inner barrel for placing said reference means at a predetermined angular position relative to said reference marking means, said interconnecting means including an adjustable connection for enabling said angle device to be turned relative to said reference marking means; and a mechanism for recording said reference means and compass at a plurality of predetermined depth intervals during the coring operation to provide a record of the orientation of the reference mark on the core at selected points along the length of the core.

10. In apparatus for orienting a core cut in a bore hole: an outer barrel; a core bit secured to the lower end of said outer barrel; an inner barrel in said outer barrel; reference marking means secured to said inner barrel to place a reference mark on the core as it passes into said inner barrel; an angle device including a compass and reference means disposed across said compass; means interconnecting said angle device and said inner barrel for placing said reference means at a predetermined angular position relative to said reference marking means, said interconnecting means including an adjustable connection for enabling said angle device to be turned relative to said reference marking means; and a camera mechanism embodying intermittent film feeding means and adapted to photograph intermittently said reference means and compass at a plurality of predetermined depth intervals during the coring operation to provide a record of the orientation of the reference mark on the core at selected points along the length of the core.

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