

Oct. 27, 1953

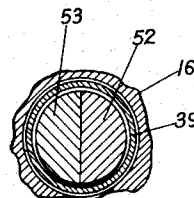
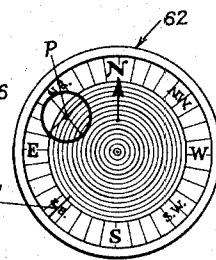
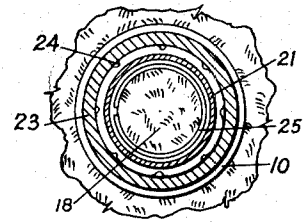
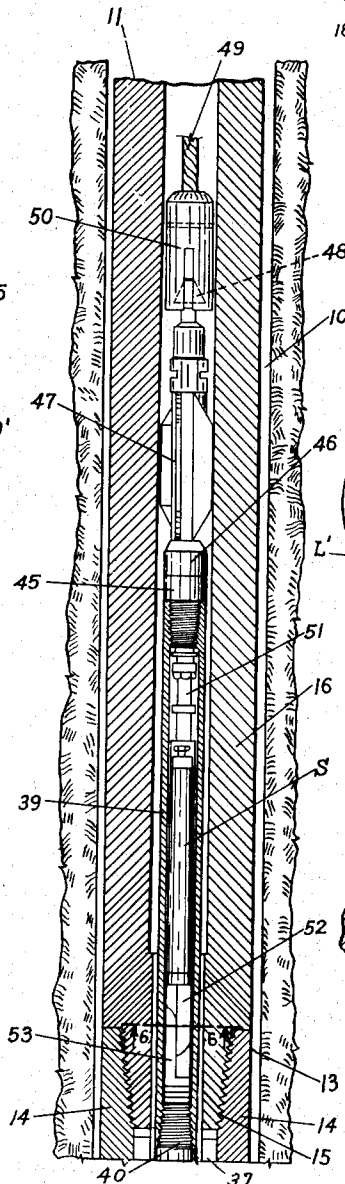
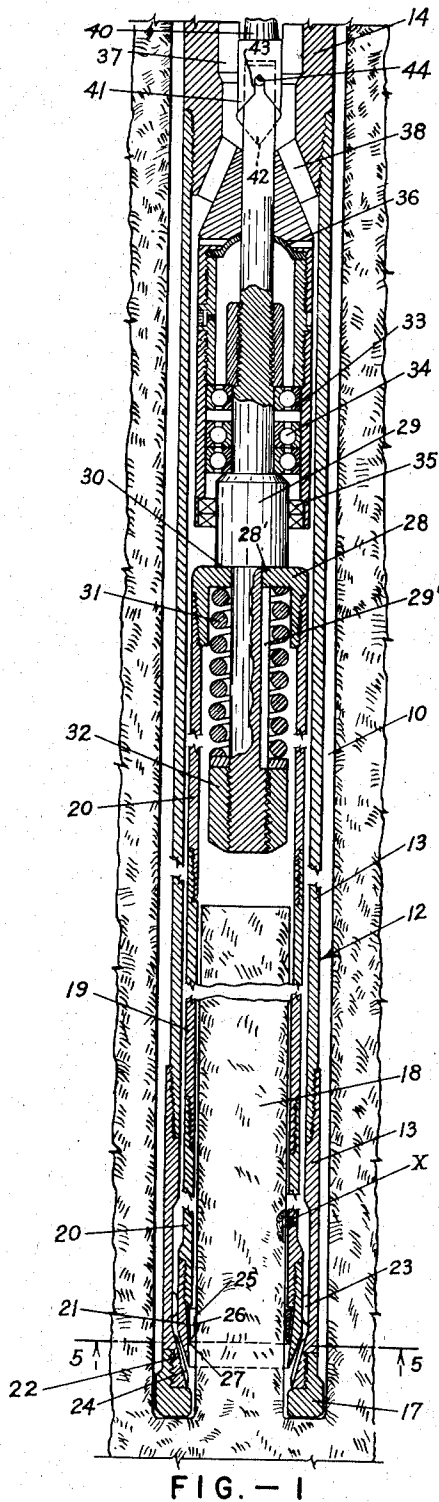
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2,657,013

CORE ORIENTING APPARATUS AND METHOD

Filed March 12, 1949

3 Sheets-Sheet 1



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CORE ORIENTING APPARATUS AND METHOD

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3 Sheets-Sheet 2

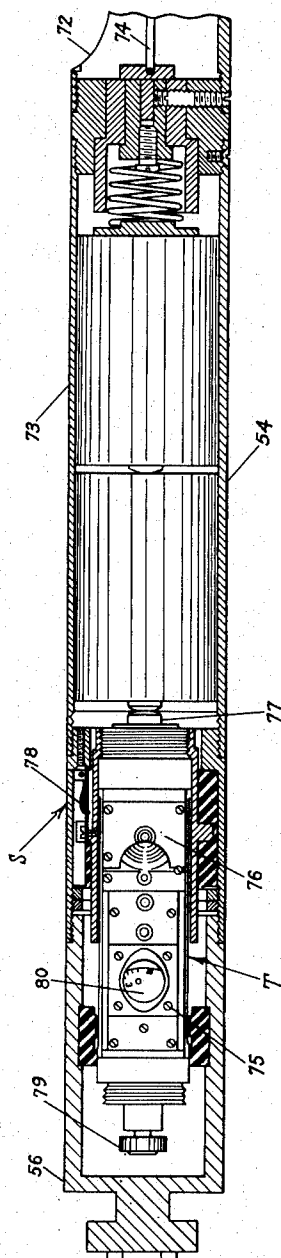


FIG. -3

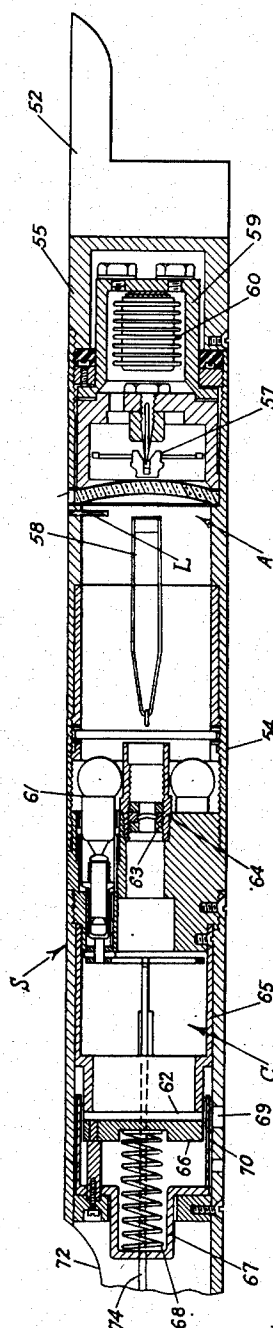


FIG. -4

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CORE ORIENTING APPARATUS AND METHOD

Filed March 12, 1949

3 Sheets-Sheet 3

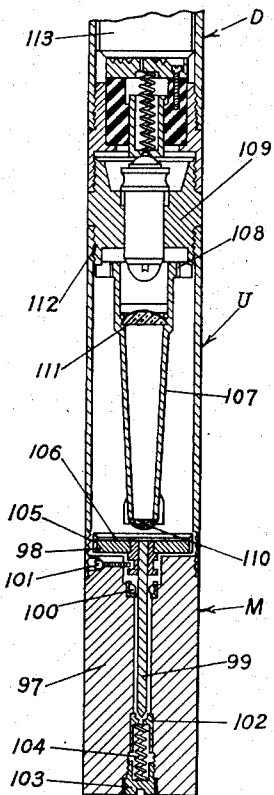
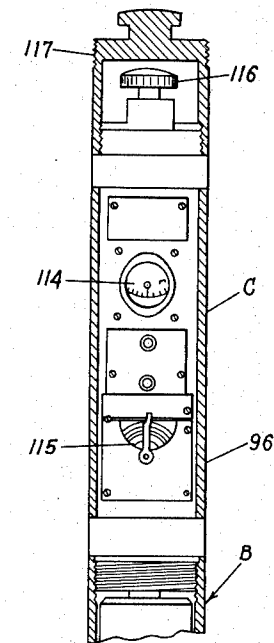


FIG.-9

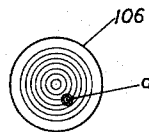


FIG.-10

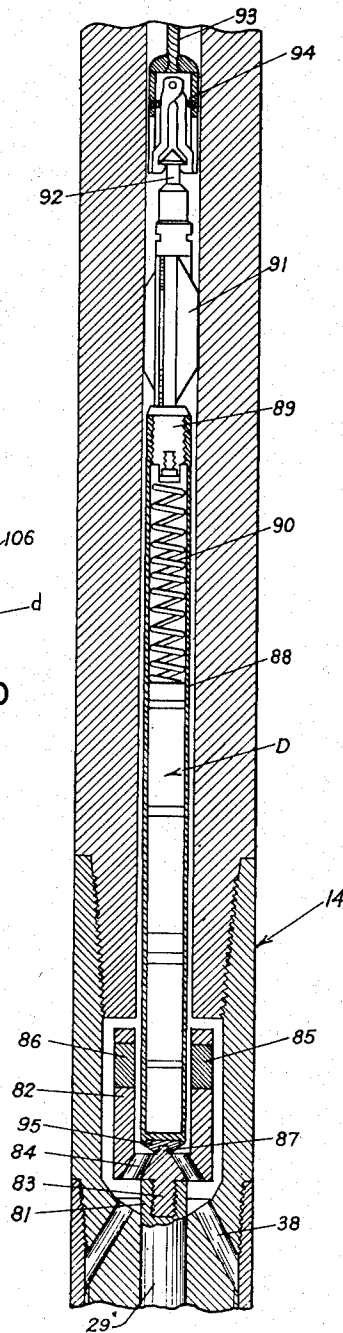


FIG.-8

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UNITED STATES PATENT OFFICE

2,657,013

CORE ORIENTING APPARATUS AND METHOD

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Application March 12, 1949, Serial No. 81,134

7 Claims. (Cl. 255—1.4)

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This invention relates to the orienting of cores taken from wells during the drilling thereof and more particularly to an improved apparatus for and method of taking and orienting a core.

In the drilling of wells, such as oil or gas wells, it is desirable to know certain data about subsurface strata which is being drilled, such as the dip and strike of such strata, as this information is highly useful in ascertaining if the well is being drilled on structure where oil or gas may be located. To ascertain dip, or dip and strike of strata and to also have knowledge of what formation is being drilled at any particular depth, it is the practice to drill a core which is a cylindrical section cut by a drill from the earth formation. The core is removed from the bore of the well and then by properly orienting it the desired information will be obtained. During taking of the core, a survey instrument is used so that data as to the position the core had in the earth can be obtained. When the core is removed it can be, because of the data obtained, again placed in the same position it occupied in the earth's formation from which it was cut. With this orientation, the dip alone or the dip and strike of the strata will become known.

In taking cores, a drill stem and a suitable drill bit are used. In presently employed methods of orientation of cores, the survey instrument for obtaining the information as to the inclination of the hole being drilled and the direction of inclination when the core is taken is either placed in the bottom of the drill stem when it is lowered to cut the core, or dropped in or lowered on a line after the drill stem has been lowered and before the core is cut. The instrument, after the core is cut, may be retracted together with the core without the necessity of removing the drill stem, or may be removed only with the entire drill stem and core. With these procedures it is necessary that the instrument be in place at the bottom of the well during the entire time of drilling the core. Consequently, the instrument is subject to considerable heat, especially in deep wells, and also to considerable abuse due to jars, blows and other forces created during the drilling of the core. These conditions may easily cause the survey instrument, which is delicate and sensitive, to be damaged or operate inaccurately, thus giving unreliable recorded information or no recorded information at all. Also, at the time the survey instrument is operated, the core may not be in proper position or condition, due to it being badly broken or disconnected at its bottom from the strata being

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cut. Another disadvantage in the present methods, where the survey instrument must be placed at the bottom of the drill stem prior to drilling the core and remain therein during the entire drilling of the core, is that the time for operation of the survey instrument to obtain the record desired must be set prior to drilling the core, thus predetermining the time period for placing the instrument in the hole and for drilling the core. The survey instrument always operates at the set time, regardless as to whether the desired length of core has been drilled or there is proper condition of the core so that the instrument will record reliable data. Consequently, there may be a record obtained that is of doubtful accuracy and thus cannot be relied upon with certainty. To be sure about the information obtained, the only thing which can be done is to repeat the entire procedure, including the cutting of a new core, which means loss of time and additional expense.

One of the objects of the present invention is to provide a core orienting apparatus and method whereby when any desired information is to be obtained with respect to a drilled core in a well bore by a recording survey instrument, it will be certain, if the instrument operates properly, that such is accurate and reliable.

Another object is to provide a core orienting apparatus and method whereby a survey instrument employable to obtain recorded information about a drilled core in a well need not be placed in the well bore until after the core has been drilled and it is certain that the core is in a proper condition for obtaining accurate information.

Yet another object is to provide an improved method of obtaining core oriented information which will permit the placing of a survey instrument in a well bore to obtain the desired information after the drill pipe and coring apparatus have been placed in the bore to drill a core and a short time prior to the core is fully drilled or after the core is made, thus eliminating the necessity of subjecting the instrument to damaging drilling abuse and prolonged bore heat.

A further object is to provide core orienting apparatus which will permit the drilling of any length of core desired without being subject to a core drilling time limitation imposed by a time setting of a survey instrument forming part of said apparatus.

A still further object is to provide a core orienting apparatus for use in well drilling which will insure that a drilled core will not be out of po-

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sition with respect to the sub-strata at the time a survey instrument is caused to be operated to obtain desired information about the sub-strata.

Yet a further object is to provide a method of core taking which will permit the use of a survey instrument for obtaining both inclination and direction information or only inclination information, depending on which is desired and wherein the survey instrument need not be placed in the bore until the core is drilled.

A further object is to provide a core taking and orientation method that will permit a survey instrument to be placed in a well bore to obtain desired recorded information after a core is drilled by use of a so called conventional core barrel attached to the end of a drill stem and removable only by removing the drill stem.

Another object is to provide in well drilling orientation, means for obtaining desired data about a drilled core while in a well bore, without the necessity of any time setting of a survey instrument to include the time for running the drill pipe and/or for drilling the core, thereby permitting cores to be drilled to any length desired before operation of the survey instrument and without regard to the time period of running in drill pipe and core taking apparatus.

A further object is to provide a method of taking and surveying a drilled core of a well being drilled which will require the taking of a single "picture" to obtain all the necessary data desired and with the certainty that no errors will be present other than those that may be caused by improper functioning of the survey instrument employed.

Other objects of the invention will become apparent from the following description taken in connection with the accompanying drawings in which:

Figure 1 is a longitudinal sectional view of the lower part of a well bore with a drill stem therein provided with a core drill and core barrel illustrating an example of structure for drilling a core and forming part of a core orienting apparatus embodying the invention, said view also showing a drilled core;

Figure 2 is a longitudinal sectional view of a part of the drill stem immediately above that shown in Figure 1 and illustrating the use of a single shot survey instrument and the manner in which it is to be associated with the drill stem and with the core taking structure of Figure 1 after a core is drilled;

Figures 3 and 4 are longitudinal cross sectional views showing details of the single shot survey instrument which is employed as part of the apparatus shown in Figure 2;

Figure 5 is a cross sectional view taken on the line 5—5 of Figure 1, showing details of the core catcher;

Figure 6 is a cross sectional view taken on the line 6—6 of Figure 2, showing the cooperating orienting legs between the instrument and its barrel;

Figure 7 is a view of a disc of sensitized paper which has been used in the survey instrument and upon which data is recorded;

Figure 8 is a sectional view similar to Figure 2, but showing how a different survey instrument to obtain drift or inclination data only can be employed with the core drilling structure shown in Figure 1;

Figure 9 is a longitudinal sectional view showing details of the instrument employed in Figure 8; and

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Figure 10 is a view of a sensitized disc which has been used in the survey instrument shown in Figure 9.

Referring to the drawings in detail and first to Figures 1 to 6, inclusive, wherein is shown apparatus for taking a core and obtaining recorded data in connection therewith by the use of a single shot survey instrument so that the core can be oriented when removed and wherein, by the use of such apparatus, the steps of my improved method can be carried out. The well bore which has been drilled into the earth's crust is indicated by the numeral 10 and within this bore is the drill pipe or stem, generally indicated by the numeral 11. On the lower end of the drill pipe there is provided a barrel 12 formed by a plurality of tubular sections 13 connected together by internal and external threads on adjacent ends thereof. The length of the barrel 12 will be long enough to receive the length of core which is desired to be drilled, such core sometimes being as long as sixty or more feet. This barrel 12, at its upper end, is screw connected with a sub 14 and to this sub is connected by a thread joint 15 a special drill collar 16 of non-magnetic material such as K-Monel metal, or any other suitable metal. Above the collar 16, but not shown, are other ordinary drill pipe sections which extend to the top of the well being drilled and are connected to be rotated by the drilling rig.

On the lower end of the barrel 12 is a core bit 17 shown as the diamond type. This bit, however, may be of any other type, such as the rotary or rock type or the drag type, constructed so as to be employable in drilling cores, as is well known practice. It will thus be seen that the core bit 17, the barrel 12, the subs 14 and 15 and the special collar 16 are all connected together as the lower part of the drill pipe so that upon any rotation of the drill pipe these parts will rotate together and result in the bit being rotated to cut a cylindrical section from the sub strata of the earth's crust at the bottom of the bore. This cylindrical section which is known as a core and is indicated by the numeral 18 will pass into the barrel 12. During the drilling of the core, cuttings will result and these cuttings will be carried away by the circulation of fluid down through the drill pipe and up the outside of the drill pipe, as is common practice. The path of circulation through the drill pipe becoming apparent from later described structure.

Within the barrel 12, which may be referred to as an outer barrel, is an inner or core receiving barrel 19. This barrel may be made up of suitable sections 20 connected together by threads to thus provide any desired length of barrel. The lower end of the core barrel 19 has threaded thereto a collar 21 having a conical outer surface at its outer end portion for cooperation with a conical inner surface 22 at the lower end of the barrel 12 to which the core bit 17 is connected. The lower end of the inner or core barrel is arranged to be held in concentric spaced relation with the outer barrel by suitable ribs 23 carried by the inner surface of the outer barrel and arranged to cooperate with the outer surface of the collar 21 as shown. Ribs 24 are also provided on the conical surface 22 for cooperation with the conical end of the collar 21 so as to maintain the two conical surfaces in spaced relation. With the various ribs employed for spacing the inner barrel from the outer barrel, a path will be provided at all times for fluid to

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circulate between the two barrels and to the drill bit to thus carry away cuttings and also dissipate heat.

The collar 21 has mounted therein a core catcher 25 in the form of a split ring. The inner surface of this split ring is arranged to be cylindrical for engaging the core 13 which is to be drilled and established a clamping action. The outer surface 26 of the core catcher is slightly conical, as shown in Figure 1, and this conical surface is arranged to cooperate with a similar conical surface 27 on the inside of the collar 21. The core catcher is permitted to have limited axial movement within the collar 21. It will thus be free to be pushed upwardly by the core as it is received in the inner barrel 19 and is caused to be expanded, since the normal diameter of the core catcher will be less than the core which is to be cut, that is, less than the diameter of the hole in the core bit. As the core moves through the core catcher, the core catcher will always yieldably grip the core. Thus, if the drill pipe should be raised and moved relatively to the core, the core catcher will also move relatively to the collar 21 and be wedged in the lower end of the collar, due to the conical surfaces 26 and 27. This wedging action will thus cause the core catcher to grip the core with additional pressure so that the core can be broken off from the earth's strata from which it is drilled.

The upper end of the inner or core barrel 19 is provided with an annular cap 28 through which projects the lower portion of a rod 29 provided with a longitudinal slot 29'. The cap has a key projection 28' engaging in slot 29' and is arranged to abut a shoulder 30 on the rod and to be held yieldably engaged therewith by means of a relatively strong spring 31. This spring is interposed between the cap and a nut 32 on the lower end of the rod which projects into the core barrel. The key and slot arrangement insures that there will be no relative rotative movement between the core barrel and rod 29. With the yieldable connection between the core barrel and the rod it will be possible for the core barrel to have relative yieldable movement in a longitudinal direction with respect to the rod so that it can move downwardly relative to the outer barrel to a limited extent and be engaged at its lower end when the outer barrel and drill stem is lifted.

The upper end of the rod 29 extends into the sub 14, already referred to and forming a part of the drill pipe. The lower end of the sub 14 has attached thereto a mounting sleeve 33 surrounding the central part of the rod and by means of which the rod 29 and the core barrel will be mounted in the drill pipe so that the drill pipe can easily rotate around the rod 29 and the core barrel during drilling of the core. Suitable bearings 34 are provided between the central part of the rod 29 and the sleeve 33 mounted in the manner shown. In order that the bearings will be sealed off from any fluid being circulated down the drill pipe to the core bit, suitable packing means 35 is provided between the lower end of the sleeve 33 and the rod below the bearings. The portion of the rod above the bearings will be sealed off from the outer surface of the sleeve 33 by a suitable sealing gasket 36. It will be noted in Figures 1 and 2 that the sleeve 33 carried by the sub 14 is spaced from the upper pipe section 13 forming the outer barrel 12 of the drill stem, and the passage 37 within the sub 14 is arranged to be connected with this space between the

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sleeve 33 and the outer barrel by drilled passages 38. Thus, fluid circulating down the drill pipe to the sub 14 can flow on down around the sleeve 33 and the inner core barrel to the core bit.

The upper end of the rod 29 is arranged to have attachably and detachably associated therewith the survey instrument whereby it will be possible to obtain information about the core which has been drilled, and from that it will be possible to determine the dip and strike of the sub-surface strata from which the core has been cut, and also other information about the hole being drilled such as, for example, the inclination thereof and its direction, if such information is not already known. The survey instrument is generally indicated by the letter S and the details thereof are shown in Figures 3 and 4. The particular instrument disclosed, by way of example in Figures 2, 4 and 5, is what is known as a single shot survey instrument. The instrument is designed so that a single "picture" only can be taken in order to obtain sufficient data with respect to inclination and direction of inclination of the well bore being drilled. From this information it will be possible to ascertain the exact position the core had in the strata when it was drilled so that the core can be reoriented when taken out of the well, and when so reoriented it can readily be ascertained what the dip and strike of the strata is from which the core was taken.

The particular survey instrument S is shown as being mounted in a special instrument barrel so it will be properly protected, and also capable of being attachable to a line for lowering down the drill stem, together with a proper connection to the rod 29 and the core barrel in which the core is received after being drilled. The instrument barrel is indicated by the numeral 39 and at the lower end thereof is attached by threads a sub 40. The lower end of this sub is cylindrical and so formed as to provide a mule shoe 41 whereby the barrel can be associated with the rod 29 in one predetermined relation only. As will be noted in Figure 1, the mule shoe has an apex 42 on one side thereof and a slot 43 on the opposite side thereof. The slot is axially spaced inwardly from the apex and the edges of the mule shoe are inclined from the apex to the slot. The upper end of the rod 29 carries a pin 44 which is arranged to be received in the slot 43 when the instrument and the barrel are lowered down the drill pipe. With the construction of the mule shoe as shown, it will be noted that upon lowering the barrel 39 the apex will always insure that the barrel will be turned so as to be guided into the slot 43.

The upper end of the barrel 39 is closed by a plug 45 and connected thereto by a so-called top sub 46 is a stabilizer 47 carrying the spear head 48 to permit a connection with a line 49 by a suitable connecting means shown as an over-shot 50. This over-shot will permit the line to be readily attached to the barrel 39 of the instrument, either when the instrument is out of the well or when the instrument is in the well.

The instrument S within the barrel 39 is arranged to be connected with the plug 45 by means of a shock absorber member 51 of any suitable construction. The lower end of the instrument S carries an aligning or orienting member or leg 52 which has a cross sectional shape similar to half of a cylindrical rod. This leg 52 cooperates with another semicylindrical orienting mem-

ber or leg 53 which is carried by the sub 40 which closes the lower end of the barrel and projects upwardly therefrom. With these orienting legs 52 and 53, it will be possible to insure that the instrument S will always be placed in the barrel in proper relation to the mule shoe carried by the lower end of the barrel 39. In other words, the legs 51 and 52 insure, when in overlapping relation, that the instrument S will be in the barrel in no other position except the proper position with respect to the slot 43 of the mule shoe which is to receive the pin 44 on the rod 29. Since the instrument can only be received in its barrel 39 in one position and the barrel 39 can only be associated with the rod 29 and the core barrel in one position, then when the instrument is placed in the well it will be known with certainty its relative position with respect to the core barrel.

It will be noted that the barrel 39 containing the instrument S is of smaller diameter than the collar 16 and the bore of the drill stem so that it can be lowered down the drill stem to its position where it is connected to rod 29 by the mule shoe. With a space surrounding the barrel 29 it will then be possible for drilling fluid to be circulated past the barrel and instrument to the sub 14 from where it can pass on down to the core drill in a manner already described.

The single shot survey instrument S shown in Figures 3 and 4 is of known construction and is shown by way of example only as one type of survey instrument which can be associated with the core taking apparatus and provide a structure whereby my improved method can be carried out. Other types of survey instruments can be employed, such as multiple shot instruments, drift indicators, etc. Briefly described, this instrument has a shell 54 made out of several sections of tubing joined together as shown. On the lower end of this shell is a cap 55 to which is attached the orienting leg 52 previously referred to. The top of the shell has a cap 58 suitably formed to provide a connection with the shock absorber 51 already referred to.

In the lower part of the shell is the angle unit A of the instrument, in the central part is the camera unit C, and in the upper part is the time control unit T. The angle unit has a compass 57 directly above which is suspended a plumb bob 58, the two being separated by a concave-convex lens. Just above the lens and out of the way of the plumb bob is a projection or lug L carried by the shell 54. This lug projects inwardly sufficiently so that it will show on the picture to be taken. Below the compass is a hollow cap 59 in which is positioned a bellows 60 providing an expansion chamber.

The camera unit C above the angle unit includes the lamps 61 to provide illumination to make an exposure on a small disc 62 of sensitized photographic paper positioned above the lamps. When exposure takes place, the image of the compass and the plumb bob will be thrown upon the sensitized paper of the disc through the small opening 65 having a lens 64 associated therewith, as is well known in photography. When the disc is developed it will correspond to the one shown in Figure 7, by way of example. It will be noted that the compass is shown and also the image of the plumb bob. Circles on the disc indicate the number of degrees of inclination. The disc 62 is arranged to be held between one end of a sleeve 65 and a plate 66 suitably attached to the instrument shell. A loading check

is provided for the disc and this comprises a spring pressed cup-shaped member 67 slidable in the shell. A spring 68 normally biases this member to a position where the loading slot 69 for the disc in the shell is covered. To open the loading slot, the loading check is pressed downwardly so as to bring a slot 70 in the cup-shaped member 67 into alignment with the loading slot. The loading check is reached for operation through a suitable hole 72 in the instrument shell 54. A source of electricity to illuminate the lights is provided by batteries 73 mounted in the shell above the camera and below the time control unit T. A conductor 74 leads from these batteries to the lights and the circuit is completed by way of the shell.

The time control unit T comprises a watch mechanism 75 and switch control mechanism 76 controlled by the watch mechanism. The switch mechanism is electrically connected to the center post of one battery by a contact element 77 and to the shell by a conductor 78. The time of operation of the watch mechanism controls the closing of the switch mechanism to complete the electrical circuit to light the lamp. The setting of the watch mechanism is accomplished by a stem 79 and a dial 80 will give the indication of the time setting.

Operation

In taking a core by the apparatus described and obtaining recorded data with respect to the said core by the survey instrument shown as a single shot instrument for taking a picture of plumb bob and compass, the lower end of the drill pipe will be made up in the manner disclosed in Figures 1 and 2. The non-magnetic collar 16 will be attached to the lower section of the drill pipe and below it will be attached the sub 14, the outer barrel 12, the core bit 17 and all the structure within the outer barrel, including the core barrel and the rod 29. The drill pipe will then be run into the bore of the well to the bottom thereof in the usual manner by attaching drill pipe sections and lowering the pipe as each section is added. The drill pipe will then be rotated in the usual manner to drill the core 18. Any length of core can be drilled, depending, of course, upon the length of the core barrel for receiving the core. As the core is drilled it will be received in the core barrel through the core catcher 25, thereby expanding the split ring of the core catcher, it being noted that the core catcher is capable of moving upwardly slightly with the core until it abuts against the end of the lower section 20 of the core barrel. After any desired length of core has been cut, the turning of the drill pipe will be stopped and twisting strain will then be taken off the entire length of the drill pipe.

Before other operations are now performed, it is preferable to ascertain that the lower end of the core which has been cut, and particularly that portion of the core from the core catcher to the earth's strata engaged by the core drill, is still integral with the strata. Of course, during taking of the core, some of the core may become detached or broken off, but this part of the core will be in the core barrel and be continuously moved relatively up the core barrel by additional core which is being cut. As long as the core at the core bit remains integral with the strata at the bottom of the bore, the core barrel will have no rotation with the drill pipe and the core bit since it has already been noted that the core barrel and the rod 29 at the top thereof are

mounted in the drill stem by means of the bearings 34 so that the drill pipe can rotate around the rod 29 and the core barrel. To ascertain as to whether the bottom of the core which has been cut is still integral, the drill pipe is lifted slightly. When this is done the bottom of the outer barrel just above the core bit will pick up the core barrel and by means of the core catcher a lifting force will be applied to the core. A driller will readily know whether the core 18 is integral or not by the recorded weight of the drill stem. When a lifting force is placed on the drill pipe, there will be a yielding resistance present, if the core is integral, due to the relatively strong spring 31 between the top of the core barrel and the drill pipe. When there is yielding resistance it will clearly indicate that the core is integral.

If it has been detected that the core is still integrally attached, it can now be broken off from the earth's strata from which it has been drilled. This will be accomplished by placing additional lifting force on the drill pipe without any twisting forces being present. However, if it is discovered that the core is not integrally attached, then the drill pipe will be lowered and again rotated so that additional core can be cut by the rotation of the core bit. After sufficient core has been cut so that it is known that a portion of the core newly cut is in the core catcher, twisting strain is again taken off the drill pipe and the drill pipe again lifted to make a test as to whether the core just cut is integrally attached and, if so, the core can then be broken off.

After the core has been broken off, the core will retain its exact bearing position it had prior to the breaking off since twisting strain will be off the drill pipe and, therefore, no turning of the core about its axis will occur to change its bearing position. The core is now known to be in condition so that recorded data with respect thereto can be obtained and this will be accomplished by the use of a survey instrument, shown by way of example in Figures 2, 3 and 4 as a single shot survey instrument for taking a picture and obtaining data with respect to the amount of inclination and direction of inclination of the axis of the core. The survey instrument may be lowered into the drill pipe, either by means of the line 49 connected therewith by the over-shot or it can be dropped in without a line. During lowering of the instrument the stabilizer 47 will act to keep the barrel containing the instrument in proper position as it passes down the inside of the drill pipe. This stabilizer, in the event that the barrel containing the instrument is dropped into the well, will act as a brake. It will not only have a dragging action on the walls of the drill pipe, but will also establish a frictional resistance by its movement through fluid which is in the drill pipe, this fluid being employed during cutting of the core, as is well known practice.

Before the instrument is placed in its barrel and the instrument and barrel prepared for taking a picture, the watch of the instrument will be set so that the instrument will operate, that is, take its picture at a particular time. The time setting of the instrument will be such as to give sufficient time for lowering of the instrument to the bottom of the well. The set time of course will vary according to the depth of the well bore and also how much time is desired to elapse from the time the instrument is in its proper position at the bottom of the well and the time at which the picture is taken. When the time setting of the instrument is made, the instrument will also

be charged with the undeveloped photographic disc 62, this charging operation being accomplished in a manner already described. When the set and charged instrument is placed in the barrel 39, it can only assume one predetermined position with respect to the barrel because of the orienting legs 52 and 53.

When the barrel containing the instrument reaches the bottom of the drill stem at the sub 14, the apex 42 on the mule shoe attached to the bottom of the instrument barrel and the inclined surfaces on each side thereof leading to the slot 43 will insure that the mule shoe will cause the barrel to assume a predetermined position with respect to the rod 29 and the core barrel containing the cut core. As the mule shoe moves down over the upper end of the rod 29 the instrument barrel and the instrument will take the position as determined by the pin 44 being received in the slot 43.

With the instrument now in a predetermined position with respect to the core barrel and the core therein, the instrument will function to take its picture whenever the set time has elapsed. When the picture is taken there will be a recording on the sensitized paper of the disc which has circles thereon indicating degrees. Recorded on the disc will be a picture of the compass showing the position of the needle indicating magnetic north, also a picture of the plumb bob and also a picture of the lug L.

After it is known that the instrument has operated to take its picture, the instrument can be immediately removed from the bottom of the drill pipe. If the instrument had been run in by a line, then to remove the instrument it will be necessary to only pull up on the line. However, if the barrel containing the instrument had been dropped into the drill pipe without the use of a line, then the barrel and its instrument is retrieved by dropping in a line having the over-shot 50 thereon. This over-shot, when it reaches the spear head 48, will slide over the spear head and engage it so that the instrument and its barrel can be pulled out of the drill pipe. When the barrel containing the instrument is at the surface, the instrument can be removed from the barrel and the disc unloaded from the instrument and placed in a suitable developing solution to develop the picture, as is well known practice. The developed disc will then appear as shown in Figure 7. It will have thereon the picture of the compass and an image of the plumb bob indicated at P. Also, a picture of the lug L will be taken to show the relationship of the compass and the core in the core barrel when the picture is taken. The picture of lug L is indicated at L' in Figure 7. The relationship of the lug L and the core is predetermined since lug L is on the instrument, and the instrument is connected to the core barrel in a single predetermined manner by the mule shoe and rod 29. The position of the core in the core barrel is known by markings or the scribe.

After the barrel containing the instrument has been removed from the drill pipe, the drill pipe can be removed from the well bore. When the core barrel section is brought to the top of the well and before the core is removed, the core will be given a scoring or scratch which will preferably be made in alignment with the pin 44. Of course it is possible to mark the core during the time it is cut by providing a marker or scribe on the inside of the core

catcher such as the one shown as X in Figure 1, as is well known practice. In place of a scratch produced by a special marker, any scratching can be used which is already on a core. The core catcher in the particular structure shown is a split ring and generally one of the ends of the ring, or both ends, will produce a suitable scratch mark which can be used as a reference point to know exactly what position the core had in the core barrel. After the core has been marked, or it is known that it is already marked either by the core ring or scriber X, it can be removed from the core barrel so as to be oriented, that is, placed in a position it had in the earth's strata from which it was cut. This orienting or reorienting of the core can be accomplished by any suitable means, as for example, by use of a core reader. The core will be placed in this reader and since it is known from the picture which has been developed that the axis of the core has a certain degree of inclination (shown by the image P of the plumb bob), a certain direction (shown by the compass picture with image P on the disc), and also the relation of the compass reading and the core at the time the picture was taken (shown by lug mark L' on picture), no problem is involved in orienting the core. After the core has been oriented it can then be ascertained what the dip and strike is and the direction of the dip of the strata from which the core has been cut.

From the foregoing description of cutting the core and obtaining recorded data with respect thereto, it will be particularly noted that it is not necessary to have the instruments in the drill stem at any time during cutting of the core. The instrument can be placed in the drill pipe after the core has been cut, thus the instrument will not be subject to any pounding or vibrations during any of the core cutting operation which might easily damage the delicate parts of the instrument and thus make the data obtained from its operation inaccurate or unreliable. Furthermore, by having the instrument at the bottom of the drill pipe for only a short period of time, there is little possibility of any excessive heat which is present, particularly in deep wells, injuring or damaging the instrument and affecting its accuracy.

It is also to be particularly noted in employing the apparatus and method of cutting a core and obtaining data with respect to the core and the earth's formation, that it is positively known before any picture is taken that the core which has been drilled is in the same position which it had in the strata from which it was cut. No data is recorded until it is ascertained that the cut core is integral. In prior methods and apparatus for taking cores and obtaining recorded data with respect thereto, and particularly those in which a long time setting of the instrument is used and the instrument is placed in the drill pipe prior to the drill stem being placed in the well bore, or in which the instrument is attached to a retractible core barrel (both requiring that the instrument be at the bottom of the bore during the entire period of taking the core) it will not be known with accuracy at the time of taking the picture that the core has the same bearings it had in the strata from which it was drilled. In such prior methods of obtaining data with respect to the core, the instrument will operate when the set time has elapsed. There is no way

to know with certainty that the core has not moved out of its position at the time the picture is taken. Thus, if a core is being drilled in crumbling strata, the core may be broken up and consequently the picture taken is of no value and the whole process has to be repeated. This is all time consuming and increases the cost of drilling the well. Of course, it might be known that the core is broken off, but there is no way to stop the taking of the picture so that additional time would be available to drill additional core. All of these undesirable features of prior methods carried out by other core taking apparatus are eliminated by applicant's invention. With applicant's invention any length of core up to a maximum of say sixty or seventy feet can be taken, and various pictures can be obtained at different times during the taking of this core. For example, if a sixty foot core were taken, a picture could be obtained when the first part of the core was drilled; another picture could be taken after the core was drilled twenty feet, and another picture taken after the core had been completely drilled. To take these pictures, all that needs to be done is take the torsional strain off the drill pipe, check to ascertain if the core is still integral and then take the picture. After each picture the instrument can be removed from the drill stem, the disc taken out, a new disc loaded and the instrument timing reset, then lowered into the well again when it is desired to take the next picture. This procedure could not be done with any other apparatus known to applicant. If a retractible core barrel, together with a survey instrument were employed, it would be necessary to remove the core barrel, together with the instrument, each time that a picture was taken.

In describing the steps involved in using the apparatus to take a core and obtain recorded data with respect thereto, these steps have been indicated in their preferred order of sequence so that the instrument can be used after the core is cut. Although it is desirable that the instrument be run after the core has been cut, it might, in some instances, be best to locate the instrument before core cutting or during cutting, notwithstanding the disadvantages of having the instrument in position during cutting. The structure described permits such locating of the instrument when found desirable. When the instrument is placed before cutting, sufficient time setting would have to be allowed so that a long enough core could be cut in order that this core could be picked up by the core catcher. When the instrument is put in after cutting part of the desired core, then the time setting of the instrument should take into account the time desired to finish drilling the core. This particular way of carrying out the method may be desirable when it is necessary to disconnect the "kelly" to put in the strumment.

It is also not necessary that the core, which has been cut, be broken off from the strata before the instrument is placed in the drill pipe and the picture is taken. It is, however, necessary, before any picture be taken, to be positive that the core is integral and that torsional strain is off the drill pipe at the time a picture is made. When the apparatus is employed and the method is carried out it will only be necessary to obtain one picture as the data recorded will be reliable if the instrument operates prop-

erly. There will be no necessity for taking a second picture to recheck a previously taken picture as the bearings of the core will be known to be accurate, due to the fact that the torsional strain is off the drill pipe so as to cause no change of the bearings of the core prior to taking the picture.

Use of core taking apparatus with drift indicating instrument

In Figures 8, 9 and 10 there is shown apparatus whereby a different survey instrument can be used to obtain recorded information with respect to the core which has been cut and placed in the core barrel. The instrument shown to be employed is a drift indicating instrument or what is also known as a "bottom hole orientation instrument." When such an instrument is used, the only data which will be obtained will be the inclination or drift of the hole. This instrument will primarily be used only when the direction of inclination of the well bore or core which is cut is already known, or it is not desired to know the direction of the inclination.

In making up the drill pipe to use a drift indicating instrument, it will not be necessary to employ any non-magnetic collar such as the K-Monel collar 16 shown in Figure 2. These non-magnetic collars are not standard equipment and must be rented. Therefore, if the information desired can be obtained without the rental expense for one of these collars, it is seen that the cost in obtaining the desired information will be considerably less than would be if it were necessary to employ such a collar.

The lower end of the drill pipe including the outer barrel, the core barrel, the core bit and the mounting of the core barrel in the outer barrel for permitting the outer barrel to rotate relatively to the core bit will all be the same as the structure shown in Figure 1. The sub 14, to which the outer barrel 12 is attached, will also be retained and this sub is shown in Figure 8. The collar 16 of non-magnetic material will be eliminated. The lower end of the drill pipe 11 will be directly connected with the sub 14. The rod 29, which was used to mount the upper end of the core barrel in the outer barrel 12, will be replaced with a somewhat similar rod 29' which will be arranged to extend into the bore of the sub 14. The upper end of rod 29' has a threaded hole 81 for attaching a cup-shaped member 82 having on its lower end a threaded projection 83 for screwing into the threaded hole 81. The cup-shaped member is provided with holes 84 so that circulation of fluid will be permitted from the drill pipe into the holes 38 of the sub and then down to the core bit in a manner already described and shown in Figure 1.

The upper part of the cup-shaped member 82 is provided with two permanent magnets 85 and 86 which are diametrically arranged in the wall of the cup-shaped member to thereby provide a magnetic field which is arranged to act on a rotating disc of the drift indicator in a manner which will become apparent. The cup-shaped member, at the center of its bottom wall, is formed with an upstanding prong 87, the purpose of which will also become apparent.

The drift indicating instrument of known construction, shown by way of example, which is to be used with the made up drill pipe structure shown in Figure 8 is generally indicated by the letter D and is shown in some detail in Figure 9. The instrument is arranged to be enclosed within

a barrel 88. The upper end of this barrel is closed by a plug 89 and connected in between this plug and the instrument is a shock absorbing spring 90. The plug 89, as shown in Figure 8, has attached thereto the stabilizer 91. The upper end of this stabilizer carries a spearhead 92 to which can be connected a line 93 by means of an overshot 94. The lower end of the barrel carries a lead disc 95 for engagement with the prong 87 projecting upwardly from the cup-shaped member 82 having the diametrically positioned permanent magnets. The purpose of this disc is to give an indication that the barrel and the instrument contained therein were in a proper position at the time the instrument operated. It will be seen that when the barrel containing the instrument is dropped down the drill pipe, the bottom of the barrel and its lead disc will engage the prong and since the lead is soft metal, the prong will make an impression therein and when such impression is made it will be known that the instrument contained in the barrel has assumed a sufficiently low position in the drill stem as to be in proper position with respect to the permanent magnets. Thus, after the instrument is withdrawn from the drill pipe, there will be positive proof by the marking on the lead disc that the instrument was in a proper position at the time it operated.

The drift indicating instrument D, as shown in Figure 9, has at its lower end a magnetic position indicator M, an angle unit U directly above said magnetic position indicator, a battery section and a time control unit C. All of the units, except the magnetic position indicator, are enclosed within a shell 96 made up from various sections.

The magnetic position indicator M comprises a cylindrical member 97 having its upper end threaded into the lower section of the shell 96. In this cylindrical member is a magnetic rotor 98 having a shaft 99 freely journaled in the axis of the cylindrical member by means of a jewel bearing 100. A screw 101 holds the rotor and its shaft in position. The lower end of the shaft has point bearing on a member 102, yieldably held in position by a plug 103 and an interposed spring 104. The magnetic rotor carries a cylindrical portion 105 to form with the magnetic rotor a cup into which a record disc 106, made of sensitized photographic paper, can be positioned. This disc is so held in the cup that it can move relative to the cup. This record disc is shown in Figure 10 in a condition after use in the instrument. The dot *d* thereon is the recorded data. The concentric lines are to indicate degrees of inclination.

The angle unit U above the magnetic position indicator comprises a plumb bob 107 suitably mounted at its upper end by a universal connection 108 with the section 109 of the shell 96. Because of the universal connection of the plumb bob, it will be free to swing in any direction. The plumb bob also carries at its lower end a lens 110 and at its upper end at the universal connection is a second lens 111. The section 109 above the plumb bob, to which it is universally connected, carries a lamp 112 and this lamp is arranged to be connected to one terminal of the battery 113.

The time control unit at the upper end of the shell is composed of a watch 114 and a switch 115 arranged to be closed by the functioning of the watch after a predetermined set time period has elapsed. The details of the watch and the

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switch are not disclosed as they are well known structures. It is to be noted, however, that one terminal of the switch will be connected with the shell 96 and the other terminal will be connected with the rear end of the battery. Thus, when the switch is closed, a circuit can be established from the battery to the lamp and from the lamp to the shell and back to the switch. To set the watch for any desired time, a setting stem 116 is provided. The upper end of the shell above the stem is closed by a cover 117 and to this cover will be connected the shock absorbing spring 90 already referred to.

Operation of the apparatus using a drift indicator survey instrument

When it is desired to use the drift indicating instrument to obtain recorded data, which data will only be the inclination of the axis of the core which is being drilled in the strata, the drill pipe will be made up with the sub 14 only therein between the core barrel and the usual pipe sections of the drill pipe. The core barrel with rod 29' and the member 82 connected thereto will provide in the drill pipe the two diametrically permanent magnets 35 and 36 which will always have a single predetermined relation to the core barrel. The core will be drilled to any desired length by rotating the drill pipe and when the desired amount of core has been drilled, torsional strain will be taken off the drill pipe and the drill pipe lifted to ascertain if the core is integral. If it is found to be integral, it may or may not be broken off, as desired. Next the barrel containing the drift indicating instrument D will be lowered into the drill pipe by means of the line 93 or dropped in without the line. This is done after the instrument has been time set and loaded. Regardless of how the instrument will be placed in the drill stem, it will assume its lowermost position where the lead disc on the bottom of the barrel will engage the prong 87 projecting upwardly into the cup-shaped member 82 carrying the permanent magnets. This will place the lower end of the instrument so that the magnetic rotor of the magnetic position indicator will be opposite the permanent magnets 35 and 36. The magnetic rotor, being free to rotate about its axis, will be pulled into the azimuth of the two permanent magnets, thus becoming properly positioned between them. The time setting of the instrument is made so that sufficient time will be allowed for the instrument to become placed in the drill pipe. When the instrument is caused to operate by the elapse of the set time, the light will be illuminated and the rays therefrom will pass through the two lenses 110 and 111 and cause the dot *d* (Figure 10) to be made on the sensitized disc. The position of this dot will indicate on the disc the angle of the plumb bob since the lenses are carried thereby. The disc with the properly spaced concentric circles corresponding to degrees will then provide the record for inclination.

After the instrument has been caused to operate, the barrel and the instrument contained therein will be removed from the drill pipe. If the instrument has been lowered by a line, all that will need to be done is raise it by the line. If the instrument has been dropped in, the line can be run in and the overshot on the end thereof connected with the spearhead to thereby connect the barrel and the instrument therein with the line so that it can be pulled out. After the in-

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strument has been pulled out, the drill pipe can be removed section by section and the core removed from the core barrel. Before removing the core from the core barrel, a scratch line can be placed on its surface, if a line is not already present due to the use of a special scribing element or produced by an end edge of the core catcher. Any line on the core will have a definite relationship with the rod 29' and the permanent magnets which are connected therewith by means of the cup-shaped member 82.

After the barrel and instrument contained therein are removed, the magnetic position indicator M can be unscrewed and placed in a suitable surface reader, which reader will have a pair of diametrically positioned permanent magnets corresponding to those carried by the cup-shaped member 82. This surface reader is a well known apparatus. With the two magnets of the reader, the sensitized disc will assume a position identical with the position it had with respect to the permanent magnets 35 and 36 in the cup-shaped member 82 when it was in the drill pipe and the drift indicating mechanism was operated to produce the dot *d* on the sensitized disc. The dot will indicate the low side of the hole or the low side of the core. Because of any scribe marked on the core, the relationship of the core with respect to the permanent magnets will be known and, consequently, it will be known from this data the position of the core with respect to the low side of the well bore at the time that the picture was taken. With this data, the core can be easily oriented since, as already noted, the direction of inclination was known prior to the obtaining of data by the drift indicator. By orienting the core, the dip and strike of the formation will then become known.

It will be noted that when the drift indicator is used with the core taking structure including the core barrel, there will be a known relationship between the instrument and the core barrel at the time the picture is taken. Since the permanent magnets which are connected to the core barrel result in the disc carried by the magnetic position indicator assuming a predetermined position with respect to the permanent magnets at the time that the picture is taken, it will then be known what relationship there is between the picture which is to be taken and the core. In using the drift indicator it will not have to be placed in the bore of the well to record data until after a core is drilled, in the same manner as in using the single shot instrument S shown in Figures 1 and 2. Thus, the drift indicator instrument will also not be subjected to vibrations and pounding present during core cutting. Further, it need not be in the well bore for any long period of time so as to be adversely affected by heat in the bottom of the well bore.

From the foregoing description of the apparatus and method of taking a core and obtaining recording data with respect thereto, it is seen that various types of survey instruments can be employed. Two are shown by way of example and others can be used. Regardless of the type of survey instrument it is not necessary to place it in the well bore until after a core has been cut. It can, however, be placed in the bore at an earlier time. It eliminates any necessity of putting it in the bore with the drill pipe and core taking apparatus. Furthermore, regardless of the type of instrument employed, that is, one for obtaining both the degree of inclination and the direction of inclination of the core axis, or one

obtaining degree of inclination only, the picture which is to be taken will always have a single predetermined position with respect to the core and this core is always known to have the same bearings at the time the picture was taken (due to the fact the core was ascertained to be integral before the picture was taken) as the bearings it had in the earth's strata from which it was cut. When the single shot instrument S is employed to obtain data, the instrument containing the disc upon which the data is to be recorded can have only one known position with respect to the core barrel and the core therein. This is brought about by the use of the mule shoe between the instrument barrel and the rod to which the core barrel is non-rotatably connected, and further the use of the orienting legs to position the instrument in one position only in the instrument barrel. The relationship of the compass and the core, when the picture is taken, is known from the mark L' of the orienting lug on the picture. When the drift indicator is used, the permanent magnets have a predetermined position with respect to the core barrel, and thus the disc upon which the data is to be recorded assumes a predetermined position with respect to the permanent magnets and the core barrel at the time the picture is taken. Because of this relationship, when either instrument is caused to operate to record data, the orienting of the core after it is removed from the well bore can be readily accomplished so that the dip and strike and the direction of dip can be readily ascertained. The method herein described, by way of example, is carried out in taking cores from the bottom of a bore. If desired, it can be employed where side wall coring is to be done.

Being aware of the possibility of modifications in the various structures disclosed as embodying my invention and by means of which my improved method can be carried out, and further being aware that other types of instruments may be employed besides those shown and which are capable of obtaining the data desired, it is to be understood that my invention is not to be limited in any manner except in accordance with the appended claims.

What is claimed is:

1. In a method of taking a core in an earth bore being drilled and obtaining data with respect thereto which comprises providing a drill pipe with a core drill and a core receiving barrel at its lower end with respect to which the drill pipe and core bit are rotatable, both said bit and core barrel being retractable only with the drill pipe, cutting the core and allowing it to be received in the core barrel, removing torsional strain from the drill pipe, testing to insure that the drilled core in the core barrel immediately above the core bit is integral with strata which has not been drilled and then placing a survey instrument in the drill pipe above the core barrel and in a position with respect to the core barrel and the core therein that will be known and obtain thereby recorded data as to the angle of inclination of the axis of the core.

2. In a method of taking a core in an earth bore being drilled and obtaining data with respect thereto which comprises providing a drill pipe with a core drill and a core receiving barrel at its lower end with respect to which the drill pipe and core bit are rotatable, both said bit and core barrel being retractable only with the drill pipe, cutting the core, continuously marking the

same and allowing it to be received in the core barrel, testing to insure that the drilled core in the core barrel immediately above the core bit is integral with strata which has not been drilled and then placing a time controlled survey instrument in the drill pipe above the core barrel in such a position that the recording element thereof will have a known relationship with respect to the core barrel and the marked core therein to obtain while the said core immediately above the core bit remains integral recorded data as to the angle of inclination of the axis of the core.

3. In a method of taking a core in an earth bore and obtaining data with respect to the position it had in the earth's strata, said method comprising cutting a core by suitable drill pipe and drilling structure, marking the core as it is being cut, testing by a manipulation of the drill pipe to ascertain if there is a marked core integral with the earth's strata, then obtaining, while the marked integral core is unchanged as to its bearings, recorded data indicating the inclination of the axis of the core, said data being obtained by the placing in the drill pipe at a point adjacent the core drilling structure a time controlled survey instrument which will have its record member in a known relationship with the marked integral core material.

4. In a method of taking a core in an earth bore and obtaining data with respect to the position it had in the earth's strata, said method comprising cutting a core by suitable drill pipe and drilling structure, marking the core as it is being cut, testing by a manipulation of the drill pipe to ascertain if there is a marked core integral with the earth's strata, then obtaining, while the marked integral core is unchanged as to its bearings, recorded data from which the inclination of the axis of the core can be determined, said data being obtained by the placing in the drill pipe at a point adjacent the core drilling structure a time controlled survey instrument including a plumb bob, a camera and a record member to be photographed, which record member will have a known relationship with the marked integral core material at the time the survey instrument operates.

5. Apparatus for cutting a core from the bottom of an earth bore, marking same on its side in a continuous manner, and making a survey to orient the core by placing a surveying instrument in the bore after the core has been cut and it is known to have its bottom integral with the earth's strata, said apparatus comprising a drill pipe having coupled sections, a core bit attached to and always rotatable with the lower end of the pipe and constituting the only cutting bit for the earth's strata, a core receiving barrel mounted within the pipe above the bit in a manner so the pipe and bit can rotate relatively thereto to cut a core, said bit and barrel being so mounted on the lower part of the drill pipe as to be removable from the bore only by removing the drill pipe in sections, a survey instrument comprising a unit separate from the core barrel and bit and free to be placed in the drill pipe at a position closely above the core barrel whenever desired after the drill pipe is in the bore being drilled, means carried by the barrel closely adjacent the drill bit for marking on the core as it moves into the core barrel the relative position the core had with respect to the core barrel, means carried by the barrel for grasping the cut core and testing its integral condition with the strata by a raising of

the drill pipe and bit by a movement relative to the core barrel and then a subsequent movement of said core barrel therewith, and cooperating means associated with the core barrel and the instrument and functioning only when the instrument is placed in the drill stem and allowed to assume its position above the core barrel for knowing with certainty the relative position between the instrument and the core barrel, said instrument when in said last named position having no connection with the drill pipe and being capable of being freely withdrawn from the bore without withdrawing the drill pipe, drill bit or core barrel.

6. Apparatus for cutting a core from the bottom of an earth bore, marking same on its side in a continuous manner, and making a survey to orient the core by placing a surveying instrument in the bore after the core has been cut and it is known to have its bottom still integral with the earth's strata, said apparatus comprising a sectional drill pipe, a core bit attached to and always rotatable with the lower end of the pipe and constituting the only cutting bit for the earth's strata, a core receiving barrel mounted within the pipe above the bit in a manner so the pipe and bit can rotate relatively thereto to cut a core, said bit and barrel being so mounted on the lower part of the drill pipe as to be removable from the bore only by removing the drill pipe in sections, a survey instrument comprising a unit separate from the core barrel and bit and free to be placed in the drill pipe at a position closely above the core barrel whenever desired after the drill pipe is in the bore being drilled, said survey instrument having a recording element and time controlled means for making a record thereon of the inclination of the bore axis where the core is to be cut, means carried by the barrel closely adjacent the drill bit for scribing a mark on the length of the core moving past the scribing means into the core barrel and indicating the relative position the core had with respect to the core barrel, means carried by the barrel for grasping the cut core and testing its integral condition with the strata by a raising of the drill pipe and bit by a movement relative to the core barrel and then a subsequent movement of said core barrel therewith, and means carried by the core barrel and the instrument and functioning only when the instrument is placed in the drill stem and allowed to assume its position above the core barrel for causing a known predetermined relation to exist between the instrument's recording element and the core barrel, said instrument when in said last named position having no connection with the drill pipe and being capable of being freely

withdrawn from the bore without withdrawing the drill pipe, drill bit or core barrel.

7. Apparatus for cutting a core from the bottom of an earth bore, marking same on its side in a continuous manner, and making a survey to orient the core by placing a surveying instrument in the bore after the core has been cut and it is known to have its bottom still integral with the earth's strata, said apparatus comprising a sectional drill pipe, a core bit attached to and always rotatable with the lower end of the pipe and constituting the only cutting bit for the earth's strata, a core receiving barrel mounted within the pipe above the bit in a manner so the pipe and bit can rotate relatively thereto to cut a core, said bit and barrel being so mounted on the lower part of the drill pipe as to be removable from the bore only by removing the drill pipe in sections, a survey instrument comprising a unit separate from the core barrel and bit and free to be placed in the drill pipe at a position closely above the core barrel whenever desired after the drill pipe is in the bore being drilled, said survey instrument having a recording element means carried by the barrel closely adjacent the drill bit for scribing a mark on the length of the core moving into the core barrel the relative position the core had with respect to the core barrel, means carried by the barrel for grasping the cut core and testing its integral condition with the strata by a raising of the drill pipe and bit by a movement relative to the core barrel and then a subsequent movement of said core barrel therewith, and cooperating magnetic means including polarized elements associated with the core barrel and the instrument and functioning only when the instrument is placed in the drill stem and allowed to assume its position above the core barrel for placing the recording element of the instrument in a predetermined position with respect to the core barrel, said instrument when in said last named position having no connection with the drill pipe and being capable of being freely withdrawn from the bore without withdrawing the drill pipe, drill bit or core barrel.

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