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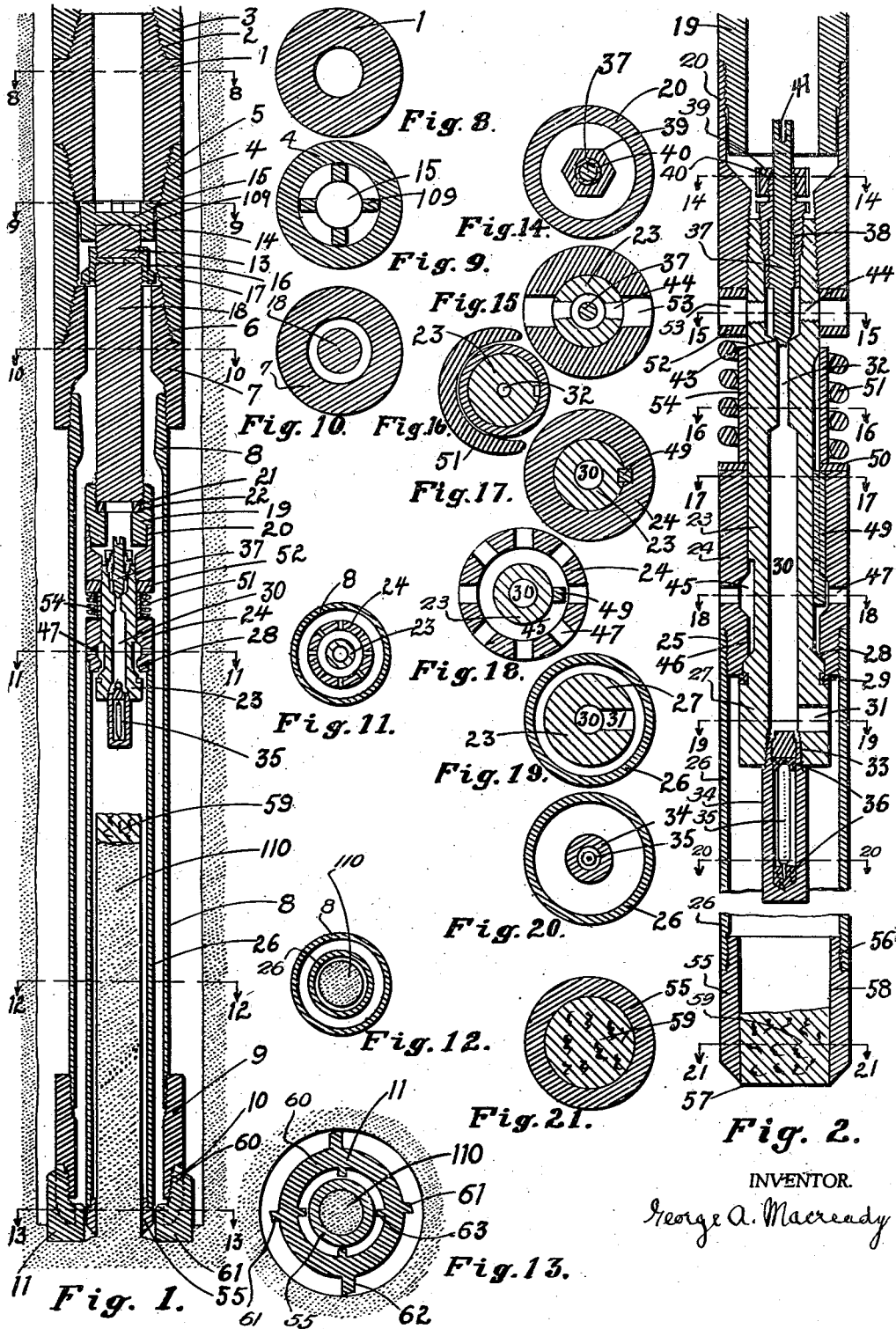
G. A. MACREADY

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PROCESS AND APPARATUS FOR PRESSURE CORE DRILLING

Filed Nov. 21, 1941

2 Sheets-Sheet 1



INVENTOR.
George A. Macready

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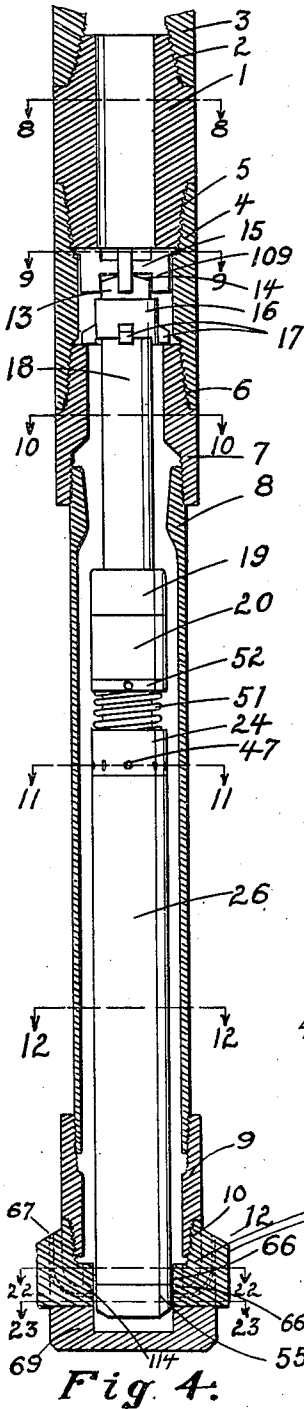
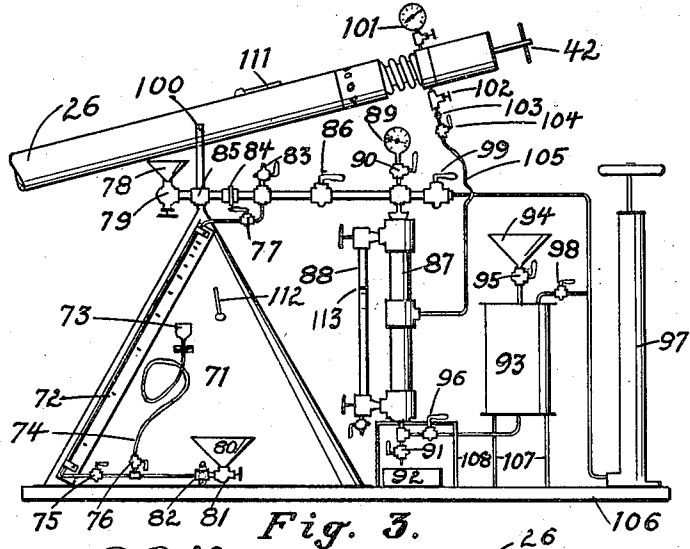
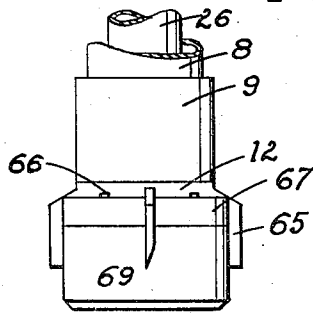
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UNITED STATES PATENT OFFICE

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PROCESS AND APPARATUS FOR PRESSURE
CORE DRILLING

George A. Macready, Los Angeles 43, Calif.

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6 Claims. (Cl. 255-1.4)

My invention relates to a method and apparatus for obtaining core drill samples from bore holes and bringing them to the surface sealed against loss of pressure so that the liquid and gaseous substances contained in the pores or interstices of the formation sampled are recovered for inspection.

An object of my invention is a process and apparatus for preventing contamination of the fluids originally contained in the formation sampled by the mud laden circulation fluid used for drilling the well.

Another object of my invention is a process and apparatus by which liquid and gaseous substances contained in the pores and interstices of the formation sampled can be brought to the surface with the core and quantitatively measured and analyzed.

Another object is a simple apparatus by which the core barrel can be closed or sealed after completing a core so that fluid cannot escape from the barrel while it is being raised to the lower pressure at the top of the well.

Another object is a simple process by which the mud laden circulation fluid used in drilling the well is prevented from coming in contact with the core or the bottom of the well to contaminate the sample.

Frequently the purpose of drilling wells is to discover or to produce liquid and gaseous substances, such as petroleum and natural gas, which occur in the interstices or pore spaces of the rock formations.

In the art of drilling wells it has been good practice for many years to take core samples of formation to ascertain the type of formation encountered during drilling.

But in ordinary coring practice fluids expand and exude from the core as it ascends to the lower pressure at the top of a well so that the sample is of spent formation with the pay fluids lost.

In order to take a more truly representative core I provide a core drill in which the tube containing the core is sealed before it leaves the bottom of the well and is brought to the surface with the fluid still contained within the tube under pressure. I further provide a measuring process and apparatus by which the pressure and quantity of gas brought up with the core can be quantitatively measured. By chemical analysis the quantity of petroleum in the core can also be determined. Since the gas is usually in solution in the petroleum as a homogenous liquid underground the data obtained gives an accurate de-

termination of the gas-oil ratio of the formation.

Another objectionable accompaniment of rotary core drilling is caused by the use of mud laden circulation fluid under higher hydrostatic pressure than the formation pressure. The mud from this fluid forms a cake or plaster on the side wall of a well which prevents caving and excessive loss of circulation fluid into the formation. But on the very bottom of the well the rotating bit continuously scrapes off the mud cake so that circulation fluid is free to percolate into the formation, particularly if the formation is porous and permeable. The result is that in permeable formations the circulation fluid acts as a water flushing drive to push through the interstices of the formation such fluids as would subsequently be produced. The extent of this drive is not sufficient to impair subsequent production but it is sufficient to contaminate the formation directly in the path of the drill so that core drill samples are contaminated before entering the core tube by displacement of original formation fluid with circulation fluid.

In order to obtain an even more representative core sample than my samples in the preceding paragraphs, although at greater expense, I provide a novel process for separating the circulating fluid from contact with the bottom of the well and also from the core within the core receiving tube. To do this I employ a pool of molten alloy on the bottom of the well as a barrier between the circulation fluid and the formation, and I prime the core receiving tube with glycerine or other distinguishable liquid as a barrier between the core and the circulation fluid. The core is taken under pressure as previously mentioned.

As a result of my new process circulation fluid cannot penetrate ahead of the drill to contaminate the formation, and neither can it enter the core receiving tube to contaminate the core. Chemically glycerine is distinct and not miscible with gas or petroleum. It is chemically distinct although miscible with water. The percentage of glycerine in the mixture can be determined by its specific gravity, glycerine being heavier than water.

With the foregoing and other objects in view which will be made manifest in the following detailed description and especially pointed out in the appended claims, reference is had to the accompanying drawings on which similar numerals refer to similar parts throughout the several views, for illustrative embodiment of my invention wherein:

Figure 1 is a longitudinal section of one form of my core drill, illustrated as in a well, for recovering the core under pressure but in which there is no provision for maintaining a pool of molten metal on the bottom of the well,

Figure 2 is a longitudinal section of the inner core tube on larger scale to show in more detail the construction of the valves and inner core shoe,

Figure 3 is an elevational view of the inner core tube with the apparatus that I provide for measuring the pressure and quantity of gas recovered with a core,

Figure 4 is a longitudinal section of a modification of the drill shown by Figure 1 but with the inner barrel shown in elevation and with the additional provision for maintaining a pool of molten metal on the bottom of the well during coring, this section being on plane 4—4 of Figures 22 and 23,

Figure 5 is an elevation of the bit shown in Figure 4 for providing the pool of molten metal,

Figure 6 is a longitudinal section of the same bit as shown in Figure 4 but taken in plane 8—8 of Figures 22 and 23,

Figure 7 is a longitudinal section of the bit shown in Figure 6 along the same plane but shown to illustrate the position of the molten metal during coring,

Figure 8 is a cross section of my core drill at plane 8—8 of Figures 1 and 4,

Figure 9 is a section at plane 9—9 of Figures 1 and 4,

Figure 10 is a section at plane 10—10 of Figures 1 and 4,

Figure 11 is a section at plane 11—11 of Figures 1 and 4,

Figure 12 is a section at plane 12—12 of Figure 1,

Figure 13 is a section at plane 13—13 of Figure 1,

Figure 14 is a section at plane 14—14 of Figure 2,

Figure 15 is a section at plane 15—15 of Figure 2,

Figure 16 is a section at plane 16—16 of Figure 2,

Figure 17 is a section at plane 17—17 of Figure 2,

Figure 18 is a section at plane 18—18 of Figure 2,

Figure 19 is a section at plane 19—19 of Figure 2,

Figure 20 is a section at plane 20—20 of Figure 2,

Figure 21 is a section at plane 21—21 of Figure 2,

Figure 22 is a section at plane 22—22 of Figure 4 through the inner core tube and the bit with meltable metal attached, and

Figure 23 is a section at plane 23—23 of Figure 4 through the inner core shoe, bit blades, and meltable metal of the modification shown in Figure 22.

Referring to the drawings, my apparatus consists of the rotary core drill of the swivelled inner barrel type illustrated in Figures 1 and 4, and the gas measuring apparatus shown in co-operation with the inner barrel in Figure 3. The inner barrel is provided with the valve assembly at the upper end and the inner shoe at the lower end as illustrated in Figure 2.

The outer barrel of the core drill consists of an upper sub 1 threaded as at 2 for connection to the lowest member 3 of the drill string. A cou-

pling 4 is connected as by threads 5 to sub 1 or both may be made integrally as one piece. The coupling or piece 4 is threaded as at 6 for connection to the upper end piece 7 of the outer tube 8. The lower piece 9 is threaded as at 10 for attachment of the bit 11 or 12.

The upper end of the inner barrel assembly is tipped by the thrust knob 13 which mates against the dish bearing seat 14 of thrust spider 15 so that during drilling the outer barrel is free to rotate without rotating the inner barrel and weight can be applied from the drill pipe to push the inner barrel down over the core.

Coupling 16 is provided with laterally projecting lugs 17 by which the inner barrel is suspended from piece 7 during raising and lowering of the drill. Bar coupling 18 is attached at its upper end to coupling 16 and at its lower end by coupling 19 to member 20 of the valve assembly. It is important with this type of drill that the relative lengths of outer and inner barrels be properly adjusted which is done by inserting shims 21 of selected thickness in threaded recess 22.

The valve assembly includes the central tubular spindle 23 attached at its upper end to member 20. Sleeve member 24 is slidably mounted about spindle 23 and is rigidly attached by an accurately finished pressure tight threaded joint 25 to inner core receiving tube 26.

Spindle 23 is provided at its lower end with an enlarged boss 27 which mates against valve seat 28 on sleeve member 24. A rubber or composition ring 29 in a groove seats over the annular crack of the seat to completely close same in the event grit lodges on seat 28 so that the valve can close off high pressure within core tube 26.

Spindle 23 is also provided with a central longitudinal passage 30 having a lateral port 31, a constricted portion 32, and a threaded lower end 33 for attachment of case 34 containing a maximum registering thermometer 35. Rubber, metal or composition shock absorbers 36 protect the thermometer.

At the upper end of spindle 23 is a needle valve 37 threaded into guide bonnet 38 having a stuffing box 39 with packing 40 to seal around the valve stem. The upper end of the needle valve stem has a notch or square 41 to mate a wrench 42 (Figure 3) so that the point 43 can be screwed against or away from its seat to close or open passage 32. Side outlets 44 are threaded for attachment of tubes for gauges or flow tubes.

Sleeve member 24 is provided with the valve seat 28 at its lower end and a counterbore 45 beside the constricted portion 32 of spindle 23. Lateral vent openings 47 provide for venting of liquid displaced by the incoming core into tube 26 when valve 28 is held open by drilling weight as illustrated in Figure 1.

A key way and key 48 may optionally be used to prevent relative rotation between spindle 23 and sleeve 24 which is desirable when a core is oriented under pressure. Ring 50 abuts coil compression spring 51 which urges boss 27 against seat 28 to normally close the valve. Spring 51 also abuts shim ring 52 through which are holes 53 which can be turned into alignment with outlets 44 when tubes are attached. The length of travel of spindle 23 in sleeve 24 is limited by sleeve 54 contacting between rings 50 and 52 as illustrated in Fig. 1.

Attached to the lower end of core receiving tube 26 is the inner core shoe 55. The threaded joint 56 is accurately made so as to seal against high pressures. The shoe 55 is provided with

an annular chisel edge 57 to punch and cut over the core and the bore 58 is slightly tapered to enlarge upward away from edge 57. Before taking each core a plug 59 of plaster of Paris or similar medium is cast in shoe 55 so that the inner barrel will retain the priming of glycerine or whatever other distinctive liquid is used.

Two forms of bit for the outer barrel are illustrated.

In Figures 1 and 13, bit 11 is illustrated where it is desired to recover a core under pressure with no special effort to prevent contamination of the formation below the bit. Bit 11 consists of a tubular shell 60 from which cutting blades 61 and 62 project externally and with internal guide ribs 63 for centering the inner core tube. The blades may all be of equal full gauge shape or they may be of the pilot and reamer form illustrated in which pilot blades 61 dig a short pilot hole to be reamed by reamer blades 62 of wider diameter. In this form of bit circulation fluid pumped down the drill pipe flows down the annular space between barrels 8 and 26 and discharges between guide ribs 63 against the bottom of the well where it is deflected upward to pass to the top of the well outside the drill string.

The more elaborate and expensive bit 12, illustrated in Figures 4 to 7, not only recovers a core under pressure as does bit 11 but it performs the additional function of preventing contamination of the formation fluid by circulation fluid permeating down into formation ahead of the core drill.

Bit 12 consists of a tubular shell 64 provided with blades 65 projecting externally and guide ribs 66 projecting internally similar to bit 11 but with the following additions. The four equal blade form is preferable because of space limitations.

Surrounding the shell 64 and spaced from it is a shield 67 extending from blade to blade and from the top of the blades to a central aperture closely fitting around inner shoe 55. Bracer ribs 68 between shield 67 and shell 64 prevent the shield collapsing onto the shell. The function of the shield is to prevent the stream of circulation fluid discharging against the bottom of the well and to deflect it upwardly to discharge above the bit blades. Circulation flows between shell 64 and shield 67.

A fusible alloy 69 is attached as by casting to the lower end of bit 12. The diameter of this alloy is less than that of the blades and the lower edge is beveled as illustrated in Figures 4 and 5 so that it will easily pass down the well bore. The alloy may extend completely across its lower facing leaving no central aperture through which heavy mud may be forced into and prematurely plug the inner core receiving tube 26. Space should be left to freely accommodate core shoe 55. Surface irregularities of the steel bit and rough projections or welded adhesions 70 provide for attachment of the alloy to the bit. The fusible alloy 69 may be selected from among many combinations of bismuth, lead, tin and cadmium melting between 150 and 350 degrees Fahrenheit.

After the core has been taken and brought to the surface the gas recovered with the core is measured by the apparatus illustrated in Figure 3. Briefly the gas measuring apparatus consists of a tank 71 for measuring gas at atmospheric temperature after water displacement, a separator 87 for separating gas from liquid and step-

ping down pressure, and auxiliaries 93 to 97 for preliminary flushing of air pockets out of the tube lines.

The gas measuring apparatus includes a closed inverted conical measuring tank 71 filled with water to be displaced by the gas sample. Depth of undisplaced water, or volume of gas sample is measured by a glass gauge and graduated scale 72. Pressure of the gas sample is brought to atmospheric by use of leveling bottle 73 attached to rubber hose 74. Valves 75, 76 and 77 control gauge and bottle. Funnel 78 and valve 79 provides for preliminary filling of the tank with water. Funnel 80 and valve 81 and pipe outlet 82 provide for draining the tank 71. Valve 83 provides for release of air when filling tank 71 with water and also for attachment of a sample bottle if it be desired to retain a sample of the measured gas for analysis. Union 84 is convenient for assembly. Pipe T 85 connects pipes to peak of cone tank 71.

Valve 86 separates the low pressure measuring cone tank 71 from the high pressure separator 87.

The high pressure separator or trap consists of a pipe chamber 87 to which is attached a conventional boiler gauge glass 88 through which the level of liquid in the separator trap can be observed. At the top of chamber 87 is a pressure gauge 89 controlled by valve 90. At the bottom of chamber 87 is a valve 91 for draining liquid from the chamber into a sample can 92.

Tank 93 provides an auxiliary storage supply of glycerine or other liquid and is filled through funnel 94 and valve 95. Valve 96 controls flow of liquid from tank 93 to chamber 87. Hand pump 97 provides air pressure which can be applied through valves 98 and 99 to tank 93 or chamber 87. Glycerine is very viscous and sluggish at atmospheric temperatures so air pressure is useful in speeding its flow.

A bracket 100 above cone tank 71 provides a support for core receiving tube 26 during measuring operations. Valve controlled pressure gauge 101 and valve 102 are screwed onto outlets 44 of the inner barrel. Union 103 connects valves 102 and 104 controlling tube 105 which leads to the middle of chamber 87.

The entire measuring apparatus may be mounted on a portable floor 106 with tank 93 and chamber 87 supported on legs 107 and 108. Or the small parts may be bracketed to a frame attached to the side of cone tank 71.

The field assembly of the core drill is as follows.

The plaster of Paris plug 59 is cast in shoe 55 which in turn is attached to inner barrel 26. The core tube or inner barrel 26 is supported in an inclined position with shoe 55 lowest and the upper valve assembly removed. The core tube 26 is then primed or filled with glycerine or such other distinctive liquid as is desired. Thermometer 35 is shaken down and placed in its case 34. With needle valve 43 open the valve assembly is securely attached to core tube 26 and the needle valve closed tight. The thrust bearing is then attached making the inner barrel assembly complete.

The proper bit 11 or 12 is selected and attached to the outer barrel 8 which is then set in the top of the well bore. The inner barrel assembly is then lowered into the outer barrel until lugs 17 rest on top member 7, couplings 1 and 4 are attached, and the drill pipe connected. The drill is then lowered into the well.

The circulation pumps are started and the circulation fluid brought to proper condition before the drill is lowered completely to the well bottom. When bit 12 with fusible alloy is used the drill must be lowered slowly because there is no downward jet to stir out heavy mud settlements.

During drilling the circulation fluid is pumped down through the drill pipe, passing between the fins 109 of spider 15, between lugs 17 around coupling 16, and down the annular space between outer and inner barrels to the bit. Usually the fluid used for circulation consists of water weighted with mud and frequently chemicals in suspension and solution. Occasionally an oil base mud free from water is used. After passing the bit the circulation fluid ascends between the drill pipe and the walls of the well carrying cuttings and debris to the top of the well.

Outer bit 11 or 12 is rotated on bottom to dig the well deeper and leaves a core standing between the blades. When weight is first applied from the drill pipe to the inner assembly coil spring 51 is compressed and valve 28 opened as illustrated in Figure 1. Inner shoe 55 is then pushed over the core standing between blades with edge 57 shaving the core to smaller diameter. Core tube 26 then passes down over the reduced core 110 with plaster plug 59 resting on top of the core. The glycerine, or other fluid, with which the core tube was primed is displaced by incoming core 110 and vented through valve 28 and side openings 47 into the circulation stream and lost.

Where drilling is done with bit 11 illustrated in Figure 1 it will be noted that the circulation fluid discharges against the bottom of the well. This combined with the scraping by the bit and high pressure by the circulation column prevents formation of a mud cake and permits circulation fluid to flow into the formation ahead of the drill. A core sample thus obtained is contaminated by drilling fluid. Consequently, while a pressure core with this bit determines the gas-oil ratio of the formation it does not determine the total original fluid in the formation.

When a more complete determination is desired the more expensive and elaborate bit 12 illustrated on Figures 4 to 7 may be used. When bit 12 is rotated on bottom the blunt end of the alloy 69 rubs on the bottom of the well and the heat of friction melts the fusible alloy to form a molten pool 69a on the bottom of the well extending as high as the top of shield 67 as illustrated in Figure 7. Circulation fluid instead of jetting against the bottom of the well strikes shield 67 and unable to escape between shield 67 and shoe 55 because of the close fit, which may be improved by a packing ring 114, is deflected up through the passage between shield 67 and shell 64 so that circulation fluid does not contact the formation until above the bit blades. It may be pointed out here that the passage between shell 64 and shield 67 may be a space between fabricated pieces, a hole cored in a casting, a hole drilled thru metal, or other suitable passage. Above the bit blades the mud cake is not scraped off and quickly plasters the well wall so that only an insignificant quantity of circulation fluid enters the formation and what little that does so remains above the bit.

Not only is bit 12 more expensive but selection of the proper alloy requires engineering knowledge of the well and alloys. The temperature of the formation at depth of coring should

be known or predictable. In California most well temperatures range between 100 and 250 degrees Fahrenheit. An alloy should be selected which melts a few degrees above the formation temperature. Alloys melting within ten degrees of any desired temperature can be selected from a large number of well known combinations of bismuth, lead, tin and cadmium which melt between 150 and 350 degrees Fahrenheit. The proper alloy will remain molten by friction heat of drilling. But unlike water it freezes or congeals before it can be forced an appreciable depth into the formation. Therefore it does not contaminate the formation fluid and is drilled up to remelt in the molten pool. The alloys used have a specific gravity of about 10 compared to 1 for water and 2.7 for formation cuttings. Cuttings therefore float quickly to the top of the molten pool to be picked up and carried out of the well by the circulation stream.

By raising the bit a few inches off bottom just before coring is completed a layer of molten metal flows completely over the well bottom. By quickly resuming coring before it solidifies and coring a few inches more the core recovered has a break of metal across it near bottom to completely seal the bottom plug should the last formation chance to be very permeable.

When sufficient depth has been drilled the drill string is raised. Spring 51 expands when weight is lifted from it to close valve 28 and seal the upper end of the core tube against escape of pressure. It has been found by usage that the form of inner shoe 55 breaks the core off flush with its lower edge 57 and that the lower piece of core wedges in the tapered bore 58 so tightly that it resists very high pressure and makes a simple and efficient pressure seal for the lower end of core tube 26.

The drill with its core is then pulled from the well and in ascending the external hydrostatic pressure on the core tube 26 and the temperature of the tube decrease. The decreasing temperature causes a greater contraction in the volume of the liquid within the core tube than of the metal or core so that the actual pressure within the barrel decreases.

When the drill reaches the top of the well the inner barrel assembly is removed from the outer barrel and the thrust bearing removed by unscrewing members 19 from 20. The inner core tube 26 is then placed in an inclined position in bracket 100 over the measuring apparatus as illustrated in Figure 3.

With valve 86 closed and valves 79 and 83 open the gas measuring cone tank 71 is filled with water from funnel 78 until it overflows through valve 83. Gauge glass 72 and leveling bottle 73 are also filled with water. All valves on cone tank 71 are then closed. Air pressure is applied by pump 97 to glycerine tank 93, gauge 89 is removed, and valves 90, 96 and 104 are opened. Glycerine under pressure then flows into chamber 87 and gauge glass 88 until it flows through valves 90, 91 and 104 expelling all air pockets. All valves are then closed and gauge 89 replaced. This preparation of the gas measuring apparatus can be done while the core drill is being pulled from the well with some advantage in time saving.

With the inner core tube 26 supported in bracket 100 valve 102 is attached to threaded opening 44 of the valve assembly and to union 103 as illustrated. Valve 96 is again opened to flush air pockets out of the last connection and

the valve controlled pressure gauge 101 attached. All valves are closed and the apparatus is ready to proceed with measurements as follows.

First, needle valve 37 is opened wide by turning wrench 42. The valve of pressure gauge 101 is opened and the initial pressure recorded as well as the temperature at putty covered thermometer 111.

Valves 90, 91 and 104 are next opened wide. Valve 102 is then opened and manipulated cautiously while observing the pressure on gauge 89 and the liquid level 113 in glass 88. Valve 91 is opened and closed to keep liquid level 113 visible in the glass 88 and the drainings are saved in sample can 92. Valve 102 is closed before pressure on gauge 89 reaches 100 pounds per square inch.

The moderate pressure gas sample in chamber 87 is then stepped down to atmospheric pressure into cone tank 71 by cautiously manipulating valves 86 and 81. With valves 75, 76 and 77 open the pressure in measuring cone 71 is brought to atmospheric by using leveling bottle 73. The volume of gas above and displacing water in the cone tank 71 can then be read on graduated scale of gauge glass 72.

After each batch of gas in chamber 87 has been reduced to atmospheric pressure the operation is repeated with succeeding batches until all gas that the core will yield has been reduced to atmospheric pressure.

The total volume of gas in measuring cone 71 is then read on graduated scale 72 and recorded and the temperature shown by putty covered thermometer 112 also recorded. To this is added the small volume of gas in chamber 87 which should have been calibrated. The volume of gas can be designated as sample "G" and all or part of it transferred through valve 83 to a sample bottle for subsequent analysis.

All valves are closed except 91 and 99 which are opened and air pressure from pump 97 is applied to force all liquid remaining in chamber 87 into can 92 to be saved for analysis as sample "L."

With the pressure in core tube 26 now atmospheric, valves 102 and 101 are removed and the main valve assembly cautiously detached from core tube 26. Temperature of thermometer 35 is recorded as the maximum on the core tube. All liquid surrounding the core is poured into a can and saved for analysis as sample "M."

The core is then removed from core tube 26 by usual means but preferably without use of water and saved for analysis as sample "C."

From the coring operation we now have as samples:

Sample "G" is a measured quantity of all gas yielded by the core. Its character can be determined by analysis.

Sample "L" is glycerine from chamber 87 with the addition of a small quantity of liquid from the core.

Sample "M" is liquid and chips exuded from the core and mixed with the glycerine or other fluid used for priming the core tube 26. By analysis the petroleum, water, dissolved minerals, glycerine and other substances can be determined. Sample "L" can be mixed with sample "M" to save labor. This sample represents the petroleum or water that would be yielded by reducing the formation sampled to atmospheric pressure.

Sample "C" is the solid core sample containing in its pores such petroleum and water as remains when the formation is reduced to atmospheric

pressure. Quantities can be determined by analysis. In addition tests can be made to determine what additional production might be obtained by water flushing drive.

From the foregoing it will be readily understood that I have disclosed a new and useful process and apparatus for determining the fluid content of formation and avoiding their contamination by circulation fluid.

I claim as my invention:

1. A process for preventing contamination by circulation fluid of core samples taken from bore holes which includes placing on the bottom of the well a fusible alloy having a melting point slightly higher than the temperature of the formation cored, melting said alloy by friction generated heat to form a barrier of molten metallic alloy on the bottom of the well between the circulation fluid and the formation during coring, maintaining a barrier between the core and the circulation fluid by receiving the core in a tube filled with glycerine, and closing the core receiving tube against escape of its contents while it is being lowered and raised in the bore hole.

2. An apparatus for recovering cores from bore holes under pressure consisting of an outer rotatable barrel, a rotary bit on the lower end thereof, an inner core receiving tube swiveled within said outer barrel and spaced therefrom, a thrust bearing between said outer barrel and inner tube, an annular bit on the lower end of the inner tube provided with a tapered upwardly expanding bore and an annular cutting edge at the lower end of its bore, a poppet type valve at the upper end of said tube, a compression spring urging said valve to close and compressible by weight from the drill string to open said valve and vent the tube into the space between inner tube and outer barrel, and a manually operable valve controlling a passage through the stem of the poppet valve to communicate the interior of the core receiving tube with side connection outlets.

3. An apparatus for recovering core from bore holes under pressure consisting of an outer rotatable barrel, a rotary bit on the lower end thereof, an inner core receiving tube swiveled within said outer barrel and spaced therefrom, a thrust bearing between said outer barrel and inner tube, an annular bit on the lower end of the inner tube provided with a tapered upwardly expanding bore and an annular cutting edge at the lower end of its bore, a poppet type valve at the upper end of said tube, a compression spring urging said poppet valve to close and compressible by weight from the drill string to open said valve and vent the inner tube into the annular space between inner tube and outer barrel, a manually operable valve controlling a passage through the stem of the poppet valve to communicate the interior of the inner tube with side connection outlets, said rotary bit being provided with a shield closely surrounding the annular bit and with a passage to deflect the circulation stream upwardly to the top of the rotary bit, and a supply of fusible metallic alloy attached to said bit below said shield.

4. A rotary bit to prevent contamination of well cores by circulation fluid consisting of a tubular body, cutting blades projecting longitudinally at one end to tips and laterally from said body, a shield between the body and the tips of the blades provided with a central aperture of smaller internal diameter than the internal diameter of the tubular body, and a supply of fusible metallic

alloy attached to said shield and extending longitudinally beyond the tips of said blades, said body being provided with threads at its end farthest from the blade tips and with passages for circulation fluid from intakes adjacent the central aperture of the shield to external discharges adjacent the threaded end of the body.

5. A valve for a pressure core drill consisting of a tubular spindle having an enlarged boss adjacent one end and a passage longitudinally through the spindle, a tubular sleeve mounted about said spindle and having a seat to engage said boss, a needle valve controlling the spindle passage adjacent the end farthest from the boss, a coupling attached to the needle valve end of the spindle, and a compression spring surrounding the spindle between said coupling and said sleeve urging the boss against its seat, the pas-

sage through said spindle being provided with threaded lateral outlets and with a seat for the needle valve between said outlets and said boss, and said tubular sleeve being provided with a counterbore having lateral vent ports communicating with the passage between the boss and its seat when opened and with means for attachment to the core receiving tube of a core drill.

6. An apparatus for recovering well cores under pressure which includes the combination of a core receiving tube having an upper and a lower end, a valve controlling the upper end of the tube to resist internal pressure, and an internally upwardly expanding tapered cutting shoe at the lower end of said tube in which a core can wedge to resist internal pressure.

GEORGE A. MACREADY.