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WELL SAMPLING APPARATUS

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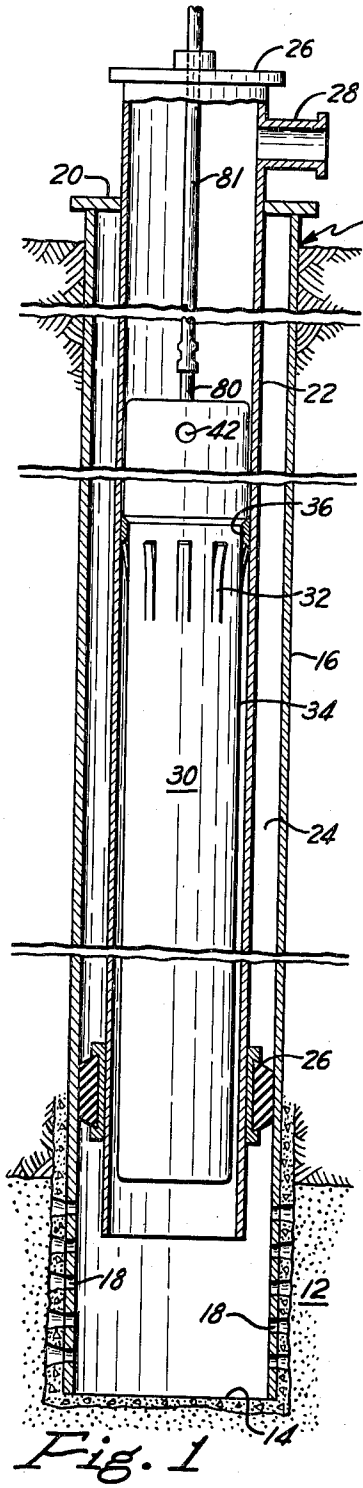


Fig. 1

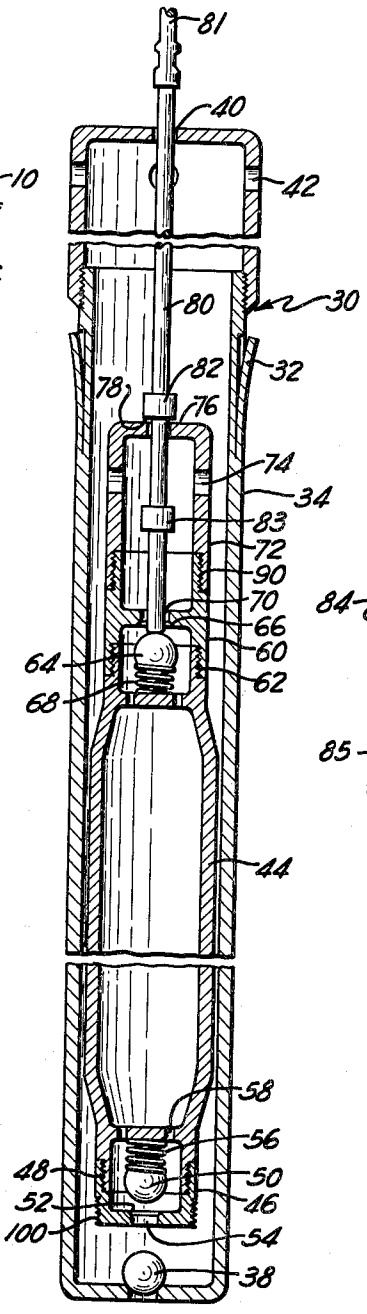


Fig. 2

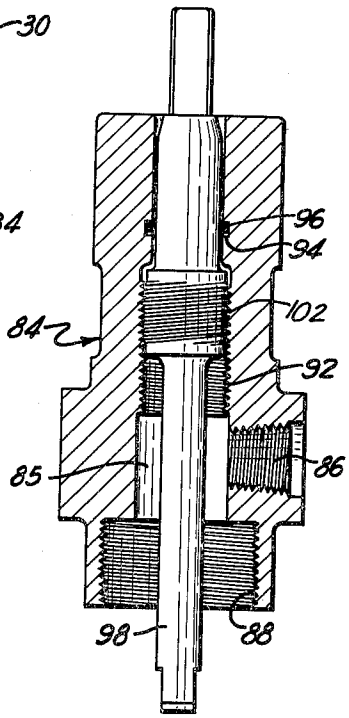


Fig. 3

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WELL SAMPLING APPARATUS

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This invention relates to a method and apparatus for testing wells and more particularly to apparatus for obtaining subsurface samples of fluids produced from wells.

The characteristics of fluids in the underground formations of oil fields have an important bearing on the predictions of the recoveries and behavior of the hydrocarbons in the underground reservoirs and the selection of the optimum methods of producing oil from the wells. When the underground reservoirs are under high pressures, the fluids delivered from the producing formations to the well head will differ substantially from the fluids present in the reservoir because of separation of gases from the liquid. Hence, samples taken at the well head are not as useful as samples taken directly from the underground reservoirs.

It is also difficult to obtain a sample of well fluids representative of the fluids in the reservoir from non-flowing wells. The procedure that has been followed in the past has been to pump the wells for a period and then pull the pump from the well and run a sampling device down into the well on a wire line. During the period required to pull the pump rods and run the sampling device substantial segregation of gases and liquids occurs and the sample obtained is ordinarily not representative of the fluids in the reservoir.

This invention resides in a plunger-type fluid sampler adapted to act as the plunger of a reciprocating-type oil well pump. The sampler is provided with an upper check valve biased to prevent flow upwardly out of the plunger and a lower traveling valve biased toward a closed position to prevent downward flow from the plunger. An extension on the sucker rod for the pump is adapted to engage the upper check valve and prevent its seating on the downstroke of the plunger whereby fluids flow upwardly from the plunger.

FIGURE 1 is a diagrammatic view of a well showing the casing and tubing of the well in vertical section and the fluid sampler of this invention in elevation.

FIGURE 2 is a vertical sectional view of the barrel and plunger of an oil well type pump containing the valve and valve releasing mechanism of this invention.

FIGURE 3 is a longitudinal sectional view of a head assembly for transfer of fluid from the sampler to suitable apparatus for measuring the characteristics of the fluids in the sampler.

Referring to FIGURE 1, a well indicated generally by reference numeral **10**, is illustrated extending downwardly through a pay zone **12** to a total depth **14**. Casing **16** is set in the well **10** and cemented in place in accordance with the conventional practice. The casing **16** is perforated, as illustrated at **18**, through the pay zone **12**. The upper end of the casing is closed by any suitable means, illustrated in FIGURE 1 by a cap **20**.

Extending downwardly through the casing **16** is a tubing string **22** which opens at its lower end within the casing **16** to receive fluids flowing from the formation **12** through perforations **18** in the casing. The annular space **24** between the tubing string **22** and casing **16** is closed by a packer **26**. The upper end of tubing string **22** is closed by suitable means indicated in the drawings by a cap **26**. A side outlet **28** opens from the tubing string above cap **20** for the delivery of fluids from the well.

For purposes of illustration, the sampling device of this

invention is shown in the drawings and described for installation in a well in which casing has been set and the casing perforated through the pay zone. This invention is not limited to such installations, but also can be used to obtain samples of fluids flowing into an open borehole.

Within the tubing string **22** is a rod retrievable insert type oil well pump indicated generally by reference numeral **30**. The pump illustrated in the drawings is of the top-lock type in which locking members **32** extending from the outer surface of the barrel **34** of the pump engage the lower surface of a seating ring **36** secured in the tubing string **22**. This invention is not limited to use in top-lock insert type pumps of the type illustrated in FIGURE 1. Insert type pumps can be used with any vertical seating type of pump anchor which allows the pump to be retrieved by lifting on the sucker rods of the pump. When the sampler of this invention is used with a tubing pump, the plunger sampler is run into a downhole pump barrel previously installed in the tubing string, and the plunger is retrievable on the sucker rods independently of the pump barrel.

At the lower end of the barrel **34** is a standing valve **38** adapted to prevent flow of fluids downwardly from the barrel and allow upward flow of well fluids into the barrel of the pump. At the upper end of the barrel **34** is a central opening **40** through which the sucker rod for the pump extends and outlet ports **42** for delivery of fluids discharged from the pump into the upper part of tubing **22**.

Within the barrel **34** is a tubular pump plunger **44** having an outer diameter such that the plunger fits slidably within the barrel **34**. Plungers and barrels from the ordinary oil well type pumps commercially available can be used for this invention. The plungers and barrels of the pumps are carefully machined or honed to narrow tolerances to provide a close fit between the outer surface of the plunger and the inner surface of the barrel.

At the lower end of the plunger **44** is a traveling valve cage **46** which is secured to the plunger by screw threads **48**. The traveling valve cage **46** encloses a ball type traveling valve **50** adapted to seat on a valve seat **52** on upward movement of plunger **44** to close a port **54** in the lower end of the valve cage **46**. Traveling valve **50** is urged downwardly towards valve seat **52** by a helical spring **56**. Openings **58** directly above valve **50** allow flow of fluids upwardly from the valve cage into the main body of the plunger **44**.

A check valve cage **60** is connected to the upper end of the plunger **44** by threads **62**. Within the check valve cage **60** is a check valve **64** urged upwardly against a valve seat **66** in the check valve cage by a helical spring **68** to prevent upward flow of fluids from the plunger **44** during an upstroke of the plunger. A central port **70** in the check valve cage is provided for upward flow of fluids from the plunger **44** when the check valve **64** is out of engagement with check valve seat **66**.

Connected by screw threads to the upper end of the check valve cage **60** is a tubular releasing rod guide **72** having side outlets **74** through which fluids entering the releasing rod guide from the check valve cage **60** are discharged. The upper end **76** of the releasing rod guide **72** is closed except for an opening **78** of smaller diameter than the main body of guide **72** through which a check valve releasing rod **80** extends. Mounted on the check valve releasing rod above the upper end **76** of the releasing rod guide **72** is an upper stop **82** having a diameter larger than the diameter of opening **78**. A lower stop **83** similar to upper stop **82** is mounted on the releasing rod **80** below the end **76** of the guide cage. Stops **82** and **83** limit the downward and upward movement, respectively, of check valve releasing rod **80** relative to the

plunger 44 by engagement with the upper end 76 of the releasing rod guide. The upper stop 82 is positioned on check valve releasing rod so that on the downstroke of the pump plunger the lower end of the releasing rod will extend through the opening 70 to engage check valve 64 and hold it out of engagement with valve seat 66. Lower stop 83 is positioned on the releasing rod 80 to allow upward movement of the releasing rod 80 relative to the plunger 44 on the upstroke to a position out of engagement with the check valve 64. The releasing rod 80 is connected to the sucker rod 81 which extends upwardly to the well head through cap 26 for connection with the walking beam of a pump unit, not shown in the drawings.

For purposes of illustration, the operation of the apparatus illustrated in FIGURE 1 is described for a non-flowing well. The insert type pump is run into the well on the sucker rod 81 and located in place by engagement of the locking means 32 with the seating ring 36. The upper end of the sucker rod 81 is connected to the walking beam of the pumping unit and the pumping operation begun. During the downstroke of the plunger 44, the releasing rod moves downwardly until the upper stop 82 engages the upper end 76 of the releasing rod guide 72. At this position, the lower end of the releasing rod engages the check valve 64 and moves it out of engagement with the valve seat 66 to allow upward flow from the plunger 44. The well fluids trapped in the barrel above the standing valve 38 exert sufficient pressure against traveling valve 50 during the downstroke of the plunger to raise it from the valve seat 52 and allow flow into the plunger. During the upstroke, the releasing rod moves upwardly relative to the plunger 44 until the lower stop 83 engages the upper end 76 of the releasing rod guide 72. The upward movement of the releasing rod 80 allows the check valve 64 to move into engagement with valve seat 66 and prevent flow from the plunger 44. During the upward movement of the plunger 44, spring 56 urges traveling valve 50 against valve seat 52, to prevent flow downwardly out of the plunger 44. The reduced pressure in the barrel 34 below plunger 44 during the upstroke causes well fluids to enter the barrel through the standing valve.

The pumping is continued at a low rate for a period sufficient to cause flow into the pump of fluids representative of the fluids in the formation. When it is desired to obtain a sample, the pump is pulled upwardly from the tubing by means of the sucker rod 81 whereupon the releasing rod 80 moves upwardly to allow valve 64 to be seated against valve seat 66. Spring 56 and the pressure of the fluids in plunger 44 urge valve 50 against valve seat 52. As the pump is pulled from the well, the pressure differential between the fluids within the plunger 44 and the fluids in the tubing in the well increases. Thus, any tendency towards sample contamination that might occur because of pressure surges resulting from the pulling of the rods and pump through some of the more viscous oils is reduced as the sampler is lifted to the surface.

Apparatus for transfer of the sample from the sampler of this invention to suitable apparatus such as a PVT cell for measurement of the property of the fluids is illustrated in FIGURE 2. A transfer head indicated generally by reference numeral 84 is illustrated having a central opening 85 extending longitudinally through it and a side outlet 86 communicating with the central opening. The transfer head 84 is internally threaded at 88 at its lower end with threads adapted to fit threads 90 by which the releasing rod guide 72 is connected to the check valve cage. The central opening 85 is internally threaded as indicated by reference numeral 92 above its intersection with the side outlet 86. Above the level of threads 92 in the wall of central opening 85 is a groove 94 adapted to receive an O-ring seal 96. A releasing stem 98 is adapted to extend through the central opening of the transfer head 84. Stem 98 is provided with external threads 102 which engage threads 92.

When it is desired to remove the sample from the sampler, the releasing rod guide 72 is unscrewed from the check valve cage 60. The transfer head 84, with the stem 98 in the uppermost position illustrated in FIGURE 2, is screwed onto the upper end of the check valve cage 60. The stem 98 is then screwed downwardly whereby the lower end of the stem engages the check valve 64 and moves it out of engagement with the valve seat 66. The sample trapped in the plunger 44 can then flow through the transfer head and outlet 86 to suitable apparatus for measurement of the properties of the fluids sampled. If desired, the sample can be displaced from the plunger 44 by connecting suitable fittings to threads 100 at the lower end of the valve cage 46 and forcing a displacing liquid, such as mercury, upward into the plunger 44. The displacing liquid lifts the traveling valve 50 from seat 52 and flows upwardly into the plunger 44 to displace the sample from the plunger 44.

We claim:

1. Apparatus for sampling fluids from a subsurface formation penetrated by a well having casing set therein and a tubing string extending downwardly through the casing for the delivery of fluids from the well, comprising a pump barrel retrievably mounted in the tubing string at a level whereby the lower end of the pump barrel is in well fluids, said pump barrel having an opening at its lower end and a stationary valve permitting flow of fluids upwardly into the pump barrel, an outlet port in the upper end of the pump barrel for flow of well fluids from the pump barrel into the tubing string, a tubular plunger fitting slidably within the pump barrel, said pump barrel having an external diameter throughout its length less than the internal diameter of the tubing whereby the pump barrel may be withdrawn upwardly through the tubing, an inlet port in the lower end of the plunger for the entrance of fluids into the plunger, a traveling valve mounted in the plunger above the inlet port adapted to close the inlet port when pressure within the plunger is higher than pressure within the pump barrel, an outlet port in the upper end of the plunger, an outlet valve positioned in the plunger below the outlet port adapted to close the outlet port when pressure within the plunger is higher than pressure above the outlet valve, a guide mounted on the plunger above the outlet valve, a central opening extending downwardly through the guide, said pump barrel having a central hole in its upper end, a sucker rod adapted to be connected to driving means at the well head extending downwardly through the central hole in the pump barrel and the central opening in the guide, an upper stop on the sucker rod above the guide to engage the guide and limit downward movement of the sucker rod relative to the plunger, said upper stop being mounted on the sucker rod at a position whereby on downward movement of the plunger the lower end of the sucker rod engages and depresses the outlet valve and opens the outlet port, and a lower stop mounted on the sucker rod within the guide adapted to engage the guide and limit upward movement of the sucker rod relative to the plunger, said lower stop being mounted on the sucker rod at a position whereby the lower end of the sucker rod is out of engagement with the outlet valve during the upward stroke of the plunger.

2. Apparatus for sampling fluids from a subsurface formation penetrated by a well having a tubing string extending downwardly therein for the delivery of fluids from the well comprising a pump barrel retrievably locked within the tubing string at a level whereby the lower end of the pump barrel is in well fluids, said pump barrel having an external diameter smaller throughout its length than the internal diameter of the tubing string, an inlet port at the lower end of the pump barrel, a stationary valve adapted to close said inlet port when pressure within the pump barrel is higher than pressure outside of the pump barrel, a pump plunger slidably fitting within the pump barrel, said pump plunger having an inlet port at its lower end and an outlet port at its upper end,

a traveling valve positioned within the plunger above the inlet port, resilient means engaging the traveling valve and urging it downwardly to close the inlet port, an outlet valve mounted within the pump plunger below the outlet port, resilient means urging the outlet valve upwardly to close the outlet port, a guide mounted on the upper end of the plunger, said guide having a central opening therethrough in alignment with the outlet port, an inwardly extending shoulder having a central opening therethrough at the upper end of the pump barrel, a sucker rod adapted to be connected at its upper end to driving means for reciprocating the sucker rod vertically within the tubing string, said pump barrel having a central opening at its upper end and an outlet port for flow of well fluids from the pump barrel into the tubing string, said sucker rod extending downwardly through the central opening at the upper end of the pump barrel and the central opening in the guide, an upper stop on the sucker rod between the shoulder and the guide adapted to engage the upper end of the guide on the downward

stroke of the sucker rod and to engage the shoulder of the pump barrel upon pulling of the sucker rod from the well, said upper stop being mounted on the sucker rod at a position whereby the lower end of the sucker rod extends downwardly through the outlet port to depress the outlet valve on the downward stroke of the sucker rod, and a lower stop mounted on the sucker rod within the guide adapted to limit upward movement of the sucker rod relative to the guide, said lower stop being mounted on the sucker rod at a position whereby the lower end of the sucker rod is above the outlet port on the upward stroke of the sucker rod.

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