Sept. 22, 1959 L. A. VESTERMARK 2,905,247

WIRE LINE LIQUID OR GAS FORMATION THIEF

Filed Sept. 1, 1955

2 Sheets-Sheet 1

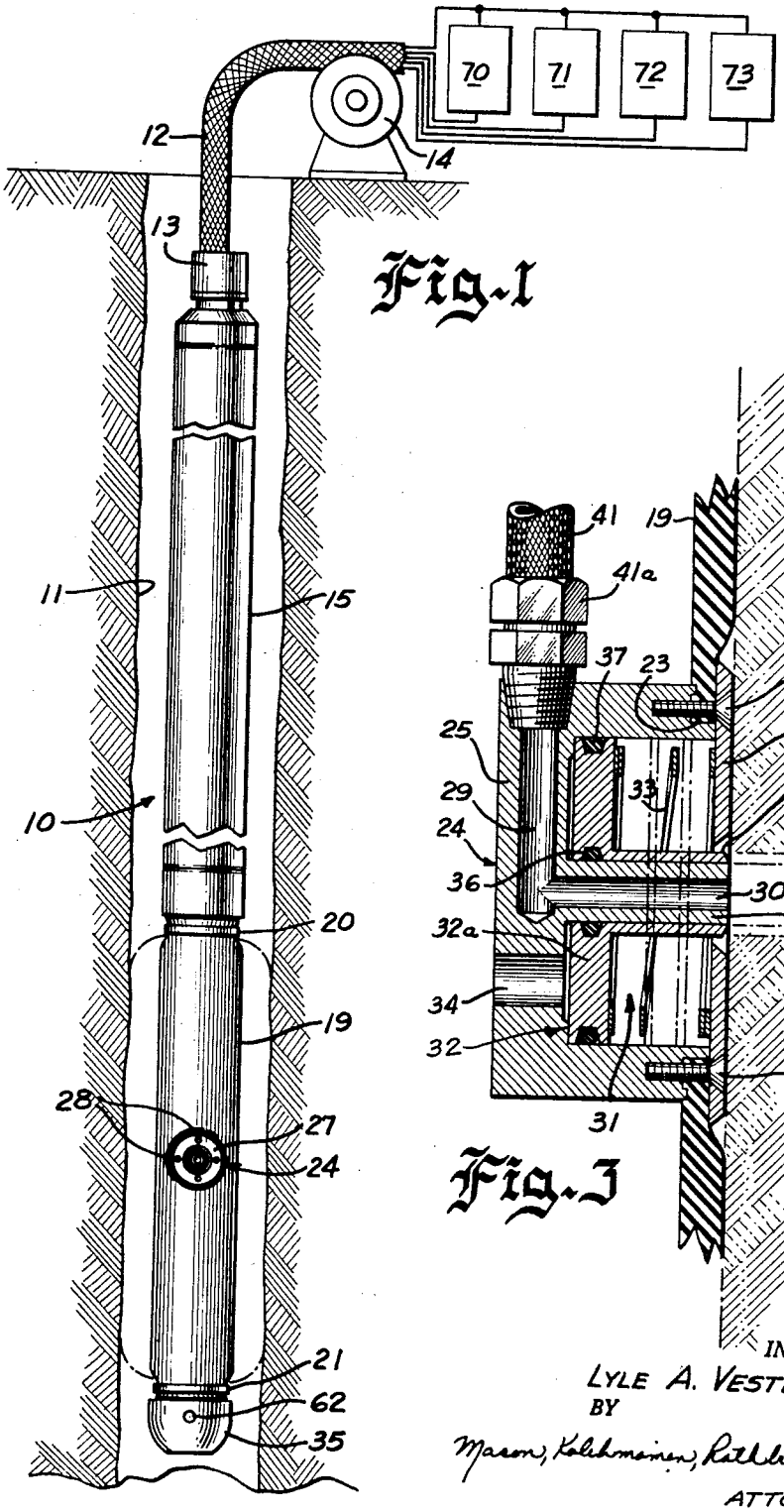

Fig. 1

Fig. 3

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2 Sheets-Sheet 2

Fig. 2A

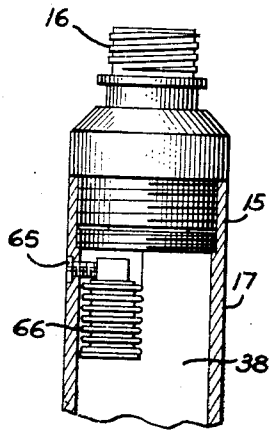


Fig. 2B

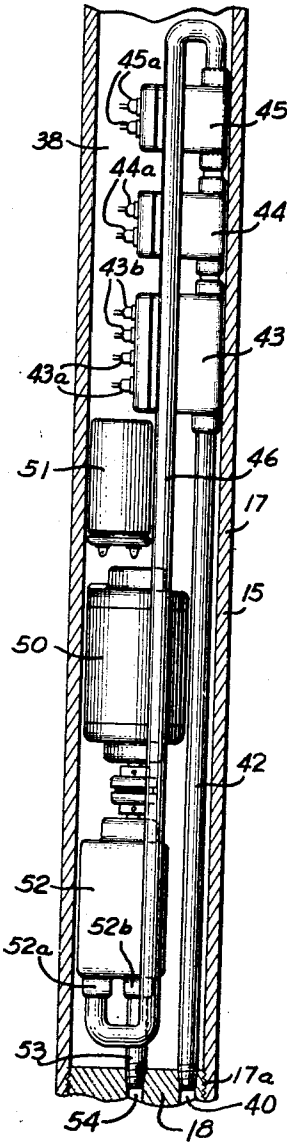
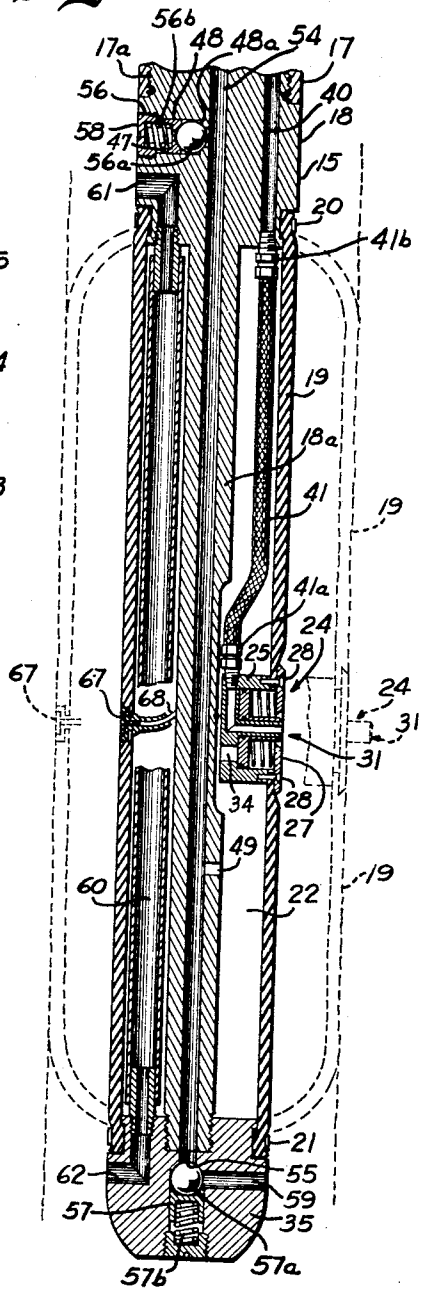


Fig. 2C



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WIRE LINE LIQUID OR GAS FORMATION THIEF

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15 Claims. (Cl. 166—100)

This invention relates to a wire line liquid or gas formation thief, and, more particularly, to an improved tool for use in determining the characteristics of fluids existing in a well bore or in the adjacent borehole formations.

The earliest proposed solutions to the problem of determining the nature of borehole and formation fluid, which will hereinafter be referred to generically as "downhole fluids," involved the capture of a specimen by a suitable subterranean sampler lowered into the borehole. However, these solutions have proven generally unsatisfactory in that a tremendous period of time is consumed in raising and lowering the device between each sampling operation. Subsequently, other types of wire line liquid or gas formation thiefs were developed which eliminated the time consuming operation of raising and lowering the device between sampling operations by employing fluid measuring units in the downhole tool producing electrical intelligence transmittable through the wire line to surface instruments. In these latter thiefs, however, complicated internal structures were required to pack-off a portion of the borehole in order to facilitate the collection of the samples of downhole liquids or gases. Customarily, in these prior art arrangements, the packing-off and the sampling are distinct and separate operations with the result that the structures employed are complex and the operating time required to complete the measurement is quite high. Furthermore, with the prior art devices, it is extremely difficult to prevent undesired admission of either borehole fluids exclusively or both borehole and formation fluids into the subsurface tool. Unless these fluids are prevented from entering the tool, the effectiveness of the sampling operation is reduced since the contaminated borehole fluids may be communicated to the fluid measuring units.

It would, therefore, be desirable to produce a simple, compact thief which avoids the complicated structures of the prior art while, at the same time, providing for expanding the thief to pack-off a portion of the borehole and for collecting the downhole fluids in order to determine their characteristics. Furthermore, it would be advantageous to provide an extensible assembly cooperatively associated with the fluid inlet port of the thief to preclude the admission of borehole fluids and permit entry exclusively of the formation fluids, thereby obtaining an accurate and a true sample of the formation fluids at any particular depth in the borehole.

According, it is an object of the present invention to provide an improved wire line liquid or gas formation thief which obviates the described disadvantages of the prior art arrangement.

Another object of the present invention is to provide a wire line fluid formation thief embodying a packer element expandable into engagement with the wall of a borehole by admission of both borehole and formation fluids into a fluid chamber defined by the packer element.

It is a further object of the present invention to provide an improved wire line fluid formation thief wherein a single driving means is adapted to draw into the thief downhole fluids for the dual purposes of measuring the characteristics of the fluid and of expanding a portion of the tool to pack-off a portion of the borehole in preparation for testing formation fluids exclusively.

A still further object of the present invention is to provide an improved wire line fluid formation thief wherein an extensible inlet assembly cooperates with the fluid inlet means of the thief so that upon selective operation of the extensible assembly a member thereof penetrates the borehole wall to effectively prohibit the entry of borehole fluids and to permit the exclusive entry of formation fluids during actual testing operations.

Other objects and advantages of the present invention will become apparent from the following description of an illustrative embodiment thereof, in the course of which reference is had to the accompanying drawings, wherein:

Fig. 1 shows a cross-section of a portion of the earth's crust and diagrammatically illustrates a measuring system including a wire line fluid formation thief which is characterized by the features of the present invention and which is shown disposed within a borehole;

Fig. 2A is an enlarged fragmentary view of the upper section of the thief shown in Fig. 1 with a portion of the casing broken away;

Fig. 2B is an enlarged fragmentary view of the central section of the thief shown in Fig. 1 with a portion of the casing removed;

Fig. 2C is an enlarged fragmentary view, principally in section, of the lower section of the thief shown in Fig. 1; and

Fig. 3 is a further enlarged fragmentary view of a portion of the lower section of the thief shown in Fig. 2C, illustrating primarily the details of the fluid inlet to the thief and the extensible assembly associated therewith.

In brief, the wire line liquid or gas formation thief of the present invention comprises an elongated device adapted to be dropped into a borehole for sampling wall formation liquids. More specifically, this tool comprises an elongated casing including an expandable packer element defining a fluid chamber, which packer element, when expanded, is adapted to engage the borehole walls in order to pack-off a portion of the borehole. Furthermore, a fluid inlet means is associated with the packer element for admitting borehole and formation fluids into the thief during operation. There is also provided a single driving means for drawing borehole and formation fluids through the fluid inlet means and for admitting this fluid, after suitable measurements have been made, to the chamber defined by the packer element in order to urge the latter into engagement with the borehole walls. In addition, an extensible assembly unit is disposed in cooperative relationship with the fluid inlet means and is operable to penetrate the borehole wall in order to prevent admission of the borehole fluids to the tool, thereby effecting the exclusive admission of the formation fluids. This extensible assembly unit, is actuated by the force of the fluid pressure admitted into the fluid chamber defined by the packer element. Fluid measuring units in the subsurface tool function to provide electrical signals representative of different fluid characteristics for transmission over the wire line to suitable measuring instruments disposed at the earth's surface.

Referring now to the drawings, and more particularly to Fig. 1, there is illustrated a subsurface fluid formation thief or tool embodying the features of the present invention and generally designated by reference numeral **10**. The thief **10** is shown disposed within a borehole **11** and suspended upon the lower end of a wire line

or cable 12 by means of a line cap 13. The wire line 12 at its upper end is trained over a sheave 14 and is then electrically connected to surface measuring and recording instruments 70, 71 and 72 to effect the collection of information. The sheave 14 is adapted to be driven by a suitable motor or the like in order to raise and lower the thief within the borehole 11, continuous information being supplied as to the exact depth of penetration of the tool.

The tool 10, as best shown in Figs. 2A, 2B and 2C, has an outer protective casing 15 comprising a hollow cylindrical body member 17 carrying an externally threaded wire line connector shank 16 for receiving the line cap 13. The cylinder 17 has its lower end internally threaded, as indicated at 17*a*, to accommodate a generally solid cylindrical support member 18 which includes a relatively large body portion of substantially the same diameter as the cylinder 17 together with a downwardly and axially extending mandrel 18*a* of somewhat smaller diameter. The body member 18 effectively seals the lower end of the cylinder 17 thus forming a chamber 38 which houses the measuring instruments to be described hereinafter. To weight the tool 10 in order to facilitate lowering the same in the borehole 11, the instrument chamber 38 is preferably filled with a suitable fluid such as oil. The lower end of the mandrel 18*a* may be suitably threaded to receive a nose stud 35 forming the extreme lower end of the tool 10.

In order to pack-off a portion of the borehole 11 and to provide engagement of the thief 10 with the borehole wall, a flexible packer element 19 surrounding the mandrel 18*a* is secured at its upper end to the member 18 and at its lower end to the nose stud 35 by bands 20 and 21, respectively. The latter bands cooperate with annular grooves formed in the member 18 and in the nose stud 35 to hold the packer element 19 against movement longitudinally of the tool. In this manner, there is defined between the packer element 19 and the mandrel 18*a* an expandable fluid chamber 22 which is adapted to be filled with downhole fluids during the sampling operation of the thief 10, described in detail hereinafter. The packer element 19 is formed of suitable resilient material to permit it to expand into engagement with the borehole wall when fluid under pressure is supplied to the fluid chamber 22 at which time the element 19 will be formed outwardly until it occupies the position indicated by the dotted lines in Fig. 2C. In the absence of fluid pressure within the chamber 22, the element 19, of course, occupies its retracted or collapsed position indicated by the full lines in Fig. 2C.

In order to accommodate structure described below for admitting borehole and formation fluids into the interior of the tool 10, an aperture 23 (Fig. 3) is provided in the packer element 19 substantially mid-way between the member 18 and the nose stud 35. This aperture receives an inlet means 24 rigidly fastened to the surrounding portions of the packer element 19. The inlet means 24, as best shown in Fig. 3, comprises a cylindrical support housing 25 recessed in such a manner as to define an upwardly depending boss 26. An apertured circular plate 27, which provides a protective cover for the inlet means 24, is secured to the housing 25 and to the packer element 19 by suitable fastening means such as machine screws 28. The latter screws are seated within countersunk holes in the plate 27 and have flat head portions lying in the plane of the plate so that a continuous flush surface is provided. The screws pass through the plate 27, through suitable openings in the packing element 19 and into engagement with tapped bores in the housing 25 in order to compress the packing element between the plate and the housing.

In order to admit borehole and formation fluids into the interior of the tool 10, there is defined within the boss 26 and the base portion of the housing 25 a substantially L-shaped passageway 29 exposed at one end 30 to the exterior of the tool and emptying at its other end into a conduit 41. The latter conduit is secured to the housing 25 by means of a fluid tight coupling 41*a* threaded into a suitable tapped opening formed adjacent the end of the passageway 29. As is clearly shown in Figs. 2C and 3, upon expansion of the packer element 19 into engagement with the wall of the borehole, the inlet port 30 is positioned adjacent to the surface of the borehole wall. Until the packer 79 is fully extended and thus capable of providing an effective seal with the walls of the borehole, the fluid entering the opening 30 comprises substantially borehole fluid.

In order to provide for the collection of formation fluids to the exclusion of borehole fluids, there is provided an extensible assembly unit 31 cooperatively associated with the inlet means 24 and movable radially of the tool 10 to penetrate the adjacent borehole formation. This extensible assembly unit comprises a piston 32 seated and reciprocally moved within the recessed portion of the support housing 25. To this end, the piston 32 includes a head portion 32*a* having a diameter substantially equal to the internal diameter of the recess within the housing 25 and a sleeve portion 32*b* encircling the boss 26. To effect a fluid tight seal in order to prohibit entry of undesired fluid into the tool 10, annular gaskets or sealing rings 36 and 37 are provided. The gasket 36 rests within a suitable groove in the inner surface of the piston 32 and prevents entry of fluid along the outer surface of the boss 26 while the gasket 37 is accommodated within a groove formed in the periphery of the piston head 32*a* to prevent fluid flow around this element. The piston 32 is biased by a coil spring 33 disposed between the piston 32*a* and the inner side of the plate 27 with the result that the outwardly disposed end portion of the piston 32 is normally held in flush relationship with the plate 27 in the full line position shown in Fig. 3. In order to supply fluid for extending the sleeve 32*b* outwardly into penetration with the borehole formations, there is defined within the base of the housing support 25 a passageway 34 which admits fluid under pressure against the work surface of the piston head 32*a*. As a consequence, whenever the force of the fluid pressure is sufficiently large to overcome the force of the coil spring 33, the sleeve member 32*b* is forced outwardly from the packer element, or, as viewed in Fig. 3, moves to the right until its end portion penetrates the borehole wall by a predetermined amount. With the sleeve 32 extended to its maximum outward position, as illustrated by the broken lines in Fig. 3, only the fluids within the formation wall are drawn through the inlet port 30 and the passageway 29 into the interior of the thief 10. Thus, for all practical purposes, the extensible assembly unit 31, has the effect of extending the depending boss 26 into the borehole wall and of exposing the inlet port 30 to formation fluids exclusively. Clearly, whenever the pressure of the fluid communicated to the working surface of the piston head 32*a* is reduced below the force of the biasing means 33, the piston 32 retracts into flush relationship with the packer element 19 to the solid line position shown in Fig. 3.

The fluid admitted into the inlet port 30 is communicated to fluid measuring or sampling units, described hereinafter, by fluid conducting means including the coupling means 41*a* and the conduit 41 interconnecting the passageway 29 with the measuring units. The fluid conducting means, as best shown in Figs. 2B and 2C, comprise a passageway 40 defined in the support member 18 connected at one end to the flexible conduit 41 by means of a suitable coupling 41*b* threaded into a tapped opening in the member 18 and communicating at its other end with a rigid conduit 42 interconnecting the passageway 40 and the input of a plurality of fluid measuring units 43, 44 and 45. As is customary in tools of this character, the fluid measuring units preferably comprise a resistivity-indicating cell 43, a pressure-indicating cell 44

and a temperature-indicating cell **45**, connected in series relationship, so as to provide a continuous flow of fluid therebetween. It will be understood that the construction and relative order of fluid flow to the above-described cells are not considered critical and do not form a part of the present invention except insofar as they contribute to the overall function of the tool. The fluid after passing through the measuring cells is delivered to an elongated conduit **46** extending longitudinally of the tool **10** for a major portion of its length. Each of the cells, **43**, **44** and **45** produces electrical intelligence which is transmitted to surface measuring and recording instruments **70**, **71** and **72**, respectively, by a plurality of electrical conductors within the wire line **12** which, at their lower ends, are fastened to suitable pairs of terminals **43***a*, **43***b*, **44***a*, **45***a*, respectively. As is well known in the art, periodic measurement of the fluid characteristics transmitted to the surface instruments **70**, **71** and **72** when correlated with the different depths occupied by the tool **10** as it traverses the borehole provides information which facilitates a determination of the type and character of wall formation fluids encountered.

Referring now to the fluid driving means of the thief **10**, as shown in Fig. 2B, there is provided a circulating pump **52** driven by an electric motor **50** electrically connected through suitable wire line conductors to the surface where it may be selectively energized at will. An accessory capacitor **51** may be employed to provide quadrature components for starting the motor **50** if A.C. energizing current is used. More particularly, the circulating pump **52** includes an input port **52***a* and an output port **52***b*, and functions to draw the borehole and formation fluids to the inlet **52***a* through the borehole and, through the fluid conducting means **41**, **40** and **42**, through the fluid measuring units **43**, **44** and **45** and through the conduit **46** connected to the output of the cell **45**. The output fluid of the pump **52** is expelled under pressure from the outlet port **52***b* into a conduit **53** emptying into an elongated passageway **54** extending axially of the support member **18** and the mandrel **18***a*. The passageway **54** is axially aligned with another passageway **55** defined in the nose plug **35**. In order to provide communication between the pump outlet **52** or, in particular, between the passageway **54** in the mandrel and the fluid chamber **22**, there is provided a passageway **49** defined in the mandrel **18***a* and extending transversely to the passageway **54**.

With the described construction, whenever the motor **50** is energized to drive the pump **52**, the downhole fluids are pumped into the fluid chamber **22** to expand the packer element **19** into engagement with the walls of the borehole at which time it assumes the configuration indicated by the dotted lines in Fig. 2C. Conversely, the pump **52**, when stopped, permits the fluid within the expanded fluid chamber **22** to bleed back through the pump and the fluid conducting means to be discharged from the inlet port **30**. As a result of the withdrawal of fluid from the fluid chamber **22**, the packer element **19** is restored to its initial size, as shown by the full lines in Fig. 2C, due to the inherent resiliency of the packer material. To insure that the fluid pressure within the packer element does not reach a value at which the packer will rupture or burst, there are employed a pair of pressure relief valves **56** and **57** biased to allow a build up of a predetermined pressure and expansion of the packer **19** before operation. The valve **56** may be of the conventional ball check type and is located within a bore **48** extending radially of the support member **18**, terminating at one end in the passageway **54** and terminating at its other end at the outer face of the tool **10**. The ball **56***a* of the valve **56** is normally urged against an annular shoulder **48***a* formed in the interior of the bore **48** by means of a spring **56***b* which is retained between a slidable piston **47** and a cap **58**. The piston **47** is mounted for movement axially of the bore **48** while the cap **58** may be threaded into the tapped end of the bore. Thus, whenever the pressure delivered by the pump **52** exceeds a predetermined value determined by the bias exerted by spring **56***b*, the bore **48** vents the passageway **54** to the borehole and, hence, releases the excess pressure. The relief valve **57** performs a similar function and includes a ball **57***a* normally urged against the lower end of passageway **54** by a spring **57***b*. In its normal position the ball **57***a* blocks both the passageway **54** and a passageway **59** extending transversely of the nose cap **35**. Under excess pressure the valve **57** vents the lower end of passageway **54** to the borehole through the passageway **59**.

To assure that there will be no borehole differential pressure above and below the packer element **19** when the latter is in engagement with the borehole wall, there is provided a bypass tube **60**, disposed within and extending through the fluid chamber **22** and interconnected between L-shaped passageways **61** and **62** defined in the support member **18** and in the nose stud **35**, respectively. By this simple bypass device, the borehole pressure at the top and bottom of the expanded packer element **19** is equalized to avoid unnecessary and undesired stresses.

In order to compensate for varying pressures encountered by the tool **10** as it traverses the borehole **11**, there is provided a pressure equalizing device comprising, as best shown in Fig. 2A, a small opening **65** near the upper end of the cylinder **17** and a conventional bellows **66**. The bellows **66** is at all times exposed on its interior to the borehole fluids and on its exterior to the fluids within the chamber **38** and, as a result, volumetric changes in the chamber fluid caused by varying temperature or pressure induce a corresponding response in the bellows. Thus, the internal and external pressures on the instrument chamber **38** will be equalized by the compensating movement of the bellows, thereby avoiding the operation of the pumps and their associated shaft packings under excessive hydrostatic pressures. Moreover, since the thief **10** is weighted by the fluid sealed within the chamber **38**, when it is lowered into increasing subterranean pressures, the undesired flotation or buoyant effect of an atmospherically sealed tool is eliminated.

For the purpose of obtaining a natural earth or self potential measurement simultaneously with the fluid characteristics measured by the cells **43**, **44** and **45**, a reference or self-potential probe **67**, shown in Fig. 2C, is imbedded in the packing element **19** at a position diametrically opposed to the inlet means **24**. The probe **67** is appropriately connected through a conductor **68** and through one of the conductors of the line **12** to a measuring instrument **73** at the earth's surface. The self-potential probe **67** and the inlet means **24** are thus located at the same depth so that the self potential measurement is correlated with the measurements of the fluid characteristics.

In operation, the following procedure is adopted at each formation testing level. The tool **10** is lowered into a borehole to a predetermined depth by the sheave **14**. The recording medium or mediums associated with the instruments **70**, **71**, **72** and **73** are, of course, driven in synchronism with the sheave **14** so that a series of readings of the various measurements as a function of borehole depth are produced. After a formation test level is reached, the motor **50** is started from the surface to drive the pump **52** and the borehole and formation fluids are drawn into the pump and driven into the fluid chamber **22** under pressure. The packer element **19** expands into engagement with the borehole wall while the pump continues to supply fluid to the chamber **22**. When the fluid pressure built up within the chamber **22** exceeds the force of the biasing means **33** of the extensible assembly unit **31**, the piston **32** penetrates the borehole wall to prohibit entry of borehole fluid and, at the same time, to permit exclusive entry of formation fluid through the inlet port **30**. Since the borehole and formation fluid is continually transmitted through the fluid measuring

cells 43, 44 and 45 prior to and during inflation of the packer element 19, the introduction of formation wall fluid exclusively into the fluid measuring cells 43, 44 and 45 substantially alters the readings of the surface electrical analyzing instruments, thereby indicating that the formation fluids exclusively are being tested. After the data supplied to the surface instruments has been recorded, the motor 50 and associated pump 52 are stopped. Immediately upon stopping of the pump 52, the force of the compressed fluid within the packer element causes the fluid to circulate back through the fluid system, in particular, through the fluid conducting means, through the pump 52, through the fluid measuring cells 45, 44, and 43, and outwardly from the inlet port 30 into the borehole. In this manner, the packer element is collapsed and restored to its initial size, thereby disengaging the tool 10 from the borehole wall. Simultaneously with the collapsing of the packer element, the piston 32 withdraws from the borehole wall and retracts into flush relationship with the packer element. If additional measurements are desired at another formation test level, the tool 10 is simply lowered or raised to the next testing level and the above operation repeated.

While the details of the present invention have been described in connection with the illustrative embodiment thereof, it should be understood that such details are not intended to limit the invention since many modifications will be apparent to those skilled in the art, which, nevertheless, fall within the true spirit and scope of the invention as set forth in the accompanying claims.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A wire line fluid formation thief adapted to be lowered into a borehole or the like comprising a casing, an inflatable packer associated with said casing and defining an expansible fluid chamber, an inlet means defined in and supported by said packer for admitting downhole fluids into said thief, said inlet means including an extensible member movable to penetrate the wall of the borehole, fluid pressure responsive means for moving said member, and a single pump for supplying fluid under pressure from said inlet means to said fluid chamber to expand said packer into engagement with the wall of the borehole and for also supplying fluid to said fluid pressure responsive means to force said member to move outwardly relative to the packer and to penetrate the wall of the borehole.

2. In a wire line fluid formation thief adapted to be lowered into a borehole, the combination of a casing, a packer defining an expansible fluid chamber, and inlet means supported from said packer and exposed to the exterior of the thief for sampling fluid, said inlet means including an extensible member for penetrating the wall of the borehole, means included in said inlet means for delivering fluid from said fluid chamber to said extensible member, means for drawing borehole fluid through said inlet means and supplying the same to said fluid chamber to expand the packer into engagement with the walls of the borehole, said drawing means causing said fluid to flow through said delivering means to force the extensible member into the borehole wall, in order to supply formation fluids through the inlet means, means in fluid communication with said delivering means for measuring the characteristics of the fluid supplied to said fluid chamber, and means for returning a portion of the measured fluid to said borehole whenever the pressure within said fluid chamber exceeds a predetermined value.

3. In a wire line fluid formation thief adapted to be lowered from the earth's surface into a borehole, the combination of a casing, a packer defining an expansible fluid chamber, an inlet means exposed to the exterior of the thief for sampling fluid, said inlet means including a fluid pressure operated extensible member for penetrating the wall of the borehole and means for conducting fluid from said fluid chamber to said extensible member, means for measuring the characteristics of downhole fluids, means for conducting fluid from the inlet means to said measuring means, means for conducting fluid from said measuring means to said fluid chamber, means including a single pump for drawing fluid through said inlet means and supplying the same first to said measuring means and then to said fluid chamber to expand the packer into engagement with the walls of the borehole and then to the inlet means to force the extensible member into the borehole wall, and means for controlling the operation of said last-mentioned means from the surface in order to measure the characteristics of the fluids at any desired borehole depth.

4. In a wire line fluid formation thief adapted to be lowered into a borehole, the combination of a casing, an inflatable packer defining an expansible fluid chamber, an inlet means exposed to the exterior of the thief and carried by said packer for sampling downhole fluid, said inlet means including an extensible member movable outwardly from said packer for penetrating the wall of the borehole, means for communicating downhole fluid between said inlet means and said fluid chamber, means for introducing fluid from said fluid chamber to said extensible member, means for measuring the characteristics of downhole fluids, said downhole fluids including borehole and wall formation fluid, and means for drawing downhole fluid through said inlet means and supplying the same through said communicating means to said fluid chamber to expand the packer into engagement with the walls of the borehole and to force the extensible member outwardly of said packer into the borehole wall in order to introduce wall formation fluids exclusively into said thief, said measuring means being disposed between said inlet means and said fluid chamber in said communicating means so that after said extensible member has penetrated the borehole wall said measuring means is immediately responsive to the characteristics of wall formation fluids exclusively.

5. In a wire line fluid formation thief the combination of packer means defining an expansible fluid chamber, an inlet means supported by said packer means or admitting borehole and formation fluid into said thief, an extensible assembly associated with said inlet means including a piston chamber and a piston reciprocable within said piston chamber, said piston being movable transversely of said packer means, biasing means for normally maintaining said piston in retracted position on said thief, means defining a fluid connection between said expansible fluid chamber and said piston chamber and and said piston of said extensible assembly, means for introducing fluid under pressure into said fluid chamber to urge said packer means into engagement with the wall of the borehole and for forcing said piston outwardly from said thief in opposition to the action of said biasing means, and means actuated by the outward movement of said piston for penetrating the wall of the borehole.

6. In a wire line fluid formation thief the combination of an inlet means having a cavity therein and an axially bored member in the cavity for admitting borehole and formation fluid into said thief, an extensible assembly associated with said inlet means, including a piston reciprocable in said cavity and having a sleeve disposed about said member, biasing means for normally maintaining said piston in retracted position on said thief, an inflatable packer defining an expansible fluid chamber in fluid communication with the cavity and the piston of said extensible assembly, means for introducing borehole fluid from said axially bored member into said fluid chamber to inflate said packer into engagement with the wall of the borehole so that the axial bore in said member is closed whereupon the force of the fluid pressure within the fluid chamber builds up to a value sufficient to overcome the force of the biasing means so that the

extensible member is actuated outwardly from said thief along said member to force said sleeve to penetrate the borehole wall in order to admit into the thief wall formation fluids exclusively.

7. In a wire line formation thief adapted to be lowered into a borehole, the combination of a casing, a packer supported by said casing and defining an expansible fluid chamber, inlet means carried by said packer and exposed to the exterior of the thief for sampling fluid, said inlet means including an extensible member for penetrating the wall of the borehole, means for measuring the characteristics of said fluid, means for conducting said fluid between said inlet means and said fluid chamber through said measuring means, means for introducing fluid from said fluid chamber to said extensible member, and a single pump for drawing fluid through said inlet means and supplying said fluid through said conducting means to said measuring means to measure the characteristics of said fluid, to said fluid chamber to expand the packer into engagement with the walls of the borehole, and to said extensible member to force said member to penetrate the borehole wall.

8. In an apparatus for determining the characteristics of fluids present in formations surrounding a borehole containing borehole fluid, the combination of a downhole tool, a cable extending from the surface of the earth to the downhole tool and supporting said tool for movement within the borehole, a packer element on the tool inflatable into engagement with the walls of the borehole, an inlet device carried by the packer element and including a cylindrical stem having an inlet opening therein communicating with the borehole when the packer element is deflated and adapted to be closed by the walls of the borehole when the packer element is inflated, an extensible assembly secured to the packer element and including a member slidably mounted on said stem for movement from a retracted position within the packer element to an extended position protruding outwardly from the packer element, biasing means for normally maintaining said member in its retracted position, a single pump for drawing the borehole fluid through the inlet opening, pressurizing it and supplying it to inflate the packer element until the packer element engages the walls of the borehole, means for delivering pressurized fluid from the pump to the extensible assembly in order to overcome the biasing means and move said member outwardly to penetrate the formations whereupon formation fluid in the formations is drawn by the pump through the member and through the inlet opening, the pressure of the fluid delivered to said extensible assembly during inflation of the packer element being insufficient to overcome the biasing means until the inlet opening is closed by the borehole walls at which time the pressure is built up to a value sufficient to overcome the biasing means and extend said member, a pressure relief system for bypassing excess fluid from the pump into the borehole, sampling means on the tool responsive to the characteristics of the formation fluid for producing electrical signals corresponding to said characteristics and for supplying said signals to said cable, and means at the surface responsive to the signals on the cable for producing indications of said characteristics.

9. In an apparatus for determining the characteristics of fluids present in formations surrounding a borehole containing borehole fluid, the combination of a downhole tool, a cable extending from the surface of the earth to the downhole tool and supporting said tool for movement within the borehole, a packer element on the tool inflatable into engagement with the walls of the borehole, an inlet device carried by the packer element and including an inlet opening therein communicating with the borehole when the packer element is deflated and adapted to be closed by the walls of the borehole when the packer element is inflated, an extensible assembly secured to the packer element and including a member mounted for movement from a retracted position within the packer element to an extended position protruding outwardly from the packer element, biasing means for normally maintaining said member in its retracted position, means for drawing the borehole fluid through the inlet opening, pressurizing it and supplying it to inflate the packer element until the packer element engages the walls of the borehole, means for delivering the pressurized fluid to the extensible assembly in order to overcome the biasing means and move said member outwardly to penetrate the formations, means for drawing formation fluid in the formations through the member, the pressure of the fluid delivered to said extensible assembly during inflation of the packer element being insufficient to overcome the biasing means until the inlet opening is closed by the borehole walls at which time the pressure is built up to a value sufficient to extend said member, and sampling means for receiving the formation fluid drawn through said member to provide indications of the characteristics of said formation fluid.

10. In an apparatus for capturing fluids present in formations surrounding a borehole containing borehole fluid, the combination of a downhole tool, a cable extending from the surface of the earth to the downhole tool and supporting said tool for movement within the borehole, a packer element on the tool inflatable into engagement with the walls of the borehole, an inlet device carried by the packer element and including a cylindrical stem having an inlet opening therein communicating with the borehole when the packer element is deflated and adapted to be closed by the walls of the borehole when the packer element is inflated, an extensible assembly secured to the packer element and including a member slidably mounted on said stem for movement from a retracted position within the packer element to an extended position protruding outwardly from the packer element, biasing means for normally maintaining said member in its retracted position, a single pump for drawing the borehole fluid through the inlet opening, pressurizing it and supplying it to inflate the packer element until the packer element engages the walls of the borehole, means for delivering pressurized fluid from the pump to the extensible assembly in order to overcome the biasing means and move said member outwardly to penetrate the formations whereupon formation fluid in the formations is drawn by the pump through the member and through the inlet opening, the pressure of the fluid delivered to said extensible assembly during inflation of the packer element being insufficient to overcome the biasing means until the inlet opening is closed by the borehole walls at which time the pressure is built up to a value sufficient to overcome the biasing means and extend said member, a pressure relief system for bypassing excess fluid from the pump into the borehole, and sampling means responsive to the formation fluid for providing indications of the characteristics of said formation fluids.

11. A wire line fluid formation thief adapted to be lowered into a borehole or the like comprising a casing, an expandible packer associated with said casing and defining an expansible fluid chamber, an extensible inlet means including an inlet opening communicable with the borehole for introducing fluid into said casing, means for conducting said fluid to said fluid chamber to expand said packer into engagement with the wall of the borehole and to actuate said extensible inlet means to force the same to penetrate the wall of the borehole, fluid pressure generating means cooperatively associated with said fluid conducting means for directing the fluid introduced into said casing to said fluid chamber and to said extensible inlet means, and means cooperatively associated with said fluid conducting means for measuring the characteristics of the fluid introduced into said casing when said inlet means has penetrated the wall of the borehole.

12. A wire line fluid formation thief adapted to be lowered into a borehole or the like comprising a casing, an inflatable packer associated with said casing and defining an expansible fluid chamber, an inlet means for admitting downhole fluids into said thief, said inlet means including a fluid conducting extensible member movable radially of the casing to penetrate the wall of the borehole, means for supplying fluid under pressure from said inlet means to said fluid chamber to inflate said packer into enagement with the wall of the borehole and to force the entensible member to move outwardly of the casing in order to penetrate the wall of the borehole and supply formation fluid from said wall, and means for measuring the characteristics of the formation fluid introduced into said casing when said member has penetrated said wall.

13. In a wire line fluid formation thief adapted to be lowered into a borehole, the combination of a casing, an inflatable packer defining an expansible fluid chamber and supported by said casing, an inlet means supported by said packer and exposed to the exterior of the thief for sampling fluid, said inlet means including an extensible member for penetrating the wall of the borehole, means in said inlet means for conducting fluid from said fluid chamber to said extensible member, and a single pump for drawing fluid through said inlet means and supplying the same to said fluid chamber to expand the packer into engagement with the walls of the borehole and to force the extensible member outwardly of the packer into the borehole wall.

14. In a wire line fluid formation thief the combination of an inflatable packer defining a fluid chamber, and an inlet means for admitting borehole and formation fluids into said thief, said inlet means having an inlet opening and a fluid conducting extensible member for penetrating the wall of the borehole, biasing means for normally maintaining said member in retracted position on said thief, means for conducting fluid between said inlet opening and said fluid chamber and said extensible member, and means including a pump for drawing fluid through the inlet opening, pressurizing it, supplying it to the fluid chamber to inflate the packer into engagement with the borehole wall, said last mentioned means also supplying said fluid to said extensible member to actuate it after the packer engages the borehole wall and to cause the extensible member to penetrate the borehole wall in opposition to the action of said biasing means.

15. A wire line fluid formation thief adapted to be lowered into a borehole or the like containing borehole fluid, said thief comprising a casing, an expandible packer associated with said casing and defining an expansible fluid chamber, an extensible inlet means supported from said packer, means defining an inlet opening communicable with the borehole for introducing the borehole fluid into said casing, means for conducting said borehole fluid to said fluid chamber to expand said packer into engagement with the wall of the borehole and to actuate said extensible inlet means to force the same to penetrate the wall of the borehole in order to gather formation fluids from the borehole wall, fluid pressure generating means cooperatively associated with said fluid conducting means for directing the fluid introduced into said casing through said opening to said fluid chamber and to said extensible inlet means, and means for measuring the characteristics of the formation fluids gathered by said inlet means when it has penetrated the wall of the borehole.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,905,247

September 22, 1959

Lyle A. Vestermark

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 65, for "arrangement" read -- arrangements --; column 7, line 45, before "fluid" insert -- said --; line 52, for "and inlet" read -- an inlet --; column 8, line 43, for "means or" read -- means for --.

Signed and sealed this 19th day of April 1960.

(SEAL)
Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents

UNITED STATES PATENT OFFICE

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