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2,903,069

APPARATUS FOR INVESTIGATING EARTH FORMATIONS

Filed Sept. 23, 1955

5 Sheets-Sheet 1

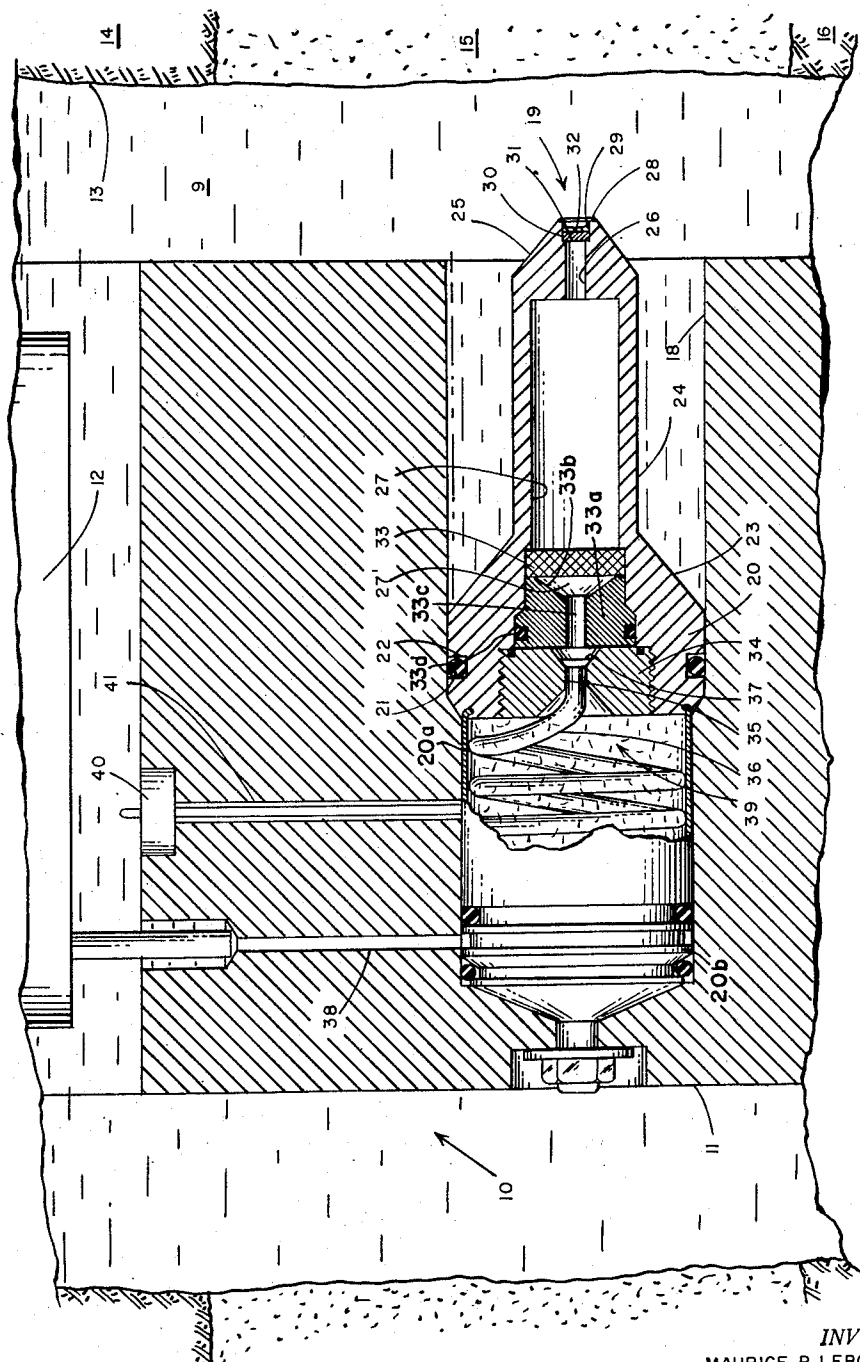


FIG. 1

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5 Sheets-Sheet 2

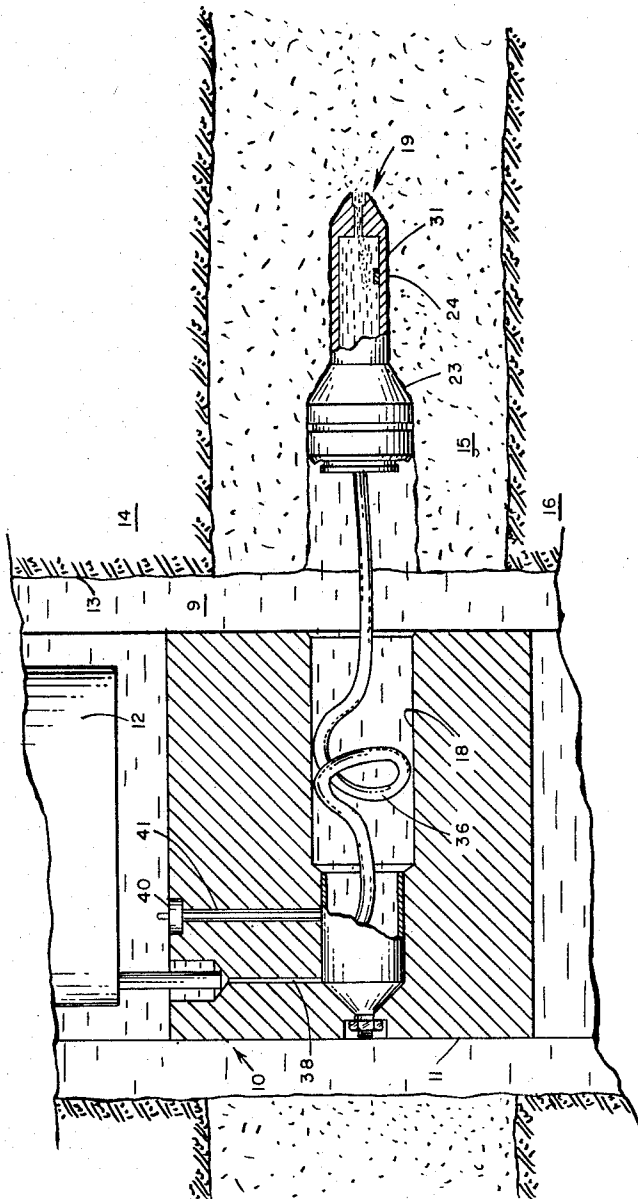


FIG. 2

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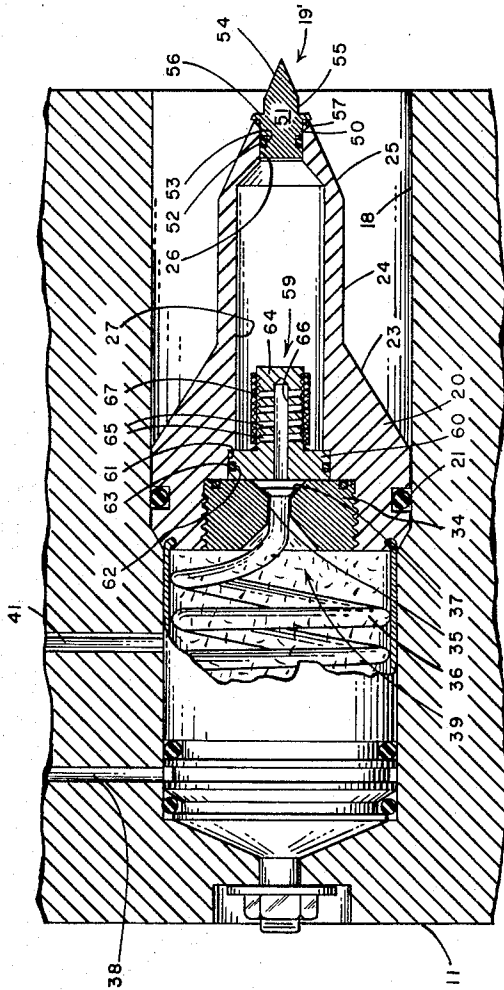
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5 Sheets-Sheet 3



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5 Sheets-Sheet 4

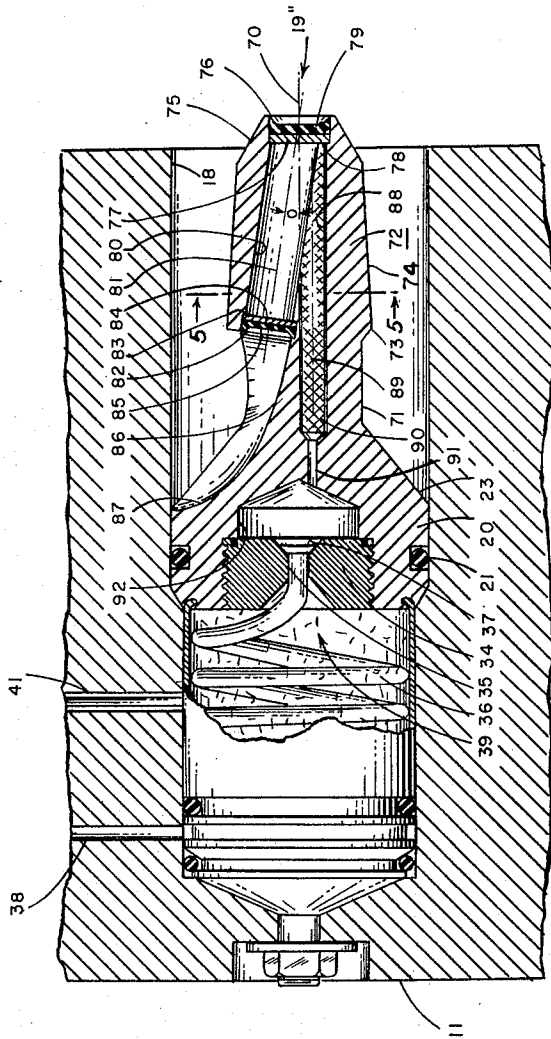


FIG. 4

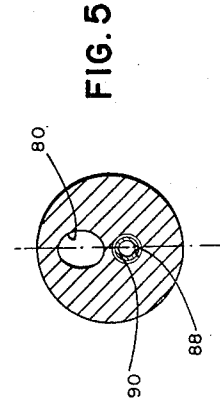


FIG. 5

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5 Sheets-Sheet 5

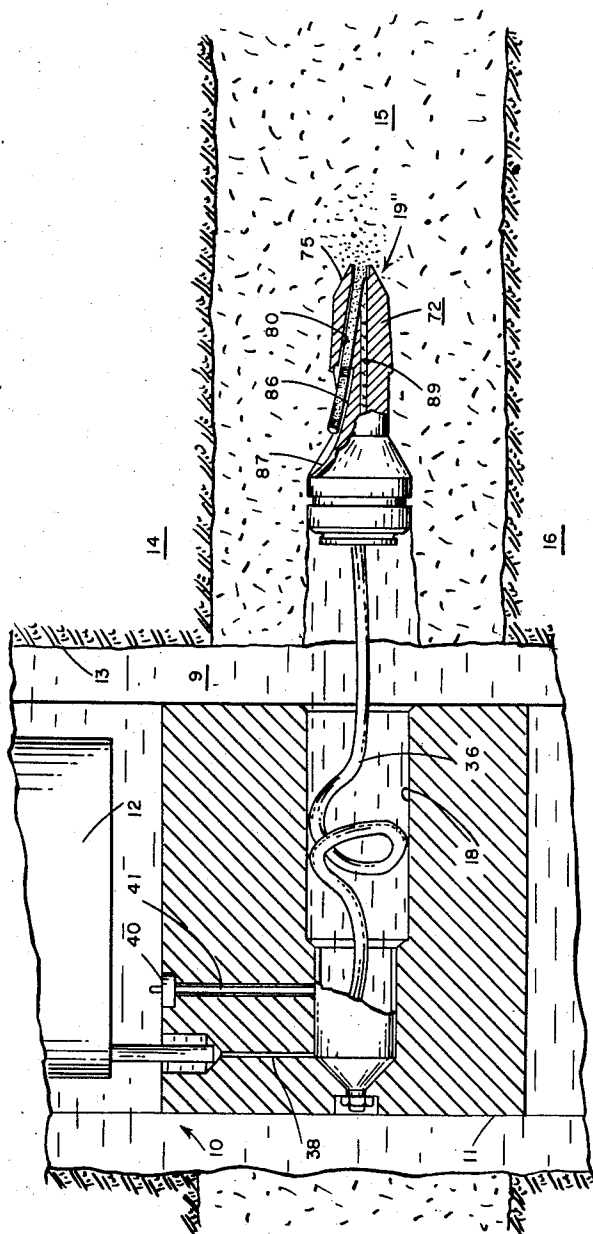


FIG. 6

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2,903,069

APPARATUS FOR INVESTIGATING EARTH FORMATIONS

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Application September 23, 1955, Serial No. 536,189

5 Claims. (Cl. 166—100)

This invention relates to apparatus for investigating earth formations and, more particularly, pertains to a new and improved projectile for use in an earth formation fluid sampler.

One type of fluid sampler proposed heretofore comprises a hollow projectile disposed within a gun block adapted to be lowered through a bore hole to a position adjacent a formation of interest. At the desired level an explosive contained by the gun block is detonated thereby to fire the projectile into the formation. The projectile is connected to a reservoir by a flexible tube and has a normally closed front aperture which is opened so that formation fluid may pass through the projectile and the flexible tube into the reservoir where it is retained by means of a check valve. The apparatus may then be raised to the surface where the sample can be recovered from the reservoir.

Experience has shown that when a solid object penetrates a formation, its lithology changes; usually the result is in the nature of a compaction of the formation. For example, if an object is forced into a sand body which does not change in volume, the voids in the sand body are decreased by the volume of the object. Such a decrease ordinarily takes place in the immediate vicinity of the object.

As these voids are decreased, the sand grains are pushed into one another in such a manner that they are crushed into an extremely fine material, and the permeability of the sand immediately adjacent the surface of the object approaches zero. Thus it may be difficult, if not impossible, to obtain a sample of formation fluid.

It is an object of the present invention, therefore, to provide a new and improved projectile for an earth formation fluid sampler which overcomes the undesirable effects of compaction of formation material into which the projectile is driven.

Another object of the present invention is to provide a new and improved projectile for an earth formation fluid sampler for obtaining samples of formation fluids with greater reliability than heretofore possible.

In accordance with the present invention, a projectile for an earth formation fluid sampler comprises a body adapted to be impelled toward a selected earth formation and having a first chamber and a second chamber fluidly communicable with the first chamber. The body further includes a forward extremity having a wall portion frangible in response to impact with earth formation material to provide an opening extending from the outer surface of the body to the first chamber. Filter means is disposed at a location in the fluid path including the first and the second chambers for permitting a fluid sample to flow through the second chamber while excluding solid formation material.

The novel features of the present invention are set forth with particularity in the appended claims. The present invention, both as to its organization and manner of operation, together with further objects and advantages thereof, may best be understood by reference to

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the following description taken in connection with the accompanying drawings in which:

Fig. 1 is a view in longitudinal cross section of an earth formation fluid sampler incorporating a projectile embodying the present invention, the fluid sampler being represented schematically and in one condition of operation;

Fig. 2 is a view similar to the one shown in Fig. 1, but illustrating the fluid sampler in another condition of operation;

Fig. 3 represents one modification which may be made to the apparatus of Fig. 1;

Fig. 4 represents another modification which may be made to the apparatus of Fig. 1;

Fig. 5 is a cross sectional view taken along line 5—5 of Fig. 4; and

Fig. 6 represents the modified apparatus of Fig. 4 in another condition of operation.

In Fig. 1 of the drawings there is illustrated a portion of a sampler unit 10 including a gun block 11 and a sample-receiving chamber 12. Sampler unit 10 (excluding the projectile of the instant invention) may be constructed in the manner described in the copending application of R. Q. Fields filed September 23, 1955, bearing the Serial No. 536,204, and assigned to the same assignee as the present invention. Although but a single unit is illustrated, any desired number of units may be employed, and the entire assembly is suspended in a bore hole 13 by a cable (not shown) in the customary manner.

Bore hole 13 traverses earth formations such as the ones designated 14, 15 and 16 and may be filled with a drilling fluid 9. It is assumed that formation 15 is the selected one from which a fluid sample is to be taken and the sampler unit 10 is positioned in the bore hole with its gun block 11 opposite this formation.

Disposed within a cylindrical, transverse bore 18 of gun block 11 is a cylindrical, hollow projectile 19 embodying the present invention. The projectile 19 has a rear end portion 20 very slightly smaller than bore 18 and an O-ring 21 seated in an annular groove 22 provides a fluid seal between end portion 20 and the wall of bore 18. A tapered section 23 extends between rear portion 20 and a forward portion 24 of a smaller diameter terminated by a generally conical formation-penetrating nose 25. This type of construction is disclosed in the copending application of Maurice Mennecier filed September 23, 1955, bearing the Serial No. 536,251, and assigned to the same assignee as the present invention. Nose portion 25 has an axial bore defining a first chamber 26 whose rear end is open to a somewhat larger cylindrical chamber 27 extending through projectile portion 24. The foremost extremity 28 of the projectile is provided with an axial opening 29 slightly larger than chamber 26 thereby defining a shoulder 30. Seated on shoulder 30 is a shear disk 31 which is held in place by a pressure seal 32 which may be constructed of a resilient material tending to expand into opening 29. Accordingly, bore hole fluids are prevented from entering chamber 26.

The shear disk 31 may be constructed of a material, such as an appropriate alloy of aluminum, so that it withstands the pressure of drilling mud 9, but ruptures upon impact with formation material. It is thus evident that projectile 19 includes a forward extremity having a wall portion frangible in responsive to impact with earth formation material to provide an opening extending from the outer surface of the projectile to chamber 26.

Disposed at the rearmost end of chamber 27 is a filter screen 33 which permits a fluid sample to flow through a rear section 27' of chamber 27 while excluding solid formation material. A cylindrical support 33a for screen 33 is seated in section 27'. It has a conically dished for-

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ward section 33b connected to an axial passage 33c, and its rear end is sealed to chamber section 27' by an O-ring 33d. A closure 34 fluidly seals the rear end of projectile 19 and has an axial opening 35 for receiving one end of a flexible tube 36 to which it is mechanically connected in an appropriate manner. For example, the tube may be silver soldered to the wall of opening 35 and an enlarged head 37 is provided on the tube. Thus, the tube is fluidly sealed to the wall of opening 35, while head 37 affords a strong mechanical connection for forward movement with closure 34. Tube 36 is in fluid communication with section 27' of chamber 27 and is wound into a plurality of helical turns disposed at the rear end of gun bore 18. The remaining extremity of tube 36 is fluidly connected by means not shown to a conduit 38 that extends to sample-receiving chamber 12. For example, the connection between tube 36 and conduit 38 may be effected in the manner disclosed in the aforementioned copending application Serial No. 536,204.

A propellant such as an explosive material 39 is disposed at the rear end of gun bore 18 and within the convolutions of tube 36. A hollow cylindrical container 20a encloses tube 36 and the material 39. The container mechanically connects portion 20 of the projectile with a member 20b which closes the rear end of bore 18. An electrical igniter 40 of conventional construction extends through a transverse opening 41 in gun block 11 and through container 20a so that its electrical heater element (not shown) is in contact with explosive 39.

To condition the fluid sampler for operation, chamber 12 may be evacuated or filled with a fluid at a pressure lower than the pressure of formation fluids. For example, chamber 12 may contain air at atmospheric pressure before it is installed and the apparatus is lowered into bore hole 13. When gun block 11 is opposite formation 15, an appropriate electrical circuit is completed between a source of electrical energy (not shown) and igniter 40 thereby to detonate explosive 39 and projectile 19 is impelled out of gun bore 18 into the formation. Tube 36 uncoils and extends from the gun bore as shown in Fig. 2 thereby permitting projectile 19 to enter the formation. The impact of formation material ruptures shear disk 31 and a formation material enters compartment 26. As formation material flows through compartment 26, the shear disk is driven into compartment 27 as shown in Fig. 2. The combined volumes of compartments 26 and 27 are great enough to receive a quantity of material greater than a volume defined by the diameter of compartment 26 times the distance of maximum penetration of projectile 19 into the formation.

Since formation material is compressed very slightly within the projectile and immediately in front of it, compaction of formation material is minimized and a sample of formation fluid may flow through compartments 26 and 27, tube 36, conduit 38 and into sample-receiving chamber 12. Thus by using a projectile embodying the present invention, samples of formation fluid may be consistently and reliably taken.

After chamber 12 is filled, unit 10 is drawn upwardly to close a valve (not shown) in the fluid path to the chamber and to break tube 36. Thereafter, the unit may be raised to the surface of the earth where the sample is removed.

In the modified arrangement of Fig. 3, where elements similar to corresponding elements of Fig. 1 are identified by the same reference numerals, projectile 19' has a forward chamber 26 receiving a rear portion 50 of a cylindrical closure member 51. Portion 50 has a diameter essentially the same as compartment 26 to effect an essentially fluid-tight fit and a fluid seal is assured by means of an O ring 52 seated in an annular recess 53 about the periphery of portion 50.

Closure member 51 has a conical, pointed forward end 54 of essentially the same apex angle as the cone defined by section 25 of the modified projectile 19'. Pref-

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erably, a portion of closure member 51 to the rear of nose 54, denoted by numeral 55, has a diameter somewhat smaller than portion 50 so as to provide a space for the collapse of a shear element 56, in the form of an integral, radial flange disposed between portions 50 and 55 of the closure member. The rear surface of shear flange 56 engages a surface 57 at the junction between the foremost end of the wall of compartment 26 and the surface of nose section 25.

Although a filter as the one designated by numeral 33 in Fig. 1 may be suitably employed, an alternative form of filter 59 may be disposed at the rearward end of chamber 27. This filter comprises a cylindrical base 60 seated in a recess 61 having a diameter slightly larger than compartment 27 defining a shoulder against which base 60 is held by closure 34. An annular recess 62 in the base 60 receives an O-ring 63 thereby to provide a fluid-tight seal.

Extending forwardly from base 60 is an integral portion 64 in the form of a cylinder having a diameter smaller than the diameter of compartment 27. A plurality of radially extending openings 65 connect numerous points along a conduit 66 extending axially through base 60 and portion 64, but terminating short of the forward end of portion 64. A sleeve-like, cylindrical screen 67 receives portion 64 and is secured thereto at its extremities, in an appropriate manner, such as by solder connections.

The modified projectile 19' operates in essentially the same manner as the projectile described in connection with Figs. 1 and 2. Accordingly, when the projectile 19' is impelled from gun bore 18 into the selected formation, the impact on nose 54 drives closure 51 toward compartment 27. The force of this impact causes flange 56 forcibly to engage surface 57 and the former is sheared off or is deformed so as to lie along portion 55 of the closure member. This permits the closure to be displaced inwardly and formation material may enter compartments 26 and 27. Thus, formation material adjacent opening 57 is compressed very slightly and a sample of formation fluid may flow through compartments 26 and 27, filter screen 67, openings 65, conduit 66 and tube 36 enroute to the sample-receiving chamber.

In Fig. 4 of the drawings there is illustrated a projectile 19'' modified in accordance with another embodiment of the present invention. Portions of the modified projectile which find their counterpart in the arrangement of Fig. 1 are identified by the same reference numerals.

Projectile 19'' has a longitudinal axis 70, and cylindrical rear portion 20 and tapered section 23 are oriented co-axially relative to this axis. From tapered section 23 there extends a cylindrical section 71 having a considerably smaller diameter than rear section 20 and terminating in another forwardly extending section 72 of generally frustro-conical configuration. Thus, section 72 has a rear end 73 slightly larger in diameter than section 71 and a front end portion 74 essentially equal to the diameter of section 71. Another frustro-conical section 75 extends from section 74 and terminates at a forward opening 76 which is closed by a shear disk 77 seated against a shoulder 78. Tightly fitted into opening 76 is a resilient pressure seal 79 that abuts against the forward face of disk 77 and provides a fluid-tight seal.

Extending through section 72 is an elongated chamber 80 of elliptical cross section (Fig. 5) having its forward end merging with opening 76. The maximum diameter of chamber 80 is smaller than opening 76 thereby defining the shoulder 78 mentioned above. The axis 81 of chamber 80 is tilted so as to define an acute angle θ with the principal axis 70 for projectile 19''. An opening 82 at the rear end of chamber 80 defines a shoulder 83 against which a disk 84 is seated. The rear face of disk 84 is covered by a resilient pressure seal 85 tightly fitted into opening 82.

A channel or groove 86 is cut into the surface of pro-

jectile section 71 effectively to form a continuation of opening 82. Section 86 merges into another cut-out section 87 in tapered portion 23. Cut-out 87 gradually curves away from axis 70 to provide a path for the ready flow of formation material, as will be more apparent from the discussion to follow, and terminates at the junction between sections 20 and 23.

Another chamber 88 extends through section 71 and 72 of projectile 19" along an axis 89 that is radially displaced from principal axis 70. Thus, a second chamber is defined whose forward end opens into the side of the first chamber 80. Chamber 88 receives a sleeve-like, cylindrical filter screen 90 also shown in Fig. 5. The screen 90, as viewed from one side has a tapered forward section (Fig. 4). This section is formed by compression of the screen to an inclined portion of a mandrel corresponding generally to the tapered forward section shown in Fig. 4 so that the screen 90 assumes the configuration shown. Hence, the screen filters the fluid influx and excludes solid matter from the chamber 88. The rear end of chamber 88 is connected with a fluid conduit 91 that extends along axis 89 to connect with an enlarged opening 92 at the rear end of projectile 19". As in the other embodiments of the invention, opening 92 is provided with a closure 34 which receives tube 36. Thus, compartment 88 is in fluid communication with tube 36.

In operation, when projectile 19" is impelled into the selected formation, shear disk 77 is ruptured and formation material is permitted to pass into compartment 80 as shown in Fig. 6. As formation enters the compartment and is driven through the compartment as a result of the forward motion of the projectile, formation material forces disk 84 out of opening 82 so that formation material may flow out of compartment 80. Since cut-out 86 merges into a gradually curved section 87, formation material is permitted to flow away from axis 70. It is thus apparent that a greater quantity of formation material may be received by the projectile constructed in accordance with this embodiment of the invention since formation material may readily pass out of compartment 80. Accordingly, a greater depth of penetration may be possible.

Inasmuch as formation material may flow freely, very slight compression occurs and an essentially undisturbed body of formation material remains in compartment 80. It is thus possible for a sample of formation fluid to pass through filter screen 90 in chamber 88, conduit 91, opening 92 and into tube 36 en route to the sample-receiving chamber. The sequence of operation subsequent to the condition represented in Fig. 6, may be substantially the same as described in connection with Fig. 2 and a sample of formation fluid may be readily recovered.

While particular embodiments of the present invention have been shown and described, it is apparent that changes and modifications may be made without departing from this invention in its broader aspects and therefore the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

We claim:

1. In an earth formation fluid sampler, a projectile comprising a body adapted to be impelled toward a selected earth formation and having a first chamber extending through said body at an angle to a central axis for said body and a second chamber fluidly connected to said first chamber and extending along said central axis, said body including a forward extremity having a frangible wall portion broken in response to impact with earth formation material to provide an opening fluidly connected to the forward extremity of said first chamber, and said body including another frangible wall portion broken in response to impact of earth formation material passing through said first chamber to provide an opening in the rearward extremity of said first chamber; and filter means disposed at a location in the fluid path for

permitting a fluid sample to flow through said second chamber while excluding solid formation material.

2. In an earth formation fluid sampler, a projectile comprising a body adapted to be impelled toward a selected earth formation and including a section having a first chamber extending from a forward extremity of said section along an axis inclined at an acute angle relative to a central axis for said body, a second chamber fluidly connected to said first chamber and extending along said central axis, a forward opening in said forward extremity aligned with said second chamber, and a rearward opening in said first chamber; a first member normally closing said forward opening and having a frangible portion broken in response to impact with formation material to permit said first member and formation material to enter said first chamber; a second member normally closing said rearward opening but movable out of said rearward opening in response to movement of formation material through said first chamber; and filter means disposed in said second chamber for permitting a fluid sample to flow through a section of said second chamber while excluding solid formation material.

3. In an earth formation fluid sampler a gun block; a gun bore in said gun block a projectile adapted to be positioned in said gun bore and impelled therefrom toward a selected formation, said projectile including: a rear portion having a cross-sectional area in a transverse plane substantially equal to the cross section area of said gun bore, a fore portion having a cross-sectional area in a transverse plane smaller than said area of said rear portion and having a forward frusto-conical extremity and an intermediate frusto-conical portion extending in a forward direction between said rear and fore portions, said projectile further including a rearward chamber and a forward chamber having a smaller cross-sectional area in a transverse plane than said rearward chamber fluidly connected to said rearward chamber, and a wall portion disposed in said forward chamber at the forward extremity thereof adapted to be breakable in response to impact with earth formation material to provide an opening extending into said forward chamber from the outer surface of said body, said forward and rearward chambers being greater in volume than the quantity of earth formation received therein, and said forward chamber being adapted to receive a quantity of earth formation material having a volume defined by the area in transverse section of said opening multiplied by the distance traveled by said body into the selected earth formation, and filter means disposed at a rearward location in the said rearward chamber for permitting a fluid sample to flow through a portion of said rearward chamber while excluding solid formation material.

4. In an earth formation fluid sampler a gun block; a gun bore in said gun block a projectile adapted to be positioned in said gun bore and impelled therefrom toward a selected formation, said projectile including: a rear portion having a cross-sectional area in a transverse plane substantially equal to the cross section area of the gun bore, a fore portion having a cross-sectional area in transverse plane smaller than said area of said rear portion and having a forward, frusto-conical extremity and an intermediate frusto-conical portion extending in a forward direction between said rear and fore portions, said projectile further including a rearward chamber and a forward chamber having a smaller cross-sectional area in a transverse plane than said rearward chamber fluidly connected to said rearward chamber and having an opening to said forward extremity; a conically pointed closure member disposed in the said forward extremity opening and adapted to be movable in response to impact with earth formation material thereby to permit said forward chamber to be opened, said forward and rearward chambers being greater in volume than the quantity of earth formation received therein, and said forward chamber being adapted to receive a quantity of earth formation

material having a volume defined by the area in transverse section of said opening multiplied by the distance traveled by said body into the selected earth formation, and filter means disposed at a rearward location in the said rearward chamber for permitting a fluid sample to flow through a portion of said rearward chamber while excluding solid formation material.

5. In an earth formation fluid sampler, a projectile comprising a body adapted to be impelled as a separate unit from a gunbore toward a selected earth formation, said body having a forward extremity and a forward portion, said body further having first and second chambers, said forward extremity having a frangible wall portion broken in response to impact with earth formation material to provide an opening into said first chamber, said body having a rearward opening in said forward portion which connects the first chamber to an outer wall surface of said body thereby permitting passage of earth formation material from the forward extremity through

the said first chamber and out of said rearward opening in said body, said second chamber having at least one portion opening into said first chamber and filter means disposed in said second chamber for filtering a fluid sample flow in said second chamber thereby excluding solid formation material from a portion of said second chamber.

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