July 28, 1970 M. G. KRUTEIN 3,521,715

METHOD AND APPARATUS FOR SAMPLING

Filed Oct. 23, 1968 2 Sheets-Sheet 1

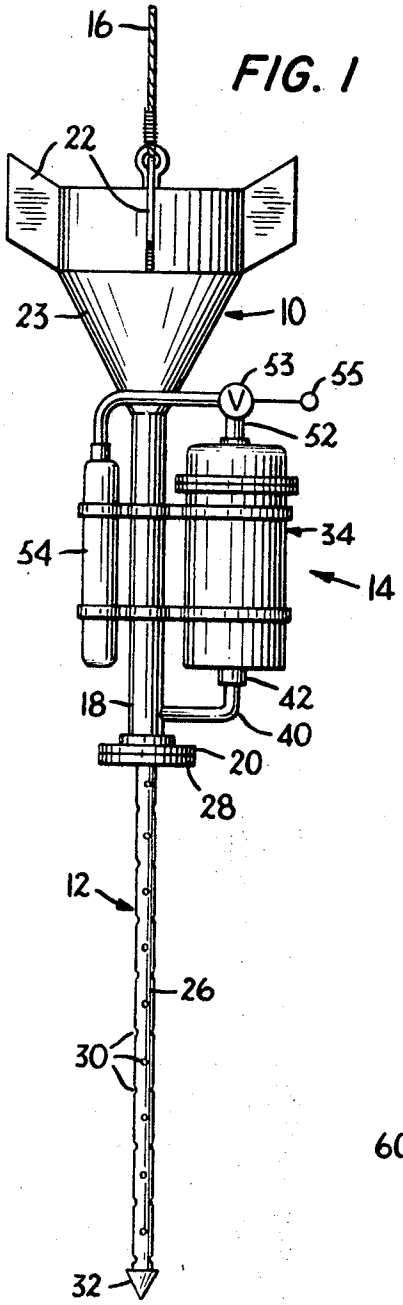



FIG. 1

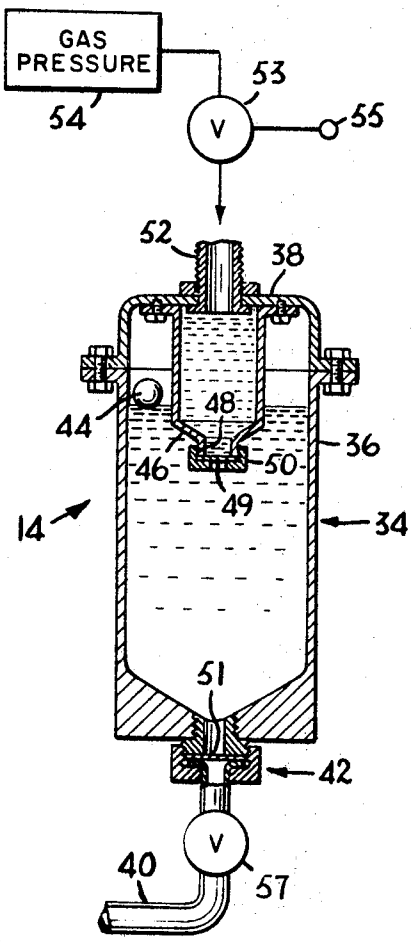



FIG. 2

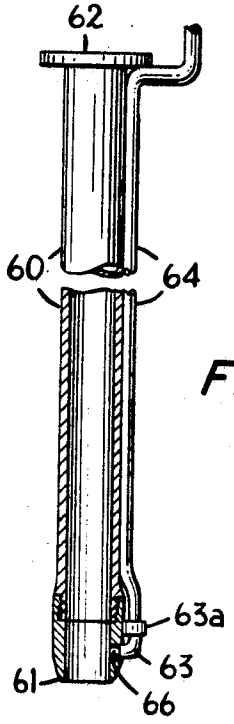



FIG. 3

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METHOD AND APPARATUS FOR SAMPLING

Filed Oct. 23, 1968 2 Sheets-Sheet 2

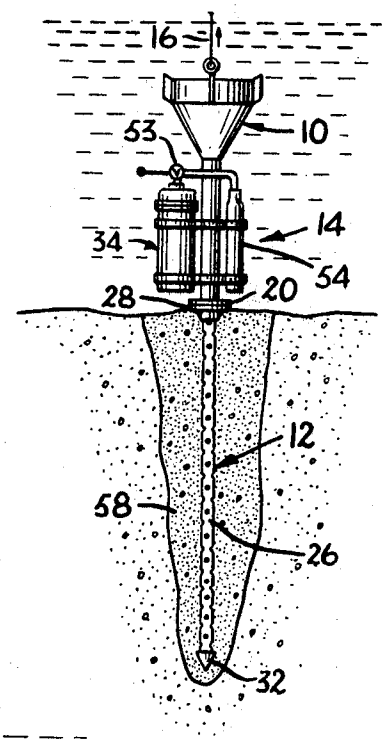



FIG. 4

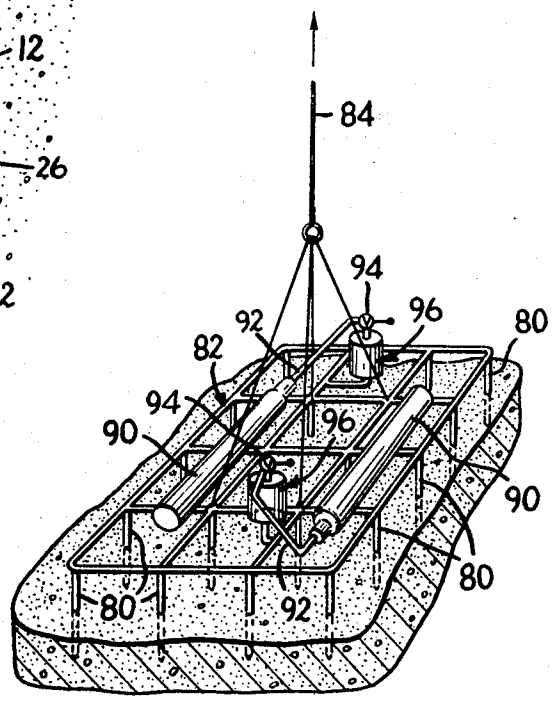



FIG. 5

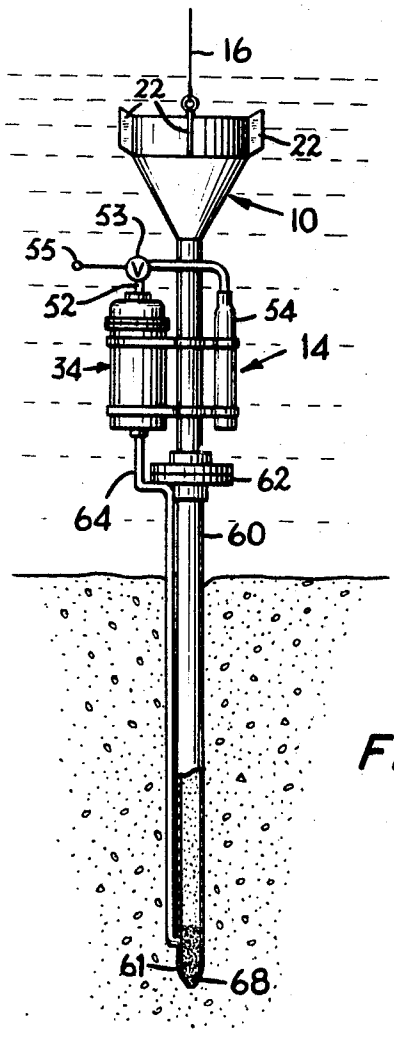



FIG. 6

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3,521,715

# METHOD AND APPARATUS FOR SAMPLING

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Int. Cl. E21b 49/00; G01n 1/08
U.S. Cl. 175—5 19 Claims

## ABSTRACT OF THE DISCLOSURE

A sample of an earth formation or other bodies of relatively permeable material may be obtained by penetrating the material with a probe and introducing into the formation adjacent the probe a chemical grout which sets to form a substantially rigid body composed of the gelled chemical grout and the material which the chemical grout permeates. When the probe is removed, the rigid gel body is removed with it.

## BACKGROUND OF THE INVENTION

This invention relates to a method and an apparatus for taking samples of earth formations on other bodies of material, the method and apparatus being particularly well adapted for underwater sampling.

The devices presently employed in taking physical samples from underwater earth formations, such as those on the sea floor, include corers, snappers, haul dredgers and drills, and various forms of these types of equipment have been proposed and used over the years. Each of them has certain limitations and disadvantages as to the sizes of samples and the condition of the samples after recovery, such as disturbance, sifting and sorting of the formation so that it is not recovered in substantially the form that it existed in place. These devices are also basically mechanical in nature and are subject to malfunctions and failures. These and other problems have restricted efforts to explore scientifically the sea floor and its upper surface layers.

Probably the most commonly used of the presently available sampling devices are corers. Basically, all corers include a tubular element which is forced into the earth formation and some mechanical device for closing the lower end of the tubular body of the corer after it is forced in to retain the sample within it when it is brought up from the sea floor. The mechanical devices for closing the corer sample tubes have been of various types, and each has its advantages and disadvantages. Many of them, however, are so constructed that they disturb the sample as they enter the earth formation. Some of them do not fully close and thus allow sifting of the sample out through openings that may be left when the device closed. Some of these devices are quite susceptible to failure to close completely so that the sample may readily fall out.

It has been proposed to take samples of underwater formations by freezing the region immediately around a refrigerating device forced into the formation. The refrigerating device may be a container of Dry Ice or a device through which a refrigerant may be circulated. Although the freezing method generally permits recovery of a substantially undisturbed sample, it requires expensive refrigeration equipment or a source of Dry Ice for purposes of freezing the sample in situ. Moreover, refrigeration and thawing equipment will generally be needed to store and process the samples. Careful thawing is necessary when the frozen samples are removed from the core tube to prevent them from breaking or cracking. Although samples of relatively large sizes can be recovered, it may require a considerable period of time for the large size sample to freeze. As a practical matter there are limits on the size of samples which can be conveniently and economically recovered and processed by the freezing method.



## SUMMARY OF THE INVENTION

There is provided, in accordance with the present invention, a novel and improved method and apparatus for recovering physical samples of earth formations as well as of other materials. The method and apparatus may be used in a variety of fields, including oceanographic research (sea floor and beaches), limnological investigations (estuaries and river beds, especially in muddy ground), industrial samples (thickeners, settling ponds, and the like), civil engineering investigations (dredged fills, swamps, and wet soils, for example), and harbor and ocean engineering research (for example, water pollution, soil and sedimentation research or testing). The method and apparatus are based on the use of an initially liquid chemical grout which forms a substantially rigid, self-sustaining gel body consisting of the gelled chemical grout material and the earth formation or other material permeated by the chemical grout after a certain reaction time.

More particularly, the invention involves the use of a probe which is forced into the material to be sampled and equipment associated with the probe for introducing a chemical grout into a selected zone of the material adjacent or within the probe. The grout is introduced into the material in liquid form and permeates the formation to an extent controlled principally by the amount of grout displaced into the formation and the pressure under which it is introduced. After a period of time, which can be controlled fairly closely by the composition of the chemical grout, the chemical grout gels into a substantially rigid body composed of the gelled grout and the material permeated by it. After the chemical grout has gelled, the probe is withdrawn carrying the gel body out with it.

The term "chemical grout" as used herein means and includes any initially non-viscous solution which will permeate a formation through which water flows and which after a predetermined period of time solidifies into a stiff gel which binds the particles together into a self-sustaining, substantially rigid body. There are a number of chemical grouts available commercially that can be used for carrying out the invention. One that has been found to provide good results is composed of a mixture of a product of American Cyanamid Company designated "AM–9" with a catalyst and an initiator in an aqueous solution. The gel time of this chemical grout may be controlled by varying the choice of catalyst and initiator and the concentrations of the grout solution, and initiator and catalyst.

Various forms of probe may be employed in the apparatus of the invention, depending upon the form of sample desired. In one form, the probe may be a relatively small diameter, elongated rod or tube. With this type, the grout is introduced into a zone surrounding the probe so that an elongated body of the formation surrounding the tube constitutes the sample. In another form, the probe may be a relatively large diameter tube in which the sample taken is the material that is contained within the tube upon penetration of the tube into the material being sampled. In the latter form of probe, the chemical grout may be introduced only to a zone within the tube and adjacent the bottom of the core of material, and upon solidification the gel body in the lower portion of the core of material acts as a plug and retains the part of the sample higher up in the tube, which is in substantially undisturbed, unsolidified condition, within the device for recovery. However, the en-

tire core of material in a core-type probe may, if desired, be formed into a gel body by introducing the chemical grout into the entire core.

In preferred forms of equipment for introducing the chemical grout into the material, the active grout solution and the initiator solution for it are contained in separate containers mounted on a carrier on which the probe is also mounted. For underwater sample, the equipment is arranged to be lowered through the water with the probe pointed down so that it will penetrate into the underwater formation when it reaches it. A source of gas under pressure, such as a tank of compressed air, is connected to one of the containers through a normally closed valve.

For underwater use, the valve may be of a type which opens upon impact of the device on the bottom so that gas pressure is released into the first container at about the same time that the probe penetrates into the bottom formation. The first container is connected to the second container through a valve or equivalent device which opens in response to the entry of gas pressure into the first container so that the solution in the first container is driven into and mixes with the solution in the other container. The second container is connected to the distribution or placement conduits which conduct the grout into the selected zone adjacent the probe.

With the form of probe that provides for recovery of a body of material surrounding a relatively small diameter probe element, which may be termed a needle type probe, the probe may be hollow and the solution conducted into the formation through the central passage in the probe and out through suitable spaced openings through the wall of the probe. With the core type probe, the chemical grout may be conducted to the lower end of the probe by a pipe located either inside or outside of the probe and discharging adjacent the lower end of the probe.

Samples of relatively larger size may be recovered by utilizing a bank of probes, preferably of the small diameter needle type, mounted in appropriately spaced relation on a carrier or frame and preferably served by one or two chemical grout supply systems. In this form of equipment, the several needle type probes provide for permeation of the chemical grout throughout a relatively large zone extending substantially continuously in the spaces between the several probes and out some distance from the outermost probes. Samples having surface areas of many square feet can be recovered in substantially undisturbed state using this form of equipment.

The apparatus and method offer the important advantages of enabling samples to be taken in substantially undisturbed condition, which in turn provides more information about the formation than where the samples are disturbed, and permits various forms and sizes of samples to be recovered with basically the same equipment and techniques. The invention is fundamentally a chemical system and does not rely to any significant extent on complicated mechanical parts—thus, it is essentially trouble-free. It is relatively inexpensive to build and operate and does not require the special, often expensive, support facilities required with some types of sampling equipment.

## DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention, reference may be made to the following description of exemplary embodiments, taken in conjunction with the figures of the accompanying drawings, in which:

FIG. 1 is a side elevational view of one form of sampling apparatus equipped with a needle type probe;

FIG. 2 is a view in cross-section, taken on a relatively larger scale, of the chemical grout supply system employed in the apparatus of FIG. 1;

FIG. 3 is a side elevational view, the view being broken away in parts, of a core type probe that may be used with the apparatus of FIG. 1;



FIG. 4 is a view showing the probe of FIG. 1, on a relatively smaller scale than FIG. 1, in place in an underwater formation, and depicting a cross-section of the earth formation and the sample being taken;

FIG. 5 is a pictorial view of a form of apparatus having a bank of needle type probes;

FIG. 6 is a side elevational view of the apparatus of FIG. 1 fitted with the core type probe of FIG. 3 in place in an undersea formation for obtaining a core sample.

## DESCRIPTION OF EXEMPLARY EMBODIMENTS

The embodiments of the invention shown in the drawings are designed particularly for underwater sampling, but they can readily be used in almost any sampling environment; when the sampling is not underwater, certain features of the equipment will not be needed, as will be readily apparent to those skilled in the art.

Referring first to FIG. 1, one form of apparatus, according to the invention, comprises a support frame or carrier **10** of suitable form, a probe **12** mounted at the lower end of the carrier, and a system **14** for selectively introducing a chemical grout into a selected part of the material penetrated by the probe **12**. The apparatus may be lowered into the water and to the bottom by a cable **16**, which also serves for recovering it after the sample is solidified, or it can be equipped wtih a suitable releasable float device which is deployed on impact of the apparatus on the bottom and floats a recovery line to the surface. These and other forms of devices for running in and retrieving the apparatus may be used without making any material difference in the basic operation of the apparatus.

In the embodiment of FIG. 1, the frame or carrier **10** of the apparatus comprises a shaft **18** having a coupling flange **20** attached at its lower end and stabilizing fins **22** attached at its upper end. The stabilizing fins serve as a guide so that the apparatus falls through the water in a generally vertical position, as illustrated in FIG. 1. Desirably, the apparatus is lowered to the bottom by sinking freely by its own weight, but it may be dropped rapidly using a cable with slight restraint to assist in maintaining the vertical orientation. The upper part of the carrier **10** has a weight section **23** appropriate to sink the equipment at the desired rate.

The form of probe **12** depicted in FIG. 1 includes a relatively small diameter tubular element **26** having a flange **28** at its upper end which enables it to be bolted to the carrier flange **20** and also serves as a stop for limiting the degree of penetration of the apparatus into the earth formation. The form of probe **12** in FIG. 1 may be termed a needle type probe. It has a central passage affording conduction of the chemical grout from the supply system **14** down through it and out into the formation surrounding the probe through a multiplicity of holes **30**. The lower end of the probe element **26** is closed and has a conical point **32** that facilitates the penetration of the probe into the ground, the point having an upwardly facing shoulder to assist in retaining a sample on the probe element.

The chemical grout supply, shown in more detail in FIG. 2, includes a main outer container **34** having a cylindrical body **36** flanged at its upper end and a flanged, removable cover **38** which is bolted to the body. The lower end of the container **34** receives a conduit **40** coupled to it by a suitable detachable fitting **42**. The bottom of the container slopes toward the outlet through the fitting **42** to ensure that a float valve ball **44** will seat on the outlet opening after the chemical grout has been discharged from the container.

A smaller inner container **46** in the form of a generally cylindrical element is fastened to the inside wall of the top **38** of the main container. It has an outlet opening **48** adapted to communicate it with the first container **34**, but the outlet **48** is provided with a valve device which is of a type adapted to open in response to a substantial increase in pressure but normally remains closed. For example, the valve device may be in the form of a rup-

turable membrane 49 installed in the opening 48 with a threaded retainer 50. A similar membrane 51 is installed in the outlet from the main container to the pipe 40. A foot valve 57 of an appropriate type is installed in the conduit 40 below the membrane to avoid back pressure on the grout supply system due to hydrostatic pressure in the underwater environment.

Installed in the top 38 and communicating with the inner container 46 is a conduit 52 which connects the container 46 through a normally closed valve 53 to a source of gas under high pressure, such as a compressed air tank 54. Although various types of valves can be employed for the valve 53, an inertially operated valve which will open upon impact of the apparatus on the bottom (as represented schematically in the drawings by a weight 55 coupled to the schematically shown valve body) is preferred in underwater type equipment. The respective main and inner containers 34 and 46 contain separately the two solutions which combine to make up the chemical grout (as described below).

Upon impact of the apparatus on the bottom, the valve 53 opens and admits high pressure gas into the inner container 46. Although the gas pressure in the tank 54 can be adjusted to suit the environmental pressure, it may be desirable to equip the grout supply system with a suitable automatic pressure balance device (not shown) so that the gas pressure, which injects the grout in the formation, automatically attains a level some predetermined, preset increment over the environmental pressure.

When the valve 53 is opened to communicate the gas pressure to the container 46, the increase in pressure in the container 46 ruptures the membrane 49 and releases the solution it contains into the main container 34. The surge of the solution in the inner container into the main container is sufficient to mix the two solutions. The increase in pressure in the main container in turn breaks the membrane 51, opens the foot valve 53 and permits the chemical grout to be forced out of the container and through the conduit 40. In the embodiment of FIG. 1, the conduit 40 communicates with the interior passage in the needle probe 26, and the chemical grout is released through the openings 30 into the zone penetrated by the probe 12 and is forced out into the formation.

Referring to FIG. 4, which shows the apparatus of FIG. 1 in position in an underwater earth formation, such as the sea floor, the chemical grout permeates the formation surrounding the probe 26. In FIG. 4, the zone of the formation which is permeated by the chemical grout is outlined and shaded slightly differently, as designated by the reference numeral 58. After a predetermined time, which will generally be on the order of a few minutes, the chemical grout gels to form a substantially rigid body composed of the gelled grout and the formation material which the grout has permeated. After the grout has gelled, the apparatus can be pulled up with the cable 16. The gel body 58 constituting the sample is retained on the probe and is pulled out of the formation and taken to the surface.

FIGS. 3 and 6 show another form of probe which can be substituted for the needle type form shown in FIGS. 1 and 4. The probe in the basic apparatus shown in FIGS. 3 and 6 is, more particularly, a core type probe and consists of a relatively large diameter tubular body 60, a flange 62 at its upper end by which it may be coupled to the carrier flange 20, and an externally mounted pipe 64 adapted to be coupled to the outlet fitting 42 of the grout supply container 34. Threaded onto the lower end of the tubular body 60 is a cutter 61. The cutter has a relatively sharp edge, which facilitates penetration of the probe into the earth formation, and is fitted with a pipe elbow 63 having a flared coupling 63*a* and welded into an opening 66 in the cutter 61. The supply pipe 64 extends down longitudinally along the probe 60 and is connected to the elbow. Accordingly, chemical grout is conducted from the container 36, in the manner described above, into the lower portion of the probe bore and permeates into the lower part of the body of the material within the bore. FIG. 6 depicts the permeated portion of the core of the material by heavy shading, designated by the reference numeral 68.

In a manner substantially identical to that described above in connection with the embodiment of FIGS. 1 and 3, except for the particular selected zone into which the chemical grout permeates, the chemical grout, after a predetermined time, gels to form a substantially rigid body composed of the gel material and the material which it has permeated. This body is substantially self-supporting and constitutes a plug in the lower end of the core type probe which retains the material within the bore above it. Accordingly, the apparatus can be pulled out of the formation and taken to the surface with the core sample intact within the probe.

With a core type probe of relatively great length, it may be desirable to provide a number of longitudinally spaced openings for conducting chemical grout into several points spaced vertically along the probe, and with relatively larger diameter cores, to provide for injection of chemical grout from several circumferentially spaced points distributed around the circumference of the probe 60 and at substantially the same level.

FIG. 5 of the drawings shows a form of apparatus, according to the invention, which is adapted to recover a large formation sample. Basically, the form of apparatus shown in FIG. 5 is like the form shown in FIG. 1 except that it includes a multiplicity of needle type probes 80. The probes 80 may be substantially identical to the probe 12 shown in FIGS. 1 and 4 except for the flange 28 used to mount the probe on the carrier. In the embodiment of FIG. 5, the probes 80 are appropriately mounted on a suitable carrier frame 82. The frame 82 may, as shown, also constitute a pipe distribution network for conducting the chemical grout to the several probes 80, in which case it is made up of tubular elements communicating with each other, with the probes and with the chemical grout supply equipment. The carrier frame 82 of the apparatus is lowered to the bottom and recovered by a cable system 84.

The grout supply system is in principle the same as that embodied in the form of apparatus shown in FIG. 1, except that it is, of course, larger in size and is made up of separate, identical supplies. The same reference numerals are applied to the elements of each supply. Each supply includes a compressed air tank 90 and a chemical grout container 96 of substantially the same construction as that shown in FIG. 2. The air tank is connected to the container 96 through an inertially actuated valve 94 by a conduit 92. The supply operates in substantially the same manner as the form shown in FIG. 2 to mix the two solutions making up the chemical grout and inject them through the pipe system 82 and the several probes 80 into the formation.

The chemical grout passes out through the holes (not shown in FIG. 5, but see FIG. 1) in the several needle probes 80 and out into the formation in a manner and to an extent sufficient to produce a substantially continuous gel body composed of gelled chemical grout and the formation material which the grout has permeated. After the chemical grout gels, the apparatus can be withdrawn with the slab sample retained on the probes.

In each of the embodiments described above, it may be desirable to retain the samples in place on the probe or probes rather than attempt to remove it immediately after recovery onto the vessel or other work platform. In this case, it is appropriate to remove the probe and install another probe on the same sampling equipment, thus making it possible for a series of tests to be carried out using a limited inventory of apparatus by providing a number of probes for each carrier and supply equipment. For each use, the chemical grout supply containers are taken apart, fitted with new valve membranes, refilled

and reassembled. When necessary the air tanks are recharged or replaced.

The needle type equipment provides a sample which is completely permeated by the grout material. If desired, the sample may be left intact and can be used as a permanent record. The samples do not lose or change their quality with time, and can be stored over a long period until needed. They can usually be removed from the probe intact upon recovery, inasmuch as the gel does not harden to a high strength level for at least several hours, even though it is self-sustaining at the time of recovery. The samples can be split, sliced and otherwise broken up into pieces of a desired form for analysis.

The plug type samples taken with the core probe can be removed by disconnecting the coupling 63*a* in the grout supply pipe and unscrewing and removing the cutter. Inasmuch as they are not permeated by the gel, they will generally break up upon removal and are, of course, in essentially their original undisturbed form. It should also be noted that the solidfied samples are also essentially undisturbed and are usually not affected in composition by the grout material.

As mentioned above, the chemical grout used for the invention is a mixture of an active gel ingredient and a catalyst in an initially non-viscous aqueous solution capable of permeating an earth formation and after a time forming a stiff gel and therefore creating a substantially rigid, continuous self-supporting body that can be withdrawn from the formation and recovered basically intact. A chemical grout which provides good results is a product of American Cyanamid Company sold under the trademark "AM–9."

"AM–9" is a mixture of two organic monomers, acrylamide and N,N'-methylenebisacrylamide. When mixed in suitable proportions with a catalyst, the monomers are polymerized and crosslinked into a stiff complete matrix. Although there are many catalysts for "AM–9," a catalyst system composed of β-dimethylaminopropionitrile (DMAPN), ammonium persulfate (AP) and potassium terricyamide (KFe) is recommended. Cyanamid has published extensive data on how to use "AM–9," and therefore only a brief discussion of compounding and other aspects of its use is warranted here.

## EXAMPLES

Exemplary chemical grout compositions and process conditions in tests on sampling fine sand are compiled in the table below. All of the samples were judged to be good on the basis of strength, appropriate gel time, and general physical characteristics.

| Material | Test No. 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Water, g | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 |
| AM–9, Sol. #1, g | 5.0 | 5.0 | 10.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| DMAPN, g | .2 | .2 | .2 | .2 | .2 | .5 | .6 | .6 | .05 | .1 | .2 | .5 | 1.0 |
| Water, g | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| AP, Sol. #2, g | .1 | .2 | .5 | .5 | .5 | .5 | .5 | .5 | .1 | .1 | .1 | .1 | .1 |
| Sand at 8% Hum., g | 190.0 | 189.6 | 239.2 | 304.5 | 274.5 | 285.7 | 279.6 | 271.0 | 279.6 | 271.0 | 300.4 | 281.2 | 319.9 |
| Gel Time, min | 10 | 8 | 8 | 13 | 9 | 5 | 4 | 5 | 4 | 5 | 8 | 20 | 60 |
| Compression, lbs | 660 | 320 | 170 | 180 | 225 | 220 | 245 | 280 | 245 | 280 | 180 | 230 | 125 |
| Compression, p.s.i | 211 | 102 | 71 | 75 | 94 | 92 | 102 | 117 | 102 | 117 | 75 | 96 | 52 |
| Ratio AM–9/AP | 50:1 | 20:1 | 20:1 | 40:1 | 40:1 | 40:1 | 40:1 | 40:1 | 501: | 50:1 | 50:1 | 50:1 | 50:1 |

Thus, there is provided in accordance with the invention, a method and an apparatus for taking samples of various forms and sizes with only relatively minor modifications of the equipment and thus offering considerable versatility. The equipment is basically a chemical device, and by virtue of not relying upon mechanical moving parts, is substantially trouble-free. Both the needle and core types provide a minimum of disturbance of the sample. The core type has the advantage over many known mechanical core samplers of ensuring against sifting or sorting of material. The needle type, by virtue of its relatively small diameter, provides for good penetration of the formation. Both forms of device are well adapted to modification of existing sampling equipment at relatively low cost, and the cost of constructing new sampling devices, according to the invention, is also relatively low. The equipment is easy to use and maintain and requires a minimum of accessory equipment.

The embodiments of the invention described above are intended to be merely exemplary, and those skilled in the art will be able to make numerous variations and modifications of them without departing from the spirit and scope of the invention.

What is claimed is:

**1.** A method of sampling a liquid-permeable material comprising the steps of penetrating the material with a probe, causing a selected zone of the material adjacent to the probe to be permeated by a chemical grout formed of a gel solution and an initiator solution in an amount sufficient to form a substantially rigid gel body composed of the gelled chemical grout and the material permeated thereby, and withdrawing the probe with the gel body retained thereon after the chemical grout gels.

**2.** A method according to claim **1** wherein the chemical grout is caused to be permeated into the material by introducing it under pressure through a conduit associated with the probe.

**3.** A method according to claim **1** wherein the probe is tubular and the selected zone includes a portion within the probe.

**4.** A method according to claim **1** wherein the selected zone includes a portion surrounding the probe.

**5.** A method according to claim **4** wherein the selected zone includes an elongated portion of the material adjacent to probe thereby to obtain a core of substantial length.

**6.** A method according to claim **1** wherein the probe is tubular and the selected zone is adjacent the end of the probe only, the zone including a portion within the tubular element thereby to create a gel body at the end of the probe constituting a plug for the probe and retaining the material within the probe upon withdrawal thereof.

**7.** A method of sampling a liquid permeable material comprising the steps of providing separate sources of a grout solution and an initiator solution, the solutions together constituting a chemical grout, and a probe associated with the sources, penetrating the material with the probe, mixing the grout solution and initiator solution to form the chemical grout in its liquid phase, causing a selected zone of the material adjacent to the probe to be permeated by the liquid chemical grout in an amount sufficient to form a substantially rigid gel body composed of the gelled chemical grout and the material permeated by it, and withdrawing the probe from the material after the chemical grout gels thereby to withdraw with the probe the material in the selected zone.

**8.** A method according to claim **7** wherein the material is submerged under a liquid and solution sources and probe are lowered into the liquid in a substantially free-falling condition.

**9.** A method according to claim **8** wherein the probe is positioned to penetrate the material upon impact at the end of the free fall.

**10.** A method according to claim **9** wherein the mixing

of the solutions is initiated upon and in response to impact of the probe with the material.

11. Apparatus for sampling a liquid-permeable material comprising a probe adapted to penetrate into the material, a supply of a chemical grout adapted to form a rigid gel, means for introducing the chemical gel into a selected zone of the material adjacent to the probe including separate initially non-communicating receptacles for a chemical gel solution and an initiator solution making up the chemical grout, and means for selectively communicating the receptacles to mix the solutions, whereby the chemical grout permeates the selected zone and sets to form a substantially rigid body composed of the gelled chemical grout and the material permeated by it.

12. Apparatus according to claim 11 further comprising a carrier member, and means mounting the probe and the receptacles on the carrier member.

13. Apparatus according to claim 12 further comprising abutment means adjacent the probe to restrict the extent of penetration of the probe into the material.

14. Apparatus according to claim 11 wherein the means for introducing the chemical gel further includes a source of gas under pressure, means for selectively communicating the gas under pressure with the receptacle for one of the solutions, and means responsive to the communication of the gas under pressure into that receptacle for bringing that receptacle into communication with the other receptacle to accomplish mixing of the solutions.

15. Apparatus according to claim 14 further comprising means responsive to the communication of gas pressure to the receptacles for introducing the chemical grout into the material under the pressure of the gas.

16. Apparatus according to claim 11 wherein the means for introducing chemical grout into the material includes a source of gas under pressure, a first container, means for communicating the first container with the selected zone of the formation, a second container, means for selectively communicating the second container with the first container in response to a substantial increase in fluid pressure therein, means for selectively communicating the gas under pressure source with the second container, a grout solution in one of the containers and an initiator solution in the other container, the grout solution and initiator solution being components of the chemical grout, whereby the selective communication of gas pressure into the second container effects the mixture of solution to form the chemical grout and effects introduction of the chemical grout into the material.

17. Apparatus according to claim 16 wherein the second container is enclosed within the first container.

18. Apparatus according to claim 16 wherein the means for selectively communicating the second container with the first container includes a rupturable element that breaks in response to introduction of the gas under pressure into the second container.

19. Apparatus according to claim 16 further comprising valve means for terminating the injection of chemical grout into the material when the first container is substantially empty.

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