This invention relates to apparatus for testing oil wells or the like and more particularly to an arrangement whereby several zones or formations in the earth can be tested simultaneously.

In most cases petroleum deposits in the earth are found above connate water. In some cases, however, particularly where lenticular formations predominate, water may enter a well bore above an oil producing horizon or in between two oil producing horizons. The production of water with the oil is a source of trouble and many expedients have been proposed for shutting off the water-bearing formations. As a necessary preliminary to shutting off the water, its exact location must be found. Various electrical devices, such as that disclosed in the patent to R. D. Elliott, No. 1,537,519, granted May 12, 1925, have been proposed and used extensively for locating the entrance of connate water into an oil well. However, difficulty in using such electrical apparatus results from the fact that the tests are normally made after fluids from the formation have stopped entering the well and the well has reached a static condition.

In accordance with the present invention it is proposed to employ mechanical means for testing several formations or zones in a well. While a well is being produced, as by means of a pump, or while a drill stem test is being made, so that a differential pressure exists between the earth formations and the well bore, a sample of fluid entering the well bore from each of several formations is entrapped and brought to the surface of the ground for examination. Thus instead of making electrical measurements of static fluids in the well bore, samples of the fluids are taken while these fluids are flowing into the well bore at approximately the same rates of flow as exist when the well is in production.

Accordingly, it is one object of the invention to devise means suitable for obtaining samples of fluids at several points of ingress in an oil well while those fluids are flowing into the well bore.

It is still another object of the invention to obtain samples of fluids from spaced points in an oil well during normal pumping operations in the well.

It is still a further object of the invention to devise apparatus suitable for use in combination with a drill stem tester or a pump which will enable samples of fluid from various depths to be obtained.

Other objects and advantages reside in certain novel features of the arrangement and construction, as will be apparent from the following description of the apparatus taken in connection with the accompanying drawing, in which:

Fig. 1 is a side view of a drill stem tester with a sampling tool constructed in accordance with the present invention mounted thereon, the assembly being located in a well bore.

Fig. 2 is a cross-sectional view, showing in detail the construction of the multiple zone sampling tool of this invention.

Fig. 3 is a diagrammatic view illustrating the application of the present invention to a pump producing from several zones in an oil well.

Referring to the drawing in detail and first to the assembly of Fig. 1, it will be seen that a testing tool 12 is shown in a bore hole 13, the tester being attached to a drill stem or tubing 14. The tester, per se, forms no part of the present invention. It may be of the type shown and described in Halliburton Reissue Patent 20,688, reissued April 5, 1938, and that is the type illustrated, though any other known tester may be used if desired.

The tester is shown provided with a cone packer 15. Obviously a wall packer or other type may be used for sealing off the well bore instead of a cone packer. The apparatus which constitutes the novel feature of the present invention is located in the tail pipe or extension 16 beneath the packer 15.

The tail pipe 16 is provided with inlet ports 17, 18, 19, and 20, located at different levels and through which all of the fluid entering the tester 12 must enter. Since all of the inlet ports are beneath the packer 15, they are all exposed to substantially the same fluid pressure in the bore hole. They are not separated or packed off, one from another in any way.

A number of sampling chambers are mounted in the tail pipe 16, one for each of the inlet ports. This construction is shown in detail in Fig. 2. As there shown, the tail pipe 16, which is secured to the bottom of the packer 15 by a coupling 21, has a number of plugs securely mounted at spaced points therein. The upper of these plugs, designated 22, has four passageways extending longitudinally therethrough, two of which are shown at 23 and 24 in Fig. 2. Each of these passageways is provided with a ball 25 which cooperates with a seat member 26 to provide a check valve.

The other plugs in the tail pipe 16 serve as means for mounting inlet ports 17, 18, 19, and
20, and each of these contains one check valve. One of these plugs is shown in Fig. 2 at 27, it being understood that the others are similar in construction. As shown, the port 17 is in the form of a screen secured in body 27 by threads. A passageway 28 in the body 27 is provided for connecting the fluid passage 22. Located in the passageway 28 is a ball check valve 30 and seat 31.

Also as shown in Fig. 3, the upper end of the pipe 29 is connected to the passage 24 in the upper plug 22. The pipe 29 thus constitutes a chamber or conduit for entrapping a sample of fluid which enters the coupling 21 through the inlet port 17. When the tester, packer and tail pipe are removed from the well bore, fluid trapped in pipe 29 will be retained by check valve 26-31 while check valve 25-26 will prevent any fluid entering pipe 29 to contaminate the fluid contained therein.

In order to remove the fluid from the pipe 29 when the apparatus has been brought to the surface, tapes 39 and 40 are provided in plugs 21 and 22 respectively.

It will be understood that three additional plugs similar to that shown at 27 in Fig. 3 are mounted in the tail pipe 16 to mount the inlet ports 16, 18, and 20, and that each of these is connected to a passageway in the plug 22 by a suitable sampling pipe or chamber. These pipes are designated 41 and 42 in Fig. 2, and similar pipes are illustrated at 41, 42 and 43 in Fig. 3. It will be understood that the plug 27 has openings which permit these pipes to pass through it and that the other plugs mounted in the tail pipe 16, beneath the plug 27, have similar provisions made to accommodate the pipes. In this way the points of ingress of connate fluid from the various formations through which the well bore passes, may be located under flowing conditions and it is important to note that there are no packers or other artificial impediments to flow in between the various inlet ports.

The operation of this sampling tool is as follows: The apparatus is lowered into a bore hole 13 with the tester 12, the packer 15 and the tail pipe 16 secured to tubing 14. Upon reaching the level in the bore hole at which the test is to be run, the packer 15 is set and the valve in the tester 12 is opened, thus allowing the formation pressure to cause fluid to flow into the bore hole and into the nearest of the inlet ports 17, 18, 19, or 20. Upon entering these ports, the fluid flows upwardly through the conduits 28, 41, 42, or 43 into the tester and drill stem 14. Before the fluid stops flowing, the tester valve is closed, thus stopping the flow of fluid, and entrapping samples in the conduits. The entire apparatus is then removed from the bore hole.

Since the inlet ports 17, 18, 19, and 20 are spaced along the tail pipe 16, the samples caught in the chambers indicate what is being produced from the adjacent formations.

A tail pipe provided with only four inlet ports for taking fluid samples has been shown and described. However, it will readily be understood that additional sample-taking devices can be added.

In Fig. 3, the arrangement of sampling pipes and valves is shown mounted beneath a packer 15 instead of beneath a drill stem tester. No packer is employed in this case, but the well is merely produced and samples are entrapped under normal flowing conditions. In Fig. 3, the inlet openings 17, 18, 19, and 28 which convey fluid into the tail pipe 16 are shown as opposite various earth formations such as might exist in a well. If the apparatus were located as shown with respect to the formations, oil from the upper oil sand would enter the inlet opening 17; water from the lower oil sand would enter the inlet openings 18 and 19; and oil from the lower oil sand and oil from other formations would enter the apparatus, or lowering it on successive tests, the exact boundaries of the various formations could be ascertained.

It is obvious that many changes may be made without departing from the spirit of the invention or the scope of the cited claims.

I claim:

1. Apparatus for locating the points of ingress of connate fluids into a well bore, comprising in combination, a tail pipe adapted to be lowered into the well bore, means for permitting fluids to flow from earth formations through said tail pipe, and an arrangement located within said tail pipe for entrapping samples of fluids from spaced points along the well bore during such flow, said arrangement including a plurality of spaced inlet ports all exposed to substantially the same fluid pressure in the well bore, chambers for receiving fluids from the inlet ports and for conveying fluids through said tail pipe means for preventing the passage of fluid from one to another of said chambers and check valves for holding fluids in said chambers while the tail pipe is removed from the well bore.

2. Apparatus for locating the points of ingress of connate fluids into a well bore, comprising in combination, a tail pipe located in the well bore, a pump connected to said tail pipe for causing fluids to flow from earth formations through said tail pipe, a plurality of conduits extending downwardly through said tail pipe with their lower ends terminating at inlet ports located at spaced points along the well bore, so as to all be exposed to substantially the same fluid pressure in the well bore and being adapted to receive fluids and convey the same through said tail pipe to the pump means for preventing the passage of fluid from one to another of said conduits, and check valves for holding fluids therein while the tail pipe is removed from the well bore.

3. Apparatus for locating the points of ingress of connate fluids into a well bore, comprising in combination, a drill stem, a tester including a packer and a valve operated by manipulation of said drill stem to permit or prevent flow of fluids from the well bore into said drill stem, a tail pipe mounted on said tester beneath the packer thereof, a plurality of conduits extending downwardly through said tail pipe with their lower ends terminating at inlet ports located at spaced points along the well bore, all of said points being beneath said packer so as to receive fluids and convey the same to said tester during the time the tester permits flow of fluids into said drill stem means for preventing the passage of fluid from said drill stem to said conduits and check valves in said conduits for holding fluids therein while the tester, packer and tail pipe are removed from the well bore.

4. Apparatus for locating the points of ingress of connate fluids into a well bore, comprising in combination, a drill stem, a tester mounted on said drill stem including a packer and a valve operated by manipulation of said drill stem to permit or prevent flow of fluids from the well bore into said drill stem, and an arrangement for entrapping samples of fluids from spaced
points along the well bore during such flow, said arrangement including a tail pipe mounted beneath said packer, said tail pipe being provided with plurality of spaced inlet ports and a plurality of chambers for receiving fluids from the inlet ports means for preventing the passage of fluid from one to another of said chambers, and check valves for entrapping fluids in said chambers, said inlet ports all being exposed to substantially the same fluid pressure in said well bore.

ERLE P. HALLIBURTON.

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