The invention relates to a combination testing and treating tool for wells wherein the tool is provided with a port for permitting equalizing of pressure in the tool with that in the well bore as the tool is being lowered into the well bore.

The present invention relates in general to a type of tool as illustrated in my prior Patent 2,837,723 dated January 7, 1941, and my copending application Serial No. 65,845, filed December 17, 1948, and issued as Patent No. 2,611,437, for a High Pressure Inflatable Packer.

This application is a continuation of my prior copending application, Serial No. 510,293, for an Oil Well Tool, filed November 15, 1943, now abandoned.

An object of the invention is to provide a port at the lower end of the testing and treating tool through which fluid from the well bore may enter the tool and supporting pipe, maintaining equal internal and external pressure while the tool is being lowered into the well bore. This port is also used for circulating fluid through the supporting pipe and tool in and out of the well bore, which action is essential in that it prevents the fluid from congealing, eliminating freezing of the tool and supporting pipe in the well bore.

Another object of the invention is to provide a foot valve for testing and treating tools which can be opened or closed by the raising or lowering of the tool as a whole or the control of the tool individually.

Other and further objects of the invention will be readily apparent when the following description is considered in connection with the following drawings:

Figs. 1, 2, 3, 4, and 5, when assembled together, show a vertical sectional view of the testing and treating tool in position in the well bore ready for operation.

Figs. 6, 7, 8, 9 and 10 illustrate a sectional view of the tool after manipulation to first set the packers by hydraulic inflation and then open the tool for circulation in the well bore thereafter.

Figs. 11, 12, 13 and 14 make up a sectional view of the tool after it has been manipulated to open the tool to the isolated formation between the packers.

Fig. 15 is a section taken on the line 15—15 of Fig. 1.

Fig. 16 is a section taken on the line 16—16 of Fig. 17.

Figs. 17, 18 and 19 make up an assembly view of the entire construction with the tool in the well bore inflated and accomplishing a testing or treating operation.

Fig. 20 shows a small view of the drag cage in open position as the tool is removed from the well.

Having reference to Figs. 17 to 19 inclusive, a well bore 2 has been illustrated as having the surface casing 3 thereof extending a short distance into the well so as to support and be closed by the well head 4. The major portion of the well is not cased. The rotary table 5 by which the well is being drilled is shown as disposed on the derrick floor 6 and deposited on the rotary table is the control head 7 by which the tool of the present invention is manipulated. This control head includes a spider 8 which is mounted on the pistons 9 arranged in hydraulic cylinders 10. The pumps 11 are arranged to pump liquid into the cylinders 10 so as to control the elevation of the spider 8. A valve 12 can be used to adjust the flow. A gauge 13 is adjustable arranged so that suitable indicia on the rod 14 will enable the operator to determine the amount of movement which has been imparted to the operating pipe 15 which extends down into the well bore.

A swivel 16 is mounted on the top of the operating pipe and a Christmas tree assembly 17 provides for the inflow or outflow of liquid to the well, thus the connection 18 may lead to a test pit where any flow from the well may be examined. The connections 20 may be attached to a suitable supply of liquid under pressure such as drilling fluid, water or air which may be circulated into the well bore through the tool and discharged from the outlet 19 on the casing head 4 if the well is to be washed. These flow lines 20 may also connect to a suitable source of cement, treating acids, or the like which are to be injected into the well bore. If desired, this Christmas tree assembly can be removed at the flange 21 so that swabbing action can be carried on in the well through the tool by lowering a swab, pump or other device through the manipulating pipe 15.

In operation the parts of the tool will be assembled as seen in Figs. 1 to 5 inclusive and will then be lowered into the well bore by adding additional sections of the operating pipe 15 until the tool arrives at the elevation of a formation such as the formation 25 in Fig. 15 where it is to be tested or treated. A suitable swivel 30 is shown as connecting the control pipe 31 with operating pipe 15 so that if desired the operat-
ing pipe 15 may be rotated in the well bore by turning the rotary table 5 due to the fact that such pipe is suspended in the slips 27 in the spider 8. Such rotation prevents the operating pipe from becoming stuck in the mud or other liquid in the well.

The control pipe 31 is normally held in raised position with respect to the housing 50, by the provision of a coil spring 32 best seen in Fig. 1 where the guide lugs 29 on the pipe limit such movement by engaging the top of the housing 50. In this position the port 34 in the lower end of the housing 50 is open so that as the tool is lowered into the well bore the pressure inside and outside of the tool will be equalized. This port 34 is uncovered during the lowering operation due to the fact that the drag cage 35 which is arranged about the lower end of the housing is urged upwardly by the drag springs 36 which engage the face of the well bore as the tool is lowered as seen in Fig. 5.

When the tool arrives at the elevation where it is to be set the well may be washed or conditioned by circulating a desired liquid through the tool and up the well bore. A slight raising of the tool will cause closing of the ports 34 due to the drag of the springs 35 on the face of the formation. The drag cage 35 will remain stationary so that the port 34 is pulled up inside of the head 31 of the cage. In this manner the tool is completely closed. The sliding movement of the cage is limited by the collar 38 on the lower end of the housing.

When the ports 34 are thus closed, pressure can be applied through the operating pipe 16 by means of the valves at the ends of the tool so that there will be a flow of liquid into the control pipe 31 and through the central passage 33 thereof.

As seen in Fig. 2 the control pipe has a series of slots or ports 46 which are arranged to be aligned with the ports 41 in the upper packer 42 so that when pressure is applied through the passage 33 that this pressure will flow into the inside of the packing element 43 of the packer 42. This pressure tends to expand the packing element to the position shown in Fig. 9 wherein the face 44 of the packing element has moved into sealing position with the face 45 of the formation of the well bore. This contact provides a seal over a considerable area as seen in Figs. 18 and 19 and this pressure applied to inflate the packer must of necessity exceed the pressure in the well bore due to the weight of the column of liquid in the bore.

The lower packer 47 is likewise inflated during this operation due to the fact that the ports 48 in the control pipe are arranged in alignment with the ports 49 in the lower packer as best seen in Fig. 4. Thus when the pressure is applied the upper packer 42 and the lower packer 47 will both be simultaneously inflated as seen in Figs. 7 and 9 respectively.

Once the packers are inflated, the housing 50 is firmly anchored in the well bore and by adjusting the control head 7 by manipulation of the hydraulic pumps 11 or the valve 12 the control pipe can be manipulated by raising and lowering the operating pipe 16. It will be noted that the control pipe 31 extends entirely through the tool or rather, entirely through the housing 50 which constitutes the support for the packers 42 and 47.

The housing 50 is thus made up of the following parts reading from top to bottom, the circulating nipple 52 as seen in Fig. 1, the upper packer mandrel 53 seen in Fig. 2 and the top of Fig. 3, the flow nipple 51 which is threaded to the upper packer mandrel at 84, and the lower packer mandrel 55 which is threaded at 56 to the flow nipple 51. This lower packer mandrel extends on through the lower packer and carries the ports 34 heretofore described and is closed by the head 58 as seen in Fig. 10.

With the packers inflated as seen in Figs. 7 and 9 the control pipe will now be lowered a short distance so as to move the ports 40 and 41 out of alignment with the upper packer port 41 and the lower packer port 49 respectively. The control pipe thus moves down to the position shown in Figs. 6 to 10 inclusive. This movement of the ports 40 and 48 away from the packer ports closes the packers and traps therein the liquid under pressure so as to hold or provide a hydraulic lock to maintain the packers inflated. The downward movement of the control pipe will be such that the circulation ports 58 will move into alignment with the ports 59 in the circulating nipple 52 at the top of the tool as seen in Fig. 3, after which the control pipe ends within the packers which have been set so that the heavy drilling mud or other liquid in the drill pipe and well bore may be wholly or partially replaced with the other liquid if desired.

The heavy drilling mud is usually provided in the well bore to overcome the formation pressure and keep the well from blowing out, but now that the formation pressure is blocked off by the packers, the heavy drilling mud may be removed if desired. Preferably, however, it is merely conditioned at this stage of the operations so as to prevent it from settling in such a manner that it would hinder the manipulating of the pipe 15 or cause it to become stuck. It may be desirable to wash the mud or other liquid out of the operating pipe and the tool so as to reduce the weight of the column of liquid inside of the tool. Thus, for instance, if the intention is to use the tool to take a test of the formation it is desirable when the tool is opened to have a pressure inside of the tool less than the weight of the column of drilling mud which has been theretofore applied against the formation. Instead, water may be circulated down through the manipulating pipe 16 and out through the circulation ports 58 and 59 into the well bore. The volume of liquid to be introduced can be calculated so as to advise the operator when the mud has all been discharged into the well bore. Thus if the drilling mud being used had a specific gravity of two and was replaced by water having a specific gravity of one, the pressure on the face of the formation when the tool was opened would be reduced one-half.

Another use of these circulating ports is to introduce a treating liquid into the tool. For instance, if an acid is to be introduced into the formation, or if the formation is to be cemented off, the acid or cement, as the case may be, can be pumped down the well bore and by adjusting the control head 7 by manipulation of the hydraulic pumps 11 or the valve 12 the control pipe can be manipulated by raising and lowering the operating pipe 16. It will be noted that the control pipe 31 extends entirely through the tool or rather, entirely through the housing 50 so that any fluid in the operating pipe will be discharged into the well bore and replaced with the liquid which is to be injected into the formation. As before, the desired volume can be controlled and pumped into place until the operator knows that the well liquid has been displaced down to the elevation of the ports 58 and 59.

This operation with the circulating ports 58 opened as seen in Fig. 6 is a conditioning opera-
tion to prepare the well for the use of the tool. With the tool and the well bore thus conditioned the next step is to manipulate the control pipe 34 so as to raise the control pipe and close the ports 61, thus trapping whatever sample has been obtained within the tool and the operating pipe. The sample may flow to the surface due to formation pressure but it may be necessary to circulate this sample to the surface. The control pipe may be manipulated to open the circulating ports 55 by moving it to the position of Fig. 6. Pressure exerted through the return pipe 19 would cause a downflow in the well and an upflow through the operating pipe so that any sample obtained could be circulated to the surface if desired without releasing the tool. The tool, however, could be released, moved to another location and reset by following the practice heretofore outlined, or the tool could be removed to the surface to retrieve the sample.

In event a treating operation is to be performed, the treating liquid, if it has been already circulated down to the tool through the operating pipe, can be forced into the formation as soon as the tool is opened and any desired pressure or volume applied. After the treating operation has been completed it is generally desirable to remove the treating liquid from the tool and equipment as quickly as possible. This is particularly true if cementing or acidizing operation has been carried out so as to avoid setting of the cement or corrosion of the equip-
the mandrel, it is difficult to insert the control pipe or to inspect the packings.

It is not believed necessary to travel all the way down the control pipe pointing out the exact function of each of these packing rings, but it should suffice to point out that one or more of such rings constituting a set is positioned adjacent each side of each of the ports in the control pipe, so that every port or opening is sealed in either open or closed position.

It seems obvious that a very careful adjustment of the tool can be had in order to manipulate it to obtain the desired results. One feature which lends itself to such operation is the provision of the swivel connection because the raising and lowering of the operating pipe while it is under torque avoids any inaccuracy due to the stretching and variation in the length of the pipe. The fact that this control pipe has been moved the required distance for any particular operation is shown on the indicia rod but there will also be an indication to the operator as to the openings or closing of the various ports due to the building up or the release of the liquid in the operating pipe. A pressure gauge on the inlet and the outlet lines will instantly indicate such changes.

The operation of the tool has been set forth as the description was given, but it might be mentioned that the particular construction of the packer-anchoring construction is somewhat similar to that described in detail in my pending applications.

The packer construction does embody some deviation from that previously stated and by having reference to Fig. 2 it will be noted that the inner seal tube or liner layer of rubber or other material carries a ring on its inner surface which is provided with a plurality of seal rings to form a seal with the periphery of the packer mandrel, that spaced outside of and confining the upper end of this liner layer is the inner packer support skirt which is threaded at 34 into a coupling or packer head which forms part of the housing. This skirt tends to support the ends of the reinforcing strands which, it will be noted, extend over the enlargement on said skirt and likewise into the recess where the ends are confined by a retainer ring which retainer ring is locked in position with the hold down ring. The outer layer of packing material overlies the reinforcing strands and the rings at the end and is itself adhered to an outer skirt which is locked with the ring. When pressure is introduced into the packer the liner layer first expands and provides a seal to retain the pressure liquid.

This arrangement of structure has been found to be particularly desirable in that it securely anchors the packing rubber against displacement and in actual tests by the manufacturers, a packer end constructed as herein described withstood a pressure in excess of ninety-one hundred pounds per square inch.

The lower end of each of the packers is anchored to a sliding head which has the packing rings to provide a seal about the packer mandrel. This lower head carries the inner and outer skirts and, respectively, the same as the head or coupling as shown in Figs. 3 and 7. When the packer is expanded this lower head will slide upwardly as the packer expands so that the parts assume the position shown in the lower part of Fig. 7 and the upper part of Fig. 8, where this lower head has moved away from the flow nipple or coupling due to the expansion of the packer in diameter and the contraction of it in length.

Broadly the invention contemplates a combination testing and treating tool where the packers are hydraulically inflated, the tool capable of almost any desired operation in connection with treating, testing, cementing or squeezing in a well bore; the structure and arrangement of said tool being such that pressures in the well bore and in the tool may be equalized.

What is claimed is:

A well packer tool comprising a hollow operating control pipe, a housing about said pipe and slightly mounted on said pipe, an inflatable packer carried by said housing, there being an opening in said pipe for communicating with the interior of said packer for inflation and deflation thereof, said pipe having an opening in the lower end thereof below said packer, a head slidably mounted on said pipe below said packer for covering and uncovering said port in the lower end of said pipe, drag spring means on said head for engaging the wall of the well as the tool is lowered to maintain said head in a position on said pipe to uncover said port as the tool is lowered into the wall, said spring means acting to retard movement of said head relative to said pipe as the tool is raised in the well so as to cover said port in the lower end of said pipe.

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