March 6, 1951 J. E. WEILER 2,544,623

FORMATION TESTER

Filed Aug. 19, 1946 3 Sheets-Sheet 1

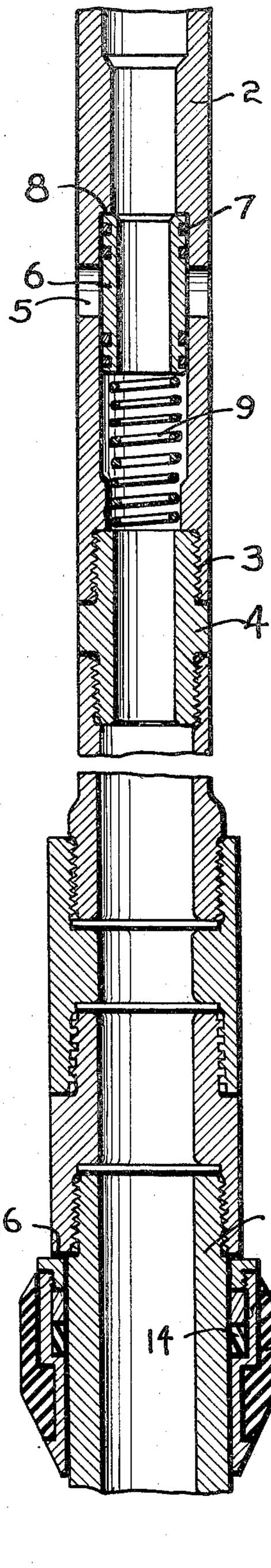

Fig. 1

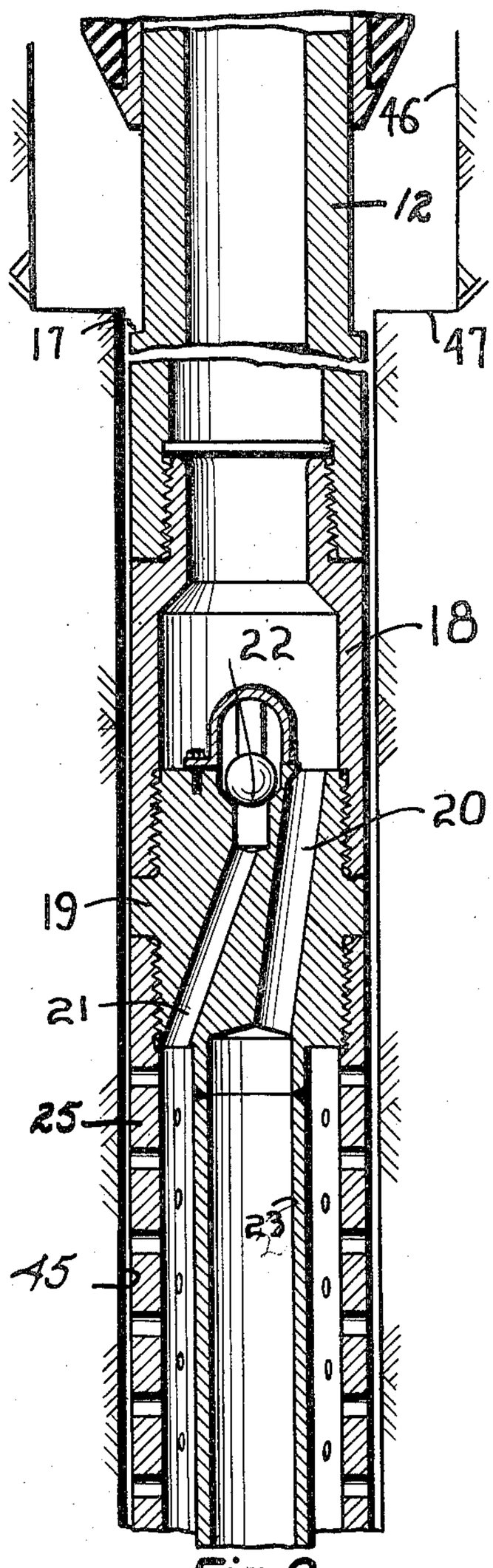

Fig. 2

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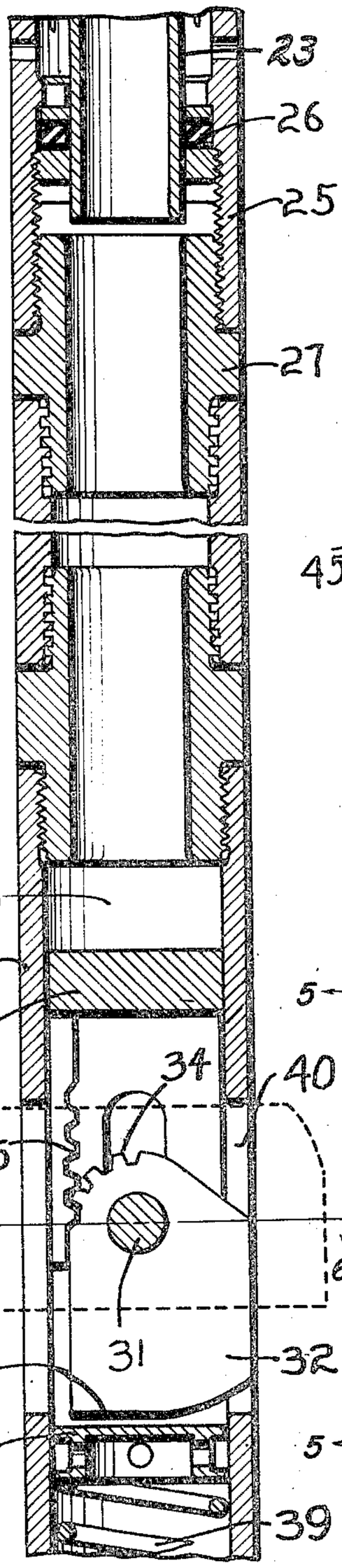

Fig. 3

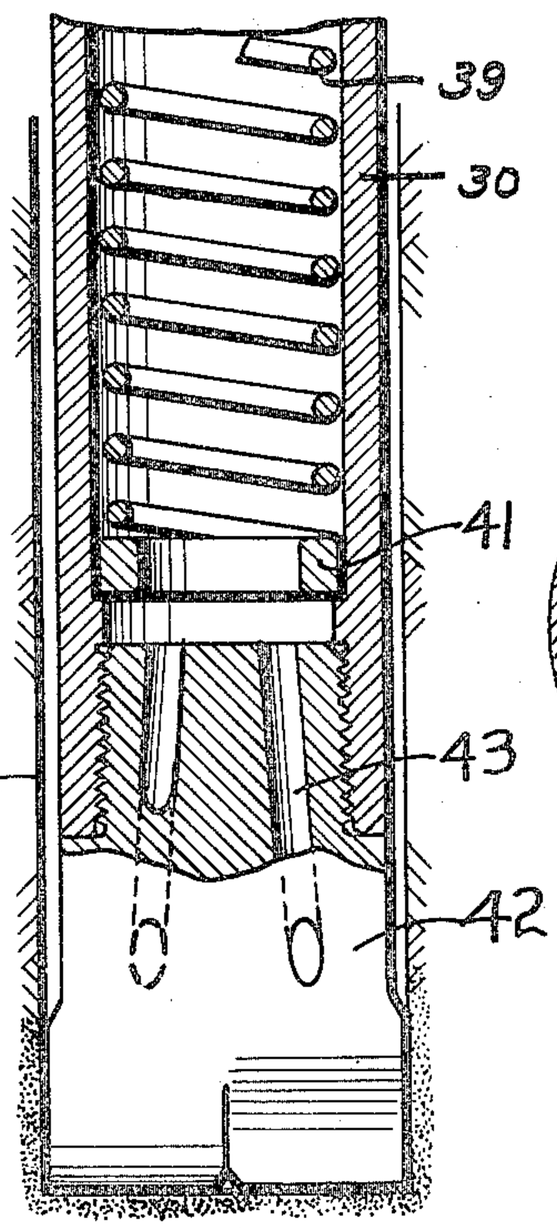

Fig. 4

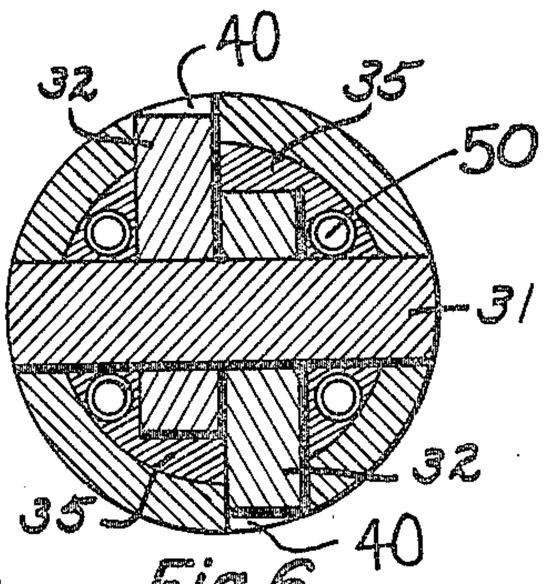

Fig. 6

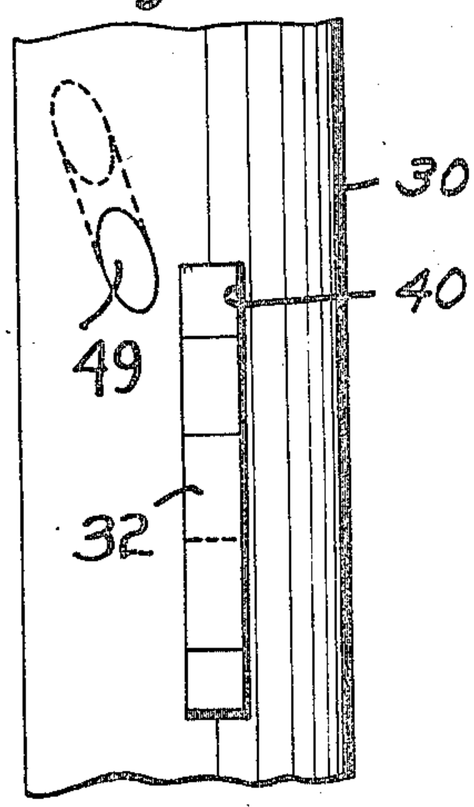

Fig. 5

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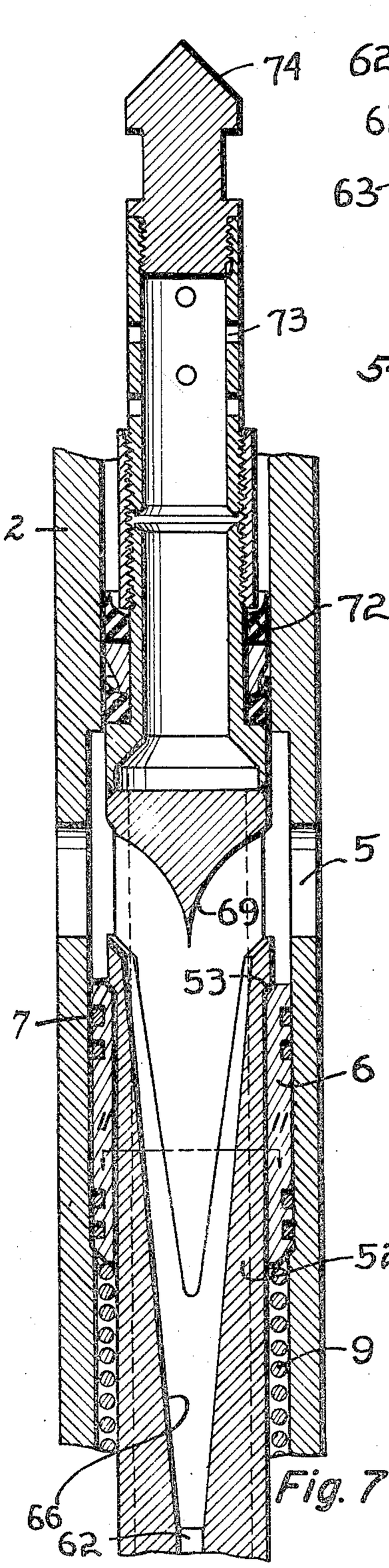

Fig. 7

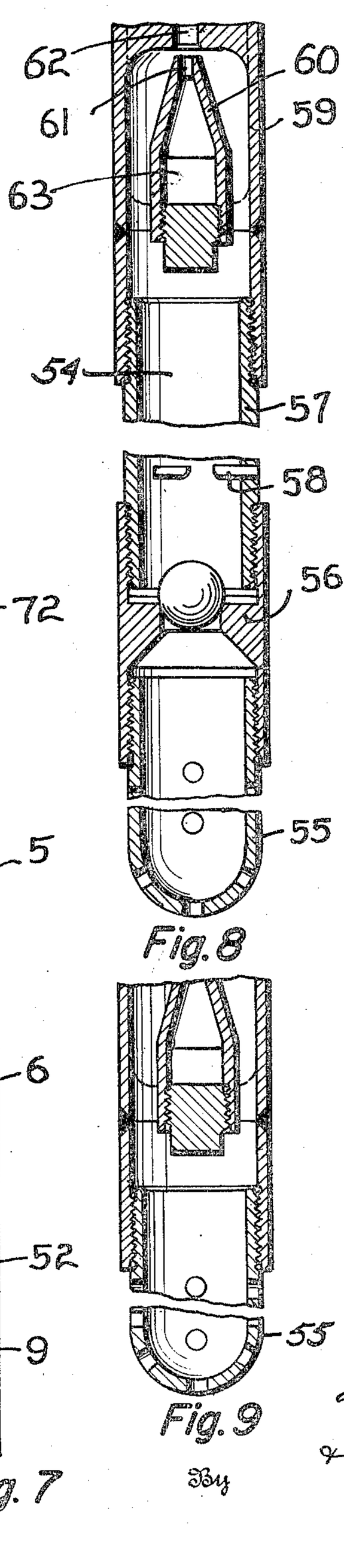

Fig. 8

Fig. 9

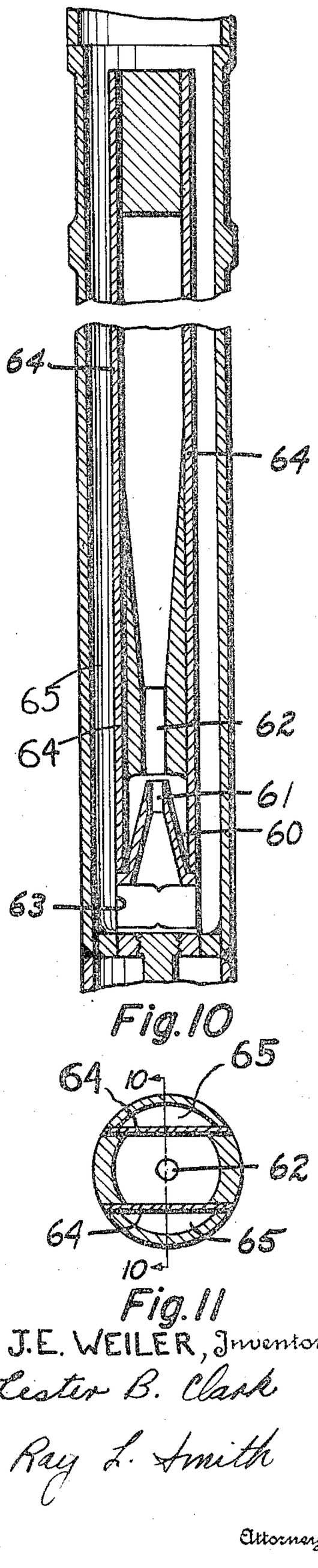

Fig. 10

Fig. 11

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UNITED STATES PATENT OFFICE

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FORMATION TESTER

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Application August 19, 1946, Serial No. 691,607

10 Claims. (Cl. 255—1.4)

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The invention relates to a tool for testing formations traversed by a well bore and particularly to such a tool where the sample is induced to enter a tube from the formation by a reduction in pressure and wherein the sample may be obtained without removing the drill bit from the well bore.

It is one of the objects of the invention to provide a drill stem and drill bit assembly for drilling hole at a reduced diameter at any time during drilling operations without the necessity of withdrawing the assembly from within the well bore, and for forming a seal within the reduced bore, said assembly being adapted to receive sampling means to obtain a sample from the formation in the small diameter bore below the seal.

Another object of the invention is to provide a formation testing tool wherein extensible cutting members are arranged on the tool to cut a seat so that a seal may be formed to assist in the taking of a fluid sample from the well bore.

Another object of the invention is to provide a drill stem and drill bit assembly having a drill bit on the bottom, extensible cutting members spaced thereabove, a packer to seat on the shoulder cut by such members and form a seal and an outlet above the packer to form an opening for circulation of drilling fluid.

Another object of the invention is to provide a construction wherein during normal drilling operations, reaming cutter elements will be extended to cut a seat in the form of an enlarged well bore, but where such elements are retractable at the will of the operator at the mouth of the well bore.

Still another object is to provide means whereby retraction of the cutter elements is effected by control of the rate of circulation of drilling fluid through the well bore.

Another object of the invention is to provide in a sampling device a jet nozzle so that upon the injection of drilling fluid there will be a reduction in pressure to encourage the entrance of fluid from the well formation.

Another object of the invention is to provide a removable jet type sampling tube for formation testing tools.

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

Figs. 1, 2, 3, and 4 when assembled end to end, form a continuous vertical sectional view of the formation testing tool as illustrated by the drill bit, reamer blades, drill pipe, and packer;

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Fig. 5 is a partial elevational view taken on the line 5—5 of Fig. 3 to illustrate the manner of directing the drilling fluid against the reamer blades;

Fig. 6 is a section taken on the line 6—6 of Fig. 3 to illustrate the reamer blades in collapsed position;

Figs. 7 and 8 when taken together illustrate a vertical sectional view of a jet type sampling tool in sampling position in the tool assembly;

Fig. 9 shows a modified view of the lower end of the sampling tool;

Fig. 10 is a sectional view of the jet arrangement taken on the line 10—10 of Fig. 11; and

Fig. 11 is a transverse sectional view through the jet construction, and is taken on line 11—11 in Fig. 7.

In Fig. 1 a drill pipe 2 of suitable size is shown as having been connected into a string of pipe and is shown as threaded at 3 to a nipple 4. This section 2 is of peculiar construction in that it has the side ports 5 which are covered by a sleeve 6 having the packing 7 thereon to form a seal above and below the ports. This sleeve engages a shoulder 8 and is urged to the position shown in Fig. 1 by the coil spring 9 which abuts the nipple 4. This sleeve type valve is provided so that the tool may be open for circulation when carrying out sampling operations. Normally, however, when no sampling tube is in position, this sleeve serves to close the ports 5 to allow normal circulation for drilling.

Any desired number of couplings and pipe sections may be provided below the nipple 4, depending upon the volume of sample desired. A mandrel 12, however, is positioned below these sections and is provided with a packer barrel 13 which is slidable along the outside of the mandrel and the stuffing box 14 serves to form a seal around the mandrel to prevent leakage through the barrel. A resilient packer or rubber 15 is affixed on the packer barrel, which may be of metal or other suitable material.

Upward movement of the packer barrel is limited by a shoulder 16 and downward movement of the barrel is limited by an outstanding shoulder 17 adjacent the lower end of the mandrel.

Below the mandrel 12 is a tubing 18 which carries a nipple 19 having a passage 20 for the flow of drilling fluid and a passage 21 for the upward flow of a sample of formation fluid. A check valve 22 requires the drilling fluid to flow downwardly through the passage 20.

The nipple 19 carries a conduit 23 for the flow

of drilling fluid and this tube is sealed in the strainer pipe 25 by a packing 26. The strainer pipe 25 is threaded to the nipple 19 and to a lower nipple 27.

A pipe section 30 connected in a suitable manner below the nipple 27 carries a transverse shaft 31 upon which the extensible reamer or seat cutting blades 32 are pivoted. Each of these blades has a cutting face 33 and the pinion teeth 34. These teeth are engaged with a rack 35 mounted on a head 36 of the cage 37. The head 36 fits slidably within the passage 38 in the pipe section 30 so that when drilling mud or other fluid under pressure moves down through the tool, the head 36 is contacted by such fluid and will tend to move and carry the rack 35 downwardly thereby extending the blades 32 to the dotted line position in Fig. 3. The spring 39 normally holds the cage 37 upwardly so as to retain the blades in retracted position within the windows 40 in the pipe 30 as shown in full outline in the drawing.

The lower end of the spring 39 sets upon a thrust ring 41 disposed in the pipe 30 above the drill bit 42. The passages 43 in the bit permit the circulation of drilling fluid.

With this construction, it seems obvious that as the drill stem and the drill bit are lowered into the well bore, the bit 42 will, when rotated, cut the small diameter bore 45 which is generally known in the industry as a rat hole. In order to drill a normal sized opening, it is only necessary to pump drilling fluid through the drill stem and against the head 36 at such a rate as to hold the blades in extended position to ream the larger diameter well bore 46, as best seen in Fig. 2, and in this manner to form the seat 47 in the bore. When the flow of drilling fluid is reduced sufficiently, the spring 39 will overcome the pressure on the head 36 so as to move the cage upwardly and retract the blades. The pipe 30 may have the discharge ports 49 therein, as best seen in Fig. 5, which extend from above the head 36, when in lowered position, and discharge to the exterior of the pipe and upon the reamer blades.

Fig. 6 shows a section through the assembly and illustrating a plurality of passages 50 therein which conduct a portion of the drilling fluid past the head 36 so as to discharge from the ports 43 in the drill bit.

In operation the parts will assume the position of Figs. 1 to 4 except the pressure will move the blades 32 to the extended position shown in dotted lines when the rate of flow of drilling fluid exceeds a predetermined value.

When it is desired to take a sample of fluid the drill bit will be raised slightly, the rate of circulation reduced, and the spring 39 will then retract the blades. The drill stem will be again lowered to place the bit on the bottom of the rat hole 45 and additional drilling of the rat hole may in this manner proceed so long as the reduced rate of flow of drilling fluid is maintained. When additional length of rat hole has been drilled sufficiently to allow the packer 15 to engage upon the seat 47, then the drilling may be discontinued.

When the drill stem has advanced sufficiently that the packer is forced against the seat 47 by the shoulder 16, then the tool is in position to obtain a sample.

The sampling mechanism, as best seen in section in Figs. 7 and 8, is now lowered or dropped into the drill pipe and moves downwardly by gravity. This mechanism comprises a tube 52 having a shoulder 53 thereon which engages the sleeve 6 and causes it to be moved downwardly, compressing the spring 9 so that the parts assume the relative positions shown in Fig. 7.

The tube 52 is of peculiar construction in that it has a perforate nose 55 on the lower end connected to the check valve assembly 56 which is in turn connected to a nipple 57 having lugs 58 therein to confine the check valve. Attention is directed to the fact that this arrangement provides a chamber 54 in which a fluid sample may be entrapped to be lifted to the surface when the sampling mechanism is withdrawn from within the drill pipe 2.

The tube 52 terminates at its lower end in a housing 59 which encloses a tapered nozzle 60 having a discharge outlet 61 arranged to direct a jet into the passage 62. The inlet to this jet nozzle 61 is by virtue of a window 63 formed in the side supporting plates 64 which carry the nozzle in supporting position inside of the housing. The windows 63 receive a flow of fluid through the side passages 65 which are formed by the side plates 64, and the surrounding tube 52.

Upwardly from the passage 62 the inner walls of the tube 52 are tapered as shown at 66 in Fig. 7 whereby the interior of the tube forms a diffuser comprising an element of the jet combination. A deflecting baffle 69 directs the flow of liquid outwardly through the ports 5 in the drill stem or drill pipe.

A plurality of packings 72 are arranged around the upper portion of the sampling mechanism so as to form a seal with the interior of the pipe 2 and to also assist in holding the mechanism in position so long as there is pump pressure in the drill pipe.

The inlet for drilling fluid to pass downwardly through the sampling mechanism and to accomplish the desired jet action comprises ports 73, a plurality of which are formed in the top of the sampling mechanism below the spear of grappling head 74. The fluid passes through the passages 65 in the sampling tool and thence to the jet nozzle 61.

As above explained, the structure shown in Fig. 8 provides a sample chamber 54 by means of which a fluid sample may be entrapped within the chamber, and made available when the sampling mechanism is withdrawn as by means of reverse flow of drilling fluid or by means of an overshot engaged with the grappling head 74. As drilling fluid is pumped downwardly through the drill stem 2 and thence through the orifice 61 and pipe 62 into the diffuser chamber within the tube 52, it produces a reduced pressure about and below the nozzle 60 whereby there is an induced flow of formation fluids into the space below the nozzle.

The structure shown in Fig. 9 does not include the sample chamber. Instead, this embodiment comprehends that the jetting mechanism will induce well fluids to enter and fill the drill pipe therebelow. The packer 15 is then unseated and pump flow is reversed whereby the jetting mechanism and the sample are lifted to the surface.

Attention is directed to the fact that the pressure at the tip of the nozzle of the jet 60 is a function of the rate of circulation and of the pressure on the nozzle causing the flow of fluid therethrough. Also, the pressure at the tip of the nozzle is approximately the pressure of the formation. The various factors affecting these pressures being determinable, additional in-

formation concerning formation pressure is thus made available. This information is of material importance in connection with further drilling operations and/or production of the completed well.

It seems obvious that there are particular advantages in connection with the invention in that the drilling may proceed and samples be taken either continuously or periodically without removing the drill bit or the drill stem from the well bore. Samples may be taken by merely dropping or lowering the sampling mechanism into position, circulating the drilling fluid to jet in a sample of formation fluid and then lifting the sample to the surface as explained.

The invention claimed is:

1. A combination drilling and formation testing tool for wells comprising a pipe, a drill bit thereon, a pair of reamer blades extensible from said pipe above said bit to enlarge the well bore, means to normally hold said blades in retracted position, a head on said means exposed to liquid pressure in said pipe so as to effect movement of said means to extend said blades to enlarge the well bore above said bit, a conduit through said pipe to conduct liquid to said head, a strainer in said pipe about said conduit, an inlet from said strainer into the pipe, a packer slidable on said pipe to seat on the shoulder of the well bore cut by said blades, there being an opening laterally of said pipe above said packer, a sleeve to close said opening, a sampling means to be positioned on and move said sleeve to uncover said openings, an annular tapered nozzle in said sampling means to create a suction to draw in a sample of formation fluid through said strainer as drilling fluid is circulated down through said pipe and out said openings.

2. A combination drilling and testing assembly including a drill stem and bit, reamer blades extensible therefrom to form a seat, a seal on the stem for said seat, sample receiving means insertible through said drill stem and an annular tapered nozzle in said insertible sample receiving means, fluid passage means to conduct fluid to said nozzle, a fluid inlet from said passage to said tapered nozzle and a fluid discharge port at the opposite end of said nozzle to jet into such stem a sample of fluid from the well formation below said seat upon the circulation of drilling fluid through said fluid passage.

3. A combination drilling and testing assembly including a drill stem and bit, reamer blades extensible therefrom to form a seat, a seal on the stem for said seat, sample receiving means insertible through said drill stem, and an annular tapered nozzle connected to said sample receiving means fluid passage means to conduct fluid to said nozzle, a fluid inlet from said passage to said tapered nozzle and a fluid discharge port at the opposite end of said nozzle to jet into such stem a sample of fluid from the well formation below said seat upon the circulation of drilling fluid through said fluid passage, and a vent in said stem to be opened by said means.

4. A formation testing tool including an operating pipe, a port therein, means to close said port, sample collecting means to be lowered through said pipe to engage said means, a seal about said sampling machine so that liquid pressure in the pipe will move said sampling means to open said port, a tapered nozzle in said sampling means and a passage into said tube from the pipe so that liquid pumped through the pipe will jet a sample of formation fluid into said sampling means.

5. A formation testing tool including an operating pipe, a port therein, means to close said port, sampling means to be lowered through said pipe to engage said means, a seal about said sampling means so that liquid pressure in the pipe will move said sampling means to open said port, a nozzle in said sampling means and a passage into said sampling means from the pipe so that liquid pumped through the pipe will jet a sample of formation fluid into said sampling means, reamer blades extensible from said pipe to cut a seat, and seal means also on the pipe to engage said seat.

6. A sample tube for formation testing tools comprising a tubular body, a spear head thereon, an annular tapered nozzle in said body to discharge upwardly, a passage to direct pressure fluid into said nozzle, an inlet into said body below said nozzle for formation fluid so that the reduction in pressure caused by the flow of fluid through said nozzle will draw in a sample of such formation fluid, and a check valve to trap a sample in said body below said nozzle, said tube being insertable and removable relative to the operating pipe of a formation testing tool.

7. A sample tube for formation testing tools comprising a tubular body, a spear head thereon, an annular tapered nozzle in said body to discharge upwardly, a passage to direct pressure fluid into said nozzle, and an inlet into said body below said nozzle for formation fluid so that the reduction in pressure caused by the flow of fluid through said nozzle will draw in a sample of such formation fluid, said tube being insertable and removable relative to a drill stem and drill bit so as to obtain a sample without removing such drill stem and bit.

8. A combination drill and sample taking assembly including a drill stem, a drill bit thereon, a packer on said stem to seal with the well bore, a sample tube to be positioned in said stem and an annular tapered nozzle in said insertible sample receiving means, fluid passage means to conduct fluid to said nozzle, a fluid inlet from said passage to said tapered nozzle and a fluid discharge port at the opposite end of said nozzle to jet thereinto a sample of well fluid from below the seal, and additional means to removably position said tube in said stem, said means including a sleeve in said stem, and means on said sleeve to engage and support said tube.

9. A combination drill and sample taking assembly including a drill stem, a drill bit thereon, a packer on said stem to seal with the well bore, a sample tube to be positioned in said stem and an annular tapered nozzle in said insertible sample receiving means, fluid passage means to conduct fluid to said nozzle, a fluid inlet from said passage to said tapered nozzle and a fluid discharge port at the opposite end of said nozzle to jet thereinto a sample of well fluid from below the seal, reamer blades extensible from said stem by drilling mud pressure to cut a seat for said packer, and additional means to removably position said tube in said stem, said means including a sleeve in said stem, and means on said sleeve to engage and support said tube.

10. A combination drill and sample taking assembly including a drill stem, a drill bit thereon, a packer on said stem to seal with the well bore, a sample tube to be removably positioned in said stem and an annular tapered nozzle in said insertible sample receiving means, fluid passage

means to conduct fluid to said nozzle, a fluid inlet from said passage to said tapered nozzle and a fluid discharge port at the opposite end of said nozzle to jet thereunto a sample of well fluid from below the seal and reamer blades extensible from said steam by drilling mud pressure to cut a seat for said packer, said sampling tube being operable by circulation of drilling mud, through said fluid passage, and additional means to removably position said tube in said stem, said means including a sleeve in said stem, and means on said sleeve to engage and support said tube, and resilient means supporting said sleeve in said stem.

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