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(54) Improvements in or relating to rods.

(57) Sucker rods for the pulsation-dampened pumping of oil provided with hollow connecting means (11) such that the interiors of the sucker rods (10) are in continuous communication. The connections are provided with sealing means (16), whereby the interiors of the sucker rods (10) may be at a pressure different to that of the exterior.

A method of making a coupling ended hollow tube (10) comprising the steps of forming two coupling units (25) and welding each to a respective end of tube (10) characterised in that the coupling units (25) are formed by forging, in that they are friction-welded to the respective ends of the tube (10) and in that prior to welding an axial bore (17) is introduced along the length of each of the coupling units (25).

An apparatus for use in the pumping of oil characterised by a downhole enclosed reservoir of gas pressurised to a pressure at least equal to that at the downhole interface prior to insertion of the reservoir downhole, the reservoir accepting an intake of oil during an upstroke of the pumping, thereby compressing the gas within the reservoir and effecting pulsation dampening.

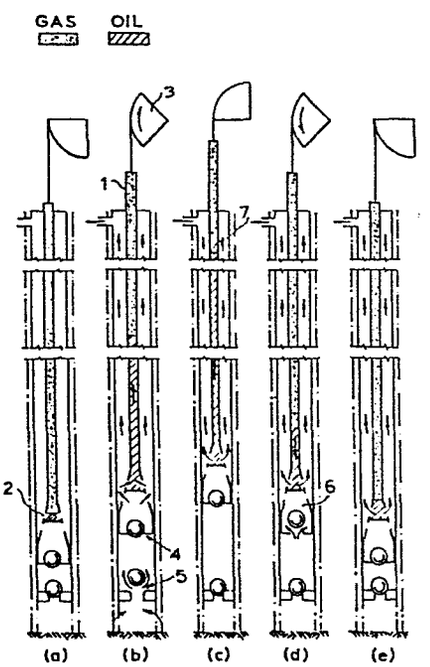

FIG.1.

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IMPROVEMENTS IN OR RELATING TO RODS

The present invention relates to a number of improvements in the general field of the manufacture and use of rods. One application for which all of the improvements are suitable, although not limited to, is that of sucker rods as used in the oil industry and in particular the pulsation dampened pumping of oil.

It is well known that an overwhelming majority of producing oil wells are operated by some form of artificial lift. Of these, approximately ninety per cent use a sucker rod pump. It is an extremely simple system and relatively trouble free. The system comprises a standing valve near the bottom of the bore hole and a travelling valve and plunger connected to a string of sucker rods. A walking beam or other surface pumping unit connected to the top of the sucker rod string causes the travelling valve to reciprocate towards and away from the standing valve. However, the pulsating nature of the operation introduces cyclic stresses in the sucker rods and in time fatigue failure sets in. Since the sucker rod string may be many thousands of feet long, the forces to which it is submitted are magnified and the pulsating movement gives

rise to considerable forces as a result of a differing elastic deformation of the pipe and the fluid. Also, any change in velocity of the crude oil gives rise to a change in pressure and as the oil is moved a pressure wave is set up which is reflected at the ends of the pipe until completely degraded by friction and absorbtion.

All the above are likely to cause failure of one or more of the sucker rods, and retrieval of the situation is an expensive problem. Even servicing of sucker rods requires that the oil well be shut down with a consequent loss of production.

In order to overcome the above difficulties and prolong the life of sucker rods, it has been proposed to use hollow sucker rods filled with compresed inert gas or air. The gas/fluid interface is close to the sucker rod travelling valve and pressure can be dissipated by oil moving up inside the hollow sucker rod. By reducing stresses on the sucker rod, there is less elastic deformation of the rods and the travelling valve moves a distance more in accordance with the stroke of the well head pump and the rate of oil flow increases dramatically. Also, of course, the life of the sucker rods is extended.

Apart from their use in the above-described pulsation dampened pumping process, hollow sucker rods have been known and used for injecting dilutant for heavy oil and for adding corrosion inhibitors for certain corrosive oils. In these two known cases, the additive is pressurised only to the extent that it prevents the rising oil from forcing its way up the interior of the sucker rod. In these circumstances leaks from the hollow sucker rod have been relatively unimportant and, at the pressures involved, unlikely to occur. However, the pulsation dampened pumping process requires a far higher pressure within the hollow sucker rod and the process has suffered from poor connections between sucker rods and resultant leakage which is problematical.

It is an object of one aspect of the present invention to overcome the above disadvantages and to provide sucker rods and connectors to form a sucker rod string useful in pulsation dampened pumping.

According to a first aspect of the present invention, there is provided a sucker rod string for dampened pumping of fluid comprising a plurality of hollow sucker rods, a corresponding plurality of means connecting each two adjacent sucker rods, said connecting means being hollow such that the interiors of the sucker rods are in continuous communication characterised in that the connecting means are provided with sealing means whereby the interiors of the sucker rods may be at a pressure different to that of the exterior of the sucker rods .

In one embodiment of this aspect of the invention, each connecting means is integral with a respective one of the sucker rods such that each sucker rod has a connecting means at one end and means to engage said connecting means at the other.

Alternatively, each connecting means comprises a housing into which may be engaged an end of each of two adjacent sucker rods.

In another alternative embodiment, the connecting means may be a "pin-pin" connector of a type which forms another aspect of the present invention in which case the ends of the sucker rods are formed as corresponding "boxes".

Preferably each sucker rod engages its corresponding connecting means by means of co-operating screw threads.

The sealing means is preferably a seal comprising glass reinforced PTFE (polytetrafluoroethylene).

In a preferred embodiment of this aspect of the invention the connecting means is a housing which is

longer than the length of two portions of the sucker rod adapted to be engaged therein and the sealing means occupies the space between the ends of the two adjacent sucker rods.

A metal casing may be provided to hold the sealing means rigid. Alternatively, a shoulder may be provided at a median internal point of the connecting means and the seals may abut the shoulder.

Seals may be provided to engage within the screw threads connecting the connecting means to each of the two sucker rods engaged therein. Alternatively the seals may be held by a shoulder of each of the sucker rods and may co-operate with an end face of the connecting means.

According to a second aspect of the present invention, there is provided a connector for a sucker rod, the connector being generally hollow and cylindrical, having means to engage a sucker rod at at least one end characterised by sealing means which provide a seal between the interior of a sucker rod connected to said connecting means and the exterior of that sucker rod.

Preferably the sealing means is an annulus of glass filled PTFE.

The form and intended location of the sealing means are variable.

As described, the process of pumping oil from wells requires a connection between a downhole plunger and a well head pumping mechanism. Such connection is achieved by a string of sucker rods connected together to achieve the desired length. Since the string may be many thousands of feet long, it is important that the connections are strong enough to take the weight of the string, the weight of oil being pumped, and the cyclic stresses to which sucker rods are put by the nature of the pumping operation.

The connection between sucker rods is usually by co-operating screw threads, one on the exterior of a male member knwon generally as a pin, and the other on the interior of a female member known generally as a box.

It is conventional that sucker rods are provided with a pin connection at each end and that they are connected by usually cylindrical hollow connectors which form, in effect, a double box. These suffer from certain disadvantages which are magnified when the sucker rods are hollow for use in a pulsation dampened pumping process.

A first disadvantage is that the comparatively long tubes are under greater tension stresses than the comparatively short connectors. The effect of this is to loosen any screw thread which is external of the tube and internal of the connector. A second disadvantage is that the external diameter of the sucker rods is limited and under certain proposals it is desired to make the internal diameter of a tube as large as possible, as described with respect to a further aspect of the present invention. This, of course, brings with it a commitant increase in the external diameter and if this were threaded for connection to a box connector, the diameter of the box would be too great.

It is an object of one aspect of the present invention to mitigate the above disadvantages and to provide an alternative connector for rods, especially sucker rods.

According to one aspect of the present invention, there is provided a connector for rods, the connector having two substantially identical opposite end portions characterised in that each end portion is provided with an external coupling means adapted to co-operate with an internal coupling means of the rods connected by the connector.

The arrangement is advantageous because the long tube has an internal thread to co-operate with an external thread of the short connector, therefore the tension stresses tend to tighten the thread.

The arrangement is also advantageous because it enables the enlarged internal diameter tube end to constitute the box connector.

Each of the coupling means is preferably a screw thread.

Preferably the connector has an axial bore extending from one of the ends to the other.

Advantageously, intermediate portions of the connector are formed with wrench flats and optionally also with an elevator shoulder.

Sealing means may be provided adapted to co-operate between each end portion of the connector and a respective end portion of the rod connected thereto. Such sealing means form part of a further aspect of the present invention.

The described hollow rods are particularly, but not exclusively adapted for use as sucker rods for pulsation dampened pumping of oil from an oil production well.

It is known to forge, preferably drop forge, solid bar stock into couplings for use with sucker rods. In

general, the rods are coupled by means of co-operating screw threads, one on a male member known as a pin member and the other in a female member known as a box. It is known from the UK patent application number 8125760 to friction weld solid rod ends to solid bars to form sucker rods.

It is also known to form coupling ends by machining bar stock and induction welding them to the rods. However the machining process is wasteful and complex especially where flats have to be milled. The resulting coupling is, in any event, not so strong or robust as a forged coupling.

It is an object of one aspect the present invention to provide a method of making a coupling ended hollow rod which mitigates these disadvantages.

According to one aspect of the present invention, there is provided a method of making a coupling ended hollow tube comprising the steps of forming two coupling units and welding each to a respective end of tube characterised in that the coupling units are formed by forging, in that the coupling units are friction welded to the respective ends of the tube and in that prior to welding an axial bore is introduced along the length of each of the coupling units.

There may be performed an additional step of removing flash from the weld after the friction welding step. Both or either of internal and external flash may be removed.

There may be another additional step of upset forging the ends of the tube before the friction welding step.

Alternatively, the step of friction welding may itself produce any necessary upset in the ends of the tube.

The coupling units may be provided with respective screw threads, the step of cutting which may be performed at any convenient stage of the process, preferably as the last step.

As previously described, the problem with sucker rod pumping is that the movement of the oil sets up a pressure change causing stress in the sucker rod. The sucker rod undergoes cyclic movement and the cyclic stresses built up thereby eventually cause fatigue failure. The increase in pressure caused by the oil movement results in an increased pressure applied to the gas/oil interface of 9,000 lbs/sq ft for each one ft/sec change in velocity. The pulsation dampened process relieves this pressure by filling a hollow sucker rod

string with compressed inert gas or air. The tube is open adjacent the plunger, ie. close to the gas/oil interface. The increased pressure is dissipated by the oil in the region flowing up the hollow sucker rod in the period of increased pressure and flowing out again during a period of reduced or normal pressure.The increased pressure is transformed into a head of oil in the sucker rod the height of which is proportional to the pressure difference. In certain case, it would be desirable to reduce this head of oil.

It is an object of one aspect of the present invention to provided means whereby the head of oil can be reduced.

According to one aspect of the present invention there is provided a sucker rod string characterised by having at least in its lower portion a plurality of sucker rods each with an internal bore of diameter greater than the diameter of the internal bore of the connections between any two of said plurality of sucker rods.

Preferably the connections have an orthodox diameter bore and the rods each have a bore of diameter at least twice as great.

The connector may be of a pin-pin type, as forms a further aspect of the present invention. Such a pin-pin

type connector may co-operate with the interior of the enlarged bore of the corresponding sucker rods, each of which is dimensioned as an orthodox box.

Alternatively, the internal diamter of each sucker rod unit may narrow in a neck portion in the region of the coupling.

The entrance through which oil may pass to said enlarged diameter bore may be by means of a member attached to the lower, in use, end thereof and provided with a plurality of feed ports.

There may be provided five feed ports, angularly spaced but directed substantially axially.

The outer surface of the rods may be grooved or smooth. The grooved surface has advantages in that the increased diameter sucker rod would hinder the free passage of oil upwardly if it were not for the increased space made available by the grooving.

According to another aspect of the invention, there is provided a sucker rod for use in a sucker rod string according to the last above-mentioned aspect of the invention.

It is known to dampen the shock pressures caused by the movement of oil within the production casing by using a hollow sucker rod pressurised with gas so that, at rest, the level of oil within the sucker rod is close to the interface. The oil rises within the sucker rod to a maximum just as the sucker rod begins its downstroke. The oil within the sucker rod will not reach the surface, but in order to pressurise the interior of the sucker rod, the hollow tubes must extend all the way to the surface. This is disadvantageous since hollow rods are more expensive than solid sucker rods and are in general heavier.

It is an object of one aspect of the present invention to mitigate the above disadvantages by providing a downhole closed reservoir system for pulsation dampened pumping of oil.

According to one aspect of the present invention, there is provided an apparatus for use in the pumping of oil characterised by a downhole enclosed reservoir of gas pressurised to a pressure at least equal to that at the downhole interface prior to insertion of the resrvoir downhole, the reservoir accepting an intake of oil during on upstroke of the pumping, thereby compressing the gas within the reservoir and effecting pulsation dampening.

Preferably the reservoir is pressurised at the well head or prior to its arrival there and is sealed.

The seal may be a flapper valve, a ball valve or a locking valve actuated by rotation of the sucker rod string.

The pressure to which the reservoir is pressurised is advantageously greater than the pressure at the down hole interface but less than the pressure created there during the upstroke of the sucker rod. The seal is then overcome during the first upstroke and the pressure within the reservoir equalises with that at the interface.

The seal, once overcome, may be held out of engagement thereafter until the reservoir is recovered for servicing.

Alternatively, where the seal is a locking valve, it may be opened and closed at will by rotation or other actuation of the sucker rod string.

The reservoir may be charged by a one way valve which may be located at the, in use, upper end of the reservoir.

The reservoir may comprise a plurality of sucker rod units of wide internal diameter, such sucker rods

forming an aspect of the present invention, as described above.

According to a further aspect of the present invention, there is provided a connector having one end adpated to couple with a sucker rod string characterised by having its other end adapted to couple with a sucker rod forming part of a downhole enclosed reservoir of pressurised gas and by a one way valve means to allow charging of said reservoir with pressurised gas when the sucker rod string is not connected to the connector.

Preferably the connector is a box-box type and the one way valve means is housed in a necked portion connecting said box couplings.

Embodiments of the various aspects of the present invention will now be more particularly described by way of example and with reference to the accompanying drawings, in which:

Figure 1 shows diagramatically the general principles of pulsation dampened pumping in an oil production well;

Figure 2 shows one embodiment of a connection between two sucker rods;

Figure 3 shows an alternative embodiment of such connection;

Figure 4 shows a seal used in the embodiment shown in Figure 3;

Figure 5 shows the seal of figure 4 in separated condition;

Figures 6, 7, 8 and 9 show various different embodiments of connecting means, in each case shown connected to one sucker rod ;

Figure 10 shows a variation of connecting means;

Figure 11 shows an embodiment in which the connecting means is integral with the sucker rod ;

Figure 12 shows a side elevation of a connector embodying one aspect of the invention when attached to a rod at one end;

Figure 13 shows a variant of the connector shown in Figure 12:

Figure 14 shows another embodiment of a connector attached to rods, each having a modified form of box coupling;

Figure 15 is an elevation, partially in cross-section, of an alternative form of box coupling attached to a hollow rod;

Figure 16 is a side elevation of a pin type end coupling formed by a method according to an alternative embodiment;

Figure 17 shows a sucker rod embodying one aspect of the invention when joined to a pin-pin type connector;

Figure 18 shows schematically a sucker rod as shown in Figure 17 but with a necked pin type coupling portion;

Figure 19 shows a sucker rod as shown in Figure 18 but with an elevator shoulder;

Figure 20 shows the lower end of a sucker rod with a feed port member;

Figure 21 shows a sucker rod similar to that shown in Figure 19;

Figure 22 shows a feed port member with a central box type coupling for connecting it to the plunger;

Figure 23 shows a flapper valve for sealing off the reservoir until positioned;

Figure 24 shows a ball valve system for sealing off the reservoir until positioned;

Figure 25 shows a first embodiment of one way valve means for charging the reservoir;

Figure 26 shows in more detail the one way valve means;

Figure 27 shows a flapper valve with a feed port member attached thereto;

Figure 28 shows a reservoir main body attached to wide diameter hollow sucker rod extending the reservoir.

Figure 29 shows one embodiment of a connection between the end of the reservoir and the end of a solid sucker rod string;

Figure 30 shows another embodiment of a connection between the reservoir and the solid sucker rod string;

Figure 31 shows a flapper valve attached to a variant of feed port member; and

Figure 32 shows a connector including a one way valve means for charging the reservoir and connecting it to the solid sucker rod string.

Referring now the drawings, in particular to Figure 1, the operation of a pulsation dampened pumping system is shown. Figure 1a shows the start-up conditions where the interior of the sucker rod is pressurised with inert gas or air so that the oil/gas interface is just above ports 2 in the sucker rod. Once set, the pressure at the oil/gas interface will remain the same.

Figure 1b shows a system on the upstroke where the well head pump 3 lifts the sucker rod 1 and thereby the travelling valve 4. This reduces the pressure below the travelling valve and oil flows through the standing valve 5 into the lower chamber defined between the valves. Oil flow is shown by the arrows and is generally upward. As soon as the oil starts to move its pressure will fall. The reduced pressure is transmitted through the oil column at considerable speed and is reflected from the production tubing's open end, and reflected again negatively from the plunger. The increase in pressure caused by this results in a pressure force of about nine thousand lbs/sq.ft for each one ft/sec change in velocity. The increased pressure is applied to the oil/gas gas interface in the sucker

rod and the gas is compressed up the hollow sucker rod. This relieves the pressure in the production tubing.

At Figure 1c is shown the system at top dead centre where the sucker rod contains its maximum amount of oil, and the gas is at its most compressed.

The downstroke is shown in Figure 1d. The standing valve is closed by the downward pressure and the travelling valve opened causing oil to flow from the chamber between the valves into the plunger 6. The fluid pressure at the bottom of the sucker rod chamber is higher than that in the adjacent production tubing by at least the height of oil in the sucker rod. Thus, the oil flows from the sucker rod to the production tubing, a shown by the arrows, until the plunger reaches bottom dead centre, shown in Figure 1e. At this time, the oil/gas interface is at the base of the sucker rod string.

In the normal course of pumping operations, the majority of the oil is delivered on the upstroke, while the only oil delivered on the downstroke is that displaced by the volume of the rods descending into the oil, which is minimal. As explined above, all the oil which moves into the hollow sucker rod during the upstroke exits therefrom during the downstroke and flows from the well.

Figure 2 shows two sucker rods 10 connected together in a box-box type couping 11 where they are held by co-operating screw threads 12. The sucker rods are shaped generally in well known manner with wrench flats 13, elevator shoulder 14 and pin-type couplings 15. All measurements are generally made to be in accordance with API (American Petroleum Institute) standards.

At a median point in the interior of the box coupling 11 is arranged an annular seal 16 of glass-filled PTFE. It is so dimensioned that when both sucker rods 10 are screwed fully home into the box coupling 11, the seal 16 comes under compression and prevents flow of fluid or gas between the interior and exterior of the sucker rods. As shown in chain dotted lines, the sucker rods are provided with an internal bore 17 and the seal is so dimensioned as not to impinge on this bore. The material of which the seal is constructed is extremely resistant to corrosive environments, is hardwearing and forms an excellent seal. It is resilient under the pressures necessary for screwing sucker rods into connectors.

In Figure 3 is shown a similar coupling arrangement but with an improved seal. Reference numerals are the same as in Figure 2. The seal in this embodiment is shown in

more detail in Figures 4 and 5 where it can be seen that the seal comprises two annuli 18 of glass-filled PTFE and a metal seal-holder 19. The seal-holder 19 comprises a ring adapted to force the interior of the seal against the bore 17 and connected thereto, a flange 20 to separate the O-rings 18.

In the embodiment shown in Figure 6, two seals 16 are provided to be compressed within the screw threads connecting the sucker rod 10 to the box connector 11. A variant of this is shown in Figures 7 and 8 where the seal 16 is compressed between a shoulder 21 of the sucker rod, an internal facing 22 of the connector, the internal walls of the connector and the exterior of the pin 15. The embodiment shown in Figure 7 has an overlap of the shoulder over the connector 11 to give better connection and sealing.

Figure 9 shows yet another embodiment where the box connector 11 is formed with an internal shoulder 23 at a median point of its length and O-ring seals 16 are inserted one either side of the shoulder 23. Since the shoulder effectively fills the space between the pin connections 15 of two sucker rods 10, the seals 16 are compressed against the shoulder when the sucker rods are tightened in the Connector 11.

Figure 10 shows an alternative arrangement where the connector 24 is a pin-pin type connector. This co-operates with the sucker rods which have a box fitting 25 at each end. The sealing means are not shown in this figure but clearly it would be possible to have a seal in the screw threads of the kind shown in figure 6, to arrange an internal shoulder within the box of the kind shown in figure 9, to fill the space between the end of the pin connector 24 and the end of the interior of the box 25 with a seal of the kind shown in figures 2 and 3 or to provide a seal of the kind shown in Figures 7 and 8.

Figure 11 shows a sucker rod which has a pin at one end as is conventional, and a box at the other. The box 25 in reality forms an integral connector thereby dispensing with the need for separate connectors. The box 25 can be friction welded to a tubular sucker rod Again, sealing means are arranged as discussed immediately above.

Other methods of sealing will occur to those skilled in the art, and it is intended that these are included within the scope of the present invention. Also, the materials of which the sealing means are made may be varied to sit varying conditions. Clearly, special

connections may have to be made for connecting the sucker rod string to the plunger at its down hole end and to the pump at its well head end. Again, these may be varied to suit conditions.

Referring now to figures 10 and 12 to 14 of the drawings, there is shown a connector having at each of its opposed ends a pin 31 formed with an external screw thread 32. These are intended to co-operate with internal screw threading 33 provided within boxes 34 attached to or formed at an end of the rods to be connected.

The dimensions of the pins and of the boxes may vary but are, in general, governed by standards set by API (American Petroleum Institute).

The connector shown in Figure 12 has its intermediate portion 35 forged to substantially square cross-section to co-operate with wrenches when being joined to a rod. Separating this intermediate portion 35 from each of the pins 31 is a respective shoulder 36 against which the edges of the box 34 abut when the connector is screwed fully home in the rod. The shoulders 36 have an outside diameter greater than that of the adjacent sucker rod so that in the event of wear taking place, the shoulder protects the rod.

Sealing means 37 may be provided to co-operate between the connector and the rod in the event that both are hollow for passage of pressurized gas or fluid.

The connector shown in Figure 13 differs from that shown in Figure 12 only in having an elevator shoulder 38 formed between the intermediate portion 35 and one of the shoulders 36.

The connector shown in figure 10 is of wider diameter than the two previous embodiments. It may thus serve better to protect the sucker rods which it connects from contracting the sides of the bore and thereby wearing. This may be particularly important where the bore is not straight, although in such a case wear pads should be provided at intermediate points of the sucker rods. In this embodiment, the shoulders 36 are of increased length and the intermediate portion is forged with wrench flats 30.

Figure 14 shows a connection similar to that shown in Figure 10. It is shown connected to two rods which have sufficiently thick walls that the box type coupling can be formed without externally upsetting the rod.

The embodiments illustrated in figures 10 and 12 to 14 have all shown an internal axially extending bore 39.

This is present for those applications of the connection which require passage of fluid through it from one hollow rod to the next. However, as will be readily appreciated, the bore is not necesarry where solid rods are used. Although it may cause the connector to be weaker than would be a correspondingly dimensioned solid one, the bore 39 may be retained in the interest of weight reduction and also possibly of standardisation of components.

The connector has been described and illustrated as being intended for screw connection with adjacent rods. This could, of course, be replaced by such other forms of connection as bayonet fittings, projecting dogs or some pneumatically or hydraulically controlled releasable connections.

The material of which the connector is made may vary according to the use to which it is intended to be put. If the connector is intended for oil pumping sucker rods, the materials should conform to API Standards. However, alternatives are possible for specialised purposes.

Although the expression "sucker rod' is used though out this description, the expression is intended to encompress rods which in the art are also sometimes

referred to as "pony rods" and rods referred to as "polished rods".

Referring now to figures 2, 3, 6-11, 15 and 16 of the drawings, there is shown a hollow tube 10 which may be of any desired length. The end of the tube is formed as a hollow coupling which may either be of a pin type 2 as shown in, for example, figures 2 and 16, or a box type 3 as shown in figures 10 and 15. The couplings are generally standard so that they may mate with other couplings and the acceptable measurements are set out and approved by API (The American Petroleum Institute).

The couplings shown are by way of example only and may be replaced by any other couplings. They are made by drop forging to give the required shape, followed by drilling out a central bore. The so-formed couplings are attached to a tube by friction welding in one of two ways. In a first, the weld is along line 40. The friction welding process requires either the tube or the coupling to be gripped in a hydraulically operated chuck while the other component is gripped by hydraulic clamps. Preferably, the coupling is held in the chuck by its squared face 13 or other flats.

The ends of the coupling and tube are aligned and the clamps hold fast the other of the members, preferably

the tube. The parts are moved into close contact and the chuck, holding the one component, is driven by a motor at a pre-set rotational speed. This speed is generally less than 500 rpm. Axial pressure is applied to generate friction heat at a controlled rate. As friction occurs, softened metal is slowly squeezed out from the hot interface to form an upset collar. When predetermined temperature conditions are established, the rotary spindle is declutched from the main motor, stopped, and the axial pressure increased to forge and hot work the interface zone to give a high strength solid state weld.

In this first method the mating face of the forged coupling is of larger diameter than the tube diameter. During the friction welding process the end of the tube is externally upset to effectively bell out to blend with the end of the forging. In a second method, the end of the tube is first upset forged to bell out. The coupling forging is foreshortened as indicated in figure 15 where the weld line is shown at 46. The diameters of the foreshortened forging and of the belled out tube are substantially identical and they are friction welded together as indicated above.

Once one end coupling has been welded to the tube, the tube can be reversed and another coupling welded to the

other end in a similar manner.

The accuracy and quality of the welded assembly exceeds the requirements specified in the API Standards. The joint has a fine grained structure, a narrow heat affected zone, and excellent chemical properties.

Either one of both of the internal and external upset collars fomed in the welding process can be mechanically removed, if so desired. The term friction welding as used herein should also be taken to include any necessary post welding treatment steps, for example, normalisation, quencing or tempering. These can be carried out imediately after the step of welding per se or as a later step in the process.

The sucker rods described above may be filled with inert gas or air under pressure for use in pulsation dampened pumping.

Referring now to figures 1 and 17 to 22 of the drawings, Figure 1 shows schematically the stages of operation in a pulsation dampened oil pumping process and the operation of the process is described above.

Sucker rods are in general of small diameter since they must fit within the production casing and the oil must

flow past the sucker rod string. Consequently hollow sucker rods can only have a narrow bore. Thus the maximum height 7 (Figure 1) reached by the oil within the hollow sucker rod may be quite considerable. Clearly, the system will work better if this maximum height is attained since then all the pressure increase has been dampened. However, the oil must flow up the hollow sucker rod during the upstroke and with narrow constricted hollow rods this may not always be the case. Thus, at least for the lower part of the sucker rod string, the present invention envisages using wider sucker rods which have consequentially wider internal diameters.

Figure 17 shows such a wide diamter sucker rod whose outer surface is provided with helical grooves to aid the upward flow of oil around the outside. Since it is of such wider diameter, it is not possible to attach a connector to the outside of the tube. Thus, as can be seen, the connector used is a pin-pin type 10, as described for example with reference to figure 12. The connector 50 screws into the end of the wide diamter sucker rod 51, the internal diameter of which corresponds to the general dimensions of standard boxes. A seal 52 is provided to prevent escape of pressurised gas.

Figure 18 shows a variant in which the end of the wide diameter sucker rod 51 is necked to form a pin type coupling 33. This can be formed by friction welding a standard pin coupling to a wide diameter tube along the line 54.

Figure 19 and Figure 21 show variants of the sucker rod shown in Figure 18 in which the pin type coupling is extended to be provided with an elevator shoulder 55. The difference between the sucker rods shown in Figures 19 and 21 lies only in the internal arrangement leading into necked portion where the edges are rounded in the rod shown in Figure 21. When these wide diameter rods are friction welded, the external flash must be removed because of size limitations but the internal flash can be left since a passage is left at least as wide as that through the connecting portion.

The diameter of the wide sucker rods is limited only by the necessity for oil to pass up the production casing around their outside. It is the intention to make them as wide as possible. This necessitates connectors between rods having a smaller internal diameter to allow the couplings to be attached.

At the lower end of the wide diameter sucker rods and immediately above the plunger 6 is a feed port member

56. This is friction welded to the lowest wide diameter sucker rod along line 57. It could however be formed as a separate component with its own coupling whereby it is connected to the lowermost sucker rod. The lower part of the feed port member is provided with a hollow coupling for connecting it to the plunger 6 and the travelling valve below that.

Figure 20 shows a feed port member with a pin coupling 58 while figure 22 shows a feed port member with a box type coupling 59.

Disposed around the periphery of the feed port member 56 are a number of feed ports 60, in the embodiments shown, the number being four. These communicate with the interior of the lowermost sucker rod and thus the oil flowing into the sucker rod string may enter trhough any one of the four outer ports 60 or through the central port passing through the coupling. The ports extend generally vertically to ensure optimum flow of oil therethrough.

It is, of course, possible to use wide diameter sucker rods throughout the sucker rod string although it is doubtful that those in the upper part would contribute to the pulsation dampening. It is also possible to use the wide diameter sucker rods in conjunction with a

closed system pulsation dampening apparatus.

Referring now to figures 1 and 23 to 32 of the drawings, Figure 1 shows in sketches a to e the general principles of pulsation damepened pumping. The operation is described above. However, it may be noted that in Figure 1C the oil rises to its maximum height 7 within the sucker rod string as the string commences the down stroke. This level is not at the top of the string. Any hollow rods provided above that point are not necessary except for the purposes of pressuring the string. This aspect of the invention recognises this fact and provides a reservoir to accomodate the upward flowing oil. The reservoir is attached to the surface by the sucker rod string.

The reservoir is charged at the well head or prior to its arrival there with inert gas to a pressure which is greater that that at the interface of the well in which it is to be used. This predetermined pressure is less than the pressure at the interface during the upstroke of a sucker rod and thus, at the first upstroke, the seal is broken and the pressure within the reservoir and the pressure at the interface equalise. For example the interface pressure may be 1,000 psi which doubles to 2,000 on the upstroke. Thus a pressurisation pressure of 1,500 psi would be indicated.

The valve may be a flapper valve as shown in Figures 23, 27 and 31. A flap 70 is pivoted to the wall of the reservoir at 71 and until the reservoir is positioned, it seats on valve seat 72. This is shown in Figure 23a. Once positioned, and when the well pressure has overcome the seal, the position is as shown in Figure 23b. The flap pivots and is held out of engagement by holding clip 73.

An alternative arrangement is shown in Figures 24 and 28 in which a ball 74 seats against a valve seat 75 until the reservoir is positioned. When the well pressure overcomes the seal, the ball moves upwardly and is optionally held out of engagement at position 76 by a ball catcher arrangement indicated generally at 77.

As an alternative to the flapper valve or ball valve, a downhole locking valve may be provided which is actuated, either to open it or to close it, by turning or otherwise actuating the sucker rod string. This valve system is more flexible than the two previously described systems since the reservoir may be freed from the well with its gas pressure intact or it may be made responsive to changes in well pressure by being closed or choked or left fully open. The flapper valve and ball valve controlled reservoirs are retreived from the

well during servicing procedure while they are held open. Other valve means could, of course, be used and it is not intended that the present application be limited to those described.

Figures 23 and 31 show a flapper valve closed reservoir attached at its bottom, in use, end to flow port member 79 having five entry ports to allow oil to flow from the well to the reservoir, and of course out again. The flow port member is more fully described above in relation to another aspect of the invention, but two variations are shown herein. The variation shown in Figure 27 has a pin type coupling 80 for connecting to the plunger while that shown in Figure 31 has a box type coupling 81, also for connecting to the plunger.

The reservoir comprises a main reservoir body 82 having a comparatively large internal volume. At the lower end of this is either formed or attached a seal unit 83 which is connected to the main body in sealing engagement and contains either the flapper valve, the ball valve or other valve means. The volume of the reservoir must vary depending on the characteristics of the oil well in which it is operating. If it is required to increase the volume then the upper end of the main body may be attached to one or more of the wide diameter hollow sucker rods which form another aspect of

the present invention. When used in this way these wide diameter rods constitute part of the reservoir.

The upper end of the reservoir is connected to a solid sucker rod string 84 as shown in figure 30, or to a continuous hollow sucker rod string, by means of a connector 85.

The reservoir is, prior to use, pressurised with air or inert gas to the predetermined pressure through a one way valve 86. This is located generally in the region of the connection between the reservoir and the sucker rod spring although the exact position may be varied. In Figures 25 and 29 the valve 86 is embedded in a pin coupling at the upper end of, in one case the reservoir main body 83 and in the other the wide diameter hollow sucker rod 87. The one way valve may alternatively be housed in a neck separating the two box couplings of connector 85 as shown in figure 32. Connector 85 is provided with a seal 88 of glass filled PTFE in the box coupling connected to the reservoir, and connector 85 is overlength to accomodate the valve 86, otherwise it is orthodox.

The one way valve is threaded at its exterior 90 (Figure 26) to co-operate with a corresponding internal thread of the neck of the connector 85 or of whatever housing

it is in. A valve stem 91 biassed by a spring 92 to hold closed the valve 93 against seat 94. The valve illustrated is merely indicative of those kinds of valve which may be used and it is not intended to limit the application thereto.

If so required, the lower end of the reservoir may be connected not directly to the plunger of the travelling valve, but to it through a string of solid or hollow sucker rods.

An indication of the various aspects of the invention is given in the following paragraphs:

1. A sucker rod string for dampened pumping of fluid comprising a plurality of hollow sucker rods, a corresponding plurality of means connecting each two adjacent sucker rods, said connecting means being hollow and provided with sealing means whereby the interiors of the sucker rods are in continuous communication and may be at a pressure different to that of the exterior of the sucker rods.

2. A sucker rod string as specified in paragraph 1, wherein each connecting means is integral with a respective one of the sucker rods such that each sucker rod has a connecting means at one end and means to engage said connecting means at the other end.

3. A sucker rod string as specified in paragraph 1, wherein each connecting means comprises a housing into which may be engaged an end of each of two adjacent sucker rods.

4. A sucker rod string as specified in paragraph 1, wherein the connecting means comprises a male member at either end thereof and wherein the ends of the sucker rods are each formed as female units.

5. A sucker rod string as specified in any preceeding paragraph wherein the sealing means comprises glass reinforced PTFE.

6. A sucker rod string as specified in paragraph 1, wherein the connecting means comprises a housing and the sealing means is provided within the housing so as to be clamped between the ends of the two sucker rods connected by the connecting means.

7. A sucker rod string as specified in paragraph 6, wherein the sealing means comprises a metal casing of hollow cylindrical shape having a radially outward extending flange, and two annular shaped seals, the seals abuting respective surfaces of the flange and being urged against the inner surface of the housing of the casing.

8. A sucker rod string as specified in paragraph 6, wherein the housing is provided with an inwardly facing flange which constitutes a shoulder against respective sides of which two seals abut.

9. A sucker rod string as specified in paragraph 1, wherein each sucker rod engages its corresponding connecting means by way of co-operating screw threads and wherein the sealing means comprises seals which engage within the screw threads.

10. A sucker rod string as specified in paragraph 1, wherein the sealing means comprises seals held between a shoulder on the sucker rod and an end face of the connecting means.

11. A connector for a sucker rod, the connector being generally hollow and cylindrical, having means to engage a sucker rod at at least one end and sealing means which provide a seal between the interior of a sucker rod connected to said connecting means and the exterior of that sucker rod.

12. A connector for a sucker rod as specified in paragraph 11, wherein the sealing means is an annulus of glass reinforced PTFE.

13. A connector for rods, the connector having two substantially identical opposite end portions, each of which is provided with an external coupling means adapted to co-operate with an internal coupling means of the rods to be connected by the connector.

14. A connector as specified in paragraph 13, wherein each of the coupling means is in the form of a screw thread.

15. A connector as specified in paragraph 13 or 14, wherein the connector has an axial bore passing therethrough.

16. A connector as specified in any of the paragraphs 13 to 15, wherein the intermediate portion of the connector is formed with wrench flats.

17. A connector as specified in any of paragraphs 13 to 16, wherein the intermediate portion of the connector is formed with an elevator shoulder.

18. A connector as specified in any of paragraphs 13 to 17, wherein the external diameter of the connector is larger than that of the rods to be connected, whereby the connector will tend to protect the surfaces of the rods against wear when the interconnected rods are used within a bore.

19. A method of making a coupling ended hollow tube comprising the steps of forging two coupling units, drilling or otherwise producing an axial bore along the length of each of the coupling units, providing a tube of any desired length, and friction welding each end of the tube to a respective one of the bored coupling units.

20. A method as specified in paragraph 19, further comprising the step of removing flash from the weld formed by the friction welding.

21. A method as specified in paragraph 19 or 20, further comprising the step of prior to friction welding, upset forging the ends of the tube.

22. A method as specified in paragraph 19 or 20, wherein the step of friction welding itseld produces an upset in the ends of the tube.

23. A method as specified in any of paragraphs 19 to 22, further comprising the step of providing screw threads on the coupling units.

24. A sucker rod string comprising at least in its lower portion a plurality of sucker rods each having an internal bore of diameter greater than the diameter of the internal bore of the connections between any of two of said plurality of sucker rods.

25. A sucker rod string as specified in paragraph 24, wherein the sucker rods each have a bore of diameter which is at least twice as large as the diameter of the bore of the connections.

26. A sucker rod string as specified in paragraph 24 or 25, wherein the connections are formed by way of connectors having a male member at each end which engage the internal bore of the

sucker rods which thereby act as a female coupling components.

27. A sucker rod string as specified in paragraph 24 or 25, wherein the internal diameter of each sucker rod narrows into a neck portion in the region of the coupling.

28. A sucker rod string as specified in any of paragraphs 24 to 27, further comprising a feed member provided with a plurality of feed ports which provide openings into the said internal bores of the sucker rods.

29. A sucker rod string as specified in any of paragraphs 24 to 28, wherein the external surfaces of the sucker rods are grooved.

30. A sucker rod for use as one of the said plurality of sucker rods of the sucker rod string as specified in any of the paragraphs 24 to 29.

31. A sucker rod for use as one of the said plurality of sucker rods of the sucker rod string as specified in paragraph 27, wherein a male coupling component is friction welded to one end of a sucker rod at the necked portion thereof.

32. An apparatus for use in the pumping of oil comprising a downhole enclosed reservoir of gas pressurised to a pressure at least equal to that at the downhole interface prior to insertion of the resrvoir downhole, the reservoir accepting an intake of oil during an upstroke of the pumping, thereby compressing the gas within the reservoir and effecting pulsation dampening.

33. Apparatus as specified in paragraph 32, wherein the reservoir is pressurised prior to insertion downhole and is sealed.

34. Apparatus as specified in paragraph 33, wherein the reservoir is sealed by a flapper valve.

35. Apparatus as specified in paragraph 33, wherein the reservoir is sealed by a ball valve.

36. Apparatus as specified in paragraph 33, wherein the reservoir is sealed by a locking valve actuated by rotation of the sucker rod string to which the reservoir is attached.

37. Apparatus as specified in any of paragraphs 32 to 36, wherein the reservoir is pressurised to a pressure greater than the pressure at the downhole interface

prior to insertion of the reservoir downhole but less than the pressure created during the upstroke of the pumping.

38. Apparatus as specified in paragraph 34 or 35, wherein the valve, once opened, is held open.

39. Apparatus as specified in paragraph 32, wherein the reservoir is charged by a one way valve located at the, in use, upper end of the reservoir.

40. Apparatus as specified in any of paragraphs 32 to 39, wherein the reservoir comprises a plurality of sucker rods of the type specified as part of the plurality of sucker rods defined in paragraph 24.

41. A connector having one end adpated to couple with a sucker rod string, the other end adpated to couple with a sucker rod forming part of a downhole enclosed reservoir of pressurised gas and comprising a one way valve means to allow charging of said reservoir with pressurised gas prior to the sucker rod string being connected to the connector.

42. A connector as specified in paragraph 41, wherein the connector has two female coupling members and the one way valve means is housed in a necked portion interconnecting the female coupling members.

CLAIMS

1. A sucker rod string for dampened pumping of fluid comprising a plurality of hollow sucker rods (10), a corresponding plurality of means (11) connecting each two adjacent sucker rods (10), said connecting means (11) being hollow such that the interiors of the sucker rods (10) are in continuous communication characterised in that the connecting means (11) are provided with sealing means (16) whereby the interiors of the sucker rods (10) may be at a pressure different to that of the exterior of the sucker rods (10).

2. A connector (11) for a sucker rod (10), the connector (11) being generally hollow and cylindrical, having means (12) to engage a sucker rod (10) at at least one end characterised by sealing means (16) which provide a seal between the interior of a sucker rod (10) connected to said connecting means (11) and the exterior of that sucker rod (10).

3. A connector (24) for rods (10), the connector (24) having two substantially identical opposite end portions (39) characterised in that each end portion is provided with an external coupling means (32) adapted to co-operate with an internal coupling means (33) of the rods (10) to be connected by the connector (24).

4. A method of making a coupling ended hollow tube (10) comprising the steps of forming two coupling units (25) and welding each to a respective end of tube (10) characterised in that the coupling units (25) are formed by forging, in that the coupling units (25) are friction welded to the respective ends of the tube (10) and in that prior to welding an axial bore (17) is introduced along the length of each of the coupling units (25).

5. A sucker rod string (1) characterised by having at least in its lower portion a plurality of sucker rods each with an internal bore (17) of diameter greater than the diameter of the internal bore of the connections between any two of said plurality of sucker rods.

6. A sucker rod for use in a sucker rod string (1) as claimed in claim 5.

7. An apparatus for use in the pumping of oil characterised by a downhole enclosed reservoir of gas pressurised to a pressure at least equal to that at the downhole interface prior to insertion of the reservoir downhole, the reservoir accepting an intake of oil during an upstroke of the pumping, thereby compressing the gas within the reservoir and effecting pulsation dampening.

8. A connector (85) having one end adapted to couple with a sucker rod string (1) characterised by having its other end adpated to couple with a sucker rod forming part of a downhole enclosed reservoir of pressurised gas and by a one way valve means (86) which allows charging of said reservoir with pressurised gas prior to the sucker rod string (1) being connected to the connector (85).

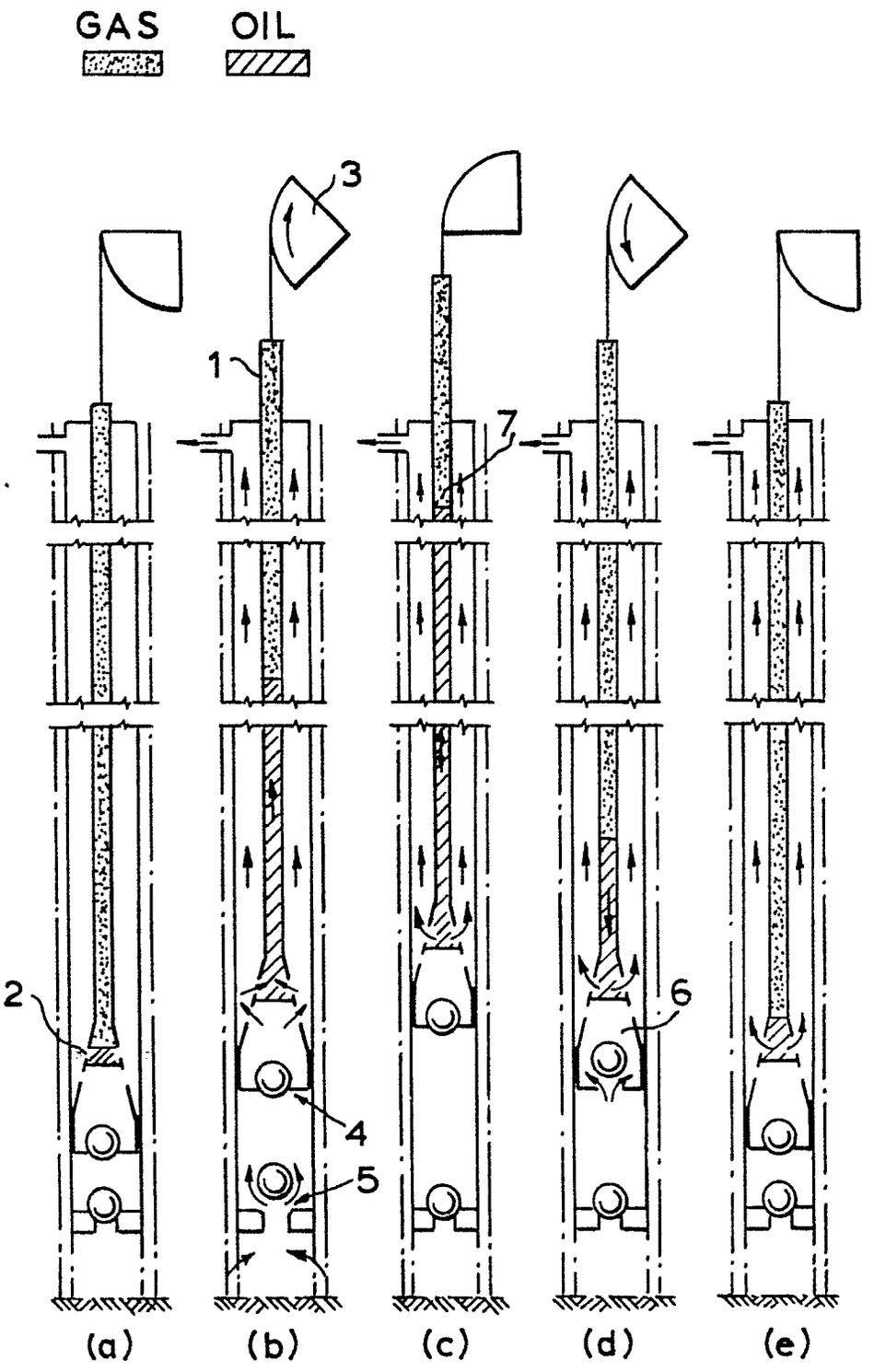


FIG.1.

FIG.2.

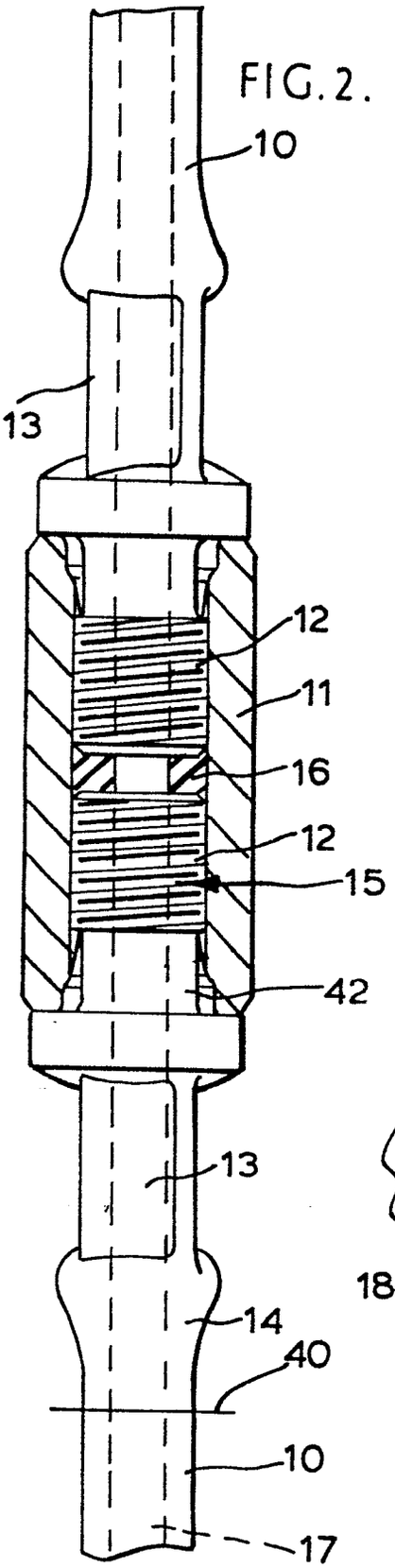


FIG.4.

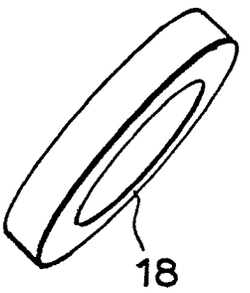
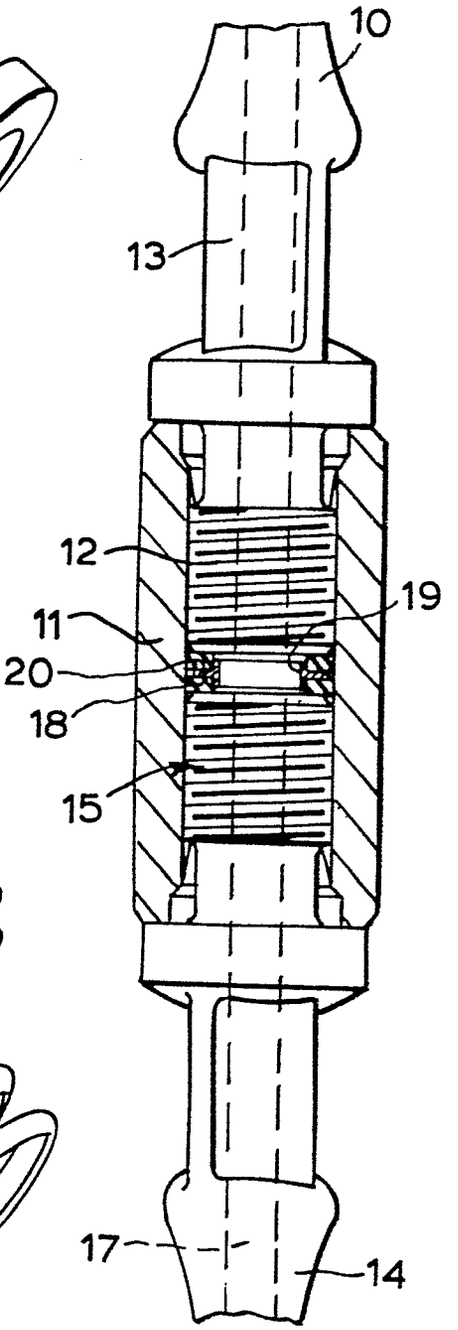


FIG.3.



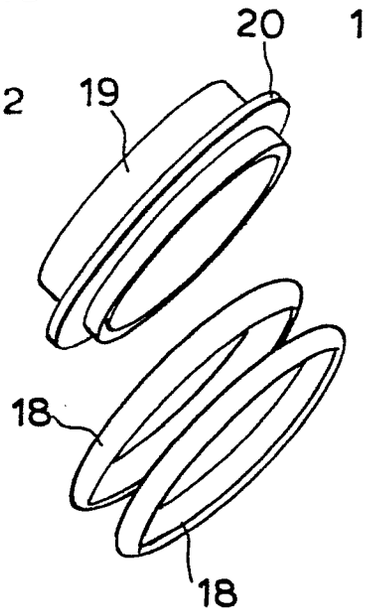


FIG.5

FIG. 6.

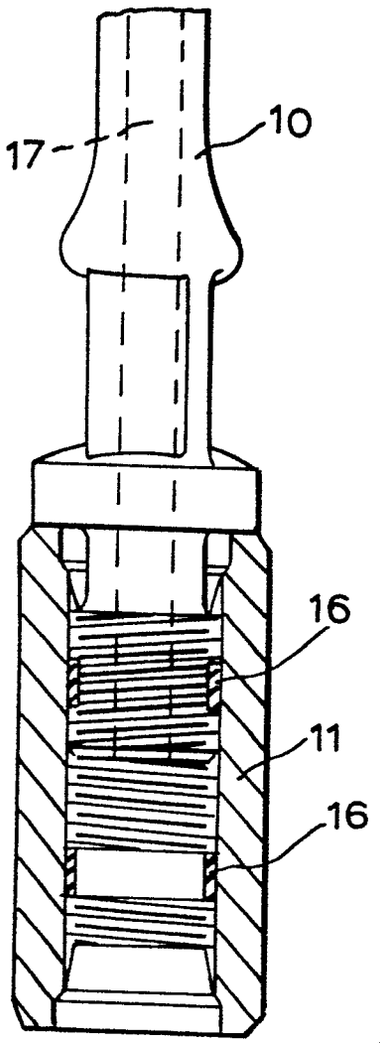
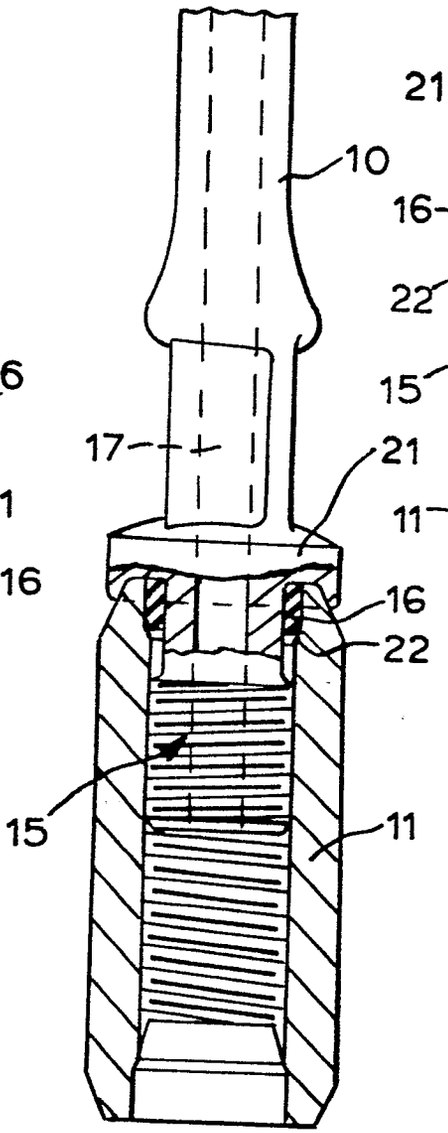


FIG. 7.



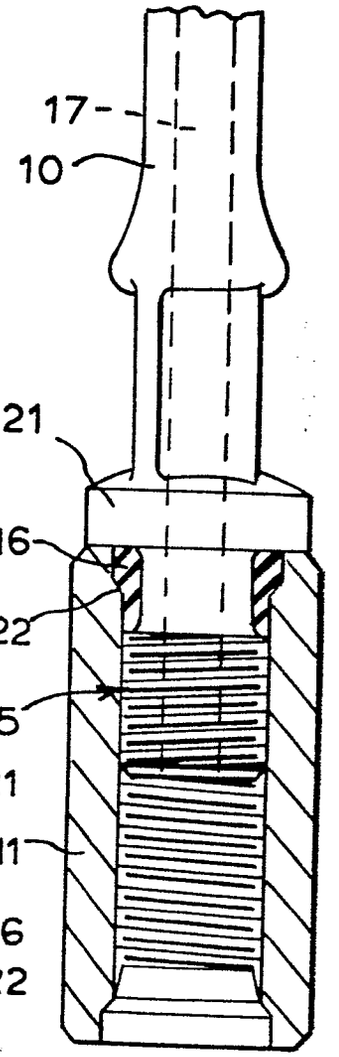
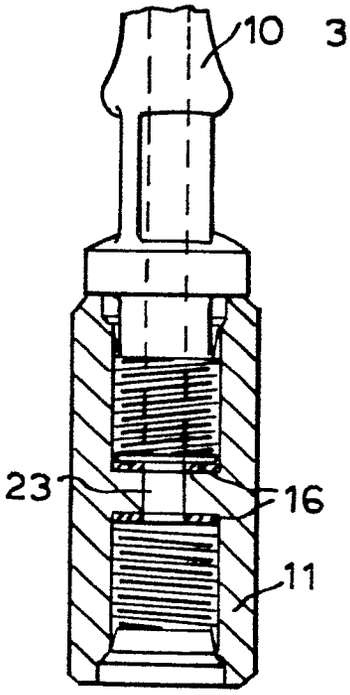


FIG. 8.

FIG. 9.



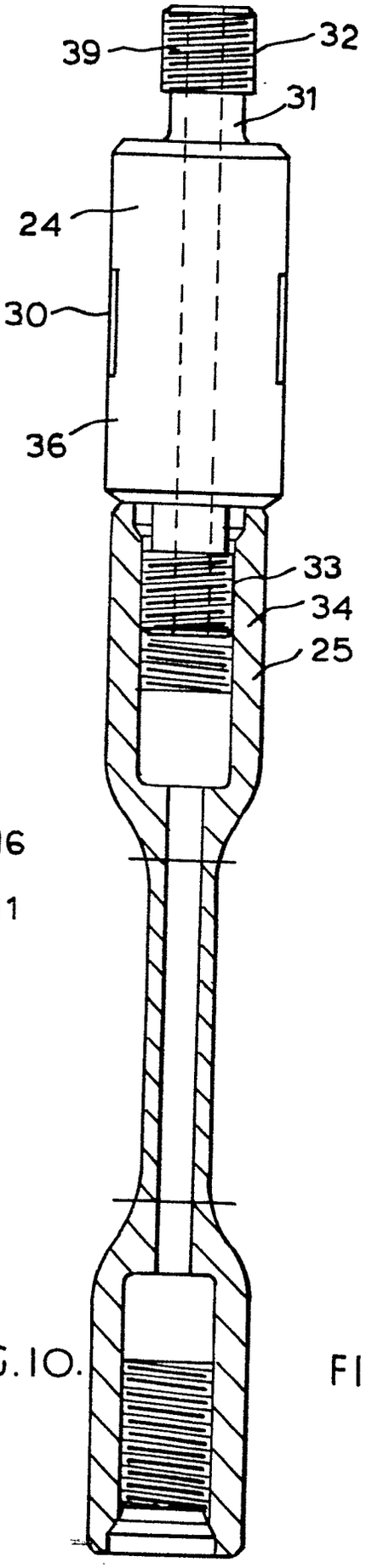


FIG. 10.

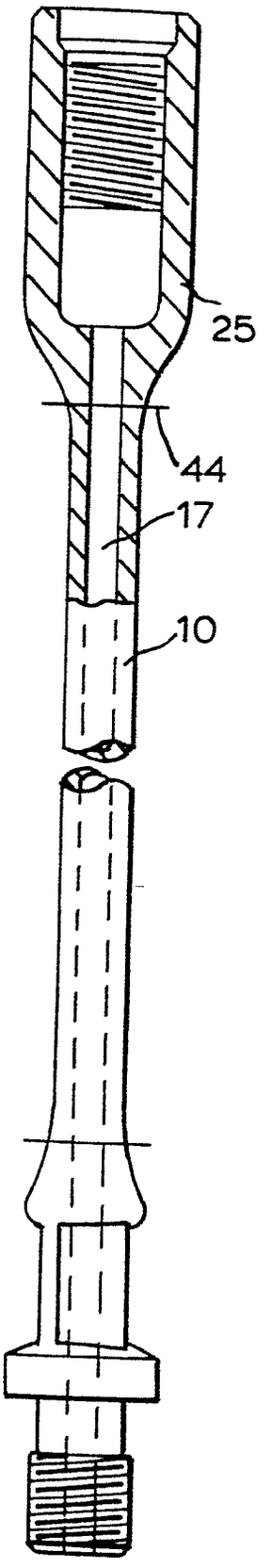


FIG. 11.

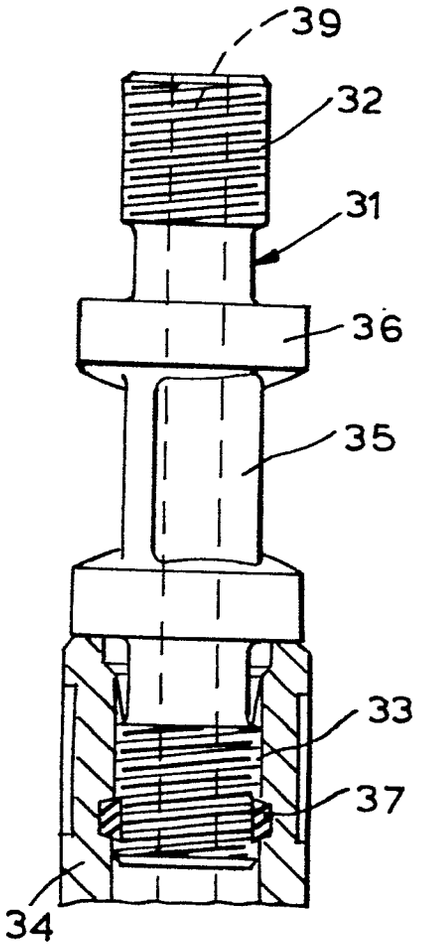


FIG.12.

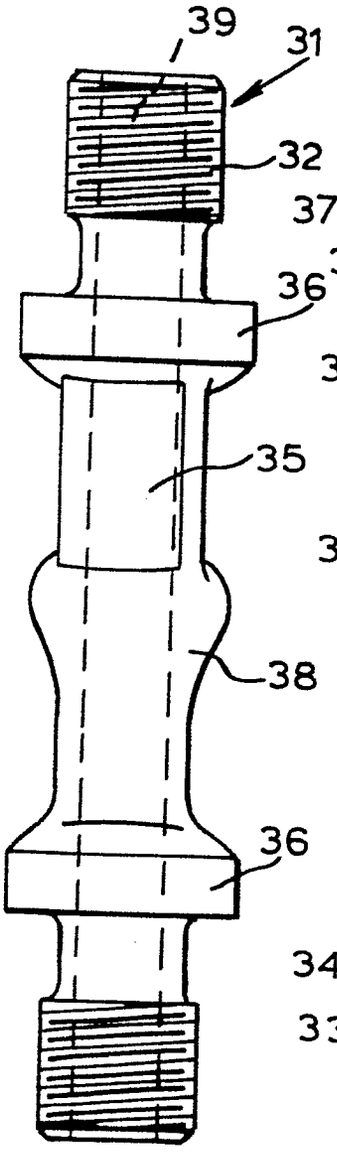


FIG.13.

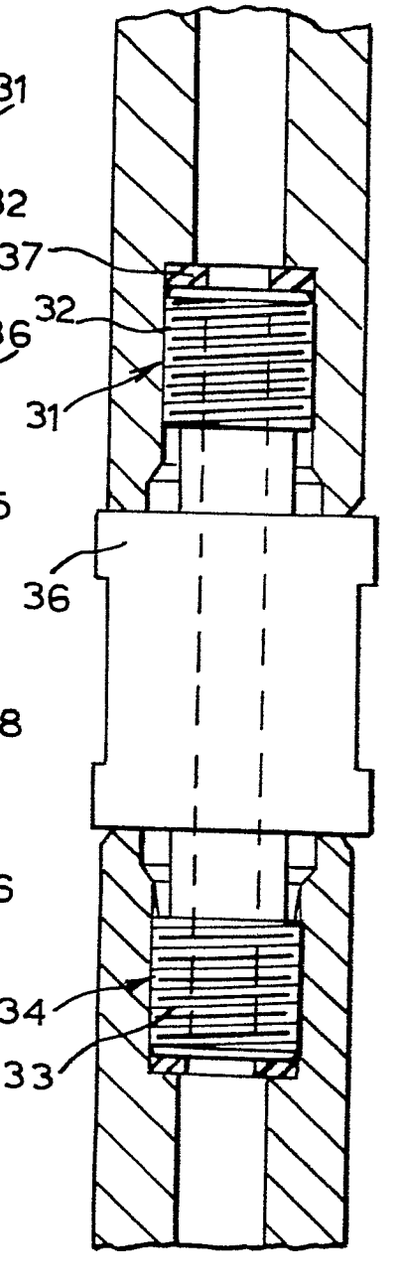
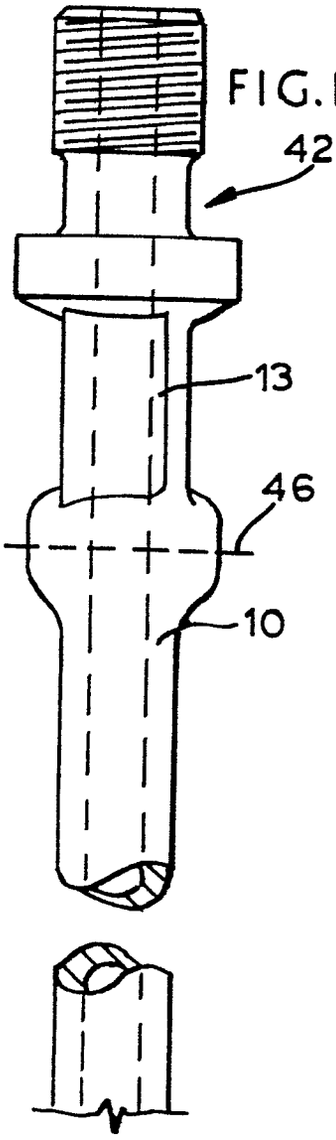


FIG.14.

FIG.15.



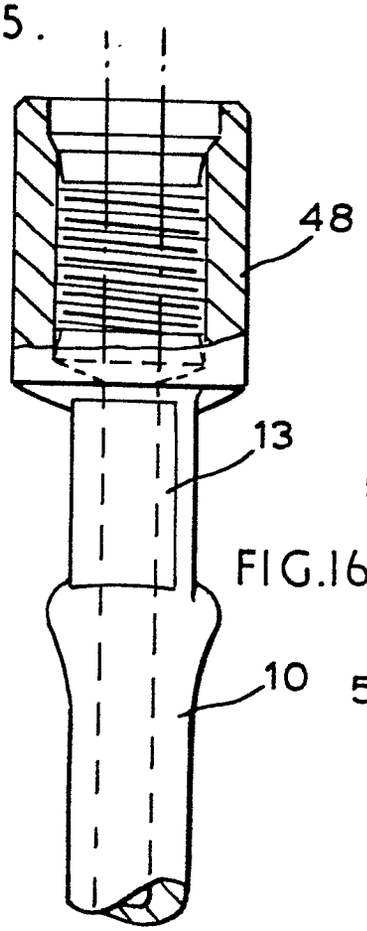


FIG.16.

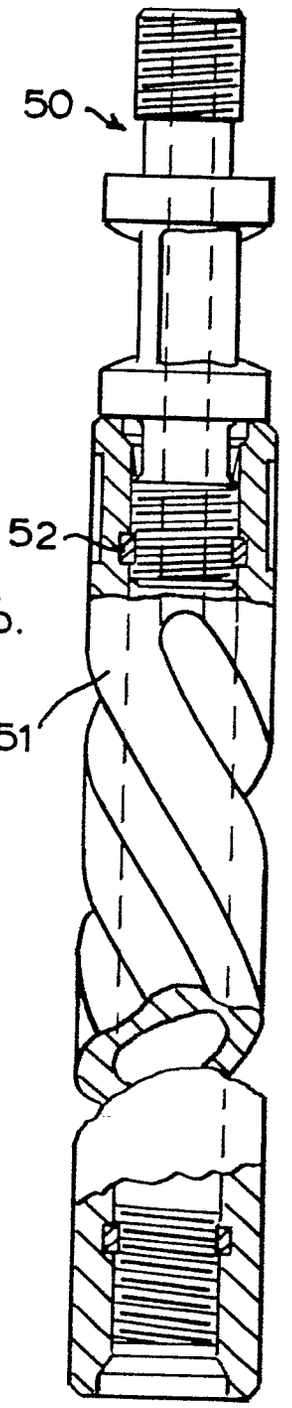


FIG.17.

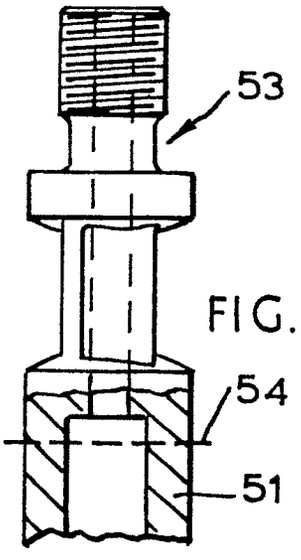


FIG.18.

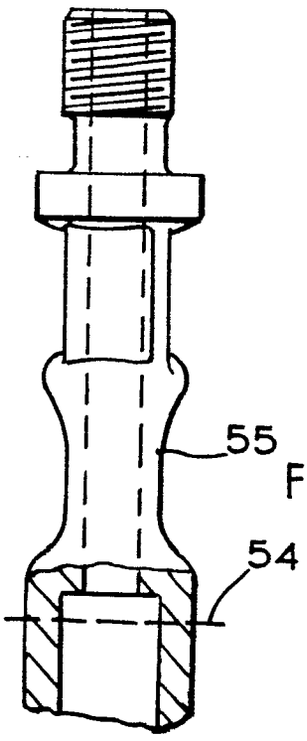


FIG.19.

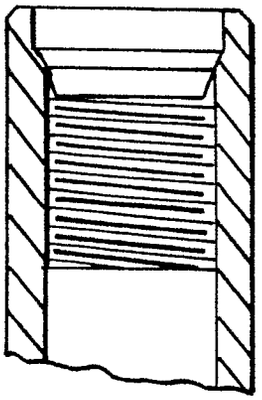


FIG.20.

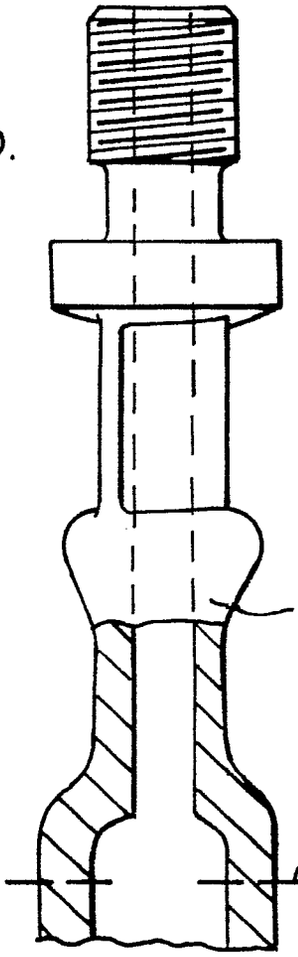
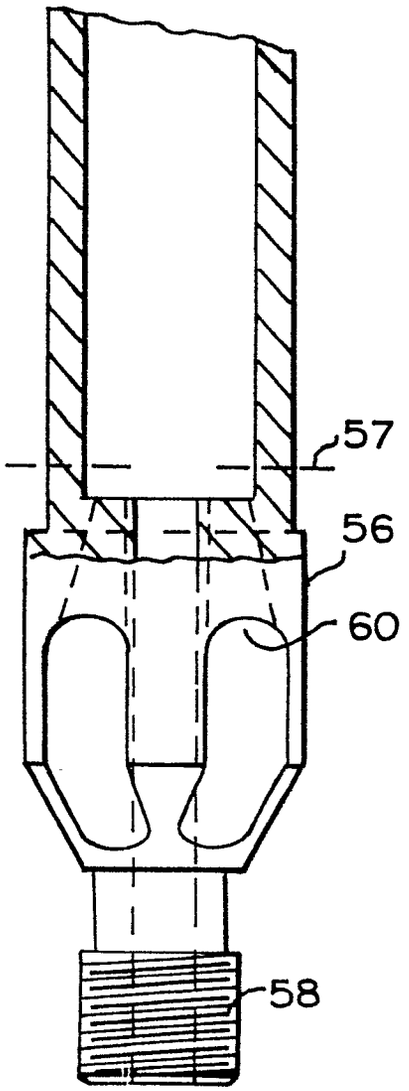


FIG.21.



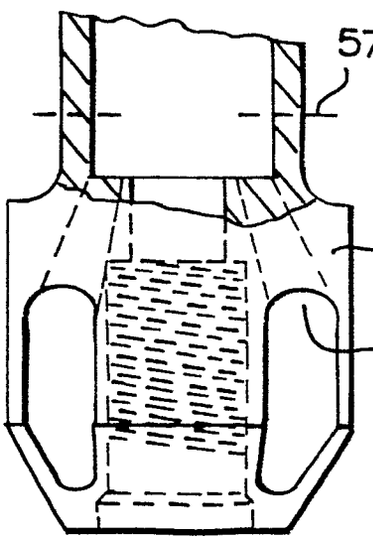
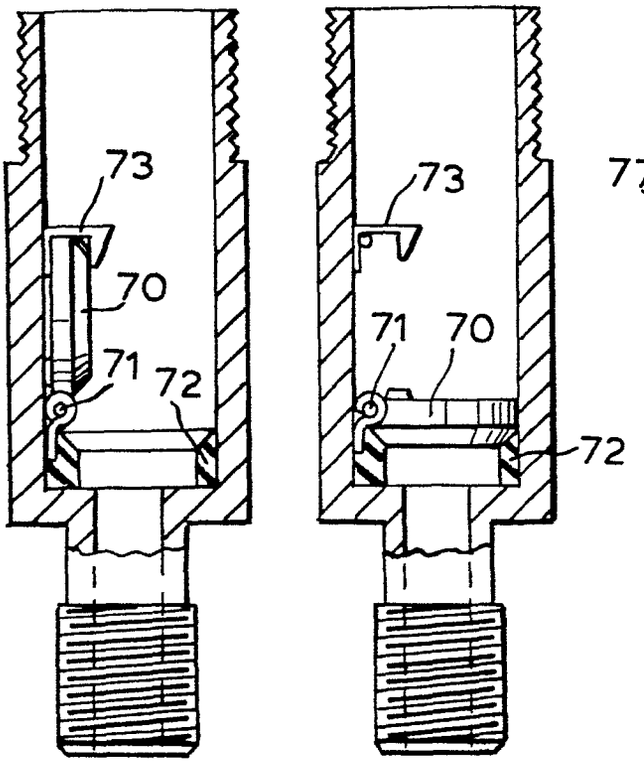


FIG.22.



(b) FIG. 23. (a)

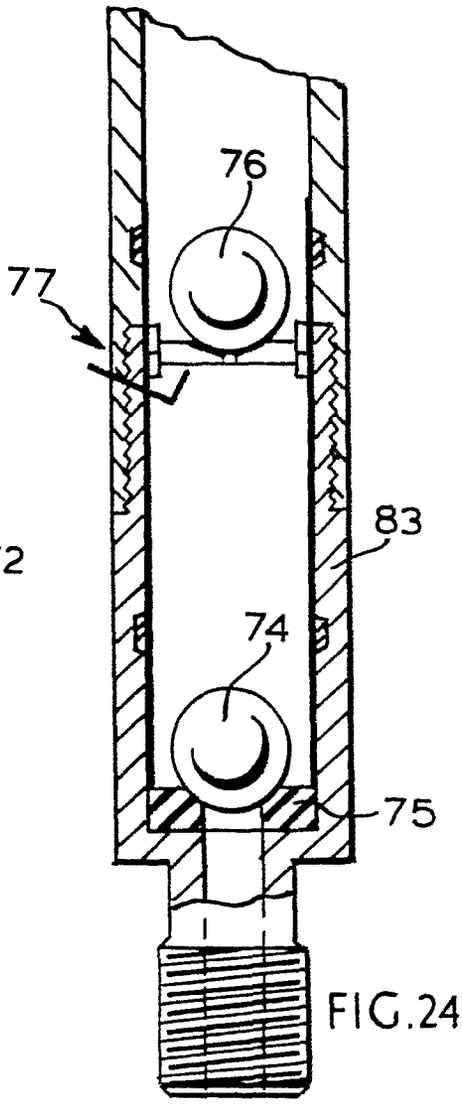


FIG. 24.

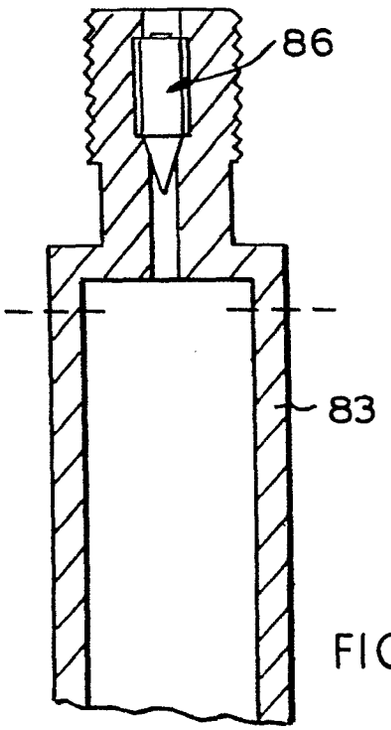


FIG. 25.

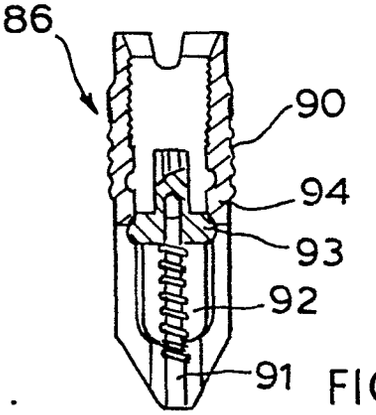
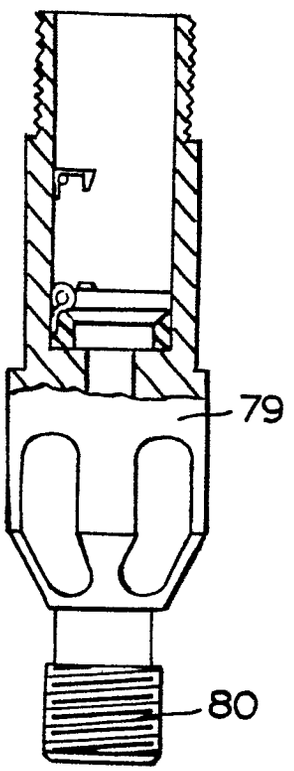


FIG. 26.

FIG.27.



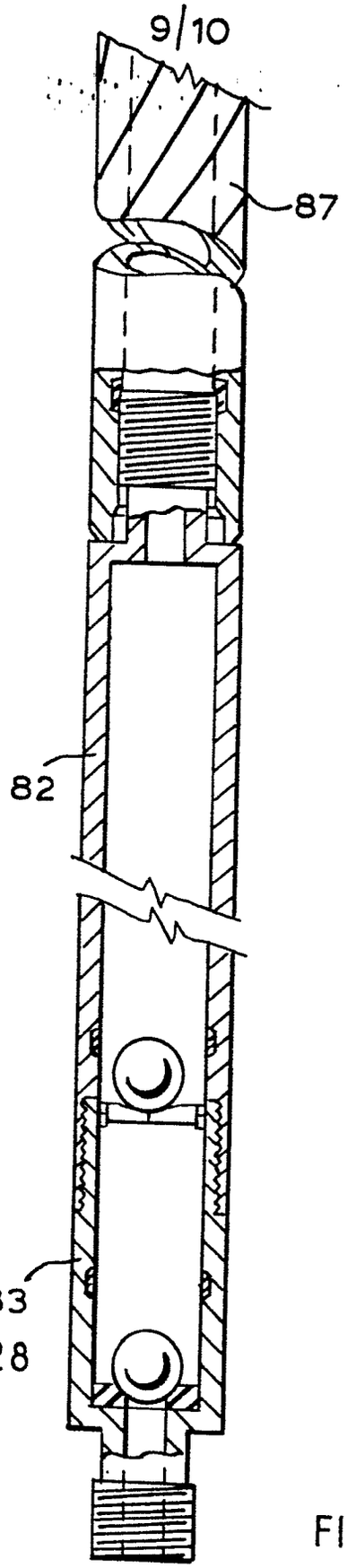


FIG.28

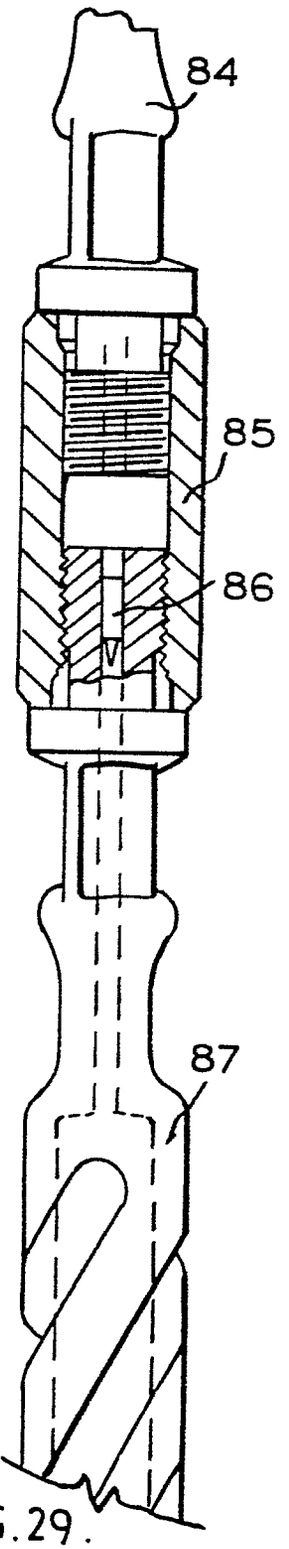
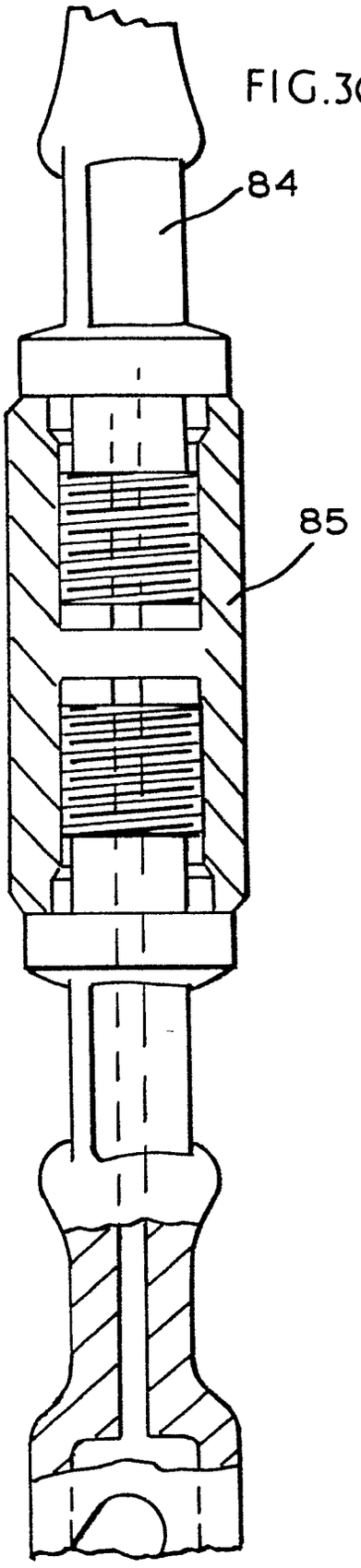


FIG.29.

FIG.30.



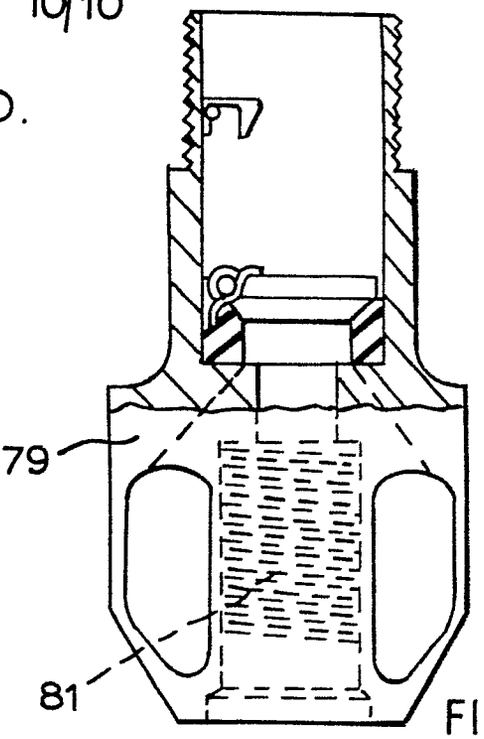


FIG.31.

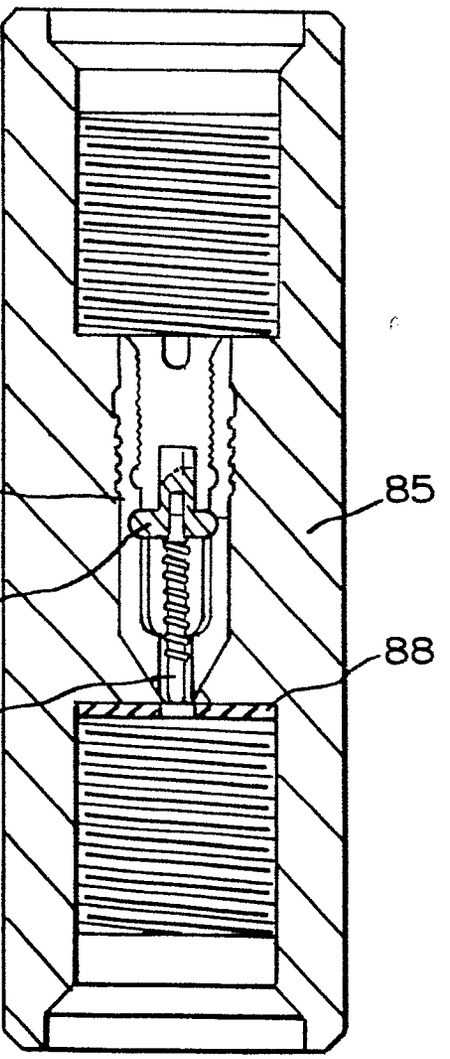


FIG.32.

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EUROPEAN SEARCH REPORT

0145154
Application number

EP 84 30 6795

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int Cl 4)
A	EP-A-0 085 647 (LENZE et al.) * Abstract; figure 1 *	1	E 21 B 17/00 F 04 B 21/04
X	GB-A-2 003 526 (DREXEL) * Abstract; page 8, lines 93-112; figure 6 *	1,2	
X	US-A-4 003 669 (FENSKE) * Figure 2; abstract *	1	
X	GB-A-2 113 745 (BENTELER) * Abstract; figure 8 *	3,4	
Y	GB-A-2 104 936 (NORTH) * Abstract *	4	
Y	GB-A-1 000 955 (AMERICAN IRON AND MACHINE WORKS) * Page 2, lines 28-58; figure 2 *	4	TECHNICAL FIELDS SEARCHED (Int Cl 4) E 21 B F 04 B
P,X	GB-A-2 119 866 (FERGUSON et al.) * Whole document *	5-8	
A	GB-A- 294 609 (H. ANGER'S SOEHNE)		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	08-02-1985	BENZE W.E.

CATEGORY OF CITED DOCUMENTS

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