Feb. 24, 1970 H. U. GARRETT 3,496,953

GAS LIFT VALVE MANDREL FOR WELL PIPE STRINGS

Filed April 18, 1968 2 Sheets-Sheet 1

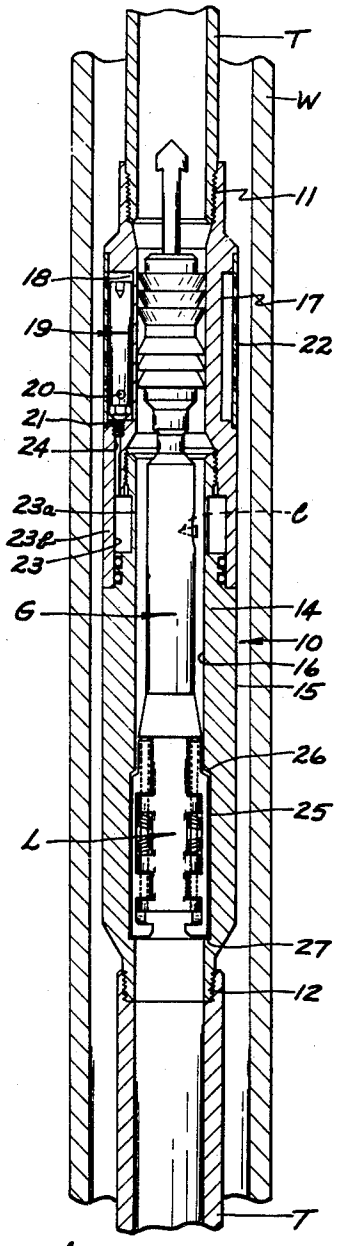


Fig. 1

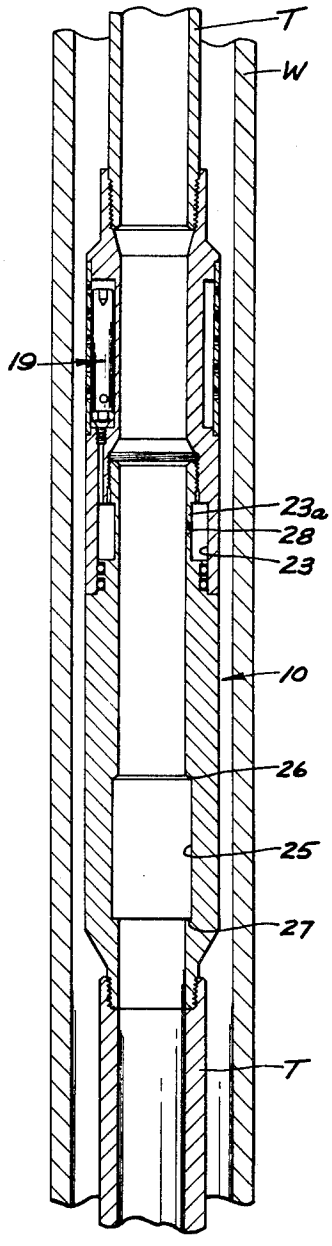


Fig. 2

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GAS LIFT VALVE MANDREL FOR WELL PIPE STRINGS

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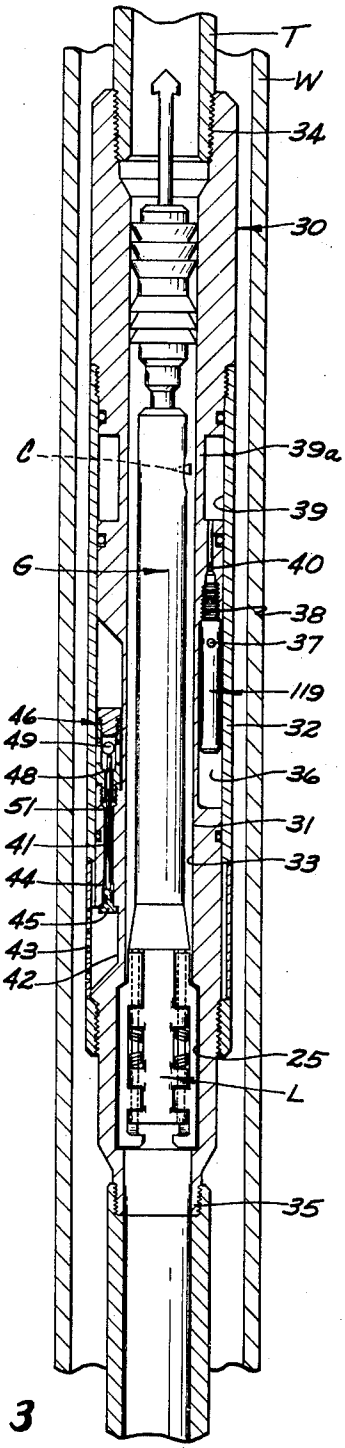


Fig. 3

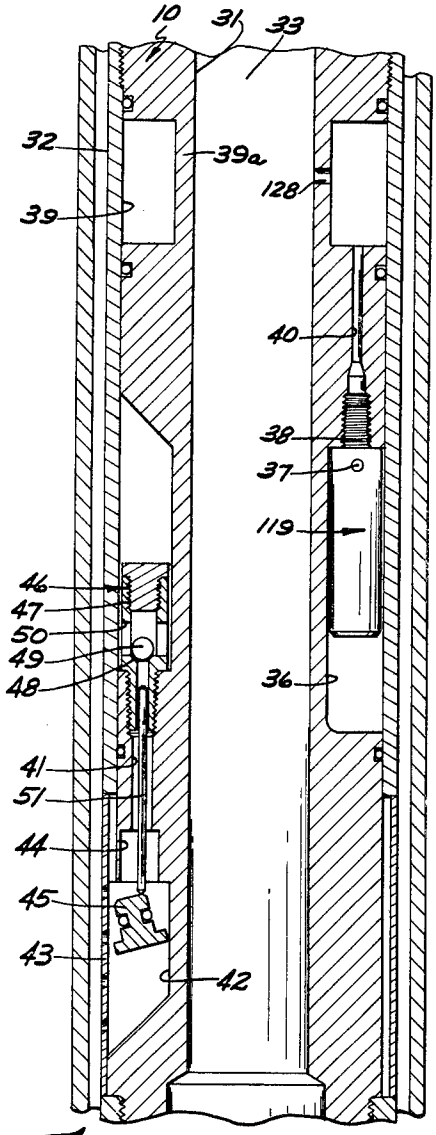


Fig. 4

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GAS LIFT VALVE MANDREL FOR WELL PIPE STRINGS

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ABSTRACT OF THE DISCLOSURE

A gas lift mandrel particularly adapted to be preinstalled in well production pipe strings and including a tubular body having longitudinally extending passage means confined between the inner and outer wall surfaces of the body for establishing fluid communication between the interior and exterior of the body, the inner end of the passage means being initially closed off by the inner wall surface of the body, a gas lift valve mounted within the passage means in flow-controlling relation thereto, and the interior of the body having means, operable when required, to position a wall-perforating device in registry with the inner end of the passage to open the latter to communication with the interior of the body.

When oil wells have been completed it is found in many cases that after production has continued for some time, the natural pressure will become depleted and artificial means must be employed to continue production of the oil. One of the common systems for artificial lift is generally referred to as "gas lift" in which gas under pressure is injected itno the production pipe string through gas lift valves under controlled conditions to assist in lifting the well fluids to the surface.

Ordinarily, the gas lift valves will not be installed until after the natural lifting forces have been depleted. This involves removing the production tubing and installing a number of gas lift valves at spaced intervals along the tubing and then running the latter back into the well to re-establish the production pipe string. This type of installation necessarily involves considerable difficulty and hazard to the well, and is particularly difficult and hazardous in the case of wells which have been completed in a plurality of producing formations, each of which is connected to a separate string of tubing, the several strings of tubing being enclosed within a surrounding casing which necessarily creates a restricted area, seriously limiting freedom of movement of tubing strings and equipment mounted thereon. Since the usual gas lift mandrels and valves ordinarily form lateral protrusions from the pipe strings, those on one string will interfere with those on another when efforts are made to run one string into the confining casing after another is already in place, and also such protrusions will interfere with rotation inside the surrounding casing of the pipe strings, such rotation being often necessary to complete the installation of the tubing strings in a multiple string well.

Wells have heretofore been equipped initially with tubing strings having gas lift mandrels preinstalled with gas lift valves in place, or with valve dummies which may later be replaced with gas lift valves, in anticipation of the time when the particular producing formation may have to be put on artificial lift. Such systems are subject to numerous difficulties, particularly in protecting the preinstalled valves from the collection thereon of sand or other detritus carried by the well fluids or from corrosion by the latter, so that when the occasion arises to place the valves in operation, they cannot be caused to function effectively and the valves or the tubing string, as a whole, must be pulled in order to correct the condition.

The present invention is directed to a gas lift mandrel which is designed particularly for pre-installation in one or more production tubing strings and which obviates the principal difficulties, such as those mentioned above, to which more conventional systems are subject.

More particularly, the present invention is directed to a form of gas lift mandrel adapted for pre-installation in a production tubing string initially installed in a well, and incorporating within the wall of the mandrel passage means adapted for establishing fluid communication between the interior and exterior of the tubing, and having preinstalled, also within the confines defined by the inner and outer wall surfaces of the mandrel, a gas lift valve in controlling relation to the passage means. The inner end of the passage means will be initially closed by the inner wall surface of the mandrel to exclude tubing fluids from communication with the valve. The mandrel is also provided with means in the bore thereof operable to effectively locate a wall-perforating device of any suitable form in registry with the inner end of the passage means, so that when required, an opening may be formed through the inner wall surface to communicate the passage means with the interior of the tubing string. Thus, the preinstalled valve is maintained in inactive condition, protected from the well fluids until such time as its operation will be required for effecting artificial lift.

In one embodiment of this invention, the outer end of the passage means is maintained in open communication with the exterior of the mandrel and, therefore, with the interior of the surrounding casing. This arrangement is particularly applicable when the casing surrounding the tubing string does not contain any fluids which might have any deleterious effect upon the valve.

In another embodiment of this invention, the outer end of the passage means will also be closed off, so that the valve will be fully protected from fluids both inside and outside the tubing string. In this embodiment, the closure means for the outer end of the passage means is constructed to be removable by fluid pressure from the interior of the tubing string, once an opening has been created through the inner wall of the mandrel, as previously described. Thus, the passage means will be opened for communicating the interior of the tubing with the exterior thereof under the control of the gas lift valve.

Other and more specific objects and advantages of this invention will become more readily apparent from the following detailed description when read in conjunction with the accompanying drawing which illustrates two useful embodiments in accordance with this invention.

In the drawing:

FIG. 1 is a longitudinal, sectional view of a well having inserted therein a tubing string fitted with a gas lift mandrel in accordance with one embodiment of this invention, the parts being shown in the condition at which the valve-controlled passage means is closed off from communication with the tubing string;

FIG. 2 is a view similar to FIG. 1, showing the passage means in opened communication with the tubing string;

FIG. 3 is a longitudinal, sectional view, generally similar to FIG. 1 illustrating another embodiment in accordance with this invention, the parts being shown in the positions occupied when communication is closed off between the interior and exterior of the tubing string; and

FIG. 4 is a fragmentary view showing details of the structure of FIG. 3 with the parts in positions occupied when communication has been established between the interior and the exterior of the tubing string.

Referring first to the embodiment illustrated in FIGS. 1 and 2, the mandrel comprises a generally tubular body, designated generally by the numeral **10**, having threaded connections **11** and **12** at its opposite ends for connecting the body into adjacent sections of a tubing string T, the

latter being shown enclosed within a well casing W. The wall of body **10** is defined by inner and outer wall surfaces **14** and **15**, inner wall surface **14** defining the axial bore **16** of the body, which is substantially flush with the bore of the tubing string. Body **10** may be made up of a plurality of inter-connected sections, as shown, or in any other suitable and known arrangement, to provide the structural details to be described.

Adjacent its upper end the exterior of body **10** is provided with an annular recess **17** which is deepened at one side to form a generally cylindrical pocket **18** adapted to receive a gas lift valve, designated generally by the numeral **19**, the depth of the pocket being such that valve **19** will be confined entirely within the body wall between inner and outer wall surfaces **14** and **15**. Valve **19** may be of any suitable and generally conventional construction, having ports **20** and **21** arranged in the conventional manner for the passage of pressure fluids through the valve under control of conventional valve mechanism, not shown, but well understood by thse skilled in the art. Recess **17** and pocket **18** are enclosed by a concentric perforate screen **22** arranged to be flush with the outer wall of body **10**. At a point spaced longitudinally below pocket **18**, body **10** is provided with an annular chamber **23** which initially is fully enclosed between the portions **23***a* and **23***b*, respectively, of inner and outer wall surfaces **14** and **15** of the body. A passageway **24** likewise confined between the inner and outer wall surfaces of the body, communicates chamber **23** with port **21** of the valve.

It will be seen that portion **23***a*, which defines the inner wall of chamber **23**, serves to initially close off communication between chamber **23** and bore **16** of the body, but when pierced or perforated in a manner to be described, will provide an opening **28** (FIG. 2) to establish such communication.

From the foregoing, it will be seen that chamber **23**, when provided with openings **28**, passageway **24**, and pocket **18** constitute flow passage means providing fluid flow communication between the interior of body **10** and the exterior of the body through pocket **18** under control of valve **19**. However, as noted, until openings **28** are provided, valve **19** will be protected from fluids being produced through tubing T and will be exposed only to fluids, if any, which may be present in casing W.

In order to provide openings, when and as required, the mandrel, in accordance with the present embodiment, is provided with means which will enable openings **28** to be formed in the inner wall **23***a*. This means includes an annular recess **25** in the wall of bore **16** spaced below chamber **23** and defined by upper and lower shoulders **26** and **27**, respectively. Recess **25** constitutes a locator seat for a perforating gun G, which may be of any known design, which carries on its lower end a hinge-type latch L, also of known design, which, when disposed in recess **25**, will serve to positively position the perforating element, indicated at C, opposite wall portion **23***a* and in register with chamber **23**.

With the arrangement above described, it will be seen that whenever it becomes desirable to activate gas lift valve **19** for controlling admission of lifting gas into the tubing string, perforating gun G will be run through tubing T by using any suitable and generally conventional operating means for this purpose, and moved downwardly until latch L engages in recess **25**. Thereafter, gun G may be fired by known procedures to perforate the inner wall portion **23***a* of chamber **23** and form perforations **28**. The gun will then be withdrawn from tubing T and fluid communication will now have been established between the interior and exterior of tubing T under the control of gas lift valve **19**, so that conventional gas lift operations may be performed.

Referring now to FIGS. 3 and 4, these illustrate another embodiment in which the gas lift valve is so arranged as to be protected initially from exposure to fluids both inside and outside the tubing string until such time as the valve is to be activated for controlling the injection of lifting gas into the tubing string.

In this embodiment, the mandrel comprises a tubular body, designated generally by the numeral **30**, defined by the inner and outer wall surfaces **31** and **32**, inner wall surface **31** defining the axial bore **33** extending through the body. The upper and lower ends of the body carry threaded means **34** and **35**, respectively, for connecting the body into adjacent sections of tubing string T, the body being shown disposed inside the casing section W. An annular pocket **36** is provided in the wall of body **30** between the inner and outer wall surfaces and is adapted to receive and fully enclose a gas lift valve **119**, as in the previously described embodiment, the valve having ports **37** and **38** for passage of fluid therethrough under control of the usual internal valve mechanism.

A chamber **39** is provided in the wall of body **30** between the inner and outer wall surfaces thereof at a point longitudinally spaced above pocket **36** and communicates with the latter by means of a passage **40** confined between the wall surfaces of the body, under control of gas lift valve **119**. The portion **39***a* of the inner wall of body **30** which defines the inner wall of chamber **39** is initially closed to communication with the bore of the body, as seen in FIG. 3.

A second passage **41** extends longitudinally between the wall surfaces of the body and is arranged to communicate pocket **36** with the exterior of body **30** through a recess **42** which is covered by perforate screen **43**. The outer or lower end of passage **41** is counterbored at **44** to receive a sealing plug **45**, which is frictionally held against dislodgement from counterbore **44**. As best seen in FIG. 4, the inner end of passage **41** is fitted with an inwardly opening check valve, designated generally by the numeral **46**, and comprising a cage **47** adapted to be screwed into the upper end of passage **41**. Cage **47** is provided with a tubular seat **48** communicating with passage **41**, a ball valve **49** adapted to cooperate with seat **48**, and outlet ports **50** communicating with the interior of pocket **36**. A spacer rod **51** is slidably disposed in passage **41** and has a length such that when its lower end rests on plug **45**, its upper end will thrust ball valve **49** away from seat **48** (FIG. 3). When, however, plug **45** has been displaced from counterbore **44**, rod **51** will fall through passage **41** allowing ball valve **49** to drop onto seat **48** (FIG. 4) and thus be made operative to perform its normal check valve function of opening to allow inward flow of fluid through passage **41** and closing to prevent fluid flow in the opposite direction.

The bore of body **10** is provided with a locator seat **125**, substantially identical in form and function to recess **25** of the previously described embodiment, in order to enable positioning of a perforating gun G in register with chamber **39** when necessary to perforate wall portion **39***a*.

As will be seen, while wall portion **39***a* remains imperforate and plug **45** is in place, closing the lower end of passage **41**, gas lift valve **119** will be completely encased within the wall of the mandrel body and will not be exposed to fluids, either from the interior or the exterior of body **30**, so that when the mandrel containing the gas lift valve is installed in the tubing string, it may be maintained in this protected and inactive condition for as long as may be necessary. When, however, it is desired to activate the gas lift valve, it is only necessary to run a perforating gun G, as in the previously described embodiment, to engage latch L in seat **125**, so as to position the perforating element C opposite wall portion **39***a* and upon firing of the gun, opening **128** will be formed through wall portion **39***a*, thereby communicating the interior of the tubing string with chamber **39**.

When this communication has been established and a head of fluid accumulated in tubing T to an extent sufficient to open gas lift valve **119**, the fluid under the pressure thus developed will flow out of ports **37** into pocket

36 and thence through the then open check valve 46 into passage 41 where the pressure will act against plug 45 to force it out of counterbore 44, allowing rod 51 to drop away from ball valve 49 and placing passage 41 into communication with the exterior of the mandrel through recess 42 and screen 43, and activating the check valve to function normally.

The gas lift valve will now be free to operate in the normal manner determined by the relationship of the pressures inside and outside of the tubing string in accordance with conventional gas lift systems.

It will be evident that with openings 128 provided through wall portion 39*a* and plug 45 expelled from passage 41, recess 42, passage 41, pocket 36, passage 40, and chamber 39 will jointly constitute a passageway enclosed entirely within the confines of the wall surfaces of body 30 and communicating the interior of the tubing with the exterior thereof under the control of gas lift valve 119. While the form of the passage thus provided may vary in many details, the important feature is that the mandrel is provided with passage means for communicating the interior and exterior thereof, and in which is mounted a gas lift valve for controlling the passage, the passage being initially closed at both its ends and adapted to be opened for fluid communication between the interior and exterior of the mandrel when openings have been made through the wall of the mandrel into communication with the inner end of the passage.

It will be understood that various other modifications and alterations may be made in the details of the illustrative embodiments without departing from the spirit of the invention.

What I claim and desire to secure by Letters Patent is:

1. A gas lift valve mandrel, comprising:
   (a) a tubular body connectible into a well pipe string to form a part thereof;
   (b) longitudinally extending passage means confined between the inner and outer wall surfaces of said body for establishing fluid communication between the interior and the exterior of said body;
      (i) the inner end of said passage means being initially closed off by the inner wall surface of said body;
   (c) a gas lift valve mounted within said passage means in flow-controlling relation thereto; and
   (d) means in the bore wall of said body operable to locate a wall-perforating device interiorly of said body in registry with said inner end of said passage means when required to form an opening through said inner wall surface to place said passage means in communication with the interior of said body.

2. A gas lift valve mandrel according to claim 1 wherein said means in the bore wall comprises an annular recess defined by longitudinally spaced shoulders.

3. A gas lift valve mandrel according to claim 1 including closure means initially closing the outer end of said passage means, and removable therefrom in response to fluid pressure in said passage means.

4. A gas lift valve mandrel according to claim 3 including inwardly-opening check valve means in said passage means between the outer end thereof and said gas lift valve, and means cooperating with said closure means to inactivate said check valve means when said closure means is in the passage-closing position and to release said check valve means upon removal of said closure means from said passage means.

5. A gas lift valve mandrel for well pipe strings, comprising:

   (a) a tubular body connectible into a well pipe string to form a part thereof;
   (b) a pocket formed between the inner and outer wall surfaces of said body adapted to receive a gas lift valve;
   (c) a chamber longitudinally spaced from said pocket formed entirely between the inner and outer wall surfaces of said body and initially closed to communication with the interior of said body;
   (d) a passageway within the wall of said body communicating said pocket with said chamber;
   (e) a gas lift valve mounted in said pocket in flow-controlling relation to said passageway; and
   (f) means in the bore wall of the body for locating a wall-perforating device interiorly of said body in registry with said chamber when required to place said chamber in communication with the interior of said body.

6. A gas lift valve mandrel for well pipe strings, comprising:
   (a) a tubular body connectible into a well pipe string to form a part thereof;
   (b) a pocket formed between the inner and outer wall surfaces of said body adapted to receive a gas lift valve;
   (c) a chamber longitudinally spaced from said pocket formed between the inner and outer wall surfaces of said body and initially closed to communication with the interior of said body;
   (d) a first passageway within the wall of the body communicating said pocket with said chamber;
   (e) a gas lift valve mounted in said pocket in flow-controlling relation to said first passageway;
   (f) a second passageway communicating said pocket with the exterior of said body;
   (g) closure means initially closing off said second passage to the exterior of said body and movable to passageway-opening position by fluid pressure in said pocket in excess of that exteriorly of the body;
   (h) inwardly opening check valve means mounted in said second passageway between said pocket and said closure means;
   (i) means operable when said closure means is in said closing-off position to hold said check valve means open and to release the same when the closure means is moved to said passageway-opening position; and
   (j) means in the bore wall of said body for locating a wall-perforating device interiorly of said body in registry with said chamber when required to place said chamber in communication with the interior of said body.

7. A gas life valve mandrel according to claim 6 wherein said last-mentioned means comprises an annular recess defined by longitudinally spaced shoulders.

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U.S. Cl. X.R.

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