GAS LIFT MANDREL AND VALVE

Filed Feb. 18, 1953 2 Sheets-Sheet 1

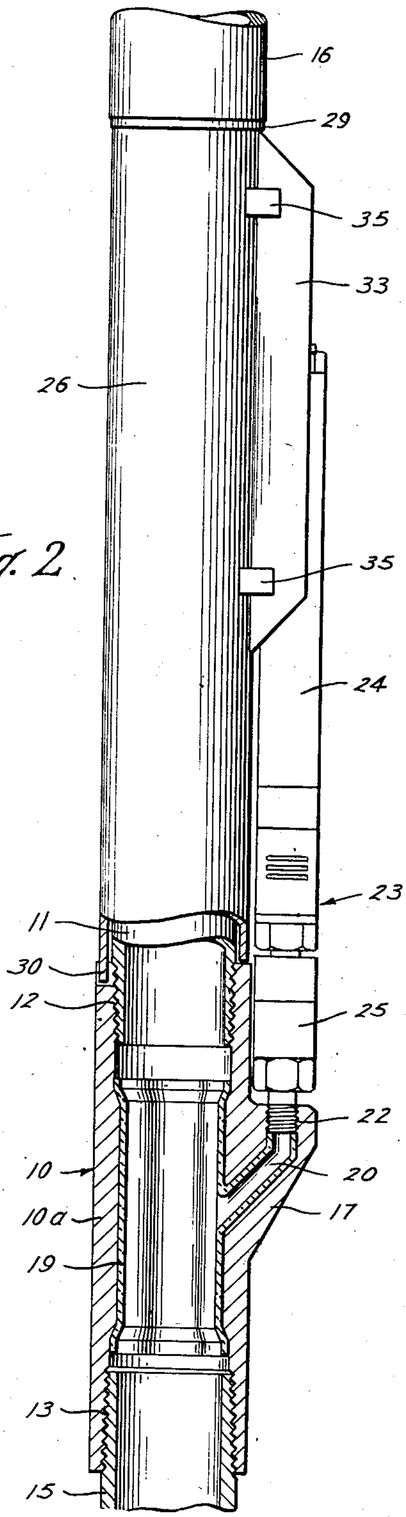
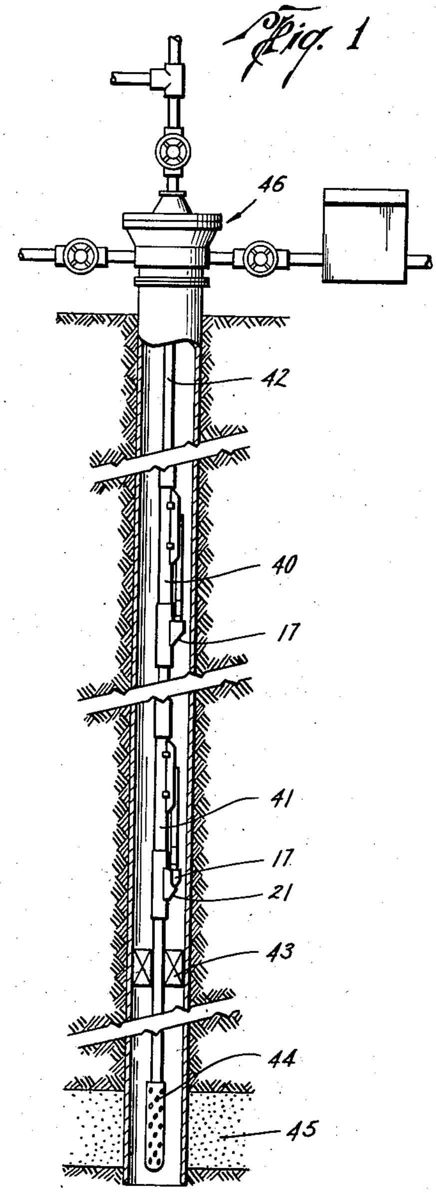


Fig. 2

Fig. 1



Henry U. Garrett
Clifford M. Peters
INVENTORS

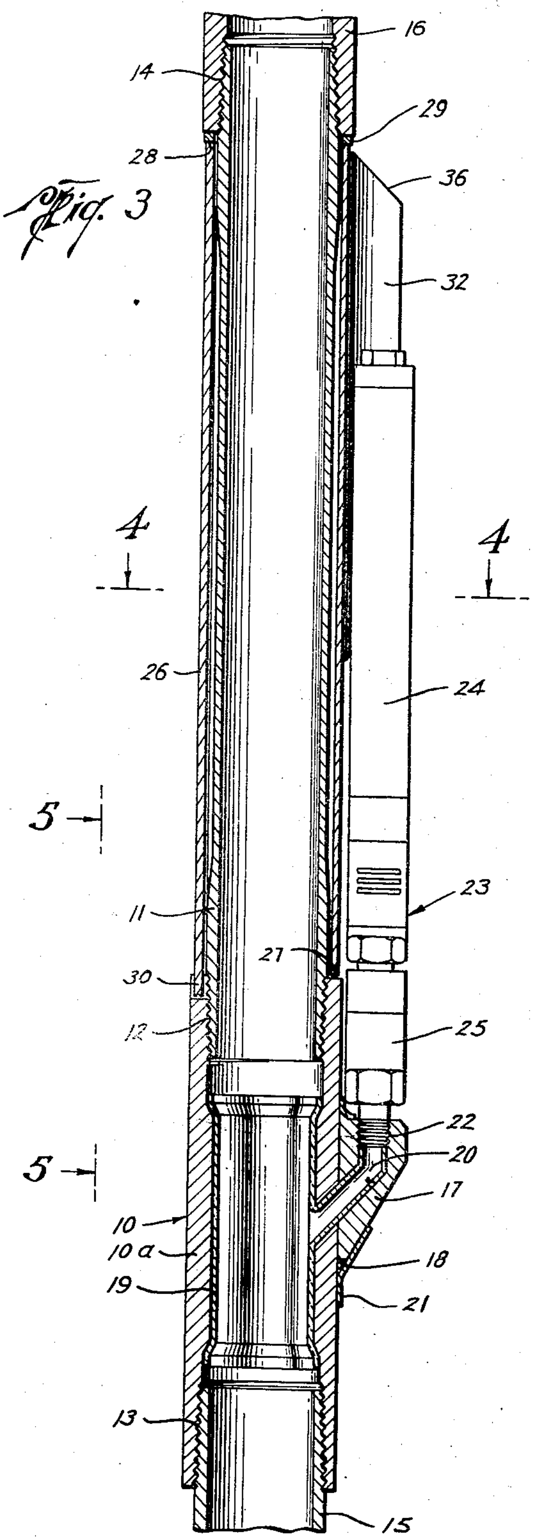
BY Browning & Simms

ATTORNEYS

GAS LIFT MANDREL AND VALVE

Filed Feb. 18, 1953 2 Sheets-Sheet 2

Fig. 3



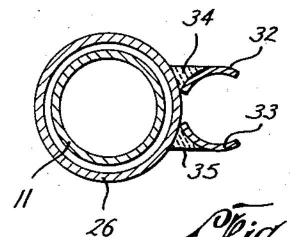
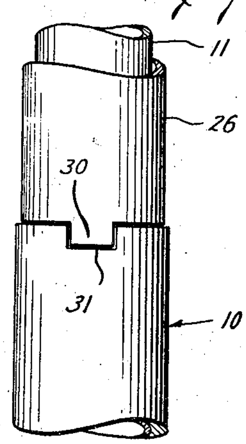


Fig. 4

Fig. 5



Henry U. Garrett
Clifford M. Peters
INVENTORS

BY Browning & Simms
ATTORNEYS

United States Patent Office

2,845,940

Patented Aug. 5, 1958

2,845,940

GAS LIFT MANDREL AND VALVE

Henry U. Garrett and Clifford M. Peters, Houston, Tex., assignors, by mesne assignments, to U. S. Industries, Inc., a corporation of Delaware

Application February 18, 1953, Serial No. 337,562

7 Claims. (Cl. 137—155)

This invention relates to a gas lift apparatus including a mandrel particularly useful in the gas lifting of wells and having a construction such that certain parts of the mandrel can be assembled by welding them together without incurring any substantial danger of mandrel failure due to the welds. In another of its aspects, this invention relates to such an apparatus in which provision is made for preventing valves which have been cut in two by fluid erosion from dropping into the well.

In the gas lift production of wells, it is common practice to support the gas lift valve apparatus upon relatively short sections of tubing or pipe termed "mandrels." A lug extending laterally of the main mandrel body is usually provided with a fluid passageway communicating with the interior of the mandrel and with a threaded portion for securing the gas lift valve apparatus adjacently parallel to the mandrel and in operative communication with the fluid passageway. In the past, the support lug above mentioned as well as another lug situated above the gas lift valve apparatus to support or protect the same have been welded directly to the mandrel body. Since the mandrel body is made up as a part of the well string, it must be sufficiently strong to support the weight of the well string therebelow and, accordingly, stresses of considerable magnitude are imposed on the mandrel body. The welding of the lugs to the mandrel body causes internal stresses to develop therein which greatly reduce the ability of the mandrel body to satisfactorily withstand the stresses imposed by the weight of the pipe string. Further, the heat of the welding process converts portions of the mandrel body nearest the welds into a type of metal different from that of other portions of the body heated to a different extent, if at all. This difference in metals causes galvanic corrosion to develop which further weakens the walls of the mandrel body. As a result of the internal stresses caused by the welding and the propensity of the body to corrode, mandrel failures caused by either perforation of the mandrel body or its complete severance in two have not been infrequent. In fact, one major producing company has reported that of all the failures in its down-hole gas lift equipment, more than fifty percent have been mandrel failures. Obviously, failure of a mandrel to an extent that it pulls in two results in an expensive fishing job to recover the portion of the well string which has been dropped into the hole and, in the event that such fishing is unsuccessful, the entire well must be abandoned. Accordingly, the risk of mandrel failure implies much more than mere replacement of the mandrel because it can result in the spending of many thousands of dollars replacing the well in operation or even its complete loss.

Mandrels are ordinarily supplied in four foot lengths although other lengths can be employed such as three foot or six foot lengths. While the internal welding stresses mentioned above can ordinarily be substantially reduced in many types of equipment by suitable heat treatment, such has been considered uneconomical and, in fact, practically unobtainable in the manufacture of mandrels due to the fact that the relatively great length of the mandrel causes it to be susceptible of warping during heat treatment. Warping would, of course, be very serious because of the greatly reduced capacity of the mandrel to withstand endwise loads.

It is therefore a general object of this invention to provide a mondrel adapted to be made up as a gas lift apparatus including a part of a well string, the mandrel being so constructed and arranged that the likelihood of failure thereof is substantially reduced.

Another object of this invention is to provide such an apparatus wherein welding together of certain parts does not result in material defects in such of the parts as are under substantial stress when installed in a well.

Another object of this invention is to provide a gas lift apparatus including a mandrel having such structure that the parts thereof which are stressed in use by the weight of a well string can be properly heated to improve their stress resistant qualities without causing warping thereof.

Another object of this invention is to provide a gas lift apparatus including a mandrel which can be economically manufactured without welding any part thereof to another part which is to be stressed by the weight of the well string.

Another object is to provide a mandrel having a corrosion and abrasion resistant lining in the vicinity of gas admission thereinto thereby reducing the likelihood of failure due to cutting or corroding away of the mandrel in such vicinity.

Another object of this invention is to provide a gas lift apparatus including a mandrel having an aligning guard means for the gas lift valve apparatus, such means being carried by a part which need not be loaded by the weight of the well string and which is separate from those other parts of the mandrel which are stressed by said weight so that such alignment means can be welded to said separate part thereby eliminating failures of the stressed parts due to welds thereon.

Another object of this invention is to provide such an apparatus wherein such aligning guard means maintains the gas lift valve apparatus in alignment with a connector lug on the mandrel even when the valve apparatus is severed between the lug and aligning guard means whereby parts of the valve apparatus so severed do not drop loose into the well and interfere with the pulling of the well string.

Other objects, advantages and features of this invention will be apparent to one skilled in the art upon the consideration of the written specification, the appended claims and the attached drawings wherein:

Fig. 1 is an elevational view, partially in section, of a well having mandrels embodying this invention installed therein;

Fig. 2 is an enlarged elevational view of an apparatus embodying this invention with a gas lift valve connected thereto, one portion of the mandrel being cross-sectioned to illustrate a preferred form of integral construction;

Fig. 3 is an elevational cross-sectional view of apparatus similar to that of Fig. 2 but showing a welded construction substituted for the integral construction of Fig. 2; and

Figs. 4 and 5 are views taken on the lines 4—4 and 5—5 respectively, of Fig. 3.

Like characters of reference are used throughout the several views to designate like parts.

In accordance with this invention, the parts which are to be assembled to provide a mandrel have either mechanical connections with each other or where such parts are welded together, the welds are made either to parts not stressed by the weight of the well string or to those constructed so as to be readily heat treated without substantial warping. In this manner, internal stresses due to welding are on parts whose failure will not result in a like failure of the well string or are either substantially reduced or eliminated.

Thus, referring to the drawings, the mandrel comprises a body including a collar **10** and a tubing, such as a pup joint **11**, extending longitudinally therefrom. The connection between collar **10** and pup joint **11** is preferably mechanical, e. g., threaded connection **12**, so that welding stresses are not developed at such connection. Pup joint **11** will ordinarily be available as a standard part so that it does not have to be specially manufactured for the mandrel. The mandrel body has a connector at each of its ends for connecting the mandrel into the pipe string. As illustrated, these connectors comprise an internally threaded portion **13** at one end of the collar **10** and an externally threaded end portion **14** of pup joint **11**. These portions respectively connect with tubing **15** and upset collar **16**, tubing **15** and collar **16** being standard parts of a well string.

Returning to collar **10** for a more detailed consideration, lug **17** extends laterally of the collar and preferably is made integral with collar **10** as shown in Fig. 2 but can be made separately and then welded to the collar as shown in Fig. 3. The integral construction is much preferred because it eliminates the weld between the lug and collar and thereby eliminates any possibility of collar failure due to the weld. The integral construction can be made by a simple casting process after which the collar is finish machined to the configuration shown in Fig. 2. However, if it is desired to weld lug **17** to the collar, as by weld **18**, the construction shown in Fig. 3 will materially reduce the likelihood of failure in view of the heat treatment and lining discussed below.

In order to prevent corrosion and erosion of the collar, a corrosion and erosion resistant lining material **19** can be disposed along the inner walls of the collar and along the walls of passageway **20** as a continuous lining up to the point where the end of the gas lift valve apparatus screws into the lug **17**. Such construction is particularly valuable with the construction of Fig. 3 since it will prevent any galvanic corrosion at the weld. It is preferred that such lining be ceramic in nature not only because of its substantial inertness to corrosive substances likely to be found in well fluids but also because it is very hard so that it will efficiently resist erosion by sand laden or high velocity fluids passing through the collar. With the construction of Fig. 3 in particular, the metal of wall **10***a* in the vicinity of weld **18** may be sufficiently different from other metal in collar **10** or even other parts of the mandrel remote from such weld, due to the change in the characteristics of the metal under the influence of the welding heat, that the collar is in effect made up of two different metals. When two such unprotected and different metals are adjacently situated in a flow string in a well, serious galvanic corrosion frequently occurs and lining **19** prevents exposure of the different metals to the well fluid so that such corrosion is prevented. To further eliminate the possibilty of such corrosion, the same or similar lining material can be applied over weld **18** around the junction between lug **17** and body **10** as a sealing lap **21**. This prevents exposure of the weld **18**, as well as the metal in the vicinity thereof, to any well fluids external of the mandrel.

In the preferred embodiment of collar **10**, its length is made to be only a fraction of the total length of the mandrel and in the mandrel shown in the drawings, its length is less than one third of such total lengh.

On the other hand, the wall portion **10***a* of collar **10** is relatively thicker than the wall of conventional well tubing. Ordinarily wall **10***a* is about twice as thick as that of ordinary tubing **15** from which mandrels have heretofore commonly been made. Weld **18**, which connects lug **17** to collar **10**, is then made on the thick walled portion **10***a* of the collar so that additional metal is present in its vicinity to withstand any internal stresses set up by the welding process. Further, the relative shortness of the collar and its thicker walls make it readily and economically susceptible of heat treatment for the reduction or removal of internal welding stresses without the collar becoming warped to an extent that it would at least have to be straightened before it could be used or even discarded. Further, even if such heat treatment does not completely nullify internal stresses in the collar, a considerably greater cross-section is present in the collar adjacent the welds than was present in the mandrels heretofore employed, to withstand the stresses imposed by the weight of the well string therebelow.

With the cast construction of Fig. 2, heat treatment of the collar to remove internal stresses therein as caused by welding is not necessary. However, even if it is desired to heat treat the casting for any reason, such can be done as discussed above.

In constructing collar **10**, it is preferred that any heat treatment thereof be performed before the ceramic lining is bonded to the collar. Such heat treatment, with ordinary steel commonly used in well strings, usually entails heating the collar to a temperature of about 1600° F. and then oil quenching the same. After this has been done, the ceramic lining can be applied as a paste or liquid and then fired to a temperature of about 1400° to harden the same and to effect its bond with collar **10**. This procedure prevents cracking or crazing of the ceramic lining as would happen if the lining were applied prior to heat treatment and then suddenly quenched. This procedure necessitates the selection of a lining material such that it can be fired at a temperature lower than the critical temperature of the metal of collar **10**, so that gradual cooling after firing of the lining does not again set up substantial internal stresses in the collar.

Lug **17** has an internal fluid passage therethrough connecting with a lateral port in the collar **10** so as to provide lateral passage **20** between the interior and exterior of the mandrel. The lug is further provided with a connector, such as threaded portion **22**, for connecting a gas lift apparatus, designated generally by the numeral **23**, to lug **17** and in operative communication with the mandrel body and well string. The gas lift apparatus shown in the drawing is illustrated as a conventional gas lift valve **24** and a check valve **25**. It will be understood that gas lift valve **24** can be connected directly to lug **17** without having check valve **25** therebetween. The term "gas lift valve" as used in the specification and claims hereof is meant to include not only the various types of gas lift valves known to those skilled in the art but also combinations of the same with various check valves and the like.

Carried by the mandrel body is a guard and aligning part for protecting the valve apparatus while the mandrel is being run or pulled and maintaining the valve apparatus on the mandrel in the event it is cut in two or works free from the lug. The guard and aligning part is separate from the body and preferably removable therefrom. As shown in the drawings, this part includes a sleeve **26** surrounding pup joint **11** and extending to have one of its ends **27** in abutment with an opposing shoulder on collar **10** and with its other end **28** positioned relative to upset collar **16** but the same are in close proximity when the mandrel is made up in the well string. Disposed between end **28** and collar **16** is a resilient ring **29** whose function is to permit some variation in the proximity of collar **16** to sleeve **22** without permitting the latter to have any substantial endwise play.

Mutually engageable parts are provided between sleeve **26** and the body of the mandrel, such as with collar **10**, preventing relative rotation between the sleeve and the body. Such parts can comprise an ear **30** on the sleeve extending into a slot 31 in an adjacent end of collar 10. This construction will maintain sleeve 26 in fixed position on the mandrel body after the mandrel has been made up in the well string. In connection with this, it should be noted that while sleeve 26 can be permitted to have some longitudinal movement when made up in the well string as long as such movement is not sufficient to permit ear 30 to become disengaged from slot 31, it is preferred that such movement be eliminated by compressing ring 29 with collar 16.

Alignment means are carried by sleeve 26 and are so constructed and arranged as to engage the gas lift valve apparatus to restrain its sidewise movement. As illustrated in the drawings, such alignment means can comprise that which is in effect a tubular member composed of elongate arcuate segments 32 and 33 welded to sleeve 26 by welds 34 and 35, respectively. It will be noted that these arcuate segments comprise in effect a slotted tube having longitudinally spaced apart portions (the inner wall of segments 32 and 33) engageable with a substantial portion of the length of the gas lift valve apparatus to maintain the same in alignment with lug 17. Such engagement is along a sufficient length of the gas lift valve apparatus so that even if such apparatus becomes unscrewed from lug 17, its lower end cannot move sidewise enough to clear lug 17. In this manner, the valve apparatus is always prevented from falling off the mandrel. It has been learned that in the operation of gas lift valve apparatus, the flow of fluid therethorugh, particularly within the vicinity of the valve seat, will cut through the valve body thereby resulting in its severance into two separate pieces. With the construction above noted, such severance does not result in any part of the valve body sliding out of its position on the mandrel because the alignment means maintains the upper severed part of the valve apparatus in sufficient alignment with the lower part still connected to lug 17 that such parts are in loose abutment which prevents the upper or severed part from falling freely into the well. As a result, the severed parts of the valve apparatus cannot jam between the flow string and the well casing which would greatly increase the difficulty in removing the flow string from the well.

It will be noted that parts 32 and 33 are of considerable length so that the gas lift valve apparatus can vary substantially in length and yet a single mandrel construction be employed to accommodate the same. Also, parts 32 and 33 extend beyond the upper end of the valve apparatus to provide in effect an overhanging part 36 which protects the valve apparatus from injury as the mandrel is being lowered into and raised out of the well.

With the above construction, sleeve 26 does not carry any of the load of the well string so that the welds made thereon have no effect on the capacity of the mandrel body to withstand the weight of the well string. Since sleeve 26 is substantially free of external loads in ordinary circumstances, any internal stresses caused by welds 34 and 35 can readily be borne by the sleeve and are practically unimportant.

While it is preferred that the mandrel assembly be supplied as comprising collar 10, pup joint 11, sleeve 26, and parts attached thereto, it is possible that the assembly can be sold without pup joint 11 which can be added in the field by the purchaser.

The manner of use of the mandrel is believed to be apparent. After it has been assembled, the gas lift valve apparatus can be installed thereon. If desired, the gas lift valve apparatus can be installed before sleeve 26 is slid over the pup joint and then the sleeve placed in its proper position merely by sliding it over the end of the pup joint with the alignment means passing over the end of the valve apparatus. The mandrel is then made up in the well string as shown in Fig. 1. While only mandrels 40 and 41 are shown to be made up in well string 42, it will be understood that other numbers can be used in accordance with gas lift practices. Similarly, packer 43 can be provided along with a well screen 44 spaced opposite producing formation 45. The usual well head structure 46 is supplied at the head of the well.

From the foregoing it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the structure.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

The invention having been described, what is claimed is:

1. An apparatus for use in well operation which comprises, in combination, a tubular collar and pup joint directly connected together to form a mandrel adapted to be made up as part of a tubing string, the collar having a length which is only a minor part of the total length of the mandrel so as to be able to withstand stress relieving heat treatment and also providing an endwise shoulder at its connection with the pump joint, said collar also having a lateral lug thereon with a passage therethrough extending to the interior of the collar, an elongate valve of the gas lift type connected to said lug so as to control flow through said passage, the valve having a length less than that of the mandrel, a sleeve surrounding the pup joint and resting one end on said collar shoulder and having its other end extending so as to be closely adjacent to a shoulder on a tubing string to be connected to the pup joint thereabove when the mandrel is made up as a part of a tubing string whereby longitudinal movement of the sleeve is limited, a connection between the collar and sleeve limiting relative rotation but permitting limited longitudinal movement therebetween so that the weight of a tubing string connected to the mandrel stresses only said collar and pup joint and not said sleeve, and an alignment means welded to the sleeve and engaging said valve at a location longitudinally spaced from said lug to restrain sidewise movement of the valve.

2. The apparatus of claim 1 wherein said collar is lined with a corrosion resistant ceramic lining material.

3. A gas lift valve apparatus adapted to be made up as a part of a pipe string in a well which comprises, in combination, a gas lift valve, a body free from welds and including a collar having a lateral port therein and a tubing extending longitudinally from said collar, said collar having a lug extending laterally therefrom and providing a fluid passage in communication with said port and also having a connection with one end of said valve so the latter controls flow through said port, said body having a connector at each end for connecting the same into a pipe string so that the body is stressed by the weight of the pipe string therebelow; a sleeve around said tubing, said sleeve and said body having interlocking parts preventing relative rotation of the sleeve with respect to the body; alignment means welded to the sleeve and engaging said valve at a locus remote from said one end of the valve to restrain such valve from sidewise movement; said sleeve being free from connection with said body and pipe string such that the sleeve would be stressed by the weight of the pipe string whereby the alignment means is welded to a portion of the mandrel unstressed by the weight of the pipe string and the weight of the pipe string is borne by the body which is free from welds.

4. The mandrel of claim 3 wherein said alignment means has longitudinally spaced apart engaging portions embracing said valve along a sufficient portion of its length as to maintain the same in alignment with said

lug despite severance of the valve between the lug and alignment means.

5. A mandrel adapted to be made up as a part of a pipe string in a well to support a valve apparatus comprising, a tubular collar threaded at each of its ends and having a lateral lug thereon providing support for the valve apparatus, a fluid passageway extending through said lug and opening into the passageway through the collar to establish communication between the inside and outside of the collar, said collar having a central section extending over a substantial portion of the collar's length and also having end sections respectively integrally joined to the ends of said central section, the thickness of the wall of said central section being substantially greater than the thickness of the walls of said end sections, the internal diameter of the central section being lesser than the internal diameters of the end sections so that shoulders are provided at the junctures between each of said end sections with the central section, and a liner of corrosive and abrasive resistant ceramic material in the passageway through the collar and the passageway through the lug, said ceramic material extending through the length of said mid-section and overlying each of said shoulders.

6. A gas lift apparatus adapted to be made up as a part of a pipe string in a well which comprises, in combination, a gas lift valve, a tubular body having connecting means at each of its ends for connecting the body as a part of the pipe string so that the weight of the pipe string below said tubular body is supported by the tubular body and the pipe string thereabove, a lateral lug on said tubular body connected to one end of the gas lift valve to support the same and operatively connecting it to the tubular body; a guard and aligning part carried by the tubular body and including alignment means welded thereto longitudinally from said lug and engaging said valve at a point remote from the valve's connection with the lug and restraining sidewise movement of the valve and protecting it while the tubular body is being run into and pulled from the well, said valve being of lesser length than said body, means connecting the body and the guard and aligning part to restrain relative rotation therebetween so that the alignment means cannot move sidewise relative to the lug, said guard and aligning part being free from connection with said body and pipe string such that the guard and aligning part would be substantially stressed by the weight of the pipe string whereby the alignment means is connected to and supported by a portion of the gas lift apparatus which is substantially unstressed by the weight of the pipe string.

7. The mandrel of claim 6 wherein said alignment means provides portions engaging the valve along a sufficient portion of the latter's length that upon severance of a portion of the valve from the lug, such portion will be maintained in alignment with the lug and thereby be prevented from falling down the well.

References Cited in the file of this patent

UNITED STATES PATENTS

1,523,709	Pendleton	Jan. 20, 1925
1,603,604	Hunter	Oct. 19, 1926
1,744,087	Watts	Jan. 21, 1930
2,008,172	Bryant	July 16, 1935
2,207,129	Millican	July 9, 1940
2,250,464	Boynton	July 29, 1941
2,278,532	Crickmer	Apr. 7, 1942
2,321,003	Boynton	June 8, 1943
2,454,160	Greene	Nov. 16, 1948
2,644,820	Gresham	July 7, 1953
2,668,553	Howard	Feb. 9, 1954