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WELL HEAD BYPASS ASSEMBLY

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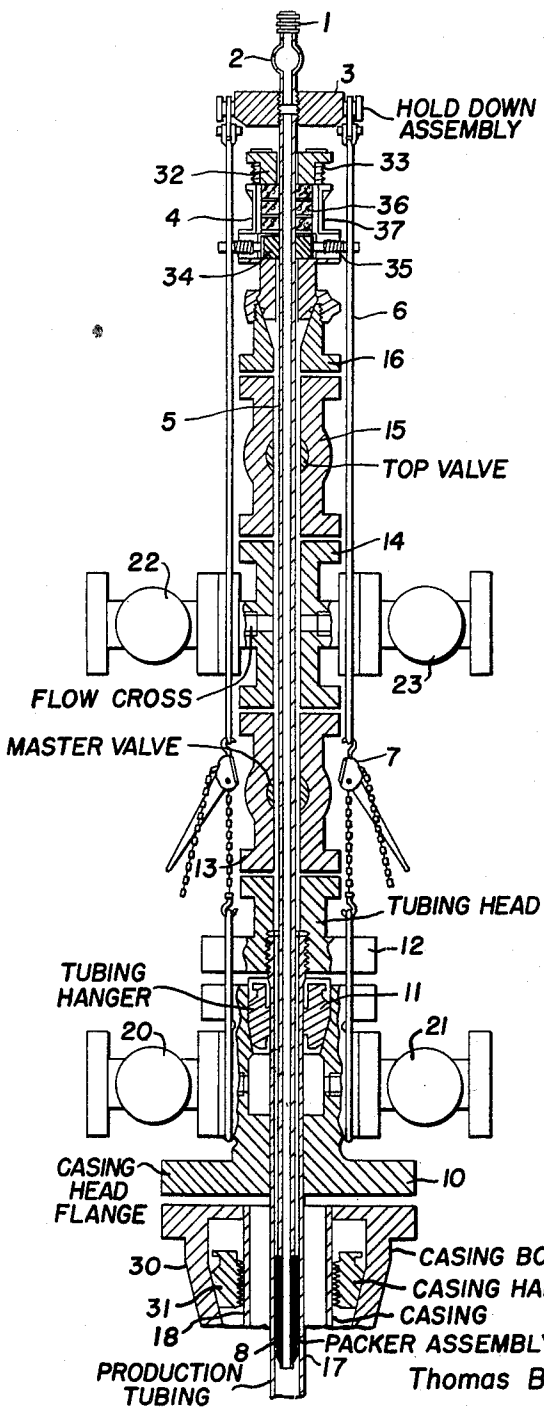


FIG-1

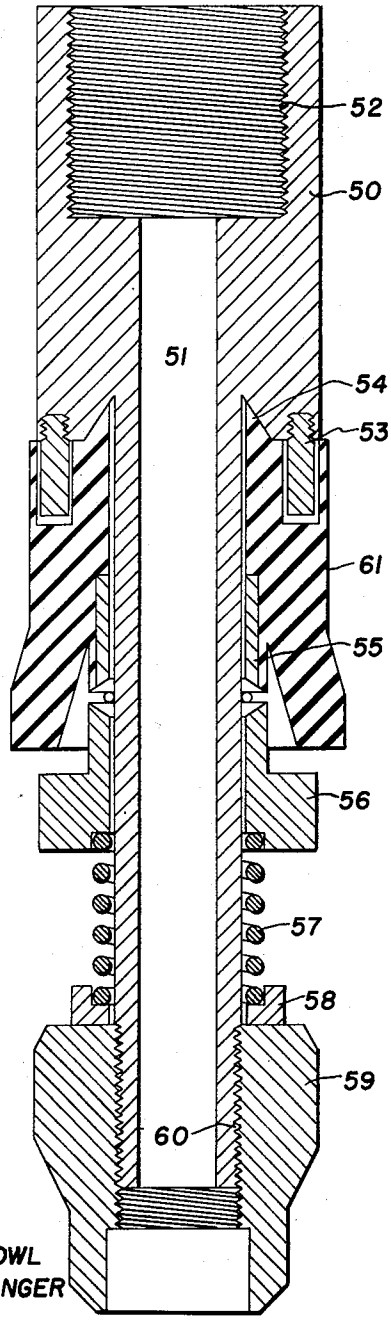


FIG.-2

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WELL HEAD BYPASS ASSEMBLY

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5 Claims. (Cl. 166—75)

The present invention generally relates to an auxiliary and temporarily placed well head construction wherein the various components of a permanent well head are isolated from the pressures existing within the well. The invention is particularly concerned with apparatus useful in conjunction with well formation fracturing processes or other treating operations where the pressures involved are beyond the safe operating limits of the permanent well head apparatus. The invention further relates to apparatus which permits for fracturing, acidizing or otherwise treating subterranean well formations without the necessity for altering or changing the valves, fittings and the like that form components of the permanent well head. The invention has application to oil wells and gas wells and also to injection wells.

In applying fracturing techniques to oil wells, it is often necessary to replace the well head equipment on the wells before the fracturing may take place. This change in well head equipment is occasioned by the fact that the equipment in many instances possesses too low a pressure rating for the pressures that are involved in the fracturing operation. Thus, it is very common in producing areas where the formation and well pressures are relatively low to use valves and other fittings in the well head assemblies which are rated for 2000 p.s.i.g. or even less. Inasmuch as most fracturing operations require operating pressures of at least 4000 p.s.i.g. and sometimes as much as 7000 p.s.i.g., it follows that change of the well head equipment is a necessary step, especially from a safety standpoint, before a fracturing operation can proceed. Such a change requires that a workover rig be moved into the well and often necessitates killing the well and making a trip with the production tubing, rendering it a costly and time-consuming operation.

With these shortcomings of the presently employed conventional techniques of formation fracturing in mind, it is an objective of the present invention to take advantage of high pressure fracturing operations in wells that possess low pressure well head apparatus without either operating at undesirably low pressures or requiring the use of a workover rig. It is further an objective of the invention to eliminate the necessity for making round-trips with the tubing and also for obviating the necessity of killing a well. It should be pointed out that, while the invention is extremely attractive in its quality of eliminating the use of a workover rig, the invention also offers outstanding advantages when used in conjunction with workover operations. Thus, the invention makes it possible first to complete a well that has a workover in progress and then to subsequently fracture the well. Otherwise, it would be necessary to again kill the well after fracturing in order to complete it, thereby in some cases making it necessary to place undesirable high mud differential pressures across a recently fractured formation.

The above-mentioned objectives as well as other objectives which will become apparent as the ensuing description progresses are realized in accordance with the

invention by the use of means for bypassing the well head assembly of a well and for isolating the well head assembly from the pressures that exist within the well during the time of excessive injective pressures. More specifically, the invention makes use of an elongated high pressure conduit which extends from a point below the casing head and within the production tubing of a well to a point vertically beyond and above the well head assembly. The conduit is selected in size—i.e., diameter—such that it may be inserted within the production tubing by lowering it vertically through the well head assembly.

At its lower end the conduit is provided with a packer assembly of a type particularly adapted for movement through the well head assembly and for sealing off that portion of the production tubing which lies vertically below the packer assembly from the well head apparatus. The upper end of the conduit is secured to and is sealed within a hold-down flange which in turn is secured to a fixed support, preferably the well head assembly itself. The upper end of the bypass conduit is further provided with a high pressure valve and any other apparatus which would be conventionally required for introducing or withdrawing fluid within the well.

The invention may be better understood by reference to the attached figures wherein—

Fig. 1 is a vertical, partially cross-sectioned view of a well head assembly which has incorporated therein an embodiment of the invention.

Fig. 2 is a view in cross section of a packer assembly which has been constructed and used as a component part of the apparatus illustrated in Fig. 1.

Turning first to Fig. 1, there is illustrated a conventional type of well head assembly including a casing head flange **10**, tubing hanger **11**, tubing head flange **12**, a master valve **13**, a cross **14**, a top valve **15**, lubricator connection **16**, production tubing **17** and casing **18**. Also illustrated in the figure are bypass conduit **5**, combination blow-out preventer and stuffing box **4**, holddown assembly **3**, valve **2**, cable members **6**, hoisting members **7**, packer assembly **8**, casing bowl **30**, hanger **31** and wing valves **20** and **21**.

In discussing the apparatus of Fig. 1, it will be understood that the well head apparatus is installed at the surface of a conventional, cased well and that the casing head **10** is secured in a conventional manner to a flange on casing bowl **30** in which casing hanger **31** (equipped with the usual slips and pack off seals) holds the casing suspended and seals the pressure to within the casing and the well head.

It will further be understood in Figure 1 that the various flanges are bolted or welded together in a conventional manner. The flanges in the figure are actually spaced slightly apart for the sake of clarity and ease of illustration.

Attached to the casing head assembly **10** are two conventional wing valves **20** and **21** such as might be employed for injecting and withdrawing fluid from the annular space between the tubing and the casing. Also included within casing head assembly **10** is tubing hanger **11** which may be of a conventional type normally employed for supporting the production tubing **17**. The production tubing itself extends from tubing head flange **12** down into the well to one or more producing formations not shown. As in the case of the casing head assembly and the tubing hanger, the production tubing may be conventionally selected from any of the sizes and types of tubing that are usually employed in oil well operations.

The upper end of the production tubing **17** may be conventionally threaded or otherwise secured and sealed within the tubing head **12** as illustrated. Tubing head

12 in turn is bolted or otherwise secured to the master valve 13 which likewise may be of a conventional type.

Immediately above and bolted or otherwise secured to the master valve is a cross 14 which may in turn be connected to one or more valves 22 and 23. Such valves are conventionally installed at this point in a well head assembly for the purpose of withdrawing oil from the production tubing within the well, for introducing various fluids within the well, etc.

Immediately above cross member 14 is top valve and a lubricator connection 16. These two component parts may also be of conventional type and are secured to one another and to the well head assembly itself as by means of bolted flanges or the like.

The conventional parts of the well head assembly in Fig. 1 having been described, attention is now directed to the remaining parts shown there which constitute in combination the apparatus of this invention. Thus, one such part is the bypass conduit 5 which extends from a point vertically below and spaced from the casing head 10 to a point vertically beyond and spaced above the lubricator connection 16. The conduit may be any conventional type of high pressure tubing, piping, or the like which is available commercially. The tubing, in accordance with the invention, is particularly characterized by possessing a pressure rating or strength which is greater than that of the well head assembly itself. The tubing is further characterized by possessing a pressure rating or strength which is at least equal to the pressures that are required in a fracturing operation.

At this point it is important to note that, for the purposes of the present description, it is to be assumed that the well head assembly in Fig. 1 is mounted on a well which is to be fractured at a fracturing pressure far in excess of the pressures to which the well head assembly may be subjected. Thus, it may be assumed that the well head assembly has a pressure rating of the order of about 2000 p.s.i.g., and that the desired fracturing pressure is of the order of about 6000 p.s.i.g. In this situation the bypass conduit 5 must be sealed such that it has a pressure rating itself at least equal to that of the fracturing operation, i.e. of the order of about 6000 p.s.i.g.

Prior to the installation of the bypass conduit within the production tubing 17, the conduit must be provided at its lower end with a packer assembly 8 which is characterized dimensionally by its ability to fit snugly within the production tubing 17 and structurally so as to withstand the aforesaid fracturing pressure. A variety of packer assemblies may be employed for this purpose. A packer that has proven to be very effective in a number of instances is the type illustrated in Fig. 2. A more detailed description of this packer assembly will be presented a little later in this description.

Prior to the installation of bypass conduit 5 within the production tubing 17, it is necessary to provide the upper member of the well head assembly (i.e. lubricator connection 16) with an apparatus adapted to provide a seal around the outer peripheral surface of the conduit 5. An effective apparatus proven in the field for this purpose is the combination stuffing box and blow-out preventer 4 which is illustrated in Figure 1. The packing members 36 within the stuffing box body 37 are compressed against the outer wall surface of the conduit 5 by means by the member 32 which is driven inwardly of the body member 37 as by means of threaded members 33. The blow-out preventer portion of the combination unit 4 consists of closure members 34 which are driven inwardly against the conduit 5 as by means of threaded members 35.

At this point it should be noted that the combination blow-out preventer and stuffing box 4 may be selected from conventional commercial pieces of apparatus and that the structure of this member in itself is not a novel feature of the invention. Rather, it is the combination of this unit along with the other previously mentioned and subsequently mentioned parts which constitutes the apparatus of the invention.

The combination blow-out preventer and stuffing box 4 is secured, as by means of the illustrated threaded connections, to lubricator nipple 16 prior to insertion of the bypass conduit 5 within any portion of the well head below the top valve 15.

Referring again to bypass conduit 5, it will be seen that the upper end of this conduit is threaded or otherwise secured and sealed within a holddown plate 3. This plate is suitably pierced and threaded or otherwise arranged to receive the upper end of conduit 5 and to transmit fluids from the conduit to a point beyond the plate itself. Thus, the plate may be conveniently provided with a suitable high-pressure valve 2 and any other connection such as a union 1 for conveying fluids in or out of the bypass conduit.

As mentioned earlier, the holddown assembly 3 is held in place by means of cable members 6 which are fastened securely to some suitable fixed point. A fixed point such as the well head itself may be used for this purpose.

The cables holding down the holddown flange may conveniently be steel cables, wire cables, steel chain, or the like. It will be appreciated of course that these holddown members may also be in part solid or tubular-like members or even threaded members. It is essential, however, that the cable (i.e. holddown) members be provided with means for changing the overall length of the cable. This may be done, as illustrated, by utilization of chain hoists. Other devices such as turn buckles, hydraulic cylinders and rams, pneumatic cylinders, and the like, may also be adopted for this work. Essentially then, the holddown flange, the holddown members and the apparatus for adjusting the effective length of the holddown members combine to act as a snubbing unit for moving the bypass conduit 5 relative to the wellhead apparatus proper.

The various parts that are illustrated in Fig. 1 having been enumerated and described, attention is now directed toward a consideration of the manner in which this apparatus is operated in a well-fracturing operation. In this vein, it will be considered that the well head apparatus illustrated in Fig. 1 is mounted at the top of an oil well which it is desired to submit to a fracturing operation. It will further be considered that the production tubing within the well is sealed at the bottom of the well to the casing by a packer and is of a strength sufficient to withstand the pressure of the hydraulic fracturing operation, but that the well head apparatus atop the well possesses too low a pressure rating for this purpose.

At the outset of the operation, a flushing oil in the form of crude oil or a refined petroleum derivative is first pumped at low pressures (substantially equal to the well pressure) into the production tubing as by means of valve 23 and suitable pumps, supply lines, transfer tanks, etc. not shown in the figure. After sufficient flushing oil has been pumped into the tubing to quiet the well, the master valve 13 and valves 22 and 23 in the well head assembly may be closed. It will be appreciated that other procedures may be employed for this stage of the operation for example, the master valve 13 and valves 22 and 23 may be closed without any pumping-in operation whatsoever.

Following the initial step described above, the blow-out preventer is mounted and secured to the top of the lubricator nipple 16, and the bypass conduit 5 with its attached packer assembly 8 and holddown assembly 3 is inserted into the top of the well head assembly and down into the assembly to a point immediately above the closed master valve 13.

The lifting and insertion of the bypass conduit may be achieved as by means of a gin pole or a boom truck or any other convenient lifting device. Alternatively,

the assembly may be stripped broken-down into the well head and tightened up in place.

With the bypass conduit in the aforedescribed position above the master valve **13**, the conduit valve **2** is closed, the stuffing box **4** is tightened, the holddown assembly **3** is secured to the bottom of the well head by means of cable **6** and chain hoist **7** or other appropriate holddown equipment such as hydraulic cylinders, etc. The master valve is now opened and the bypass conduit is lowered into the production tubing **17**. If there is no pressure or substantially no pressure within the well, the bypass conduit may be lowered of its own weight into the tubing. If the well is under pressure, however, the chain hoist **7** or other appropriate equipment may be employed to pull the assembly downward. Any pressure within the well reacts against the cross sectional area of the conduit until the packer assembly **8** enters within the production tubing. At this point the pressure reacts opposite the cross sectional area of the inside of the tubing. As the bypass conduit is forced downward within the tubing **17**, the packer assembly **8** slides along the inner surface of the tubing but continues to maintain its sealing position with respect to the tubing.

Once the bypass conduit has been lowered to a predetermined suitable position and tightly fastened, a pump truck or other pumping apparatus may be connected to the top end connection of the bypass conduit **5**, and a fracturing liquid may be forced down within the conduit and the production tubing to the formation that is to be fractured. Since the packer assembly seals the well head components from the fracturing pressure, there is no danger of the pressure rupturing or damaging the well head.

Following the fracture treatment, the pumping apparatus may be disconnected, the holddown released and the bypass conduit removed from the well. If the well head is under pressure, the assembly valve **2** should be closed and the holddown assembly **3** or other appropriate equipment released slowly while removing the overall assembly to a point just above the master valve. When the packer assembly **8** clears the master valve **13**, that valve may be shut and the bypass assembly removed from the well.

It has been mentioned earlier in this description that the packer assembly **8** in Fig. 1 may conveniently be of a construction such as is illustrated in Fig. 2. Turning then to Fig. 2, it will be seen that this form of packer assembly includes an elongated, cylindrically-shaped mandrel **50** which possesses a central passageway **51** extending the entire length of the mandrel.

The mandrel **50** is provided with a threaded section **52** at one end which is adapted to be connected with the lower end of the bypass conduit. The mandrel is further provided with a threaded lower end **60** which may be connected to a suitable end piece **59** or a second such mandrel. It may be desirable on occasion, especially in very high pressure wells, to employ two or more such packers in series. Hence, the provision is made for connecting more than one of these packers together in one integrated assembly.

At a point intermediate the end of the mandrel **50**, a rubber packer or other elastic collar **61** is mounted upon the mandrel and secured there as by means of locking recess **54** and retaining pins **53**. It will be appreciated that the rubber packer **61** may be bonded directly to the mandrel **50**. The rubber packer **61** is held in position on the mandrel as by means of a locking gland **56** which is pressed against the rubber packer **61** by means of a compressed spring **57**. The spring in turn is anchored suitably by a shoulder member **58** which is secured to or held in position by the end piece **59**.

The rubber packer **61** is preferably flared as indicated so as to contact the inner wall surface of a production tubing and to be thrust against the tubing with ever increasing force in response to increasing pressures within the tubing.

Thus, the packer assembly generally consists of a suitable mandrel threaded on each end and provided with a rubber packer which is adapted to be thrust radially outward from the mandrel when pressure is applied to the collar.

The present invention having been described in detail, it will be noted that numerous variations and modifications may be employed without departing from the spirit or scope of the invention. Thus, the apparatus may be constructed of steel or any of the other metals or metal alloys that are conventionally employed in apparatus of this type. Furthermore, a variety of tubing hangers, valves, blow-out preventers, tubing clamps, etc. may be used to suit any particular type of well or well head construction. Furthermore, devices other than the chain and chain hoist apparatus may be employed to regulate the movement of the bypass conduit within the well head assembly. Hydraulic cylinders, pneumatic cylinders, etc. may be readily adapted for this purpose, and hydraulic cylinder or ram means are preferred.

The great value of the invention is perhaps best illustrated by reference to the following example in which the invention was employed in an actual fracturing operation. In this operation a well, which was provided with 5½" casing and 2½" production tubing with a 7260 p.s.i.g. internal bursting pressure, was desired to be fractured at a pressure of the order of 6000 p.s.i.g. The well head was constructed of series 600 valves and other fittings and therefore was characterized by a working pressure rating of 2000 p.s.i.g. and a test pressure rating of 4000 p.s.i.g. As is conventional in the art, the lower end of the production tubing was sealed to the casing adjacent the producing formation by means of packers.

To have performed this operation without the use of the present invention, it would have been necessary to kill the well, to take off the well head, to perform the fracture without the tubing head and to then reinstall the tubing head and bring in the well. This procedure would have entailed a period of at least four days. With the present invention the entire operation took only four hours.

In carrying out the operation in accordance with the present invention, a 1½" double extra strong steel pipe was used as a bypass conduit and was provided at its upper end with a 1", 15,000 lb. valve and a 2" 15,000 lb. union. A 3,000 lb. test blow-out preventer was mounted at the top of the well head along with suitable clamping apparatus for holding the bypass conduit in a fixed position. The blow-out preventer was required since the well had a natural well head pressure of the order of 800 p.s.i.g.

The bypass conduit was lowered into the well head to a point immediately above the closed master valve and was held in position by means of four 6-ton chain hoists and ⅝" wire rope. At this point the blow-out preventer was forced against the bypass conduit, the master valve was opened, and the chain hoists were operated to force the conduit down within the production tubing. The conduit was provided at its lower end with a double packer of the type shown in Fig. 2. Once the packer was in position within the production tubing, fracturing fluid was pumped into the bypass conduit and thence into the production tubing and down to the producing formation at a pressure up to 6800 p.s.i.g. Maximum differential pressures of the order of 5000 p.s.i.g. were observed across the two packers, 1800 p.s.i.g. being maintained on the well head. The maximum pressure on the well head itself never exceeded a safe value of 1800 p.s.i.g. Following the fracturing operation, the bypass conduit and associated equipment were removed from the well head assembly and the well returned to a producing condition.

What is claimed is:

1. An apparatus for bypassing the well head assembly of a well apparatus and for isolating the assembly from the pressure prevailing within the well wherein the well apparatus is provided with a production tubing and a well head assembly including a master valve which apparatus comprises in combination an elongated conduit having an overall diameter which is smaller than the diameter of the passageway extending through the master valve and into the production tubing, a packer assembly movable through said passageway and mounted on the lower end portions of said conduit for forming a seal in the annular space between the production tubing and said conduit, sealing means disposed around the upper end of said conduit for effecting a seal between the wall of said passageway and said conduit, means including a valve in said conduit for introducing and withdrawing fluid to and from the interior of said conduit, and snubbing means for moving the conduit in vertical relation to the production tubing.

2. An apparatus for the transfer of fluid within a well apparatus wherein the fluid is at a pressure greater than the operating pressure of the well apparatus head assembly atop the well but not greater than the operating pressure of the production tubing within the well which apparatus comprises in combination an elongated vertically disposed conduit having a smaller outside diameter than the passageway defined by the master valve and the production tubing, a packer assembly movable through said passageway mounted at the lower end portions of said conduit for blocking off the annular space between the conduit and the production tubing, means for snubbing the conduit through the master valve and into the production tubing, and means including a valve in said conduit for transferring fluid within said conduit.

3. An apparatus for introducing a treating fluid within a well apparatus wherein the fluid is at a pressure greater than the safe operating pressure the well head assembly including the master valve will withstand but not greater than the safe operating pressure of which the production tubing within the well is capable which apparatus comprises in combination an elongated vertically disposed conduit having a safe operating pressure greater than the pressure of the fluid introduced, a packer assembly mounted at the lower end portion of said conduit, said conduit and said packer assembly being freely movable through the passageway defined by said master valve and said production tubing, snubbing means for moving said conduit and said packer assembly through said passageway, means including a valve in said conduit for establishing the flow of said treating fluid within said conduit, and means for effecting a seal between said conduit and the inner wall of said passageway near the upper end of said conduit.

4. An apparatus for bypassing the well head assembly of a well which contains a production tubing and for isolating the well head from the pressure prevailing within the well wherein the well head assembly includes a master valve and a lubricator connection which comprises in combination an elongated conduit of smaller outside diameter than the port in the master valve and the inner diameter of the production tubing, a packer on the lower end of said conduit adapted to move through said port and said tubing and actuated to block off the annular space between the conduit and the production tubing, a holddown flange sealed to the upper end of said conduit, at least one holddown member of adjustable length securing said holddown flange to a fixed support, means including a valve for establishing fluid flow within said conduit, and sealing means disposed around an upper portion of said conduit for sealing the space surrounding said conduit within said well head assembly from the atmosphere.

5. An apparatus as defined in claim 4 in which the sealing means is a combination blow-out preventer and stuffing box.

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