SUBSIDENCE WELLHEAD ASSEMBLY AND METHOD

Inventor: Andre H. Drouin, Houston, Tex.
Assignee: Rockwell Manufacturing Company, Houston, Tex.
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3,134,610 5/1964 Musolf............................... 166/88
3,166,125 1/1965 Hubby............................... 166/67

ABSTRACT

Production casing is re-tensioned with hydraulic jacks placed between tubing head flange and pack-off flange connected to casing head flange, the production casing being screwed into tubing head and also supported in casing head by slip type casing hanger whose slips are spring biased downwardly. The pack-off flange has a packing gland accessible from the top for seal replacement. The jacks are of the spring retract and fluid expand type adapted for actuation by a manual pump. A fluid pressure gage is calibrated to read in pounds of casing tension and is marked to show maximum permissible load on jacks.

12 Claims, 9 Drawing Figures
3,738,426

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SUBSIDENCE WELLHEAD ASSEMBLY AND METHOD

BACKGROUND OF THE INVENTION

1. Field of Invention
This invention pertains to well head assemblies and methods and is particularly directed to solution of the problem created by ground subsidence.

2. Description of the Prior Art
i. Terminology
A conventional wellhead assembly may include a string of pipe known as surface casing extending from the earth's surface several hundred or more feet down into the ground and cemented in place, providing a passage from the surface down through the part of the earth wherein surface water is apt to be encountered. Inside the surface casing extends a string of pipe known as production casing, the latter extending from the earth's surface to the production zone which may be several thousand feet down. To the upper end of the surface casing is connected a heavy walled annular member having side outlets and connection means at its upper and lower end and adapted to support a pipe therewithin such member being known as a wellhead. Within the wellhead is suspended the production string.

Depending on the well, additional strings of pipe may be provided inside the surface casing. For example, a string of casing may be provided between the surface casing and production casing to allow for a change in well bore diameter, or a string of pipe known as tubing may be provided inside of the production casing to improve flow. Each additional string of pipe is usually suspended in an additional wellhead which is supported by the wellhead in which is suspended the pipe next outside thereof. The wellhead in which the tubing is supported is called a tubing head. The other well heads are called casing heads and may be distinguished as a lower casing head connected to the surface casing and supporting a protection casing string, and an intermediate casing head on top of the lower casing head and supporting the production casing string. Surrounding the stack of wellheads is an assembly of valves to the top of which is connected a group of pipes and pressure gages. The entire assembly of wellheads, valves, and piping may be called a Christmas tree, but more often the pipes, with or without valving, is referred to as the tree, the pipes alone constituting the upper tree manifold.

ii. Casing Stress Reversal
Initially, the production casing is usually hung in tension, placing a compressive load on the upper part of the surface casing. Due to surface ground subsidence the surface casing tends to move down relative to the production casing, the latter being supported at its lower end by cementing. As the surface casing moves down, the tension in the production casing is first relieved, as is the compression in the upper part of the surface casing. Further downward travel of the surface casing places the surface casing in tension and places the production casing in compression. In this regard it should be noted that it is usual to provide a hold down means in the casing head or valve or tree element thereabove which prevents or limits rising of the production casing in the casing head.

iii. Casing Parting and Retensioning
Compression in the production casing is considered undesirable and it is known to retension the casing by bringing a workover rig to the well, killing the well, disassembling the wellhead-tree assembly, lifting the production casing and resetting it in the casing head, and reassembling the structure. To eliminate the need for a workover rig, a method has been devised as shown in U.S. Pat. No. 3,369,793 to Boldrick et al. according to which the surface casing is first parted to allow the casing head and production casing to rise. Then a set of hydraulic jacks is interposed between the flange at the top of the casing head and a special wrap around bowl temporarily affixed to the surface casing below the part therein. The jacks are extended to elevate and tension the production casing. Then a short length of pipe is fabricated around the production casing between the parted ends of the surface casing to maintain their new spacing and support the casing head in its new positions. The jacks are removed and the tension load in the production casing is transferred to the surface casing through the casing head. During the retensioning procedure a wrap around blowout preventer is placed in the annulus between the production casing and the lower part of the surface casing to prevent any flow. At all times, before, during, and after retensioning, the production casing is connected to the casing head and the force used to retension the production casing is transmitted through the casing hanger. After retension and resuspension, the production casing is no longer free to rise, being held down by the casing head, which in turn is connected to the surface casing.

One using the aforementioned patented method of retensioning production casing with hydraulic jacks must be prepared to kill the well and recut the surface casing each time the production casing is retensioned.

iv. Steam Injection Wellhead
A related problem to that of ground subsidence occurs in connection with steam injection wells. Injection of steam into the tubing causes the tubing to expand. To relieve the resulting compression, a special steam injection wellhead assembly has been developed, as is shown, for example, on page 4280 of the Composite Catalogue of Oil Field Equipment and Services, 27th revision (1966-67) published by World Oil, a Gulf Publishing Company Publication, Houston, Texas. In the steam wellhead assembly there shown, an extra wellhead is employed between the usual tubing head and casing head. Instead of hanging the production casing in the lowermost casing head, it is merely sealed therein and extends thereabove into the extra (intermediate) casing head where it is suspended and sealed. The intermediate head is not bolted to the lower head. The tubing, instead of being suspended and sealed in the tubing head, is merely sealed therein, and extends thereabove into an adapter flange into which it is screwed. As the tubing expands, it rises, carrying with it the adapter flange, the tubing head bolted thereto, and the intermediate head bolted to the tubing head. A gap then opens between the intermediate head's lower flange and the flange at the top of the lower head. The annulus remains closed however by the seal in the lower casing head.
v. Permafrost Wellhead

A further problem encountered related to normal ground subsidence is that of melted permafrost. For use in areas subject to this phenomenon, a wellhead assembly has been used incorporating a special casing head including upper and lower parts, the upper part having a flange at its lower end overlying a flange at the upper end of the lower part. When the well is completed and placed in production these flanges are not bolted together. The production casing is hung in the upper part, which is free to rise with the production casing as the lower part falls with the surface casing screwed therein. This is similar to the construction of the steam wellhead assembly, viewing the upper part of the special permafrost head as analogous to the intermediate head used in the steam injection construction, and the lower part of the special permafrost head as analogous to the lower head used in the steam injection assembly. However the permafrost special head is provided with jack screws between the adjacent flanges of its upper and lower parts whereby they can be pushed apart to tension the production casing. In this regard the permafrost wellhead is similar to the construction of the aforementioned patent except that the new jacks are substituted for hydraulic jacks. If the range of the screw jacks is exceeded a further extension head is placed between the special head and the lower casing head.

In the just described permafrost wellhead design the screw jacks carry the load until further subsidences relieve the tension, following which the construction provides a free standing or floating production string as in the steam injection construction, until such time as the screw jacks are reactivated to retension the production casing. Absent the use of special and delicate instrumentation, there is no way to determine the extent of retensioning effected by reactivation of the screw jacks. The alternative is to bring in a work over rig to elevate the production string prior to resetting the screw jacks. This is an expensive procedure.

For a further description of the aforementioned permafrost wellhead, see the articles published in the Oil and Gas Journal, Dec. 8, 1969 at pages 69–72, and Feb. 16, 1970, pages 76–78, the latter article article being by applicant.

vi. Adjustable Casing Head

In the U.S. Pat. No. 3,166,125 to Hubby there is disclosed, as stated therein at column 1, lines 38–40, 53–59, "a casing head supporting member that is adjustable, so as to be able to make changes in the tension being applied to the upper end of a casing string as desired," and which comprises "a first collar attached to the upper end of said casing string and a second collar attached to" the "surface pipe *** and means for supportedly connecting the said first collar to said second collar and including continuously adjustable means for varying the load applied to said surface pipe." Both screw jacks and hydraulic jacks are shown for varying the load.

vii. Summary of Prior Art of Casing Retensioning

From the prior art discussed above, it is clear that it is known to cut the surface casing and lengthen it after jacking up the casing head and production casing with jack means clamped to the lower part of the surface casing, as shown in the aforementioned Boldrick et al. Pat. (see also Boldrick et al.'s companion U.S. Pat. No. 3,316,963), and that it is known to provide an extra head between the tubing head and casing head to allow for relative motion thereof as in the steam wellhead, and to provide a special casing head which is extensible, as in the permafrost wellhead and as shown in the Hubby patent. But killing the well and cutting the surface casing as in Boldrick et al.'s methods is both time consuming and unattractive from the production standpoint, and the other constructions, having no support in the lower part of the casing head (or in the casing head in the case of the steam injection construction) leave the production casing free standing, i.e. unsupported by the surface casing head when the latter subsides or the casing expands. Furthermore, all of the latter constructions employ additional or very special wellheads.

viii. Objects of Present Invention

It is to overcome the aforementioned disadvantages of the prior art constructions that the present invention is directed. Particular objects are to increase the speed of the retensioning operation, reduce the cost thereof, and to employ as nearly as possible only conventional wellhead parts. Other advantages and objects of the invention will become apparent from the following description thereof.

SUMMARY OF THE INVENTION:

According to the invention the production casing is cut off above the casing head and a threaded nipple slipped on and welded thereto, whereby the casing is extended into the lower part of the tubing head which is screwed thereon. The production casing is long enough so that the lower flange of the tubing head is spaced above the upper flange of the casing head leaving space into which hydraulic jacks can be easily inserted to accurately retension the production casing whenever desired. When the jacks are released the load is transferred to the casing hanger placed in the casing head as is conventional. Spring loaded, smooth backed slips are used in the casing hanger to insure that it resets. To enable testing of the seal between casing head and production casing in the usual manner a packoff flange is used on top of the casing head. The packoff flange is conventional except that since it is accessible from the top it is provided with a replaceable sealing element actuated by a gland ring from the top of the flange. The tension placed in the tubing by the hydraulic jacks is measured by a special pressure gage on the hydraulic line connected to the jacks, the gage being calibrated to read in pounds of casing tension. A hand pump can be used to actuate the jacks. The jacks and pump are then easily transported from well to well as a retensioning program is carried on. A red line on the gage indicates maximum permissible load on the jacks. If the travel range of the jacks is exceeded, cylindrical shims are placed beneath the jacks.

After the tensioning of the production string, should further subsidence occur, the production string is free to rise through the casing hanger.

The invention and the history of its development, from the time of placement of a design and development purchase order in late 1969 through the building and lab testing in January 1970, modification, and ultimate initial installation of a prototype in a Texas well field on Feb. 23, 1970, followed by further field testing.

Preferred procedures for carrying out the method of the invention are described in more detail in the aforementioned SPE paper which is incorporated herein by reference.

Following the design, building, testing, modification, installation, and further testing of the aforementioned initial experimental prototype of the invention, the construction was made the subject of a Data Sheet or special sales catalogue dated Mar. 24, 1970.

For a further description of the present invention reference may be made to the aforementioned data sheet which is entitled Ground Subsidence Wellhead, SK-5404-1, which is incorporated herein by reference. (Drawings SK 5404-1 through 4 and SK 5997 referred to in the data sheet correspond to FIGS. 7-13 of the SPE paper.)

BRIEF DESCRIPTION OF THE DRAWINGS:

For a detailed description of a preferred embodiment of the invention reference will now be made to the accompanying drawings wherein:

FIG. 1 is an elevation of a wellhead assembly incorporating the invention;
FIG. 2 is a semi-schematic view similar to FIG. 1 showing hydraulic jacks in place for retaining the production casing in accordance with the invention, the left and right hand sides of the FIGURE illustrating different positions of adjustment of the wellhead assembly;
FIG. 3 is a section showing the casing hanger used in the FIG. 1 assembly, with the casing seal and casing head being indicated in dashed lines;
FIG. 4 is a section showing the seal of FIG. 3;
FIG. 5 is a section showing the packoff flange forming part of the FIG. 1 assembly;
FIG. 6 is an elevation, partially in section, showing a slip on and weld nipple forming part of the aforesaid assembly incorporating the invention;
FIG. 7 is an elevation showing a cylindrical shim for use in the invention.

FIGS. 8 and 9 are views similar to FIG. 1 showing modifications.

DESCRIPTION OF THE PREFERRED EMBODIMENT:

Referred to FIGS. 1 and 2 there is shown a surface casing 11 to which is connected a conventional casing head 13, e.g. by a threaded or welded connection. The casing head includes a bowl 15 within which is disposed casing hanger and seal means (shown in FIGS. 3 and 4) for suspending production casing 17 in casing head 13 and sealing the annular space between the casing head 13 and production casing 17. Conventional lock screws 19 disposed around casing head flange 21 provide means for actuating the seal means in the usual manner.

Disposed above and bolted and sealed to the casing head flange 21 is a packoff flange 23 (shown in detail in FIG. 5). The packoff flange 23 is of conventional construction except perhaps for the seal actuation means 25 as will be described hereinafter in more detail. The packoff flange includes the usual screw plugs 27, 29 closing ports which lead into passages (not shown in FIG. 1) communicating with the annular space between the flange seal and the seal in casing head, whereby the latter seal can be tested for leaks in the usual manner.

The production casing 17 extends up through and beyond flange 23 and is screwed into the bottom of otherwise conventional tubing head 31. Normally, the production casing, being supported in the casing head by the casing hanger, merely extends into a seal in the lower end of the tubing head to provide a means for testing the casing head seal, but since the tubing is to be tensioned by lifting the tubing head, the threaded connection with the tubing head is provided.

The tubing head 31 includes a bowl 33 in which is disposed a conventional tubing hanger (not shown) which supports tubing 35 and seals between the tubing and tubing head. A conventional Christmas tree manifold 37 (see FIG. 2) has a lower flange 39 bolted and sealed to upper flange 41 of the tubing head.

There is a vertical space A between the lower flange 43 of the tubing head and the packoff flange 23. This provides room for insertion of hydraulic jack means 45 (see FIG. 2) when it is desired to tension the production casing subsequent to initial installation.

Referring now to FIG. 3, within the casing head bowl is disposed split, wrap around casing hanger 61, comprising a split wrap around false bowl 63 and slips 65 in a conventional manner. The slips have smooth backs 67 so that they can be repeatedly reset without galling the conical face 69 of the false bowl. The bowl has an annular outer shoulder 71 which rests on annular shoulder 73 of the casing head. The teeth 75 on the inner faces of the slips are adapted to indent and support the casing 17 in the usual way. To insure that the slips move into casing engaging position they are urged downwardly by springs 75 in a known manner. The upper ends of the springs bear against back-up ring 77 secured to the top of the hanger by screws 79. The slips are secured to the bowl and guided in their movement therein by pins 81 moving in slots 83 in the false bowl.

Initially when the hanger is first lowered into the casing head, it is suspended by four eye bolts 83 screwed into the slips through holes 85 in ring 77. Nuts 87 on the eye bolts are positioned to hold the slips retracted until the hanger is initially positioned. Thereafter, with desired tension in the casing, at the time supported by the drilling rig, the four eye bolts are unscrewed gradually to release the slips so they engage the casing. Then the drill rig cable is lowered slightly to transfer the load from the rig to the slips.

After the production casing has been properly tensioned, conventional split wrap around seal 89 is positioned in the casing head above the casing hanger. The seal 89 rests on annular shoulder 91 in the casing head. The seal includes upper and lower diametrically split metal rings 93, 94 between which is sandwiched resilient packing ring 95. Ring 95 is split at 97. The rings 94, 93, 95 are held together by screws 99. Ring 93 has a downwardly facing annular shoulder 101 adapted to rest on shoulder 91 of the casing head. Ring 94 has an upwardly facing tapered shoulder 103 adapted to be engaged by conical tips 105 of lock screws 19, thereby
to hold the seal down and pressurize ring 95 into sealing engagement with the casing head and production casing.

Referring to FIG. 5 there is shown packoff flange 23 through which extend a plurality of circumferentially spaced apart bolt holes 107. Removable plugs 27 and 29 provide access to passages 109 leading to the lower side of the flange and the space in the casing head above seal 89. Annular groove 110 on the underside of the flange is adapted to receive the usual steel ring gasket (not shown) to seal the packoff flange to the flange therebelow to which it is bolted. Packing 111 positioned on annular shoulder 112 on the inner periphery of the flange is adapted to be compressed by compression ring 113 having a flange 114 overlying the flange 23 and positioned by screws 115 as in the usual packing gland. The packing 111 provides means to seal between the production casing 17 and the flange 23. As compared with prior packoff flanges wherein the packing gland compression ring had no flange overlying the packoff flange, being recessed within it, there is no well or sump formed in which water and other materials could accumulate. See pages 2361 and 2364 of said Composite Catalog, 15th edition, 1946-47, for a disclosure of such prior known packoff flange, same being incorporated herein by reference.

Referring to FIG. 6, there is shown a slip-on and weld nipple 121 having a threaded end 123 for engagement with the lower end of the tubing head 31 and a smooth box 125 to slip over the upper end of the production casing and be welded thereto, the nipple 121 thus forming the upper end of the production casing string. This nipple makes it a simple matter to properly space the tubing head 31 above the packoff flange 23. After the production casing has been hung in casing hanger 61, and sealed with seal 89, and the packoff flange 23 installed and packing 111 energized, the production casing is cut off at the desired height and nipple 121 welded thereto. It would be impractical to try to thread the upper end of the production casing in the field.

After the nipple 121 is welded to production casing 17, the tubing head is screwed onto the nipple and the tubing hung therein and the valves and pipes of the upper tree installed.

After a period of time, if it is concluded or determined that the production string needs to be repositioned, e.g., as indicated by increase in the distance A, the hydraulic jack means can be installed in space A as shown in FIG. 2. The hydraulic jack means includes hydraulic cylinders 147 within which move hydraulic pistons 149 in the usual manner. The cylinders 147 are connected by hoses 151, 153 to conventional pressurized hydraulic fluid source (pump) 155 whereby the pistons 149 can be raised as desired. Springs 156 move the piston downwardly when the hydraulic pressure is relieved. Pump 155 may be a hand pump. Pressure gage 157 is responsive to the pressure of the hydraulic fluid, which in the static condition is a measure of the tension in production casing 17. The gage is calibrated to indicate casing tension in pounds. A red line 159 is marked on the gage to indicate the maximum permissible load on the jacks.

If the space A has gotten so large that it exceeds the range of the jacks, cylindrical shims may be placed under the jacks. A suitable shim 161 is shown in FIG. 7. The shim comprises a pipe nipple 163 of suitable length, to the upper and lower ends of which are welded circular plates 165, 167.

Referring once again to FIG. 2, the left-hand side of the drawing shows the positions of the parts prior to extension of the jacks. The right-hand side of the drawing shows the positions of the parts after extension of the jacks to the extent required to reposition the production casing sufficiently, as indicated by the needle on gage 157 giving a desired reading on the gage. The jack pressure is then relieved, either by back pumping or with a valve, allowing the tubing head and production casing to drop slightly. Only a short travel causes the casing hanger 61 to take the load, so that the desired tension is maintained. The jack means 45 is then removed.

The invention is equally applicable to wellhead assemblies including one or more intermediate heads, as may be required for casing programs calling for more than one string of casing. As shown in FIG. 8 the jack space is left between the packoff flange above the lower casing head and the lower flange of the intermediate head 171. The jacks will then reposition protection casing 173 as well as production casing 17.

Also, in the case of a wellhead assembly incorporating more than two wellheads, the jack means may be placed between any adjacent pair of well-heads dependent upon which pipe string is primarily subjected to ground subsidence, the jacks being placed on top of the wellhead (or each of them) which is connected to the pipe string subjected to subsidence, such pipe string being the outermost of the two pipe strings connected to such wellhead, as shown also in FIG. 9.

The invention can also be utilized in tubingless completions, the tubing head being replaced by a suitable extra head or spool or flange.

While preferred embodiments of the invention have been shown and described, modifications thereof can be made by one skilled in the art without departing from the spirit of the invention.

I claim:

1. Wellhead assembly comprising a first wellhead, a second wellhead disposed above the first wellhead, each of said wellheads being a heavy walled annular member adapted to support a pipe disposed coaxially therein and including side port means extending laterally at the side of said member to provide a side outlet from said annular member, pipe extending from inside the second wellhead down into the first wellhead, support means in the first wellhead for supporting the pipe therewith, connecting means connecting the pipe to the second wellhead to enable pulling up on the pipe by elevating the second wellhead, said wellheads being unconnected by means other than said pipe whereby they can be separated by jacking them apart, and force transmitting means on said first wellhead and said second wellhead adapted to engage and transmit force to said wellheads from hydraulic means, said force transmitting means each including flange means extending laterally from the axis of said annular member beyond said side port means, said force transmitting means being spaced apart a distance sufficient to receive hydraulic jacks therebetween, i.e. a distance greater than the diameter of said pipe, and being free to move farther apart.
2. Assemble according to claim 1 wherein the support means includes a slip suspension means with smooth backed slips and spring means biasing the slips downwardly.

3. Assembly according to claim 2 including seal means associated with the first head for sealing between the pipe and the first head.

4. Assembly according to claim 3 wherein said fence transmitting means on said second wellhead includes an annular flange at the lower end thereof, said connecting means comprising a threaded connection between said pipe and the lower end of said second wellhead.

5. Wellhead assembly comprising a first wellhead,
a second wellhead spaced above the first wellhead, pipe extending from inside the second wellhead down into the first wellhead, support means in the first wellhead for supporting the pipe therewithin, connecting means connecting the pipe to the second wellhead to enable pulling up on the pipe by elevating the second wellhead, said support means including a slip suspension means with smooth backed slips and spring means biasing the slips downwardly, seal means in the first wellhead for sealing between the pipe and the first wellhead, said second wellhead including an annular flange at the lower end thereof, said connection means comprising a threaded connection between said pipe and the lower end of said second wellhead, said first wellhead including an annular flange at the upper end thereof, said assembly further including a packoff flange sealingly connected to said flange of the first wellhead and including means for sealing between the packoff flange and said pipe and further including port means extending from the space between said flanges through said packoff flange to the exterior thereof and means to close said port means, said seal means in said packoff flange including a packing gland accessible from the top of the flange whereby the seal can be easily replaced when desired, said packoff flange being spaced below said flange of said first wellhead.

6. Assembly according to claim 5 including hydraulic jack means between said packoff flange and said flange of said second wellhead.

7. Assembly according to claim 6, said jack means including piston and cylinder means and cylindrical shim means between said piston and cylinder means and said packoff flange.

8. Assembly according to claim 5 wherein said pipe includes a nipple threaded into said second wellhead forming therewith said connection means, said nipple being welded to the upper end of the remainder of said pipe.

9. Assembly according to claim 1 including means between the wellheads for exerting a force to separate same, said means comprising hydraulic jack means.

10. Assembly according to claim 9, including further manual pump means, conduit means connecting said pump means to said jack means for supplying fluid thereto to extend same, said jack means including spring means to effect contraction of said jack means, and pressure gage means connected to the system that is made up by said pump means, conduit means, and jack means to indicate in response to fluid pressure thereof the tension in said pipe said gage being calibrated in pounds and bearing indicia means to indicate when the maximum permissible load is on the jack.

11. Method of retensioning production casing comprising elevating the tubing head to which is connected the production casing, the casing rising through the casing hanger in the casing head, the elevation being accomplished by expanding jack means between the tubing head and casing head, and contracting the jack means, thereby allowing the slips in the casing hanger to reset to hold the tension, whereby the jack means can be removed while leaving the casing retensioned.

12. Wellhead assembly comprising a wellhead, pipe extending down into the wellhead, support means in the wellhead for supporting the pipe therewithin, said support means including a slip suspension means with smooth backed slips and spring means biasing the slips downwardly, seal means in the wellhead for sealing between the pipe and the wellhead, said wellhead including an annular flange at the upper end thereof, said assembly further including a packoff flange sealingly connected to said flange of the wellhead and including means for sealing between the packoff flange and said pipe and further including port means extending from the space between said flanges through said packoff flange to the exterior thereof and means to close said port means, said seal means in said packoff flange including a packing gland accessible from the top of the flange whereby the seal can be easily replaced when desired, said packoff flange being adapted to and providing means to support hydraulic jack means thereon for elevating said pipe relative to said wellhead.