United States Patent [19]

Drouin

[11] **3,741,297**

[45] **June 26, 1973**

[54] **SUBSIDENCE WELLHEAD ASSEMBLY AND METHOD**

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[73] Assignee: **Rockwell Manufacturing Company,** Houston, Tex.

[22] Filed: **Feb. 17, 1971**

[21] Appl. No.: **115,961**

[52] **U.S. Cl.** **166/89**

[51] **Int. Cl.** **E21b 33/03**

[58] **Field of Search** 166/67, 75, 88, 89, 166/315

[56] **References Cited**

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1,932,570	10/1933	Black	166/89
2,312,476	3/1943	Fenick et al.	166/89
3,166,125	1/1965	Hubby	166/67
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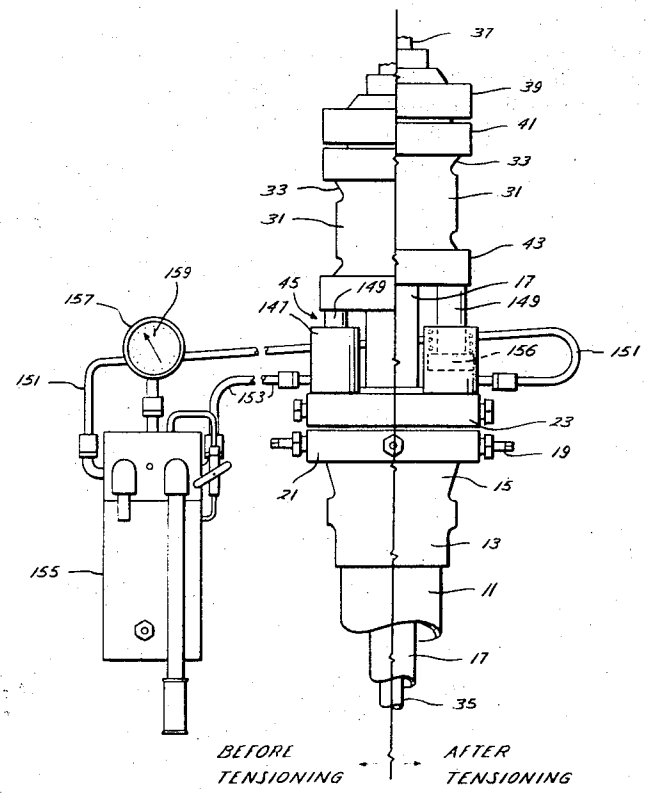
Primary Examiner—James A. Leppink

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[57] **ABSTRACT**

Production casing is retensioned with hydraulic jacks placed between tubing head flange and packoff 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 packoff 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.

2 Claims, 9 Drawing Figures



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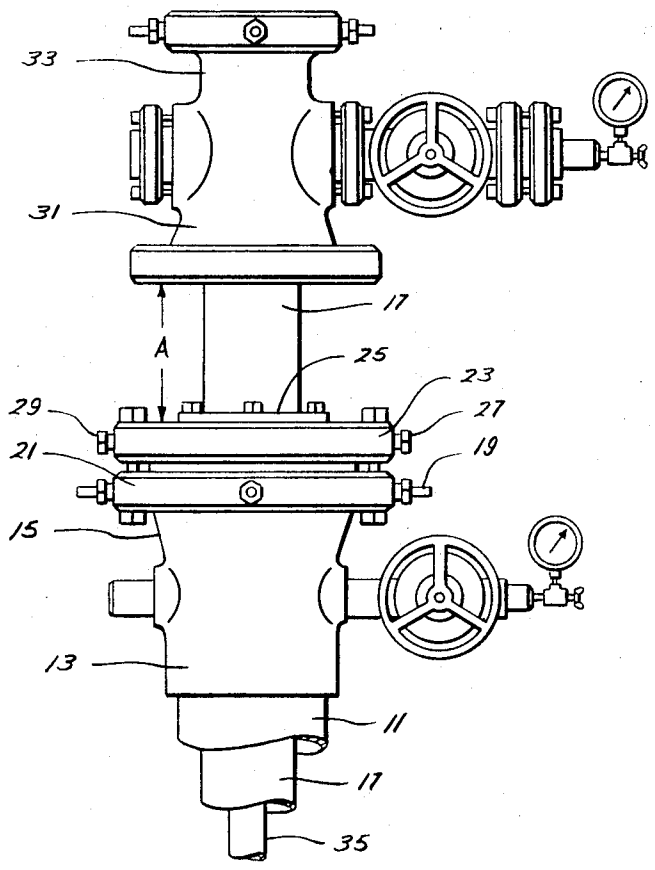


Fig. 1

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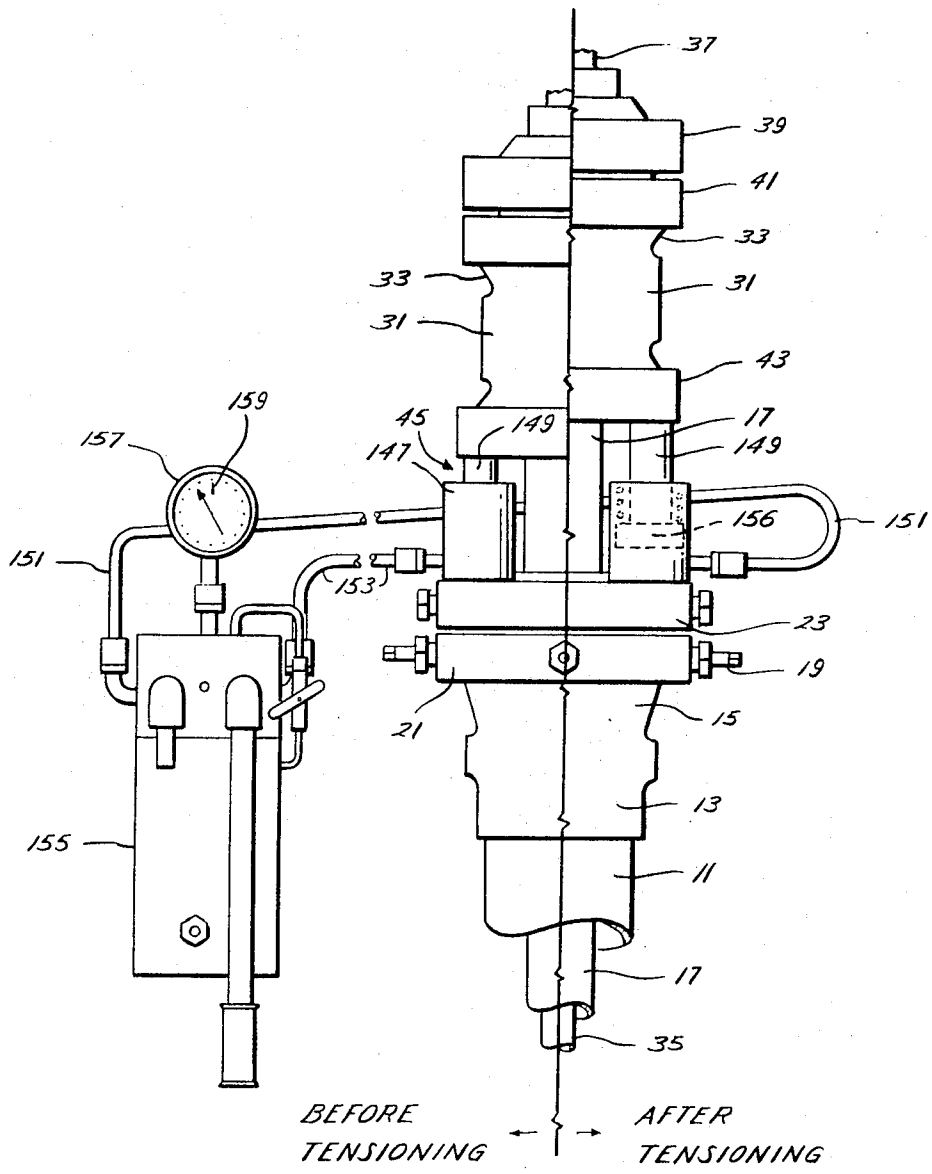


Fig. 2

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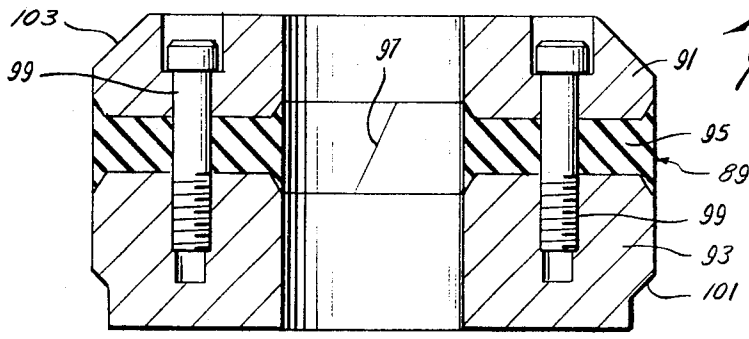


Fig. 4

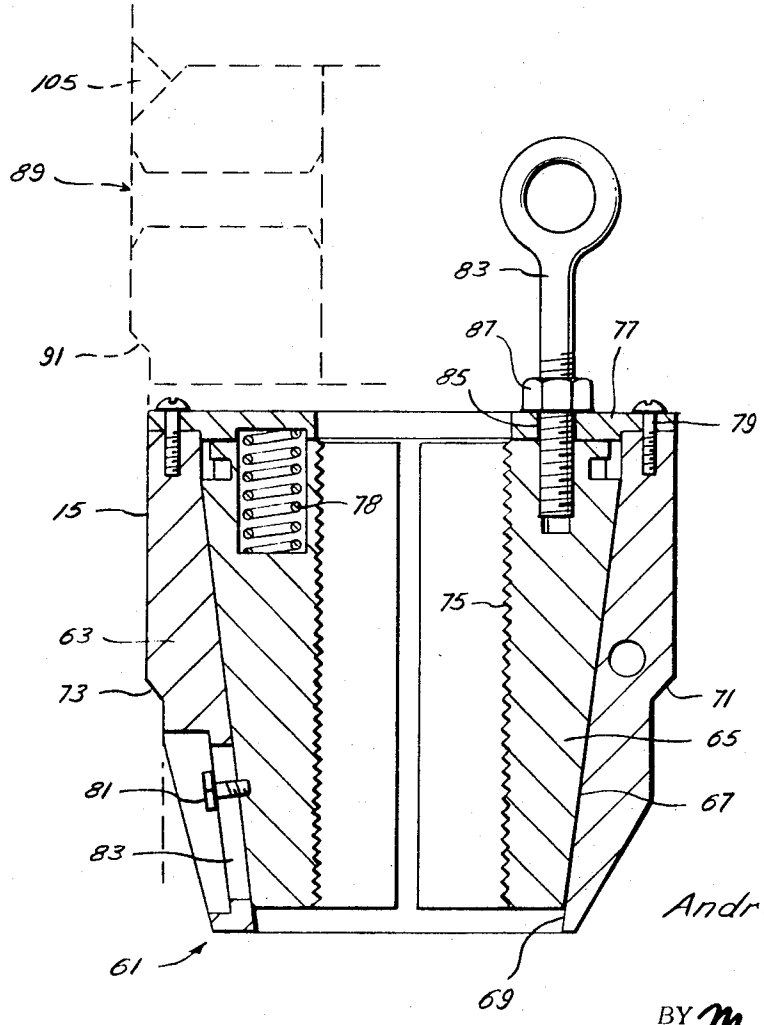


Fig. 3

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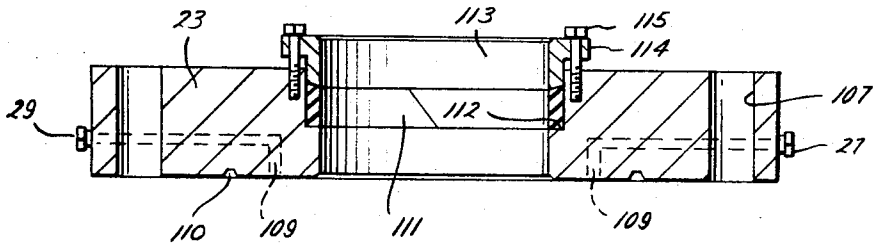
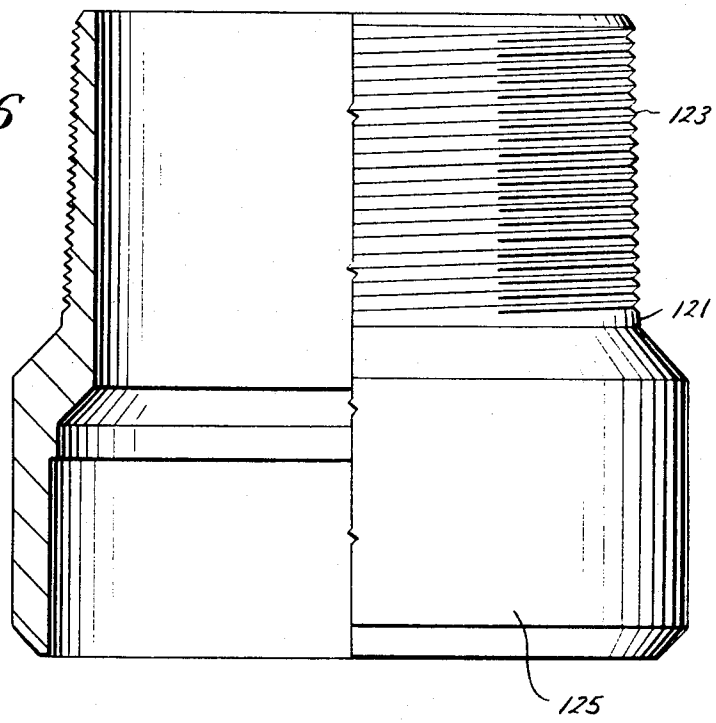


Fig. 5

Fig. 6



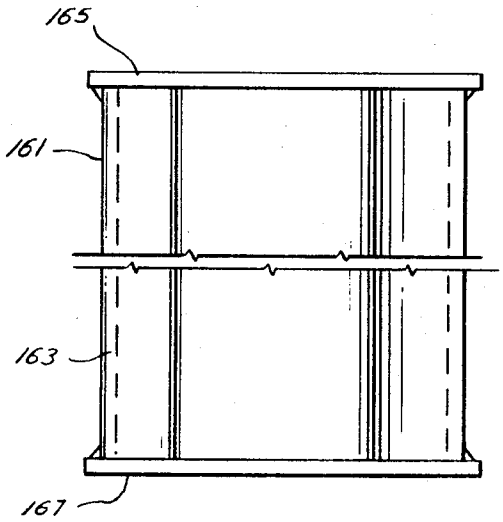


Fig. 7

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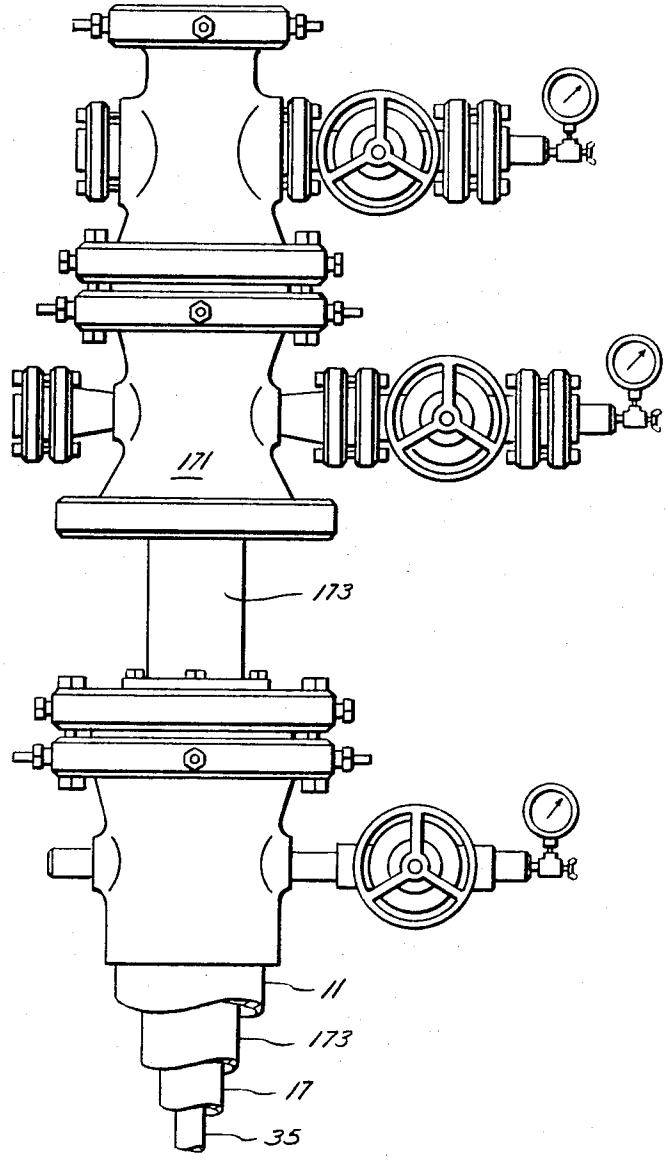


Fig. 8

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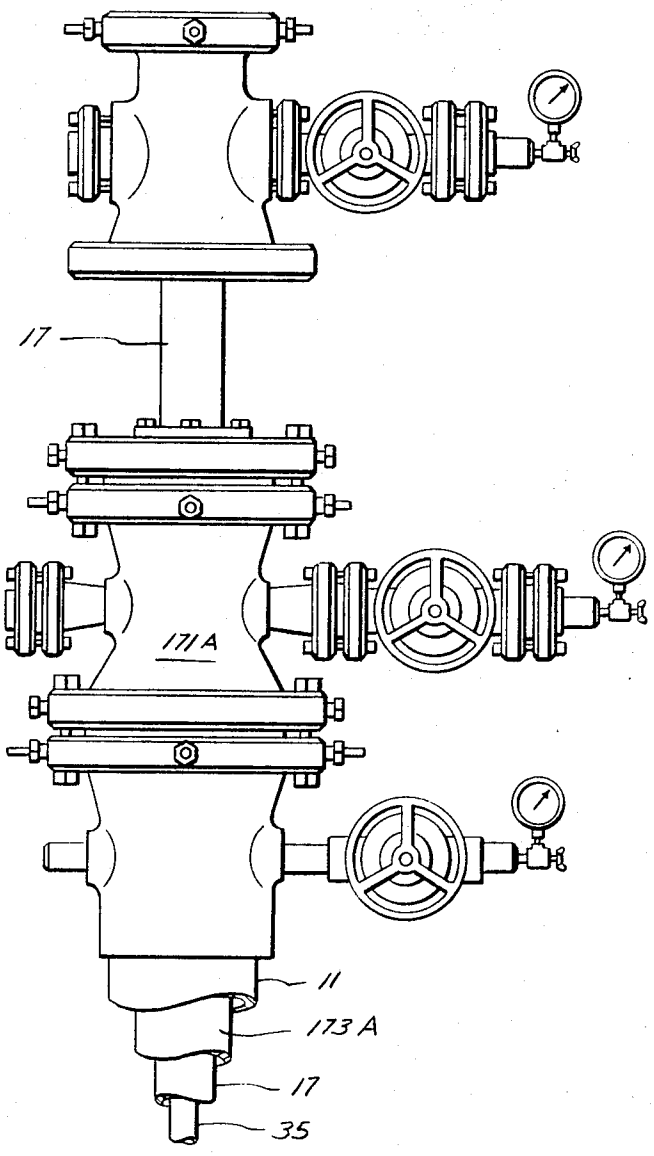


Fig. 9

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SUBSIDENCE WELLHEAD ASSEMBLY AND METHOD

BACKGROUND OF THE INVENTION

1. Field of Invention

This invention pertains to wellhead 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. Surmounting 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, dissassembling 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 retentioned.

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 jackscrews 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 screw 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 relieves 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 reactuated 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 reactuation 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, pages 69–72, and Feb. 16, 1970, pages 76–78, the latter article being by the 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 is 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 patent (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.

vii. 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

and a final report on Mar. 13, 1970 is described in a paper entitled "A Solution to Ground Subsidence Problems in Casing Strings and Wellheads" by J. D. Burley and Andre H. Drouin presented at the annual Oct. 4–7, 1970 metting in Houston, Texas of the Society of Petroleum Engineers of the American Institute of Mining, Metallurgical and Petroleum Engineers, Inc., paper number SPE 3000, copyright, 1970.

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.

Follwing the design, building, testing, modification, installation, and further testing of the aforementioned initial experimatal 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–5397 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 retensioning 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:

Referring 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 retension 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 conventional 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 retensioned, 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 righthand side of the drawing shows the positions of the parts after extension of the jacks to the extent required to retension 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 retension 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 including

an annular member having side port means,

upper and lower connection means respectively at the upper and lower ends of said annular member,

said annular member being adapted to support a pipe disposed coaxially therein,

force transmitting means about the lower end of said annular member for engaging and transmitting force to said wellhead from hydraulic jack means disposed therebelow,

said force transmitting means including lower flange means extending laterally from said annular member radially beyond said side port means,

said lower connection means including a threaded socket at the lower end of said annular member,

said lower connection means further including a slip on and weld nipple screwed into said thread socket, said nipple having an unthreaded belled out socket at its lower end adapted to slip over and be welded to another pipe.

2. Wellhead according to claim **1**,

said upper connection means including upper flange means to receive lock screws,

said lower flange means extending laterally at least as far as said upper flange means.

* * * * *