METHOD AND APPARATUS FOR SUSPENDING AND SEALING WELL CASINGS

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METHOD AND APPARATUS FOR SUSPENDING AND SEALING WELL CASINGS

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This invention has to do in a general way with the art of casing all wells and is more particularly related to improvements in the method and apparatus whereby a so-called inner string or inner strings of casing are suspended and sealed at their upper end within an outer string of casing.

As is well known to those familiar with oil well drilling practice, it is particularly necessary to support the various strings of casing which line the successively smaller sections of the bore hole at the surface of the ground. It is also desirable to effect a seal between the various strings of casing at the point of support or suspension so that the fluid pressures between the different casings can be controlled independently of one another. In territories where subterranean pressures exist it is customary to suspend and seal the inner string or strings of casings in either of the two following ways.

The first method is to suspend the casing from a screw threaded connection which may consist of the pipe or casing coupling itself or may consist of the section of the casing head screw threaded to the casing. The sealing between the inner and outer casings supported in this manner is generally effected by allowing the weight of the inner casing acting through the medium of the threaded connection, to rest upon a packing member which is supported by the outer casing, or by suitable connections secured thereto.

Since it is customary to suspend the casings in the bore hole to specific depths and cement them in the formation at their lower ends, it rarely happens that a casing string terminates with its upper end just at the point where the existing coupling or screw thread on the casing can be used for the suspension means. Due to this fact, it is usually necessary to release the inner string of casing allowing it to rest upon the bottom of the hole or the "cement job" therein, and remove the uppermost section of casing so that it can be cut to length and rethreaded for use as the suspension connection. This practice obviously has an undesirable effect upon the cement which supports the casing, particularly in locations where there are no ready facilities for rethreading and in which event the casing must consequently rest upon the cement for a substantial period of time. Under these circumstances it frequently happens that the casing may "freeze" in the drilled hole due to the side walls sloughing off and settling around the string of casing.

The second method usually employed involves the use of serrated sectional wedges or slips which are supported upon a tapered seat in the casing head and grip and suspend the inner string of casing. This procedure eliminates the necessity of removing and rethreading the last section of casing since the projecting portion can be removed by an acetylene torch or other means, but in order to seal the two strings of casing it is necessary to employ a compressible packing of some kind, such packing being subject to at least partial combustion in case of fire obviously introduces a further hazard.

Although this latter method has an advantage over the former in that it does not necessitate the removal of the upper section of the inner casing and the consequent subjection of the cement to the weight of the entire string, the finished construction has at least one disadvantage over the other type in that there is a tendency for the inner string to expand or heave upward through the slips in the event the fluid passing therethrough is of relatively high temperature. Furthermore in both of these constructions the use of packing glands has proved to be undesirable first for the fire hazard mentioned above and second for the reason that there is a tendency for the materials constituting a compressible gland to deteriorate which is obviously a disadvantage in a structure which must of necessity be of a stable and more or less permanent character.

It therefore becomes a primary object of this invention to provide a method and apparatus for landing well casing in which the wall metal of the inner casing itself constitutes the means for suspending or supporting the inner casing and in which such wall metal also has pressure engagement with the suspending means thereby effecting a metal to metal seal between the two adjacent strings of casing. This object is accomplished by expanding or deforming the inner string of casing at a predetermined point therein so that the wall metal thereof is forced out into pressure engagement with a specially formed interrupted surface in the suspending member.

As is well known to those familiar with the art, it is desirable in the installation of the inner string or strings of casing to place such casings under a predetermined tension before locking their upper ends in place with respect to the outer string of casing. It becomes a further object of this invention to provide a method whereby the inner string of casing may be placed and held under a predetermined tension while it is being locked in place, the lock or permanent suspension of the inner string being such that there is no substantial settling of the inner string after
it is released such as is the case in the event a compressible packing seal is used.

Another undesirable feature in the structures of the prior art resides in the liability to breakage of the casing and as a result of the wall metal being cut away and consequently weakened in the case of threads, or as a result of the crushing and biting action combined with the tensile strain on the pipe in the event the casing is supported solely by a slip or wedge construction. In the method and structure end wall metal by this invention, the wall metal of the pipe is cold rolled into pressure engagement with the supporting surface, thereby obtaining a support without removing any of the wall metal, and as a result of the cold working of the wall metal, its strength is actually increased in the region of the joint. Furthermore, the wall of the pipe is not subjected to the crushing action which is present in the case of the slip or wedge type of support, so that the liability of breakage at the joint is reduced to a minimum.

It is a further important feature of this invention that the suspension contemplated thereby is of a character such that up-heaving of the inner casing is prevented, and the fire-proof metal to metal suspension and sealing connection makes for maximum safety in construction so far as fire is concerned.

A further noteworthy feature of the method and apparatus contemplated by this invention resides in the fact that the inner casing can be secured within the casing head at any desired point along its length thus eliminating the necessity of having to remove a section of the casing as is now practiced in the first method referred to above.

The details in the method and apparatus contemplated by this invention, together with other objects, are best understood from the following description of the accompanying drawings which are chosen for illustrative purposes only in which:

Fig. 1 is a sectional elevation illustrating a preferred form of casing head contemplated by this invention and showing the first step in the process followed in suspending and sealing an inner string of casing therein;

Fig. 2 is a sectional elevation similar to Fig. 1 illustrating one method and apparatus which may be employed in expanding a portion of the wall metal of the inner casing into the interrupted surfaces of the casing head;

Fig. 3 is a sectional elevation similar to Figs. 1 and 2, but illustrating the first inner string as having been installed and further illustrating the manner in which a second inner string of casing can be suspended and supported within the first inner string;

Fig. 4 is a fragmentary sectional elevation illustrating a preferred form of connection contemplated by this invention;

Fig. 5 is a sectional elevation illustrating a modified form of apparatus which may be employed in the practice of this invention;

Fig. 6 is a sectional elevation similar to Fig. 5 showing a further step in the operations involved in the use of this form of apparatus; and

Fig. 7 is a plan section taken from the plane represented by the line 7-7 of Fig. 5.

More specifically describing the invention as herein illustrated with particular reference to Figs. 1 to 3 inclusive, reference numeral 14 indicates the upper end portion of an outer well casing to which the bottom flanged section 12 of a casing head 13 is secured by means of a threaded connection indicated at 14. Reference numeral 15 indicates an inner string of casing which has been built up and lowered through the outer string to the bottom of the hole in the conventional manner by means of an elevator generally indicated by reference numeral 16.

The casing head 13 in this embodiment of our invention includes an upper section 18 which rests upon the bottom flanged section 12 and is secured thereto by means of bolts 19. The top section 18 of the casing head is installed by slipping the same over the last section of the inner string of casing 19 before it is attached to the next lower section, so that it is lowered into place as the inner string of casing is settled to the bottom. The upper section 18 of the casing head is formed with a throat portion or throat section 19, the internal diameter of which is only slightly greater than the external diameter of the pipe, such throat section being provided with an interrupted inner surface shown as being formed by providing the interior of the throat section with a plurality of annular grooves 20.

The upper section 18 is also shown as being provided with vent openings 21 which may be used in the conventional manner to control the pressure between the two strings of casing after they have been installed and sealed.

When the inner string has been landed in the manner referred to above, and the top section 18 of the casing head locked in place, the bottom of the inner string is cemented to the formation in the conventional manner and after the cement has set, a predetermined tension is applied to the inner string 15 by means of the elevator 16 and its associated hoisting mechanism not shown.

When the required tension has been applied to the inner string 15, it is temporarily supported or suspended in slips 25 which are supported in a segmental collar or split spider 26 assembled about the casing section 15 and resting upon the upper edge of the top section 18 of the casing head. When suspended in this manner (see Fig. 2) the elevator 16 may be removed and an expanding tool 28 is inserted through the upper end of the inner casing 15.

The purpose of the expanding tool 28 is to expand or bulge a portion of the wall metal, of the inner casing 15, which is located adjacent the interrupted inner surface of the throat 19 into pressure engagement with the interruptions or grooves 20.

Various types of tools may be employed for this purpose and for the purpose of illustrating this step in the process, we show an expanding tool consisting of a cage or sleeve 30 having a plurality of rollers 31 supported near its lower end in any suitable manner. The cage or sleeve 30 slideably extends through a collar 32 which is adapted to rest upon the collar 34 at the upper end of the casing 15. The cage 30 is lowered into the casing section 15 until it reaches a point at which the rollers 31 are opposite the interrupted inner surface of the throat 19. At this point the cage is locked against further downward movement by means of a set screw or other suitable means indicated at 36. For the purpose of expanding and rotating the rollers 31 to bulge or expand the wall metal of the casing, we employ a mandrel 40 which has a tapered lower end indicated at 41. Pressure and rotation is applied to the mandrel in any suitable manner such as by means of a cross bar 43 or a power device 45.
(not shown) which may be attached to the square end 44.

As the wall section of the inner casing is subjected to the radia pressure and rolling action of the expanding tool, the metal thereof is bulged outwardly as indicated at 45 in Fig. 4, so that portions of the metal indicated at 46 flow out into the interruptions, or grooves 20 of the suspending or suspension member. This, as has been previously indicated, gives a permanent suspension to the inner string of casing and provides a positive metal to metal permanent seal between the inner casing and the casing head.

When this permanent suspension and seal has been effected in the manner described above the split spider and slip assembly 25-46 is dismantled and removed and the inner casing is cut off in any suitable manner immediately above the top or intermediate section 16 of the casing head as indicated by reference numeral 48 in Fig. 3.

It is to be understood that any number of casings may be suspended and sealed in the manner described above and in Fig. 3 we illustrate the manner in which this successive casing suspension may be carried on to any desired extent depending upon the external diameter of the outer casing 11. It will be observed that the casing head section 16 which we have hereinafore referred to as the upper casing head section is provided with flanges 50 at its upper end. These flanges support the base portion of another casing head section 52 which is secured to the flange 55 by means of bolts 53. The upper casing head section 52 is provided with a throat section 54 which has an interrupted inner surface and which, as is shown in Fig. 3, is adapted to support another casing or tubing member indicated by reference numeral 55. The casing head section 55 also has a flanged connection 56 at its upper end and the assembly may be completed by mounting a finishing cap 57 to the flange 58 by means of bolts 59, such finishing cap having a threaded connection 59 to which the flow tree is connected. The casing head section 52 is also shown as being provided with vents indicated by reference numeral 24.

In Figs. 5 to 7 inclusive we show a modified form of apparatus which may be employed in the practice of the general method contemplated by this invention. In these views reference numeral 14a indicates the outer casing and reference numeral 15a indicates the inner casing which has been lowered and cemented in the well in the general manner described above.

Casing head 13c in this form of our invention comprises a base member 60 which is shown as being threaded to the upper end of the outer casing 16, such base member having a vent opening 61 therein. Supported in the top of the base member 60 is what we may term a top or body member 62, such body member having flanges 63 which extend out over the top of the base member, the flanges being engaged by pressure screws 64 which are mounted in a bonnet 65, screw threaded to the base member as indicated at 66.

The body section or casing head section 52 may be installed upon the last section of casing 16 in the same manner described above in connection with the casing head section 16 and is locked in place by means of the bonnet set screws referred to above. The bottom portion of the body member 62 is shown as being formed in the nature of a throat section 70 having an interrupted inner surface formed in any suitable manner such as by means of the annular grooves 71. Immediately above the throat section 70 we provide an enlarged annular chamber 73 which is adapted to permit the free action of a cutting tool for the purpose which will be hereinafter described. Above the annular groove 73 the body member is formed with upwardly divergent wall surfaces indicated at 75, such wall surfaces being adapted to co-operate with removable slips 76 for the purpose of supporting the casing 15a after it has been placed under tension in the manner described above in connection with Figs. 1 and 2.

When the casing 15a has been placed under tension in this way and supported by the slips 76 in the manner just described, an expanding tool 77 is inserted within the casing and is operated to expand or bulge the wall section adjacent the throat so as to lock the casing 15a within the casing head section 63.

The expanding tool 77 in this form of our invention is adapted to be operated by the rotary table (not shown) on the drilling rig through the medium of a standard Kelly bar indicated by reference numeral 79 and is shown as comprising a mandrel member 80 the upper end of which is provided with a collar 81 which is secured to the Kelly bar 79. In addition to the mandrel 80 the expanding tool consists of a cage member 82 which is supported at its lower end by the mandrel through the medium of a nut or screw 83. The cage member 82 is provided at an intermediate portion with a plurality of rollers 85 mounted in any suitable manner so as to have rotary and radial movement, both of these movements being imparted to the rollers by means of a tapered sleeve 87. The sleeve 87 is adapted to be rotated by the mandrel 83 by means of a key 88 which is mounted in the mandrel and is contained within a slot 89 formed on the inner face of the sleeve. Downward movement is imparted to the sleeve during its rotation by providing the lower end of the sleeve with threads 90 which are received in a threaded throat 91 within the cage 82.

When the wall metal of the casing 15a has been expanded into the interrupted surface of the grooves 71 of the throat in the casing head, the expanding tool 77 is withdrawn and the casing 15a is cut off as indicated at 93 (Fig. 6) by means of a circumferential cutter of any desired type. In this connection it will be observed that the annular chamber 73 will permit the free action of the cutter without injury thereto.

The next string of casing or tubing 95 (see Fig. 6) is lowered through the casing 15a in the conventional manner and is supported by means of a second pair of slips 96 which are installed about the tube 99 and rest upon the tapered surface 78 which had previously supported the slips 76. The last mentioned slips were of course removed when the top of the casing section 15a was cut off and withdrawn. After the casing 95 has been supported upon the slips 96 a collar member 97 is threaded into the top of the body 62. This collar member is provided with an interrupted or grooved inner surface indicated by reference numeral 98 and the wall metal of the tubing 95 is expanded into the interruptions or grooves of the throat formed by this collar member. In this particular construction the slips 96 become a permanent part of the installation and serve to assist in the support of the casing or casing 95 so that the throat formed by the collar 97 acts more as a seal and may therefore be formed...
with a smaller surface area than the throat described hereinafore.

After the tubing or casing 95 has been suspended in the manner described above it may be cut off as indicated at 99, a finishing cap 100 placed thereon and locked in place by means of a bonnet and cap screw assembly generally indicated by reference numeral 101.

It will be observed from the foregoing description of Figs. 5 to 7 inclusive that we have devised a method and an apparatus whereby two strings of casing may be supported from a single casing head thereby materially reducing the overall height of the casing head assembly. It will also be apparent from both forms of our invention that the method and apparatus contemplated by this invention provides means for eliminating the use of compressible packing and also provides means whereby an inner string of casing may be supported and positively sealed without releasing the weight of the casing upon the cement at the bottom of the hole.

It is to be understood that while we have herein described and illustrated certain preferred forms of apparatus contemplated by this invention and have described in detail certain preferred procedures to be followed in the practice of this invention, that the invention is not limited to the precise construction or procedure described above but includes within its scope whatever changes fairly come within the spirit of the appended claims.

We claim as our invention:

1. The method of suspending and sealing a casing within a well which includes: providing a permanent suspension member having an interrupted inner face; suspending said casing through said suspension member by temporary suspension means; and during such suspension deforming the casing wall between its ends into engagement with the interrupted inner surface of said suspension member and subsequently removing the temporary suspension means.

2. The method of landing an inner well casing within a well having an outer casing installed therein which includes; lowering said inner casing into the well through said outer casing; cementing the lower end of said inner casing within the well; mounting a permanent suspension member having an interrupted inner face on the top of said outer casing; mounting temporary suspension means in said permanent suspension member at a point above said interrupted inner face; applying tension to said inner casing; temporarily supporting the upper end of said inner casing by said temporary suspension means, and deforming said inner casing at a point between its ends into engagement with the interrupted surface in said suspension member thereby providing a permanent suspension and seal; and subsequently removing said temporary suspension means.

3. The method of suspending and sealing an inner well casing within an outer well casing which includes; providing a permanent suspension member having an interrupted inner face on top of said outer casing; temporarily suspending said inner casing through said suspension member by means apart from said suspension member; and during such temporary suspension, deforming said inner casing into engagement with the interrupted surface of said suspension member, and then removing the temporary suspension means.

4. In an oil well, the combination of an outer casing; a suspension member secured to the upper end of said outer casing; a throat section on said suspension member having an inner surface, said inner surface having a plurality of annular grooves therein, and an inner casing extending through said throat section into said well, a temporary support for said inner section located above the suspension member and carried thereby said inner casing having a portion of its wall metal adjacent said throat and below said temporary support deformed into locking engagement with said inner surface, whereby the inner casing is suspended and sealed within the outer casing and said temporary support may be removed.

5. The method of landing an inner well casing within a well having an outer casing installed therein which includes; lowering said inner casing into the well through said outer casing; cementing the lower end of said inner casing within the well; mounting a permanent suspension member having an interrupted inner face on the top of said outer casing; mounting temporary suspension means in said permanent suspension member at a point above said interrupted inner face; applying tension to said inner casing; temporarily supporting the upper end of said inner casing by the temporary suspension means, and deforming said inner casing at a point between its ends into engagement with the interrupted surface in said suspension member thereby providing a permanent suspension and seal; cutting said casing above said deformed portion; and subsequently removing the portion of said casing above the cut and removing said temporary suspension means.

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