The present invention relates to the art of drilling and completing wells, and pertains more particularly to methods and apparatus for landing or suspending a string of casing in a well and performing the desired setting and cementing operations.

As described, for example, in U. S. Patent 2,188,989, a well completion method in common use at present consists of first cementing the lower end of the casing string through the drilling riser and then, after the cement has hardened, placing the casing string under a predetermined tension, cutting the top casing joint to a required length and flanging or fastening it to the casing or landing head by means of a special coupling. This method requires many relatively intricate fitting manipulations, for example, to accomplish axial alignment of the casing string with the casing head. Likewise, the hoisting equipment is immobilized for several days while the cement is hardening. Another disadvantage of this method is that heavier pipe is necessitated when an extra pull is applied to the casing string.

To avoid these difficulties, attempts have been made to land or to support the casing string, for example, by means of a tapered bushing attached to the casing string and a tapered seat in the landing head for receiving said tapered bushing, and then to cement in the lower end of the casing. However, the difficulties in this method are that additional line connections are necessitated and that the circulation of wash water or drilling mud must be carried out through the small vent ports and lines in the landing head so that a sufficient fluid circulation cannot be obtained thereby. If, to overcome the latter, the vent ports are enlarged, the strength of the landing head is considerably decreased.

It is therefore an object of this invention to provide a method for setting a string of casing in a well wherein said string is first landed or flanged at the casing head, and is then cemented at the level of its lower end.

It is also an object of this invention to provide a method for setting casing wherein said casing is run into the well and landed or flanged at the head without subsequent adjustment of tension.

It is also an object of this invention to provide a method of landing or suspending a string of casing from a casing head without interrupting fluid communication through the annular space surrounding said casing below and above said point of suspension.

It is also an object of this invention to provide a casing head structure whereby casing may be lowered into the borehole through the casing head while controlling the pressures within said casing and within the annular space surrounding said casing.

It is also an object of this invention to provide an improved well head structure to carry out the process of this invention.

It is still another object to provide a superior casing support in which the annular space around the inner casing being supported remains open for fluid flow until closure is desired, and means are provided for effecting said closure when desired.

It is a further object to provide an improved casing support of compact design which is inexpensive and requires simple manipulations to install.

It is another object to provide a compact well head structure comprising a tubing head in which is embodied the casing vent outlet or outlets.

With the above and other objects in view the invention has particular relation to certain novel features of construction, operation and arrangement of parts, an example of which is given in this specification and illustrated by the accompanying drawings, wherein:

Figure I is a vertical sectional view, showing the general arrangement of apparatus used in landing casing and circulating in cement according to the present invention;

Figure II is a vertical sectional view of a well head structure, showing two inner casing strings landed according to the present invention;

Figure III is a vertical sectional view of the completed casing head structure;

Figure IV is a plan view taken along the lines IV—IV of Figure III, with the tubing head, sealing ring and packing rings removed;

Figure V is a vertical sectional view of the segmented bushing detail;

Figure VI is a plan view of said segmented bushing.

Briefly, the method of the present invention comprises the steps of landing or suspending a casing string on a casing, or landing head, circulating fluid from above the point of suspension down through said string and up through the annular space outside said casing and on through the casing head out of the well, and cementing the lower end of the casing string.

The equipment used according to the present invention in setting or landing an inner or intermediate casing string 18 in a borehole 16 is shown generally in Figures I and II of the drawings.

An outer or surface casing string 5 is shown...
as already cemented in the borehole and is provided at the top with a casing head, generally designated as 1, which rests on a concrete or other suitable foundation, such as on the bottom of a concrete cellar, being provided for this purpose with a wide diameter landing base 10 and supporting radial webs 11, as shown in Figures I and III. As shown in more detail in Figures III and IV, the casing head 1, as well as any head which may be used to support further casing strings within the outer string 5, is formed with a tapering shoulder 3 protruding into the upper portion of the bore 4 of the casing head and forming therein a tapered seat. The lower portion of the bore 4 of the bottom head may be threaded to engage the outer surface casing 5, although any other suitable means for supporting the surface casing, such as welding, may be used instead. A horizontal vent port 14 and-valved line 15 connected thereto may be provided in the body portion of the casing head 1 for use in subsequent testing and purging. The casing head 1 is formed with an upper flange 7, which may have circular grooves 8 adapted to receive packing rings 9, as shown in Figure III, and which may also have circumferentially spaced bosses 6, serving as means for connecting to a drilling riser, smaller casing heads, tubing heads, etc., as desired.

The upper end of the casing string 19, which is to be landed or hung in the bottom casing head, is fitted with a special coupling 20 (shown in detail in Figures V and VI), having an axial bore 23 preferably threaded at the lower end for connection with the casing string 18 and threaded at the upper end for a subsequently-described purpose. The body of the coupling 20 is provided with radial ribs or bushing segments 21 projecting outside from the coupling body. The lower portion of the rib 21 is tapered at substantially the same angle as the tapered shoulder 3 of the casing head and is adapted to seat on said shoulder 3, as shown in Figure III. The upper face 22 of each of ribs 21 is horizontal and the ribs 21 are so formed that these faces 22 are a short distance below the upper end of the coupling 20. When the coupling 20 and the casing string 19 attached thereto is seated in place on the tapered shoulder 3, the portion of the upper rib faces 22, the upper end of the body of the coupling 20 and the upper end of the bore of the casing head 1 together forms a groove 25, as shown in Figure III. Fluid can pass upward (as well as in the reverse direction) from the annular space between the outer casing 5 and the inner casing string 19 through the spaces or channels between the ribs 21 and through the groove 25. As hereinbelow described, after the lower end of the casing string 19 is cemented, a sealing ring 26 is placed in the groove 25 and preferably welded or otherwise attached thereto, whereby the above-mentioned fluid passage is closed. The sealing ring 26 is preferably formed with a circular groove 27 in its upper face, as shown most clearly in Figure III, whereby the ring may be easily welded into place.

In a like manner, as shown in Figure II, further casing heads 37 of similar construction but smaller size may be surmounted on the above-described base casing head for supporting and hanging further casing strings 61 within the outer casing 5. Surmounting the uppermost casing head, such as the base or bottom head 1 (when only one casing string besides the surface casing is used), as shown in Figure III, is a tubing head, generally designated as 40, for suspending the tubing string 41 in the well. The tubing head 40 is preferably a flanged body having circumferentially spaced bores 42 for connecting by means of bolts 43 to the upper flange 1 of the casing head 1 or the like and having an axial bore 44 preferably formed, such as with threads, for attachment to the upper end of the tubing string 41. The lower end of the axial bore 45 is counterbored as at 46 to a diameter about that of the bore of the casing head to which the tubing head 40 is attached. A horizontal vent bore 47, which may be formed with a threaded extension 48, is provided in the tubing head 40 and opens into the counterbore 46. Suitable attachment means, such as upward-projecting stud bolts 49, are provided in the upper horizontal face of the tubing head for fastening thereabove a "Xmas" tree and the control equipment, as shown at 50 in Figure II.

In carrying out the method of the present invention, which for purposes of illustration will be described in relation to the above-described preferred apparatus, shown in Figure I, the surface casing 5 and the bottom casing head 1 having tapered seat 3 are installed in the usual manner well known to the art. After the borehole has been drilled to the desired depth for setting the second casing string 18, said casing string 18 is run into the hole through a drilling riser generally designated as 50, which may be connected by means of a flange 54 to the flange 1 of the casing head 1. The drilling riser 50 may comprise a blow-out preventer 51, a mud line T 52, a suitable packer 53 or another blow-out preventer, or the like. The blow-out preventer 51 and packer 53 of drilling riser 50 permit the introduction of the casing string 5 while maintaining the well under pressure control, and the mud line 52 allows circulation of drilling fluid, as is well known in the art. Before lowering the last section of casing 19 into the drilling riser 50, the special coupling 20 is threadably or otherwise attached to the upper end of the casing string 19, and a lifting nipple 55 is attached to the upper end of the coupling. The casing string 19 and coupling 20 are then lowered into the drilling riser 50 and borehole by means of the drilling nipple 55 until the tapered radial ribs 21 seat upon the tapered annular shoulder 3 of the casing head 1.

With the well thus under pressure control and the casing string 19 lowered and the blow-out preventer 51 open, drilling mud, water, oil or any other suitable fluid is circulated (as indicated by the arrows in Figure I) down through the lifting nipple or pipe 55 and casing string 19 and up through the annular space between the casing string 19 and the walls of the borehole 10 or outer casing string 5 and through the space between the supporting ribs 21 and on through the annular space between the landing nipple 55 and the drilling riser and on out the mud line T 52 to a disposal or recovery pit or the like. The circulation of fluid washes the borehole wall free from adhering mud fluid in order that cement will be able to form a good bond with the walls. After the borehole is sufficiently cleaned, a cement slurry is forced down through the pipe 55 into place behind the lower end of the casing string in any suitable manner, such as by means of spacer plugs and an overload of mud fluid, oil or the like, while the overflow of liquid displaced from the annular space between the casing string
5 and borehole walls passes freely out of the well through mud line T 52. While the cement is hardening, the lifting nipple 55 may be disconnected from the coupling 28, the drilling riser 50 removed, and annular packing ring 25 suitably sealed into the groove 25, closing the fluid passage between the radial ribs 21.

If the well is deepened by continued drilling, additional casing heads are surmounted on the bottom casing head as they are needed for suspending the additional casing strings, as shown in Figure II. For each casing string the above-described method of landing the casing in the casing head, circulating the wash liquid and cementing in the lower end or suitable portions of the casing string is applied.

With the desired casing strings installed, a tubing string 41 may be suspended in the well from a tubing head, such as the preferred form 48 hereinafter described. With the tubing head 48 in place and the tubing string 40 attached thereto, the desired control equipment, such as blow-out preventer, gate and flow valves, etc., commonly known as the "Xmas" tree 58, may be surmounted on the tubing head 40 by means of the stud bolts 50.

Although the method of the present invention has been described in relation to the illustrated preferred form of apparatus, it will be readily understood that the present invention is not limited to the apparatus described but refers broadly to the method of landing a single casing string or a casing string within an outer casing string, controlling well pressures within said string and within the annular space around said string, circulating a fluid through said string and said annular space past the point of suspension of said string, and cementing said string.

I claim as my invention:

1. The combination of a casing head having an axial bore constricted by a tapered annular shoulder, a casing coupling having spaced radial outwardly projecting ribs, each of said ribs having an upper horizontal face spaced a short distance below the upper end of said coupling and a lower inwardly tapering face adapted to seat on said shoulder, and means for closing the passages formed between said spaced ribs, said means comprising an annular sealing member insertable between the walls of said axial bore and said coupling above said ribs, said sealing member being adapted to be permanently secured to said walls and said coupling, said annular member having on its upward face a circular groove. 3. In a well head structure, the combination of a casing head having an axial bore provided with an annular constriction, an outer casing string attached to said casing head at the lower portion of said bore, an inner casing string, a coupling rigidly attached to the upper end of said inner casing string, said coupling having spaced radial outward projections adapted to seat on said annular constriction, a tubing head surmounted on and attached to said casing head, said tubing head having an axial bore, a tubing string attached to the upper portion of said tubing head in said bore, the lower portion of said bore being counterbored to a greater diameter than the upper portion, and a transverse bore in said tubing head leading from said counterbored portion of the tubing head to the outside, said transverse bore forming a vent outlet from the space between the tubing string and the inner casing string.

4. In the process of landing on a casing head a casing string having an outwardly enlarged axially channeled portion, the steps of lowering said string into the borehole until said enlarged portion engages the inner walls of the casing head, thereby suspending said string from the casing head, lowering a charge of cement into the borehole through said string and forcing it behind said string by controlling from a point above the casing head the pressure within said string and the pressure in the annular space between said string and the walls of the borehole, said last control being effected through the channels in said enlarged portion of the string.

5. In the process of landing on a casing head supporting a shorter outer casing string a longer inner casing string having an outwardly enlarged axially channeled portion, the steps of lowering said inner string into the borehole within said outer string until said enlarged portion engages the inner walls of the casing head, thereby suspending said inner string from said casing head, circulating in the borehole a fluid by passing it in one direction through said inner string and in the other direction through the annular space between the outer and the inner strings and through the channels in said enlarged portion of the inner string, lowering a charge of cement into the borehole through said inner string by applying fluid pressure from the top, and permanently securing said inner string to the casing head, thereby closing said channels.

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