Well Heads

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HISTORY

The various gushers which came in at the turn of the century made evident the need for better seals between the casing strings and more effective means to shut in wells.

The early wells used a master gate attached to the top of the last casing string. In the event a blowout started, the crew immediately attempted to get the tools out of the hole and close the master valve. Later ram blowout preventers were developed which gave control even when the pipe was in the hole.

Early Christmas trees used screwed fittings and were often held together with tie rods for additional strength. Originally these trees were field assembled. In 1932, the first factory assembled and tested trees were made available to the industry. Flanged Christmas trees first appeared around 1933-1934.

Most casing hangers were of the threaded-on type although several other unique devices were used. The conventional slip-type hangers we know today made their entry in the late thirties.

API seal rings were first used around 1936. Tie rods were used with the first flanged trees, but their use was discontinued when it became obvious there was considerably more strength in the flange bolts than in the two tie rods.

Casing flow was standard practice except for those wells which were on the pump. Tubing made its appearance in flowing wells about the mid-twenties.

WELL-HEAD COMPONENTS

A typical well head consists of the following basic components:

1. Casing or Bradenhead
2. Casing Spool (Optional)
3. Casing Hangers
4. Tubing Head
5. Tubing Hangers
6. Christmas Tree

Casing Head

The casing or Bradenhead is screwed or slip-on welded to the surface pipe. It provides the means to land and pack off the intermediate or oil string, if only two strings are run. Side outlets give entry to the surface pipe — intermediate or oil string annulus, depending on the casing program. Lockdown screws for retaining the casing hanger are optional equipment.

Casing Spool

A casing spool is required if an additional protective string is run. This provides the means for hanging the oil string and packing off the intermediate-oil string annulus. Side outlets give entry to this annulus. A recent modification, which will be discussed later, permits the spool to be used as a casing or tubing head for single or multiple completions.

Casing Hangers

As mentioned previously, the early casing hangers were of the threaded or boll weevil type. Most of the hangers in use today are the slip suspension, wrap-around type. These hangers can be wrapped around the pipe and dropped through the preventers while the pipe is still hung on the elevators. In most instances, the seal is self-energized, once the casing weight is transferred to the slips when the elevators are slacked off.

In certain instances, the "O" rings are used to effect a seal between the casing and the head after the pipe weight is suspended on the slips.

While the slip assembly is designed to carry maximum pipe weight, it must not collapse or crush the pipe from too high contact pressure. The well head manufacturers take this factor into account and run numerous pull tests, measuring the internal pipe deflection at various pipe loads.

Tubing Head

The tubing head provides the tubing hanging facility for single or multiple completions. Through its side outlets, an entry is given to the oil string annulus. In certain multiple completions, the annulus is used as a producing medium. Aligning means are incorporated in the tubing head to correctly orientate the hanger with respect to the bolt circle for multiple completions. Alignment can be obtained by retractable pins, welded lugs, or a slotted section with the hanger having a male or female connection,

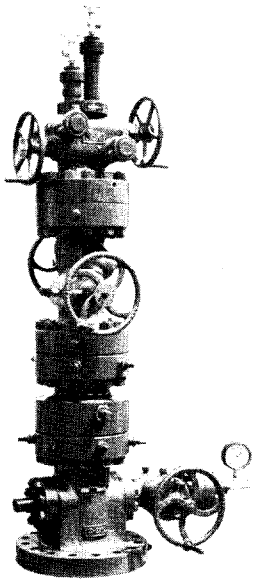


Fig. 1 Dual Completion Christmas Tree with Solid Block Valve and Dual Port Flow Control

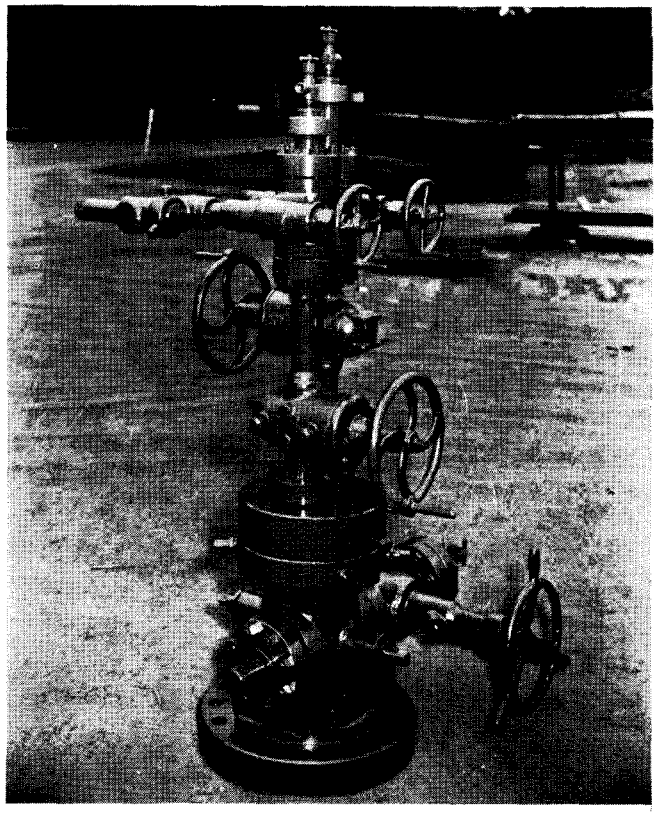


Fig. 2 Dual Completion Christmas Tree with Recessed Body Crescent Flanged Valves and Flow Controls

depending on the aligning mechanism.

Lockdown screws are provided to firmly lock the tubing hanger in place once the tubing has been landed and, if needed, to positively energize the tubing hanger seal.

The side outlets can be furnished with either threaded or flanged connections. Where flanged connections are used, the flange is usually tapped for a valve removal plug. In the event of a bad casing wing valve, the operator can go through the valve with a valve removal tool and insert a plug in the threaded connection. After the pressure is bled off, the valve is removed and repaired. It can be replaced by reversing the procedure.

Tubing Hangers

Tubing hangers for single completions are usually available in four types:

1. Threaded or boll weevil hanger
2. Wrap-around hanger
3. Slick-joint hanger
4. Bonnet hanger

Both the slick-joint and wrap-around hangers are used with some type hanger coupling, which, in turn, is screwed into the bonnet assembly. The tubing can be screwed directly into the tree, if desired.

Most hanger couplings are furnished with grooves or threads to receive back pressure valves. This valve closes the tubing string and gives the operator complete protection against tubing blowouts when the blowout preventers are being removed after the tubing is landed. Back pressure valves can also be inserted and set when it is necessary to change the lower master valve.

The slick-joint and wrap-around hangers are used in setting packers requiring vertical movement of the tubing through the tubing head. Often in high pressure wells the tubing movement is accomplished with the tree in place.

Christmas Tree

The upper tubing bonnet assembly or Christmas tree is usually custom assembled to customer specifications. For example, in certain high pressure areas, some operators desire double master and wing valves. Others prefer to equip the tree with a swabbing valve. Nearly every Christmas tree is usually equipped with a bottom hole test adapter or connection to permit ready access to the well for bottom hole pressure work, sampling, paraffin cutting, etc.

Testing

The entire Christmas tree assembly is shop tested hydrostatically to the test pressure which, in most instances, is twice the working pressure. After this test, the tree is painted and skid-mounted for domestic use or crated for foreign shipment.

Provisions are made to field test all seals by means of test ports located in the flanged connections. Loss of pressure applied through these ports indicate a seal failure. This test also shows if the casing hanger packoffs are holding satisfactorily.

Multiple Completions

The first dual completion, using two parallel strings of tubing, was run in 1941. Little activity continued in the field of dual completions until approximately 1954 when large scale multiple completions commenced.

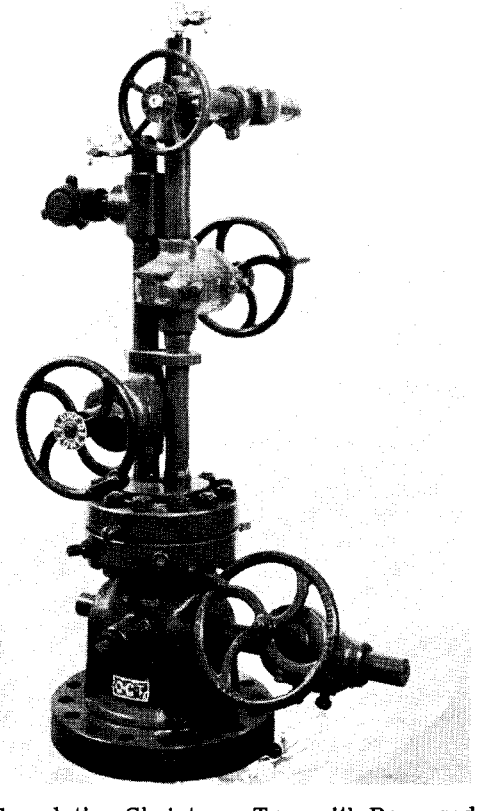


Fig. 3 Dual Completion Christmas Tree with Recessed Body Screwed Valves

The development of multiple completion equipment has expanded to quadruple completions. One operator is currently contemplating running five string of tubing, a quintuple completion!

Valve Combinations

Close cooperation between the valve and well head manufacturers has resulted in some standardization of valve centerlines for the various size tubing strings. Numerous special assemblies are still manufactured, however.

Three choices of multiple valve arrangements are available to the operator — solid block valves, individual recessed body flanged valves, and recessed body valves for screwed connections. All combinations have the same centerline distances for a given valve size. These installations are shown in Figs. 1, 2 and 3.

In most instances, the individual flanged valve gives the operator the rigidity of the flanged connection at a somewhat lower cost than the block valve. Multiple completion wells with screwed connections are usually used in the lower pressure ratings.

Flow Controls

A flow control is a unique unit which performs the functions of a Christmas tree cross or tee, wing valve, adjustable or positive choke, and bottom hole test adapter. It also eliminates the flanged connections between the tee and bottom hole test adapters, tee and wing valves, and between wing valve and choke.

This device, which is currently available for both single and dual completions, is shown in Fig. 4. The operator can readily use the unit with a positive or adjustable choke if desired. This unit connects directly to the flanged valve top.

A dual flow control for single completions, which permits the operator to change choke sizes without shutting in the well, is also available.

Tension Hanging of Tubing Strings

Well heads incorporating tension hanger assemblies are now becoming more prevalent for dual completions. Hanging tubing in tension eliminates the possibility of helical buckling of tubing strings when one or both zones are sucker rod pumped. According to some reports, the possibility of tubing collar leaks is minimized by tension hanging. Tension heads also attempt to straighten tubing strings in crooked holes, making wireline work less difficult.

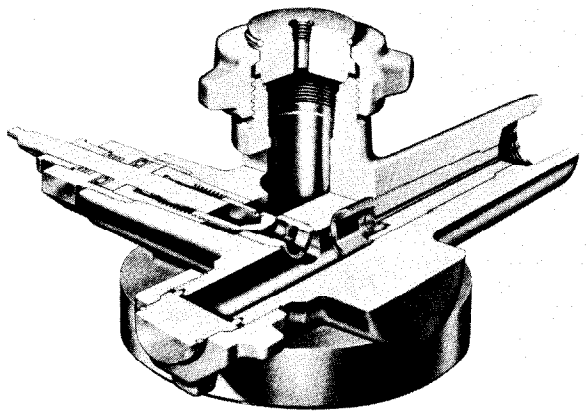


Fig. 4 Flow Control — Sectional View

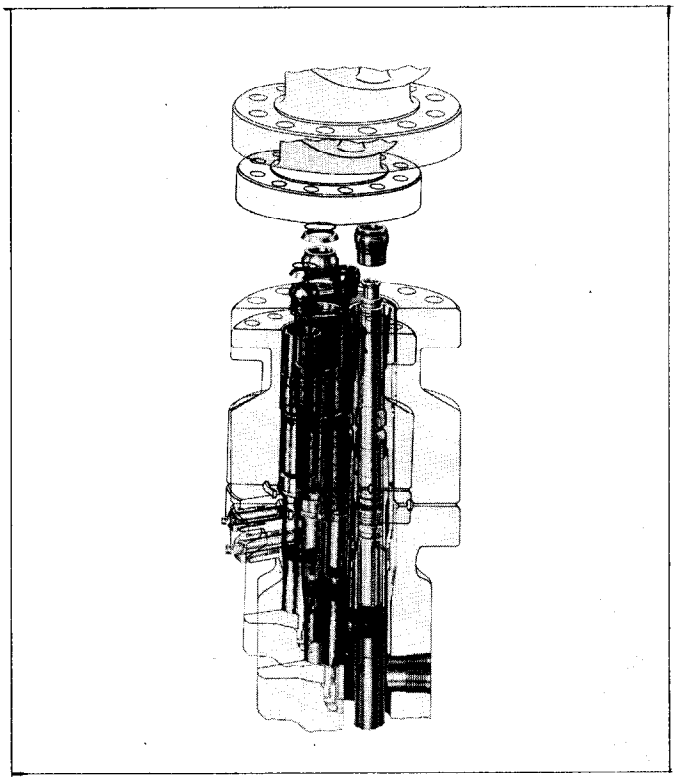


Fig. 5 Sectional View Dual Tubing Hanger Assembly for Lifting Both Tubing Strings with Christmas Tree in Place

Versatility

Well head manufacturers are continuously attempting to build more flexibility into their equipment. A good example of this trend is the combination head now available which permits an operator to hang a casing string or one to four strings of tubing in the same head without removing the blowout preventers. This insures the operator complete safety as all work is done through the preventers. No stripping is required to change heads with resultant loss of rig time.

Multiple completion equipment using split hanger sections giving maximum opening permits the operator to run any type gas lift valves through the preventer system.

In certain high pressure installations, operators are running dual parallel strings of 2-7/8 in. tubing with concentric 1-1/4 in. macaroni strings. Inhibitor is injected in the 2-7/8 - 1-1/4 in. annulus while the well is produced through the macaroni string. The concentric strings also offer a simple method to kill the well if necessary. An installation of this type is discussed in the October 1957 issue of World Oil.

Completions Through Christmas Trees

Recent developments permit an operator to complete or kill a well through the Christmas tree, eliminating the need for circulating sleeves. This system requires an additional tubing attachment and stuffing box type hangers. A cross section of this tree is shown in Fig. 5.

The entire tree is lifted and mud displaced from both strings. The stuffing box isolates the tubing head. During the lifting operation, the packer seals are broken, but the stingers remain in the packer to assure re-entry. After circulation is complete, the tree is lowered and attached to the tubing head. Basically, the same process is followed if it becomes necessary to kill the well.

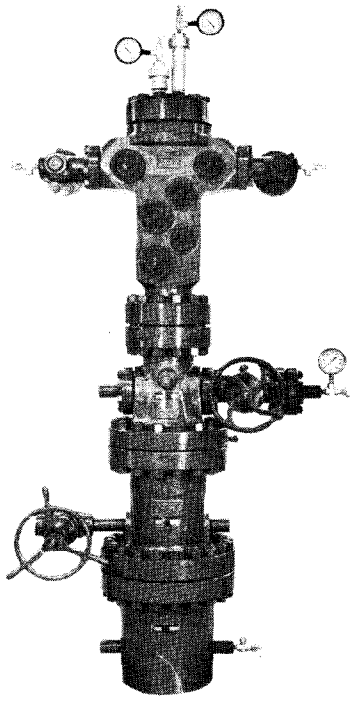


Fig. 6 Dual Completion Unitree with Double Master and Wing Valves

Unitree or Unitized Tubing Head

One of the most recent developments in well head art has been the unitized Christmas Tree which eliminates numerous flanges and reduces the height and weight considerably. These trees are available in two types: (1) The valve is an integral part of the tree, and (2) The valve is a complete independent unit which can be inserted or replaced at will. In one unit, which uses this type valve, the seals between the valve and tree have been thermally shock tested with dry nitrogen to 17,500 psi and hydrostatically tested to 35,000 psi. A typical dual Unitree is shown in Fig. 6.

Generally, these trees are less expensive than conventional units. Since the tree is quite compact, the need for platform or scaffolding is eliminated.

Safety

Complete well control during drilling and completion is of paramount importance. The blowout preventers are only removed when the tubing has been landed and the annulus sealed.

The equipment of all leading well head manufacturers permits the running and pulling of tubing strings through the blowout preventer. Thus, no stripping operation is necessary and the well is under complete control at all times.

By using efficient casing annulus seals and back pressure valves for the tubing bore, the well is effectively shut-in when the blowout preventers are removed prior to the final nippling up of the Christmas tree. The back pressure valves can be lubricated through the tree, if necessary, under full well head pressure. If the Christmas tree must be removed for repair or change, the back pressure valves can again be inserted into position prior to unbuttoning the tree. As mentioned previously, all Christmas tree seals can be field tested if necessary.

Seals

While API seal rings between flanges are used on most equipment to insure standardization and interchangeability, the inner seals in the run of the tree vary with the various suppliers.

These inner seals include the Flex-Float metal seal rings which are pressure energized, "O" rings, plastic energized rings, plastic packing, and resilient sandwich type seals. All these seals perform satisfactorily when used as the manufacturer prescribes.

AWHEM Flange

The large flange sizes required for high pressure ratings can be decreased somewhat in both size and weight by sealing on a restricted area. As a result, the present AWHEM flange has been tentatively adopted as an API standard for 10,000 and 15,000 psi working pressure trees. A comparison between the standard API flange and the AWHEM flange is shown in Fig. 7.

Tubingless Completions

In its constant search for methods to reduce drilling and completion costs, the petroleum industry has developed the tubingless completion technique. The well is completed with 2-7/8 in. pipe as the casing string for both single and multiple completions.

Almost all the downhole equipment required for conventional wells has been modified for this method. Wells can be artifically lifted through 1-1/2 in. integral joint or 1-1/4 in. tubing using 1/2 in. rods. Directional perforating technique, to assure positive orientation of the gun before firing, is readily available.

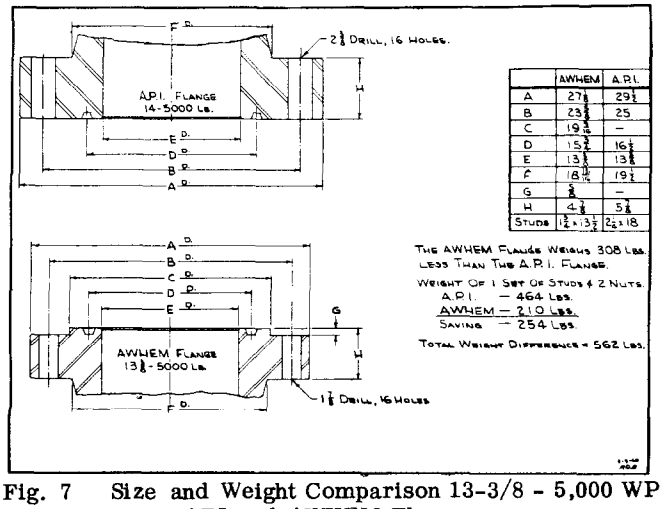
The success of tubingless completions demands a perfect cement job to insure elimination of any possible channelling or communication between zones.

Well heads are now available to permit individual running of each string. Large openings are needed to pass the centralizer and turbulizers through the head. Flexibility permits the running and hanging of the macaroni strings in the same head.

CONCLUSION

The well head industry is continuously striving to improve its products and develop those required for new drilling and completion techniques.

Improved engineering staffs are organized to help recognize the equipment problem and solve it for the customer with low cost, fully tested, and well engineered equipment. Highly automatic machines are being installed to reduce the manufacturing costs and to pass this savings on to the customer.



	AWHEM	A.P.I.
A	27⅛	29½
B	23⅜	25
C	19⅝	—
D	15½	16½
E	13⅝	13⅝
F	18⅛	19½
G	⅝	—
H	4⅜	5⅛
Studs	12 x 1 3/8	2½ x 18

Fig. 7 Size and Weight Comparison 13-3/8 - 5,000 WP API and AWHEM Flanges