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CASING HEAD STRUCTURE

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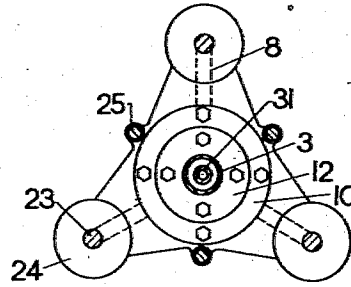
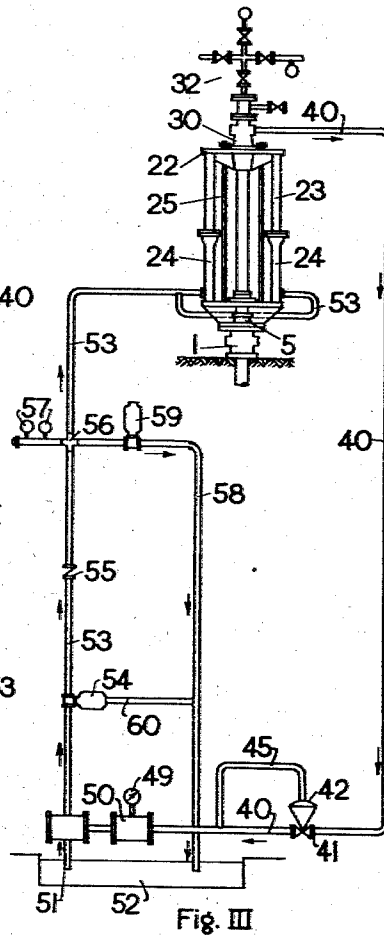
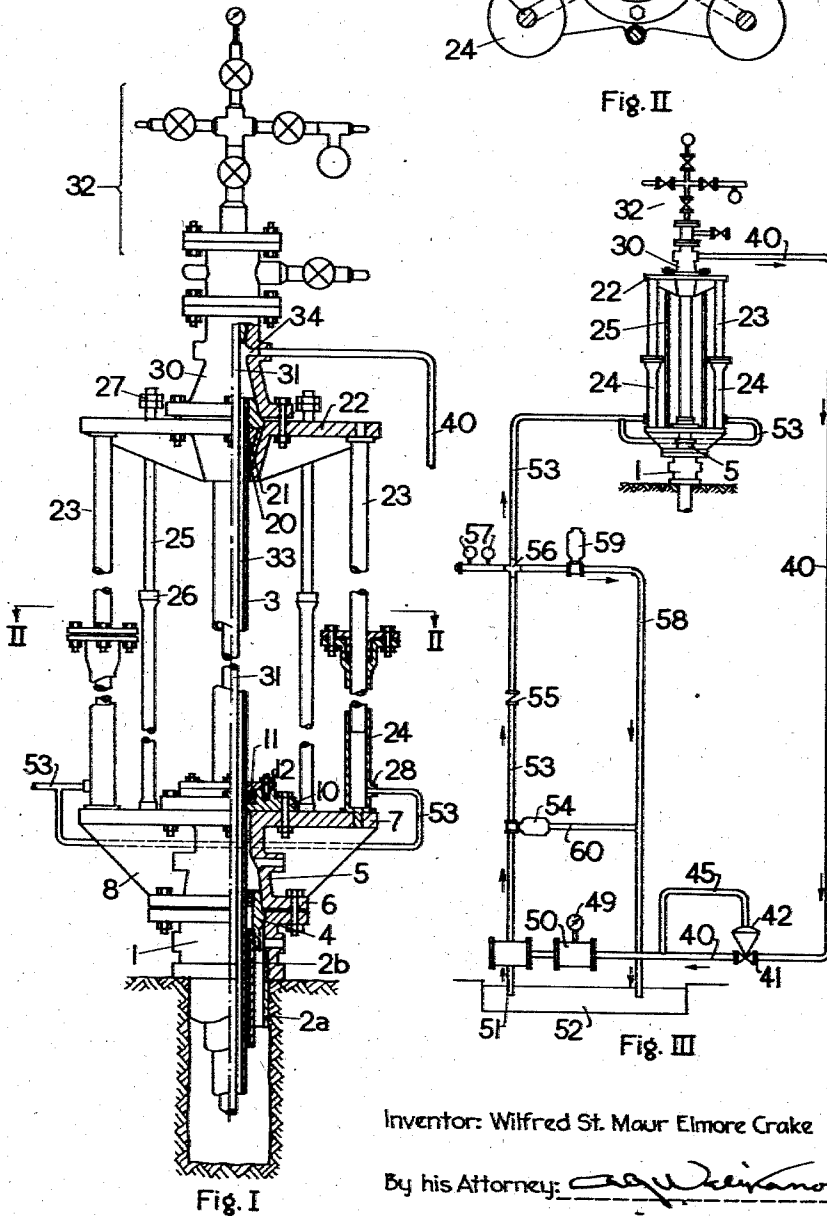


Fig. II



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CASING HEAD STRUCTURE

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The present invention relates to oil and gas well casing heads and tubing supports and pertains more particularly to a device of the expansion joint type adapted to maintain the load or stress on the elements supporting a casing string at an approximately constant value by compensating for the expansion or contraction of said casing string due to temperature variations within the oil well.

In deep wells, casing strings are set under certain temperature conditions with the lower end imbedded and held in cement and with the upper end held by the casing head. Since the ends of the casing string are thus rigidly fixed, a different set of temperature conditions causes the casing string to be stretched or compressed by various amounts. Particularly in deep wells, a change in temperature of the casing string which may be due to variations of the temperature of the fluid flowing therethrough, and which may sometimes have amplitudes as high as 100° F., often causes failure of the string and results in highly expensive corrective measures and replacements or even in a total loss of the well.

It is therefore an object of this invention to provide means for supporting casing strings wherein the point of support is not rigidly fixed at the casing head, but is capable of a limited axial motion whenever such motion is made necessary by a temperature-responsive elongation or contraction of the casing string.

It is also an object of the present invention to provide a device for maintaining a constant load on the casing head by compensating for variations in the length of a casing string caused by temperature variations.

It is a further object of this invention to provide a system wherein a compensation in the length of casing string is automatically effected in response to any changes in the length of said string caused by well conditions.

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 in the accompanying drawing, wherein:

Figure I is a partial vertical sectional view of a preferred embodiment of the present invention.

Figure II is a transverse sectional view taken along the lines II—II of Figure I.

Figure III is a schematic view of the present

casing support and a preferred control system as installed at a well.

Referring to Figures I and II of the drawing, the present device comprises a casing head generally indicated at 1. Any number of such casing heads may be used if desired to suspend a plurality of casing strings. For purposes of illustration, however, a casing string 2a is shown directly suspended on casing head 1 and a casing string 2b is shown suspended indirectly on casing head 1 by means of a tapered coupling 4. The last or so-called "oil string" 3 is suspended as subsequently described on the casing supporting device of the present invention. For this purpose a special casing head spool 5 is attached by means of flanges above the casing head 1 and is added to the assembly, in the illustration shown, after the intermediate or penultimate string 2b has been set. This special spool 5 has a flange 6 in its lower portion, preferably a large flange 7 in its upper portion, and vertical radial braces 8 between said flanges 6 and 7. Above and fastened to the upper large flange 7 is a packing ring 10 carrying a packing gland 11 and packing retainer ring 12. This packing assembly or any other suitable packer means is adapted to effect a seal about the last casing string 3 which extends therethrough, and to prevent the escape of fluid from the annular space between the intermediate casing string 2b and the last casing string 3.

The oil string 3 is suspended in any suitable manner, such as by means of a tapered bowl 20 and tapered grips 21, in a transverse head 22, which is supported by rams 23. The rams 23 fit slidably in cylinders 24, which are supported and project up from the large flange 7 on the special spool 5. Means, such as ports 28 and conduits 53, are provided in the lower portion of the cylinders 24 for injecting fluid thereinto from the subsequently described control system.

In a preferred embodiment, as shown in Figure 2, three hydraulic cylinders 24 and rams or pistons 23 are provided and vertical radial braces 8 for the spool flange are positioned with their outer ends directly under said cylinders. Likewise, attached to the upper surface of the flange 7 and spaced in between said cylinders 24 are combination guiding and motion-limiting rods 25, which project through the head 22 and are fitted with limiting stops in the form of shoulders 26 below said head and nuts 27 above said head.

Above the head 22 is a tubing head 30, which supports the tubing 31 and closes the annular space between the tubing 31 and oil string 3.

The tubing head 30 is surmounted by a suitable valve assembly or "Christmas tree" 32, as shown in Figures I and III.

Pressure fluid is injected through ports 28 into the cylinders 24 to raise the rams 23 and is withdrawn therefrom to lower the rams 23 in response to increases and decreases, respectively, in the length of the casing supported by the floating well head. The amount and the pressure of fluid in the supporting cylinders 24 may be regulated either manually, for example, in accordance with the readings of suitable temperature and pressure indicating devices, or by means of a suitable control system, such as described hereinbelow.

The control system comprises broadly any suitable means for regulating the amount of fluid in the cylinders 24, in response to changes in the load imposed on the suspending assembly as a result of variations of the temperature of the casing.

In a preferred embodiment pressure fluid is obtained from the annular space 33, as shown in Figure I, between the casing 3 and tubing 31 and is led from a port 34 in the tubing head 30 through conduit 40, preferably to a suitable regulating valve such as a diaphragm motor valve 41. The diaphragm 42 of motor valve 41 is preferably exposed by means of line 45 to the fluctuating pressure in the line 40 on the downstream side of the motor valve 41 or, if desired, directly to the pressure in the cylinders 24. By means of such a diaphragm motor valve the application of pressure fluid through line 40 to the impeller side of a duplex piston-type pump 50, for example, may be accurately controlled. A gauge 49 connected to the impeller side of the pump 50 is provided to aid in setting the control valve 41. Pump 50, having a suction line 51 depending into a sump or reservoir 52, forces pressure fluid, such as oil, water, etc., through a line 53 leading to the cylinders 24. Line 53 contains a safety or regulating valve 54, for example, of the spring-loaded type, a check valve 55, and a line cross 56. The safety valve 54 is provided to control the maximum pressure applied to the cylinders by means of the pump action and may be provided with a return line 60, discharging back into the sump 52. The check valve 55 prevents any pressure, in excess of that for which valve 54 is set, from flowing back through valve 54 and the pump 50. To one side of cross 56 a pressure gauge or, preferably for accuracy, a pair of pressure gauges 57 are connected and to the other side of said cross 56 is attached a bleeder line 58 discharging to the sump 52 and containing a bleeder or relief valve 59 set to release from cylinders 24 and line 53 any pressure in excess of a predetermined value.

In operation of the present device the well head structure is assembled as described above. In the preferred embodiment the pressure fluid which provides the motive power for the pump 50 is obtained from the annular space 33 between the casing and tubing, as shown in Figure I. However, any other source of pressure fluid or other types of prime mover units which can be easily regulated may be used, if desired, the important object being mainly to effect an axial displacement of the point of support of the casing as a function of an elongation or contraction of the casing string. In the preferred form, as shown, the application of pressure fluid to the pump 50 is controlled by the diaphragm motor control valve 41. The pump 50, which is actuated by said controlled pressure, forces fluid, such as

oil, from the sump or reservoir 52 through the line 53 into the ram system.

By means of the regulating valve 54 in line 53 and the bleeder valve 59 and line 58, which valves are set for a predetermined pressure, the pump 50 maintains a constant upward force on the rams 23 and will pump fluid into the cylinders 24 as long as the ram-supported casing 3 continues to extend in length. Pressure developed by the pump in excess of this pressure is discharged by safety valve 54 through line 60 back into the sump 52. The upward limit of movement of the rams is governed by the stop nuts 12 on the upper end of the rods 25. Beyond this limit, as determined in advance by conditions for which the system is designed, the compensation will not be effective or necessary.

When contraction of the casing string 3 occurs, the increased weight applied to the fluid in the cylinders 24 will cause the bleeder valve 59 to open and discharge through the line 58 into the sump or reservoir 52. The bleeder valve 59 is set to relieve at a slightly higher pressure than the inlet regulating valve 54. The pressure gauges 57 are used in setting the valves 54 and 59 to a previously determined calculated value which is designated as p_2 and may be calculated by the equation:

$$p_2 = \frac{W - [p(A - A_2) + p_1 A_1]}{A_3}$$

wherein:

W is the portion of the weight of the casing which it is desired to support at the casing head (usually as determined by field practice requirements from $\frac{1}{3}$ to $\frac{1}{2}$ of the casing weight) plus the weight of the tubing string, floating casing head assembly, rams, etc.;

A is the internal area of oil string 3;

A₁ is the internal area of tubing 31;

A₂ is the external area of tubing 31;

A₃ is the area of the rams 23;

p is the pressure inside the oil string 3;

p₁ is the pressure inside the tubing 31; and

p₂ is the pressure required in cylinders 24 to balance the load W.

Friction, since it will be negligible in comparison with other forces involved, is neglected in the above formula. It may be readily seen that W represents the force acting downward and the force acting upward is the expression within the brackets, which expression may be readily revised to suit different conditions, such as for example when more than one casing string is supported by the floating head.

Since A, A₁, A₂ and A₃ are constants for any specific assembly and p and p₁ do not normally vary rapidly, p₂ may be calculated for any set of conditions of the upward forces. Further, since p₁A₁ is usually small compared with W, while the well is flowing, a suitable constant may be substituted by assuming p₁ at a maximum value, which would be the tubing "shut-in" pressure. The major and only variant, within the accuracy required, would be casing pressure p which, if assumed to be bottom-hole pressure, would also be a maximum. By thus using maximum estimated upward forces, the conditions that the net upward force does not exceed the weight of the casing and equipment desired to be supported is satisfied.

It is therefore possible by controlling the ram pressure at a predetermined pressure p₂ to keep a substantially constant vertical load supported by the casing head. Increases or decreases in

the length of the casing string due to temperature changes will cause increases or reductions, respectively, in the volume of fluid supporting the rams 23 due to the system of automatic valves and controls feeding or removing fluid from the ram cylinders 24.

I claim as my invention:

1. In a well head structure for supporting a substantially constant portion of the weight of inner casing strings, a stationary casing head member supporting an outer casing string, a second casing head member movably carried by said stationary member, engaging means on said second member for supporting an inner casing string said inner casing string comprising tubular members rigidly connected together and having its lower end held stationary, and pressure means slidable in a direction co-axial with the casing strings for supporting said movable member on said stationary member.

2. In a well head structure for supporting a substantially constant portion of the weight of inner casing strings, a stationary casing head member supporting at least one outer casing string, a plurality of vertical hydraulic cylinders mounted on said member, rams adapted for reciprocation in said cylinders, said rams extending vertically upwards from said cylinders, a crosshead carried by said rams, engaging means on said cross head for supporting at least one inner casing string said inner casing string comprising tubular members rigidly connected together and having its lower end held stationary, and hydraulic means in communication with said cylinders for applying fluid pressure to said rams.

3. In a well head structure for supporting a substantially constant portion of the weight of inner casing strings, a stationary casing head member supporting at least one outer casing string, a plurality of vertical hydraulic cylinders mounted on said member, rams adapted for reciprocation in said cylinders, said rams extending vertically upwards from said cylinders, a crosshead carried by said rams, engaging means on said crosshead for supporting at least one inner casing string said inner casing string comprising tubular members rigidly connected together and having its lower end held stationary, vertical guide means mounted on said casing head member slidably engaging said crosshead, stop means on said guide means for limiting the vertical travel of said crosshead, and hydraulic means in communication with said cylinders for applying fluid pressure to said rams.

4. In a well head structure for supporting a substantially constant portion of the weight of inner casing strings, a stationary casing head member supporting at least one outer casing string, a plurality of vertical hydraulic cylinders mounted on said member, rams adapted for reciprocation in said cylinders, said rams extending vertically upwards from said cylinders, a crosshead carried by said rams, engaging means on said crosshead for supporting at least one inner casing string said inner casing string comprising

ing tubular members rigidly connected together and having its lower end held stationary, hydraulic means in communication with said cylinders for apply fluid pressure to said rams, and valve means for maintaining said pressure at a substantially constant value, said valve means comprising a regulating valve adapted to maintain the pressure applied from said hydraulic means to said cylinders at a predetermined value, and a safety valve adapted to release from said cylinders pressures in excess of said predetermined value.

5. In a well head structure for supporting a substantially constant portion of the weight of inner casing strings, a stationary casing head member supporting at least one outer casing string, a plurality of vertical hydraulic cylinders mounted on said member, rams adapted for reciprocation in said cylinders, said rams extending vertically upwards from said cylinders, a crosshead carried by said rams, engaging means on said crosshead for supporting at least one inner casing string said inner casing string comprising tubular members rigidly connected together and having its lower end held stationary, hydraulic means in communication with said cylinders for applying fluid pressure to said rams, and valve means adapted to regulate the amount of pressure fluid in said cylinders in response to changes in the length of the casing strings supported by said crosshead.

6. In a well head structure for supporting a substantially constant portion of the weight of inner casing strings, a stationary casing head member supporting at least one outer casing string, a plurality of vertical hydraulic cylinders mounted on said member, rams adapted for reciprocation in said cylinders, said rams extending vertically upwards from said cylinders, a crosshead carried by said rams, engaging means on said crosshead for supporting at least one inner casing string said inner casing string comprising tubular members rigidly connected together and having its lower end held stationary, hydraulic means in communication with said cylinders for applying fluid pressure to said rams, and valve means adapted to regulate the amount of pressure fluid in said cylinders in response to changes in the pressure in said cylinders.

7. A producing well structure comprising outer and inner rigid casing strings depending into a well borehole, said strings having their lower ends rigidly held in the borehole, in combination with a well head structure comprising a stationary casing head member supporting said outer casing string, a second casing head member movably carried by said stationary member, means on said second member for engaging said inner casing string, and pressure means slidable in a direction coaxial with the casing strings for supporting said movable member and a substantially constant portion of the weight of said inner casing string engaged by said movable member on said stationary member.

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