Scientific Observation Hole Program

SOH-2

Drilling Permit Amendment

DRILLING PROGRAM
Hawaii Scientific Observation Hole Program
Prepared for
Hawaii Natural Energy Institute
by
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General

The following drilling program is for a series of observation holes to be drilled on the islands of Hawaii and Maui. The wells are designed for observation purposes only and not for the discharge of geothermal fluids. A combination of rotary and core drilling methods will provide the maximum flexability to handle the variety of anticipated drilling conditions.

Casing and cementing programs and the blowout prevention ("BOP") equipment to be used will provide protection from any potential overpressured zones and allow the hole to be shut in at any stage during the drilling after the upper 100 feet of conductor casing is in place. The BOP equipment will conform to or exceed specifications in Title 13, Chapter 183-74.

Below 100 feet continuous core will be taken. This will provide invaluable information for determining the nature of loss-of-circulation zones, fracturing, permeability, rock type and reservoir characteristics. With this information, in addition to mud and down-hole temperatures and surface elevation, casing points and intervals requiring spot cementing will be determined on a hole-by-hole basis as the drilling progresses.

Drilling Plan

Phase 1: Conductor Casing

1. Drilling for, and installing conductor casing will be performed with either the Universal 5000 drilling rig or by a local cable drilling contractor.

2. Move drilling rig on site, rig up and drill a minimum 16.5 inch diameter hole from surface to 100 feet. Hole may be deepened if competent formation is not encountered by 100 feet.

3. Set 13.375 inch, K-55, 61 lb/ft casing from surface to total depth ("TD").

4. Cement annulus from surface to TD with approximately 60 cubic feet of 7-sack Redimix concrete (7 sacks Portland cement per cubic yard with 1 inch minus gravel.)

Phase 2: Surface casing

1. Install a 12 inch Series 900 (3,000 psi) wellhead flange, a 12 inch 3,000 psi hydraulic double-gate preventer with pipe and blind rams and a high speed rotating head. Wellhead flange will have 2 inch choke-kill lines, with 3M (3,000 psi) 2 inch gate valves, connected to the mud pump (see Figure 2).

2. Test BOP equipment to 200 psi for 20 minutes. Repeat test for both pipe and blind rams.

3. Core drill from casing shoe to 400 - 1,000 feet with CHD-134 coring equipment (5.35 inch hole). Depth of each hole will be determined by hole conditions, surface elevation, lithology and bottom hole temperatures. Drilling fluids will be contained in above ground tanks.

4. Open hole to 12.25 inch diameter using rotary hole opener.

5. Run 9.625 inch, K-55, BT&C, 40 lb/ft casing with float shoe and centralizers to TD.

6. Condition hole by circulating through casing.

7. Cement through casing with Class G cement with 40% silica flour using services of a cementing company (ie. Halliburton, Dowell, BJ or equivalent).

Phase 3: Intermediate casing string #1

1. Core drill from float shoe to 1,000 - 2,000 feet with CHD-134 (5.35 inch hole) coring equipment. Depth on each hole will be determined by hole conditions, surface elevation, lithology and bottom hole temperatures.

2. Open hole to 8.5 inch diameter using rotary hole opener.

3. Run 6.625 inch, L-80, BT&C, 32 lb/ft casing with float shoe and centralizers to TD.

4. Condition hole by circulating through casing.

5. Cement through casing using API Class G cement with 40% silica flour using services of a cementing company.

6. Remove 12 inch BOP equipment.

7. Install a Series 900 (3,000 psi) wellhead flange with two 2 inch flanged outlets on the 6.625 inch casing. Choke/kill lines will be attached to the wellhead and have 3M (3,000 psi) 2 inch gate. Install BOP equipment consisting of a 6 inch gate valve (3,000 psi minimum), a 6 inch 3M LWP hydraulic double-gate preventer with pipe (rams for CHD-134, HQ and NQ rods will be on location) and blind rams, a 7 inch hydraulic annular preventer and high speed rotating head (see Figure 3).

8. Test pipe and blind rams to minimum of 1,000 psi for 20 minutes each. Test annular preventer to 500 psi for 20 minutes.

Phase 3-A: Intermediate casisng string #2. If hole conditions prevent setting 6.625 inch casing to a sufficient depth, an additional string of casing will be installed as follows:

1. Core drill from float shoe to 1,800 - 2,900 feet with CHD-134 (5.35 inch hole) coring equipment. Depth on each hole will be determined by hole conditions, surface elevation, lithology and bottom hole temperatures.

2. Cement CHD-134 drill rods in place by cementing through the drill rods with API Class G cement with 40% silica flour. Cement will overlap a minimum of 200 feet into the annular space between the CHD-134 drill rods and the 6.625 inch casing.

3. Upon completion of drilling operations, a mechanical cutter will be used to cut the CHD-134 drill rods above the 200 foot cement overlap and the uncemented portion of the string removed.

Phase 4: Coring and completion

1. Drill out of 6.625 inch casing with CHD-134 core equipment and complete hole to final TD of 4,000 - 6,500 feet. If Phase 3-A was utilized and CHD-134 rods are cemented in the hole, drilling will continue with HQ core drilling equipment (3.85 inch hole and 2.50 inch core).

2. If down hole formation conditions require temporary casing to continue drilling, the core drilling equipment can be "nested", stepping down from CHD-134 rods (5.00 inch O.D. x 4.125 inch I.D. in a 5.35 inch hole) to HQ (3.50 inch O.D. x 3.06 inch I.D. in a 3.85 inch hole) to NQ (2.75 inch O.D. x 2.38 inch I.D. in a 3.04 inch hole) and using each previous string of drill rods as temporary casing.

3. Complete hole by running 2.75 inch tubing (NQ drill rods) to TD. The tubing may be run inside CHD-134 or HQ drill rods to eliminate problems caused by unstable formation intervals in the hole. Maintain fluid level in hole by continual pumping of drilling fluid through kill line during all completion operations.

4. Pull drill rods.

5. Remove BOP equipment and install a Series 900 tubing head on the existing wellhead flange and cap with two 3M 3 inch gate valves to permit access. Install 3M 2 inch gate valves on each side of wellhead flange (see Figure 4).

6. Rig down and move equipment off location.

Drilling Fluids Program

Details of the drilling fluids program will be adjusted as drilling conditions change. The general program will be as follows:

100 - 1,000 feet:
Use extra high yield bentonite for viscosity. Maintain weight at 8.5+ lbs/gal and viscosity at 40 - 50 seconds. Loss of circulation will be controlled with the use of fiberous materials such as cottonseed hulls, Multi-Seal, sawdust or locally available materials. Spot cementing may be necessary in severe intervals.

1,000 feet to TD, mud temperatures less than 300 F:
Use extra high yield bentonite and liquid polymer for viscosity. Control loss of circulation with fiberous materials or spot cementing.
Concentrations:

Bentonite	5 - 10 lbs/bbl
Liquid Polymer	0.2 - 0.5 lbs/bbl
Rings Out (or equivalent)	0.1 - 0.2 lbs/bbl

1,000 feet to TD, mud temperatures 300 F - 450 F:
Use small quantities of sepiolite with additions of Aquatex (or similar polymer) for yield point control and a drilling mud surfactant (DMS) to aid in even flow properties and rod vibration. Control loss of circulation with fiberous materials or spot cementing.
Concentrations:

Sepiolite	2 - 5 lbs/bbl
Aquatex	2 - 4 lbs/bbl
DMS	1 - 2 lbs/bbl
Oxygen scavenger	0.25 - 1.0 lb/bbl (above 400 F)

1,000 feet to TD, mud temperatures 450 F - 600 F:
Use high temperature polymer and oxygen scavenger. As temperatures increase, viscosity becomes more difficult to maintain. Control loss of circulation with fiberous materials or spot cementing.
Concentrations:

High temperature polymer	1.5 - 4 lbs/bbl
Oxygen scavenger	0.25 - 1.0 lbs/bbl

Note: Mud temperatures reflect actual mud temperatures in hole, not formation or geothermal fluid temperatures.

Monitoring

Temperature Measurements

Measurements of the return drilling fluid temperatures will be made with a continuous recording thermograph. While making bit changes and runs for core, bottom hole temperatures will be measured using a series of maximum recording thermometers, in pressure tight containers, lowered to the bottom of the hole.

Hydrogen Sulfide Monitoring

Although dangerous levels of hydrogen sulfide gases are not likely, a H2S safety system will be employed. A detector will be located at the base of the wellhead and a second detector near the fluid discharge line will sound visual and audio alarms if H2S gas is emitted from the well. Three Scott air packs will be kept on site for use by personnel if dangerous concentrations of H2S occur.

UNIVERSITY OF HAWAII
SOH casing program

Figure 1

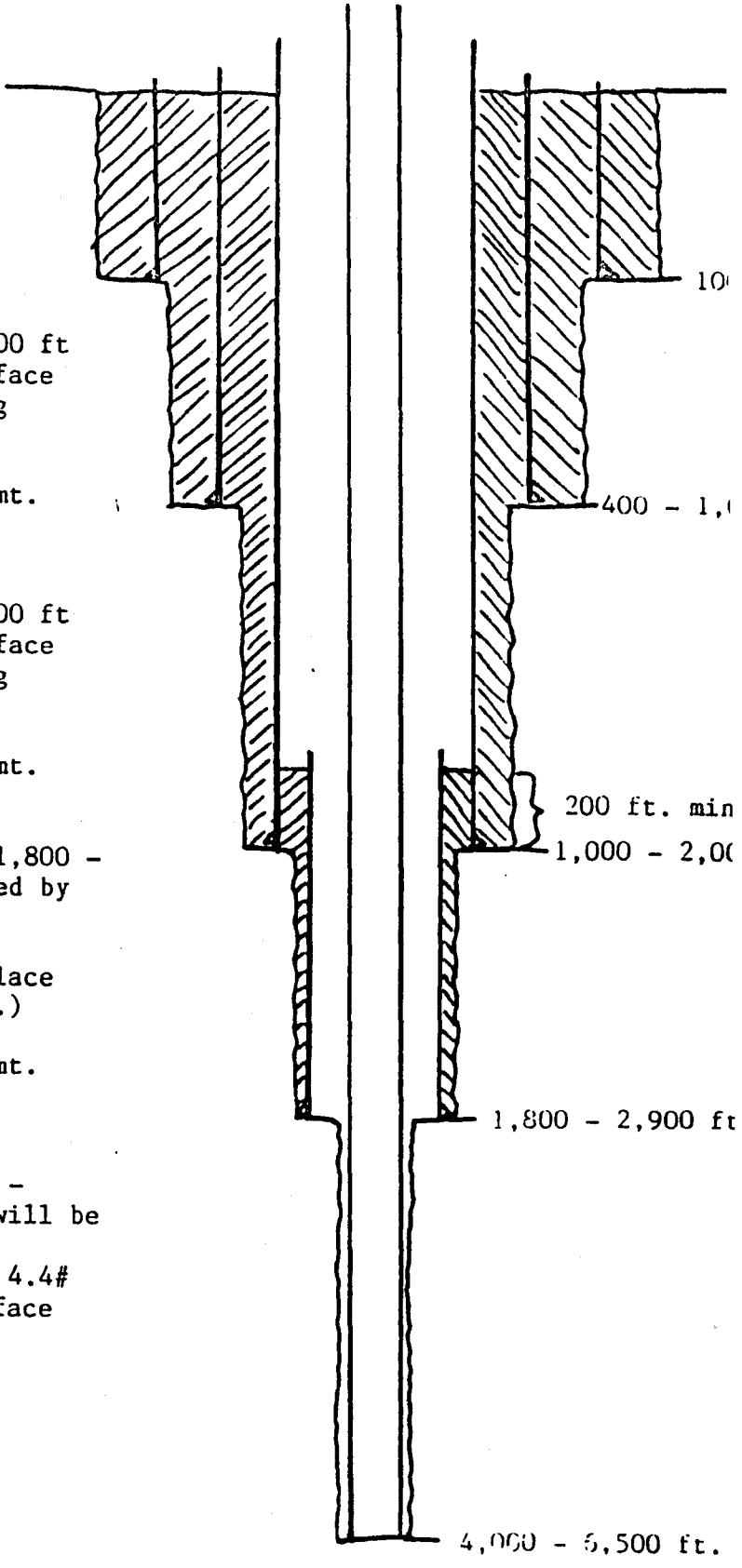
Phase 1: Drill 16.5" hole from surface - 100 ft.
Run 13.375" K-55 61# casing
Cement with redimix

Phase 2: Drill 12.25" hole to 400 - 1,000 ft (depth to be determined by surface elev., hole temp., and drilling conditions)
Run 9.625" K-55 40# casing
Cement w/ Class G high temp. cmt.

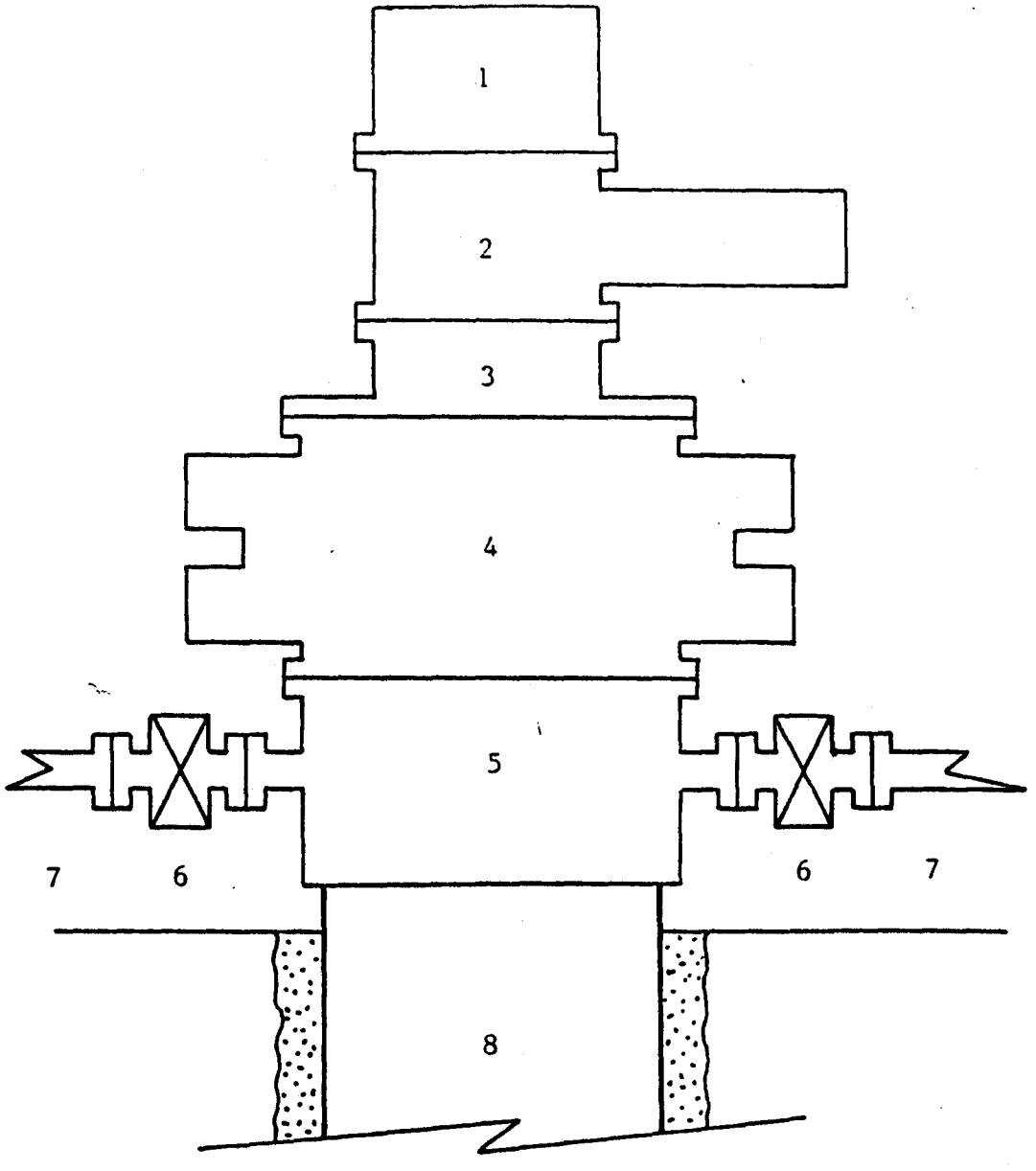
Phase 3: Drill 8.5" hole to 1,000 - 2,000 ft (depth to be determined by surface elev., hole temp., and drilling conditions)
Run 6.625" L-80 32# casing
Cement w/ Class G high temp. cmt.

Phase 3-A If required: Drill 5.35" (CHD-134) hole to 1,800 - 2,900 ft (depth to be determined by surface elev., hole temp., and drilling conditions)
Cement CHD-134 drill rods in place and overlap cement 200 ft (min.) into 6.625 x 5" annulus)
Cement w/ Class G high temp. cmt.

Phase 4: Drill 3.85" hole (HQ) to 4,000 - 6,500 ft. If necessary, hole will be reduced to 3.04" (NQ).
Complete hole by hanging 2.75" 4.4# tubing (NQ drill rod) from surface to TD.



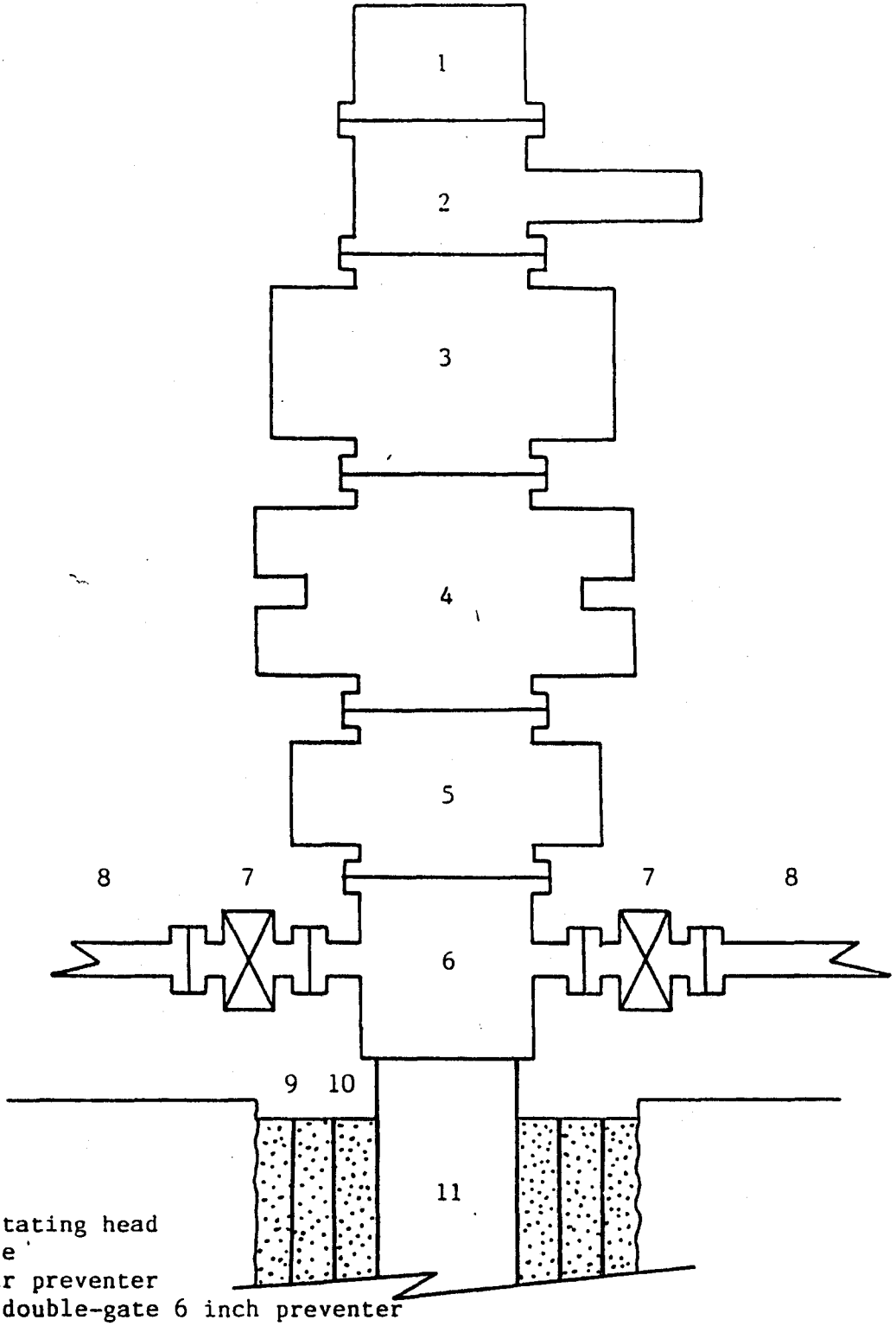
Wellhead equipment for 13.375 inch casing



1. High speed rotating head
2. Picture nipple
3. Reducing spool
4. Hydraulic 3M double-gate 12 inch preventer
5. Series 900 wellhead flange
6. 3M 2 inch gate valves
7. 2 inch choke/kill lines
8. 13.375 inch, K55 casing

Figure 3

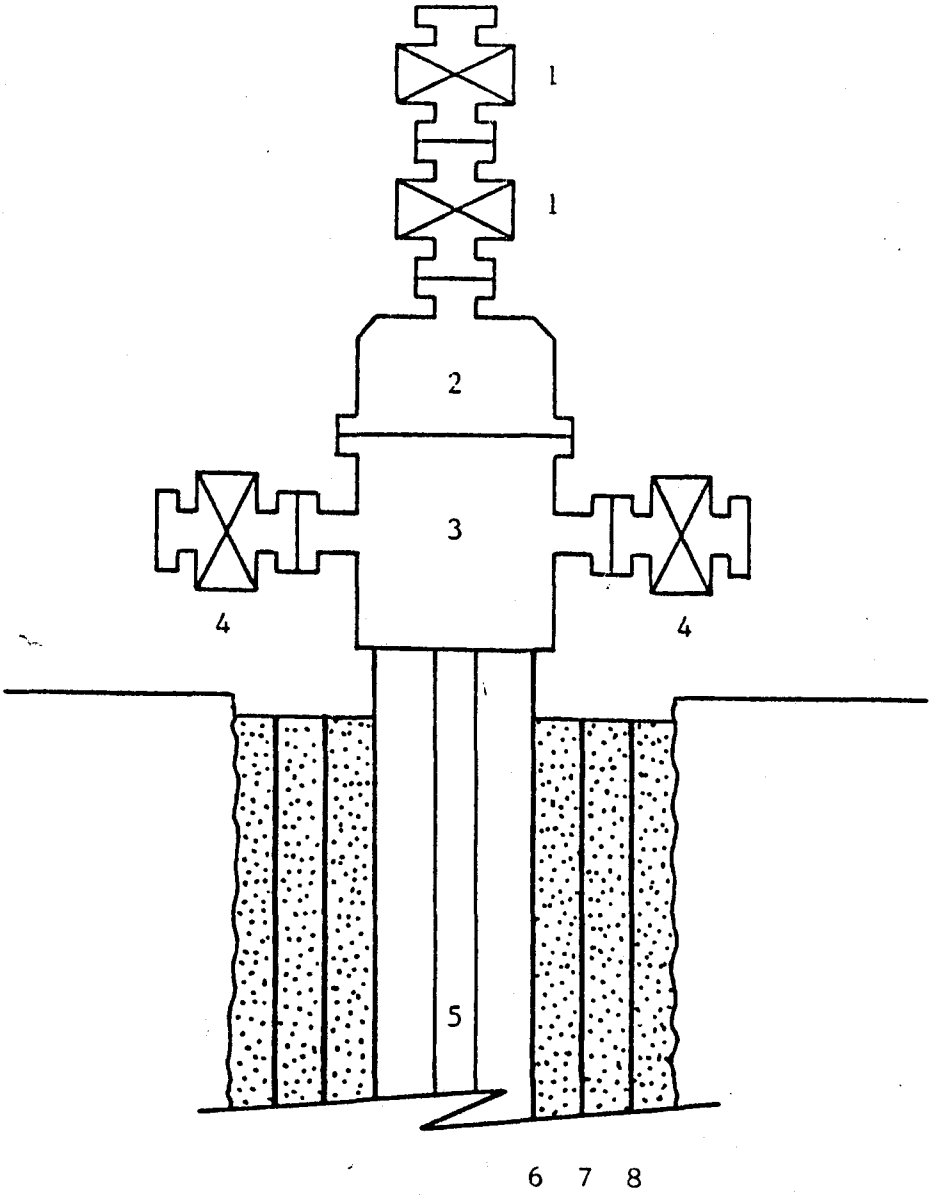
Wellhead equipment for 6.625 inch casing



1. High speed rotating head
2. Picture nipple
3. 6 inch annular preventer
4. Hydraulic 3M double-gate 6 inch preventer
5. 6 inch 3,000 psi gate valve
6. Series 900 6.625 inch wellhead w/ 2 inch flanged outlets
7. 3M 2 inch gate valves
8. 2 inch choke/kill lines
9. 13.375 inch K-55 casing
10. 9.625 inch K-55 casing
11. 6.625 inch L-80 casing

Figure 4

Completion wellhead



1. 3M 3 inch gate valves
2. Series 900 tubing head
3. Series 900 6.625 inch wellhead w/ 2 inch flanged outlets
4. 3M 2 inch gate valves
5. 2.75 inch completion tubing
6. 6.625 inch L-80 casing
7. 9.625 inch K-55 casing
8. 13.375 inch K-55 casing