54. Gas is held in solution in oil when the pressures are (above/below) the bubble point.

55. For a dissolved gas drive to occur, reservoir pressure must be above the _____ _____ of the reservoir fluid.

56. When the pressure on a liquid drops below the bubble point for the liquid at that temperature, _____ breaks out of the liquid.

57. For efficient recovery from a gas drive reservoir, gas is produced (rapidly/slowly) and the GOR is (allowed to rise/held steady) while the well is flowing.

58. In some reservoirs, the water is under hydrostatic pressure from a ground water connection.

    These reservoirs may continue to produce from an active _____ drive after most of the gas has left the formation.

WELL-BORE STRUCTURE

The Flowing Well

For frame numbers 59 through 73 look at Exhibit 1, which shows a completed well-bore for a flowing well.

59. Exhibit 1 shows a completed well-bore for a flowing well.

    Find the casing strings.

    During drilling, the well-bore is lined with two or more strings of _____.

60. As drilling continues, casing strings with (larger/smaller) ODs are set in the borehole.

61. The well-bore in the exhibit is completed with (one/two/three) casing strings.

62. The first casing string set during drilling protects the borehole from loose surface formations and keeps drilling fluids out of fresh water supplies.

    This casing string is called the _____ casing.

63. The casing string that completes the well-bore to a producing formation is called the _____ casing.

64. In very deep wells, one or more strings of intermediate casing may be run.

    Intermediate casing is run inside the _____ casing.

65. In the well shown in the exhibit, the production casing is run inside the _____ casing.

66. Look at the way the casing strings are sealed in the borehole.

    In the well, each casing string is held in place by _____.

67. The space inside the production casing is called the well-bore.

    In a fully completed well, reservoir fluid enters the well-bore through _____ in the production casing.

68. Find the tubing string.

    Most wells are produced through a string of tubing run inside the _____ _____.

69. Any ring-shaped space between two pipes may be called an annulus.

    In the well-bore, the annulus is the space between the tubing and the _____ _____.

70. As fluid enters the well-bore from the reservoir, some of it may rise up into the annulus.

    In the well shown, the annulus is sealed off at well-bottom by a _____.

71. When a packer is used, fluid cannot enter the _____.

72. In many flowing wells, production is controlled by a *bottom-hole choke.*

    The bottom-hole choke is set in the (tubing/casing).

EXHIBIT 1

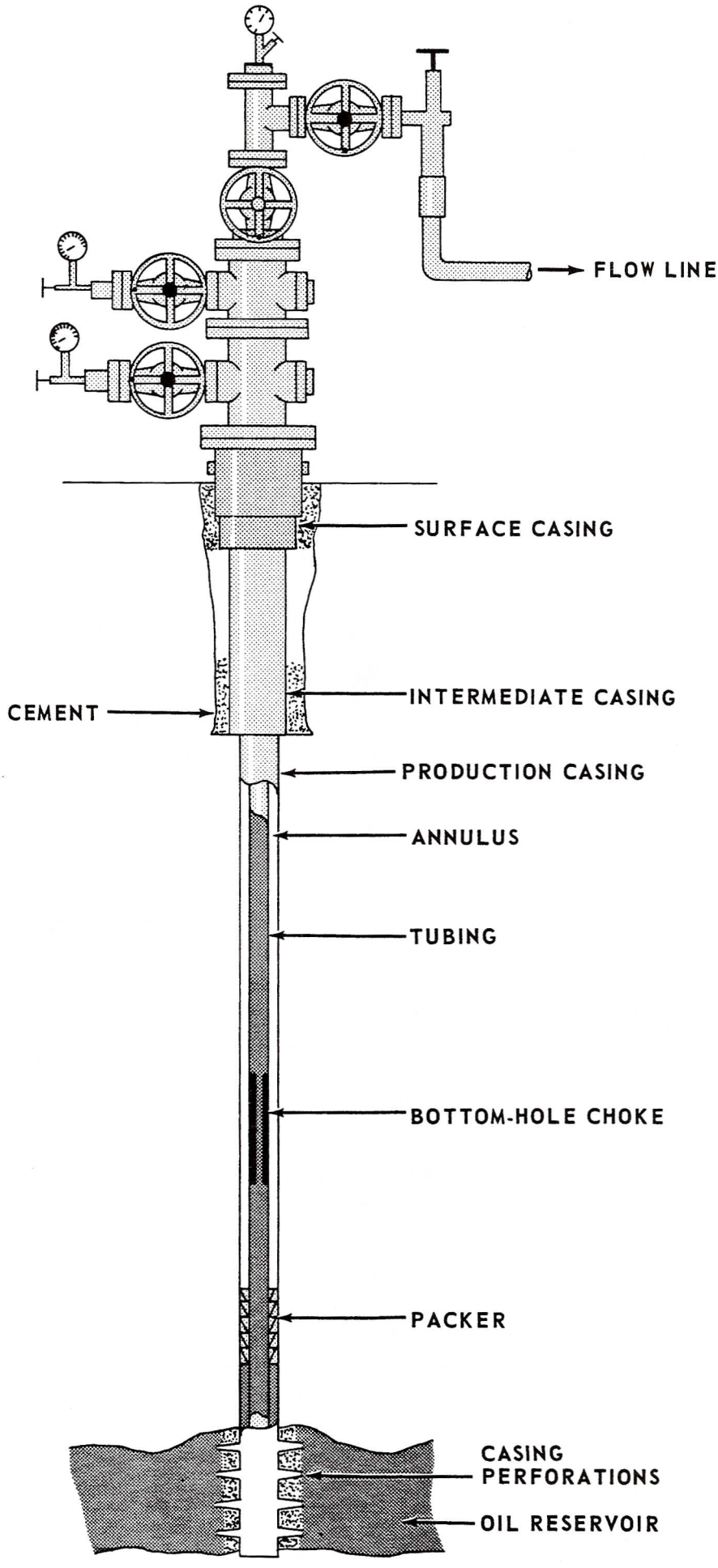
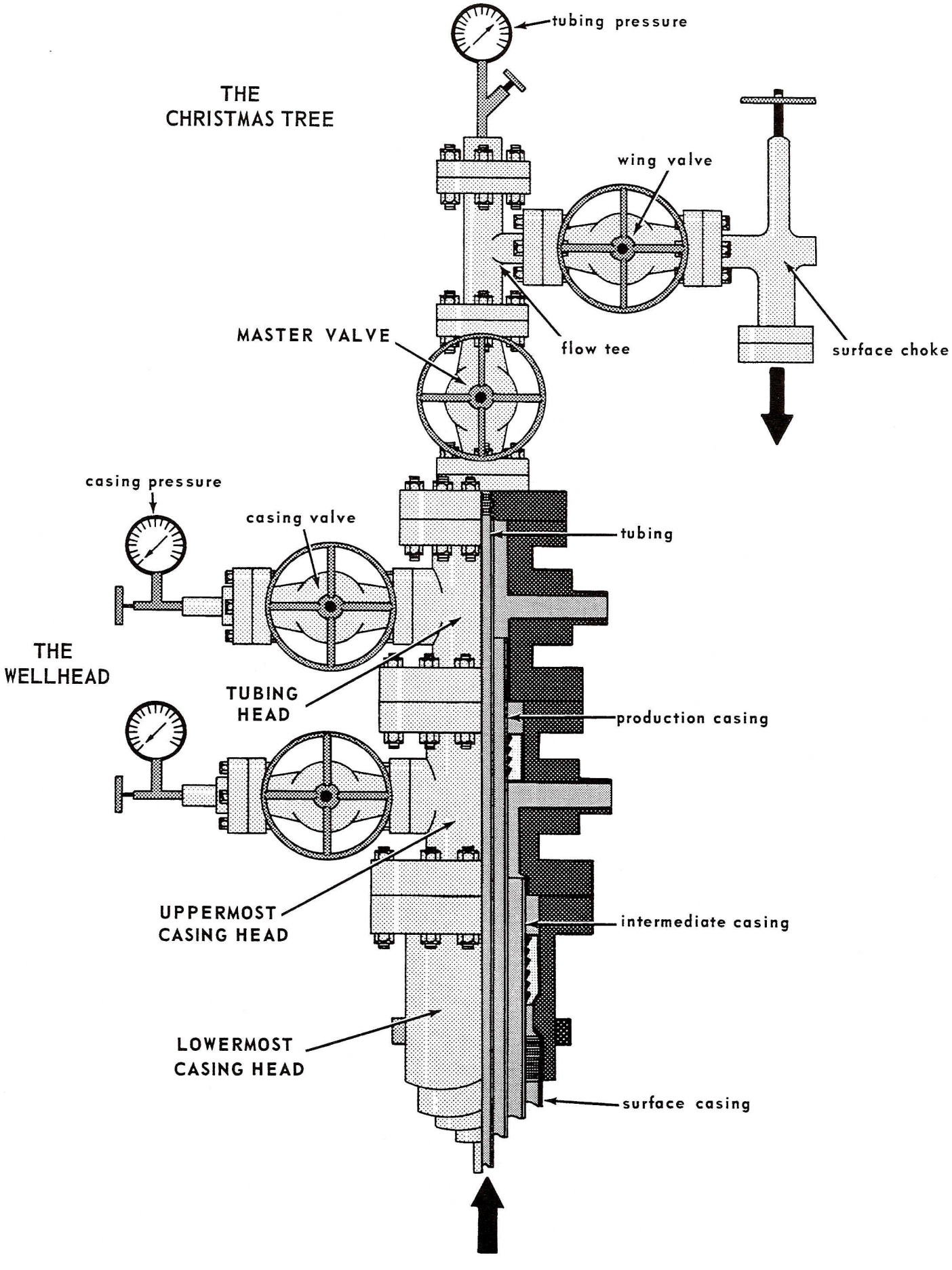

FLOW LINE
SURFACE CASING
CEMENT
INTERMEDIATE CASING
PRODUCTION CASING
ANNULUS
TUBING
BOTTOM-HOLE CHOKE
PACKER
CASING PERFORATIONS
OIL RESERVOIR

EXHIBIT 2


THE
CHRISTMAS TREE
tubing pressure
wing valve
MASTER VALVE
flow tee
surface choke
casing pressure
casing valve
tubing
THE
WELLHEAD
TUBING
HEAD
production casing
UPPERMOST
CASING HEAD
intermediate casing
LOWERMOST
CASING HEAD
surface casing

73. The bottom-hole choke controls flow by (increasing/decreasing) the effective ID of the tubing.

For frame numbers 74 through 96 look at Exhibit 2, which shows the well head and the Christmas tree for a typical flowing well.

74. Find the master valve.

    The equipment set above the master valve is called the _____ _____.

75. The well head is the surface equipment set (above/below) the master valve.

76. In a flowing well, the fluid flows from the well head through the _____ _____ into a flow tee in the Christmas tree.

77. At the tee, the produced fluid is directed through a wing valve and surface _____ before it reaches the surface flow lines.

78. At the top of the tree, a pressure gage indicates the pressure in the (tubing/casing).

79. Look at the well-head equipment in the exhibit.

    This well head is made up of two _____ heads and one _____ head.

80. The lowermost casing head rests on the surface casing and supports the _____ casing.

81. The uppermost casing head supports the (intermediate/production) casing.

82. Besides supporting the casing strings from the surface, the casing heads seal off the annular spaces between casing strings.

    Fluid that becomes trapped between the production casing and the intermediate casing can be vented off at the valve on the (uppermost/lowermost) casing head.

83. The tubing head supports the tubing string from the surface and seals off the tubing-casing annulus.

    Look at the outlets at the tubing head.

    The valve at the tubing head is called the _____ valve; the gage at the tubing head is called the _____ pressure gage.

84. At the well head, flow from the tubing-casing annulus in the well-bore is controlled by the _____ valve.

85. Pressure in the tubing-casing annulus is shown on the _____ pressure gage.

86. The tubing-casing annulus is sealed and controlled at the (tubing/casing) head.

87. Flow from the tubing is controlled by opening or closing the _____ valve.

88. At the surface, the production rate is controlled by a surface _____.

89. Let's review the course of flow through the well-bore and well head.

    Fluid enters the well-bore through perforations in the _____ _____ and casing cement.

90. Fluid rises in the well-bore to the bottom of the _____ string, where some of it enters the tubing.

91. In an unpacked well-bore, fluid may also enter the tubing-casing _____.

92. At the well head, the fluid in the tubing flows up through one or two _____ heads and a _____ head.

93. Flow from the tubing-casing annulus is controlled by a *casing valve* in the _____ head.

94. Above the well head, the fluid in the tubing flows through the _____ valve, into a tee, through a wing valve, and on through a surface _____.

95. Flow may be choked down at two places in the well:

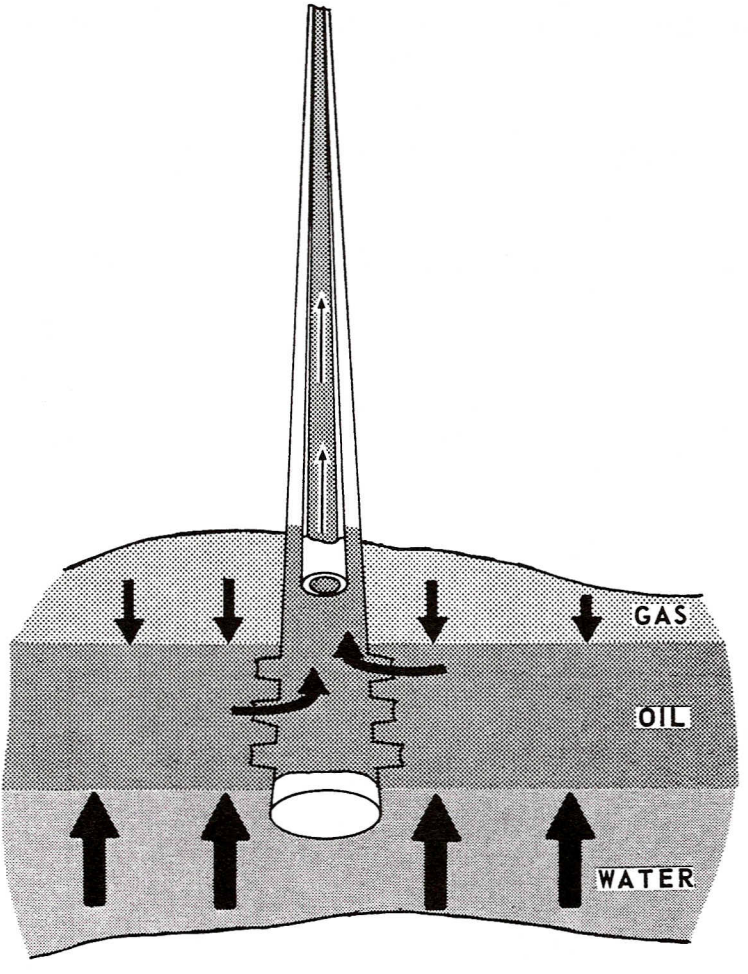
    by a bottom-hole choke set in the _____ string; or

    by a surface choke set in the _____ tree.

96. Both surface chokes and bottom-hole chokes control flow by (increasing/decreasing) the effective ID of the flow path.

Well-Bore Pressures

97. Let's look at the pressures and fluids in a flowing well.



In the reservoir, the oil is trapped in a reservoir of porous rock, usually between an upper layer of _____ and a lower layer of _____.

98. The oil is pushed into the well-bore by the pressure of the _____ above it and the pressure of the _____ below it.

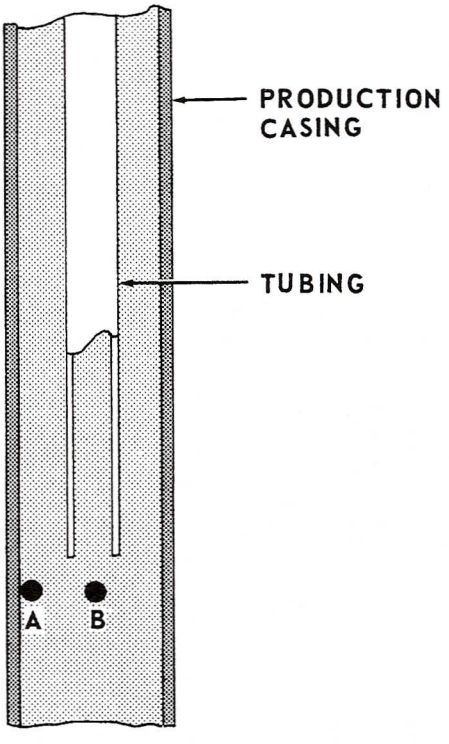
99. The water in the formation may be under hydrostatic pressure because of a connection to the ground _____ table above.

100. More often the reservoir fluids are under pressure from the _____ expanding in and above the fluids.

101. The flowing fluids in the well-bore are also under hydrostatic pressure.

Hydrostatic pressure is caused by the density and _____ of the fluid above.

102. A fluid under pressure exerts a force on everything it touches.



In this well, the fluid at point B is touching only the fluid around it.

Hydrostatic pressure is (the same/different) at A and B.

103. At any one level in the well, hydrostatic pressure is the same at all points and is exerted equally in all _____.

104. Hydrostatic pressure is always greatest at the (top/bottom) of a well-bore, and decreases going (up/down) the well-bore.

105. At any point in the well-bore, the hydrostatic pressure is greater when the fluid in the well-bore has a (higher/lower) density.

106. There is a *higher* hydrostatic pressure at well-bottom when the fluid is mostly (oil/gas).

107. There is a *lower* hydrostatic pressure at well-bottom when the fluid is mostly (oil/gas).

108. In the well-bore, the proportion of oil, gas, and water changes from time to time.

As the density of the fluid mixture changes, hydrostatic bottom-hole pressure also _____.

109. The gas in the fluid may be in bubbles, or it may be dissolved gas.

A gas bubble weighs less than an equal volume of dissolved gas.

Hydrostatic pressure is lower when most of the gas in the well-bore is in the form of (gas bubbles/dissolved gas).

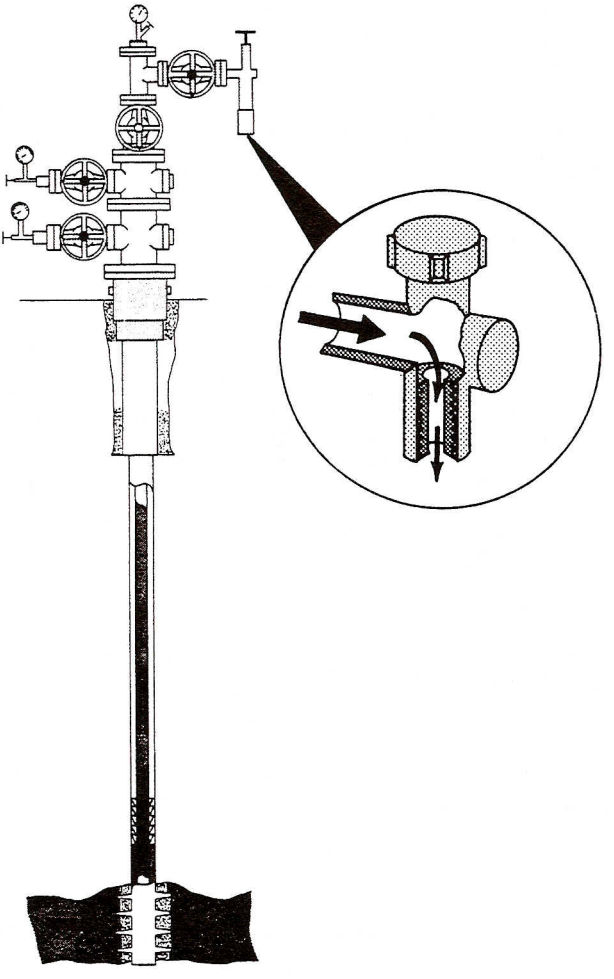
110. In most flowing wells, the production rate is controlled by chokes.

Choking causes back pressure in the (upstream/downstream) lines.

111. Flowing wells may be choked down at the surface, or they may be controlled by a choke set in the _____.

112. Both surface and subsurface chokes create _____ pressure in the line by (increasing/decreasing) the velocity of upstream flow.

113. The back pressure caused by chokes and other restrictions increases the bottom-hole pressure.



Increasing the bottom-hole pressure (increases/decreases) the pressure drop from the reservoir to the well-bore.

114. So, increasing back pressure in the well-bore (increases/decreases) the flow rate from the reservoir.

115. Back pressure adds to the hydrostatic pressure in the well-bore; both pressures tend to balance the pressure from the _____.

116. While the well is flowing, the bottom-hole pressure is greater than both the _____ pressure caused by the weight of the column of fluid in the well-bore, and the _____ pressure caused by chokes and other narrow openings in the well-bore and surface lines.

REVIEW AND SUMMARY

117. There are basically three ways that flow from a well can be *increased:*

by (increasing/decreasing) reservoir pressure; or

by (increasing/decreasing) hydrostatic BHP; or

by using a (larger/smaller) size choke.

118. To decrease the rate of flow to a safe or profitable volume and velocity, a smaller _____ is usually installed in the tubing or Christmas tree.

119. Sometimes a well is *killed* for equipment repairs by forcing high-density fluids into the well-bore.

The killing fluids stop flow by increasing (hydrostatic/back) pressure in the well-bore.

120. As the reservoir approaches depletion, reservoir pressures (increase/decrease) and the rate of flow becomes (larger/smaller).

121. When hydrostatic BHP balances the reservoir pressure at the well-bore, the well (produces/does not produce) by natural flow.

122. Artificial lift is then used to maintain _____ from the reservoir.