THE MULTIPLE COMPLETION CHOKE ASSEMBLY - A NEW PROFIT MAKING TOOL

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Abstract

This paper describes the construction, method of operation, and field performance of the Sun Oil Company-developed Multiple Completion Choke Assembly.

This down-hole commingling tool has been in operation since March, 1960. It has been used in approximately 75 wells located in Louisiana, Texas, Mississippi, Oklahoma, Mexico, Kuwait, and India.

Sun Oil Company's Gulf Coast Division, through the use of this tool during the past four years, has saved approximately $289,000 in tubular goods, and produced approximately $282,750 worth of hydrocarbons not otherwise recoverable.

The paper reports the results of Sun Oil Company's installations and discusses the various applications and limitations of the tool.

The method of allocating production to each zone is explained.

Advantages and disadvantages in simultaneous production of two separate reservoirs through a single tubing string are enumerated.

Construction and Operation

Fig. 1 shows a well equipped to receive a multiple completion choke assembly. A retainer type packer separates the two producing zones. The upper packer is optional. A side-door choke landing nipple hookup is located in the tubing string above the lower packer. The multiple completion choke assembly will be locked in this landing nipple. Normally located a joint or two above the upper zone, the position of the landing nipple hookup can be varied to suit well conditions. For example, where the two zones are widely separated, it might be placed just above the lower packer to facilitate bottom hole pressure tests of the lower zone.

The tool consists of two separate assemblies, as shown in Fig. 2. The outer assembly, which is run on a wire line and locked in the landing nipple, contains the check valves and packing seals which prevent flow from one zone to the other.

The orifice-head assembly, which carries the tungsten-carbide choke beans, is run separately and is seated and locked in the outer assembly. The method of running each section is illustrated in Fig. 3.

Fig. 4 is a schematic drawing which shows how the device works. Production from the lower zone enters the assembly through a slotted section, flows through a sleeve-type check valve, enters and flows through the tube of the orifice-head assembly, is choked and - now regulated - flows into the tubing. Produced fluids from the upper zone enter the casing opposite a blast joint on the tubing, flow through the ported collar of the side-door choke landing-nipple hookup, through the upper slotted section, through the upper check valve, into the annulus surrounding the tube, and through the upper-zone choke bean into the tubing. Here the two controlled flow streams, which have been segregated to this point, combine and flow to the surface.

Allocation of Production

Detailed instructions for testing and allocation of production are available in the manufacturer's "Service Manual for

Otis Type 'S' Multiple Completion Choke Assembly--Dual Flow"; in general, however, allocation is based on the results of a stabilized test of one of the zones while the other zone is blanked off. The established rate from this zone is then subtracted from the commingled rate to calculate production from the second zone.

Test procedure will depend on whether or not one of the zones is in critical flow. A stream is in critical flow when alterations in pressure downstream from an orifice do not affect the rate of flow. The critical point in a gas stream flowing through an orifice occurs when the pressure downstream from the orifice is 53% of the upstream pressure; for gas-liquid mixtures, the critical ratio is higher but should not exceed approximately 0.58.

If one of the zones is in critical flow, alterations in the tubing inlet pressure (the pressure immediately downstream from the multiple completion tool) will not change the predetermined rate from that zone, and the allocation process is simplified.

If neither zone is in critical flow, the zone with the higher pressure is tested individually at several rates in a range of tubing inlet pressures expected to occur during commingled flow. By plotting the rate versus tubing inlet pressure, a graph is obtained from which the production from the zone can be determined during commingled flow. Fig. 5 shows the results of such a test in the Kinder Field, Louisiana. This graph can be used to determine the rate from the lower zone during commingled flow. If the zone is out of critical flow, its rate is a function of the tubing inlet pressure.

The method of allocating production with the multiple completion tool is basically the same as that used in conventional practice; i.e., determining the rate from each zone by testing, commingling the production downstream from the choke beans, and allocating the interim production between test periods on the basis of the individual tests. In either case, accurate allocation depends upon the consistency with which each zone continues to produce at its tested rate, and this is in large measure dependent upon accurate flow rate control. The tungsten carbide choke beans in the multiple completion choke assembly, being highly resistant to erosion and located below the zone of paraffin deposition (precluding plugged chokes) will provide better flow rate control than will conventional surface chokes. In Sun's wells, the orifice head has been pulled approximately 450 times, and in each instance the chokes have remained true to gauge.

Applications

The multiple completion choke assembly is not a specialty tool. It is applicable in almost any type of multiple completion. Sun Oil Company has made nineteen installations in wells ranging in depth from 3790' to 15,576' and in bottom hole pressure from 814 psi to 8173 psi.

It is applicable in multiple oil, multiple gas, and combination oil-gas wells.

It can be run on initial completion, or in the conversion of a concentric or twin string dual completion. In the latter case, when either zone becomes deficient, the tool can be installed with wire-line tools, preferably in a Type "S" side-door choke landing nipple; a hook-wall tool is available, however, if a side-door nipple has not been run.

A list of its applications follows.

1. In wells where one or both zones require artificial lift, one set of gas lift valves can be used to produce the two zones through the tool at reduced cost and greater efficiency than is possible in other types of dual completions.

2. As a means of using gas-cap gas to lift liquids from the lower part of the same sand.

3. Two multiple completion tools can be used with dual strings of tubing to produce either three, four, or five zones simultaneously.

4. The tool is compatible with slim hole multiple completions.

5. Applicable to tubingless completions and permanent type completions.

6. Can be used to produce selective completions dually.

7. Can be modified and used to inject salt water or gas into separate reservoirs with reasonably accurate allocation to each reservoir.

There are two limitations to the use of the tool: 1) where there is excessive sand production and 2) where there is insufficient reservoir energy for required production and external gas is not available for gas lift.

Table No. 1 describes the wells in which Sun has used the multiple completion choke assembly.

Advantages

The advantages in using the multiple completion choke assembly are as follows:

1. Reduction in well equipment costs. In Sun Oil Company's Belle Isle Unit #1-56, Belle Isle Field, Louisiana, approximately $42,000 was saved on equipment alone as compared to a twin string dual.

2. Increased ultimate recovery. The economy of the method has resulted in production from reservoirs which would not have been tested otherwise. For example, in Sun's Belle Isle Unit #3-5, over $97,000 worth of hydrocarbons were produced in the first year of operation from a questionable zone that would have been written off if this tool had not been available.

3. Increased daily production. The income from Sun's Vicksburg Unit #3, Kinder Field, Louisiana (the lower zone in a dual completion), has increased from $2770 per month to $8500/month since installation of the tool in March, 1960. The gas-oil ratio has decreased from 54,000 c.f. per bbl to 19,600 c.f. per bbl. See Fig. 6.

4. Reduction in workover costs (compared to multiple-string completions.)

5. Reduction in surface equipment costs. This includes heaters, separators, compressors, high pressure gas-lift lines, meters, etc.

6. Maximum use of reservoir gas. By bottom hole choking and commingling production immediately above the tool, gas breaking out of solution at this point results in the lowest possible gradient in the tubing. When a strong well is combined with a weak well in this way, the weak well can be produced at its maximum potential. This not only prevents waste; it is also quite economical to the operator, as it postpones or eliminates the need

to provide artificial lift for the weaker zone. Conventional completions, by maintaining separation of production to the surface, in this respect act contrary to the principles of conservation.

The multiple completion choke assembly is in effect a single-point injection, retrievable flow valve, utilizing gas supplied directly from the formation at maximum efficiency. To illustrate the degree of efficiency, in Sun Oil Company's Dishman-Lucas #1, Sour Lake Field, Texas, a comparison was made between this method and a conventional gas lift system. This study showed that the multiple completion tool used one-sixteenth as much gas and produced twice as much liquid.

7. Reduction in corrosion inhibitor and paraffin treatment costs.

Disadvantages

1. Cost of testing. The periodic testing required results in wire-line costs otherwise not incurred; however, there are two important considerations that should not be overlooked: (a) the future value of the money saved by virtue of using the tool. In Belle Isle Unit #1-56, the $42,000 saved in initial cost is worth $44,520 at 6% compound interest after one year, $56,205 after five years, and $75,215 at the end of ten years. Obviously, this gain in value will absorb wire-line costs (which have run from $50 per month to $150 per month in Sun's nineteen wells); (b) the use of the tool will result in an increase in production in most wells. The income from just one additional barrel of oil per day will in most instances pay the wire-line costs.

2. Somewhat more complicated (technical) method of

production accounting. The engineer in charge must practice more of his production technology than is normally required in routine production accounting. This may or may not be a disadvantage, and the bulk of the work can still be handled by the production clerk.

Attitude of the Conservation Agencies

Co-operation of the various State agencies has come about through recognition that 1) commingling down hole with the choke assembly is no different from commingling at the surface; 2) the tool is mechanically sound; 3) the tool will prevent waste and increase ultimate recovery; and 4) most of the people in the oil industry are honest. Those that aren't will find a cheaper way to produce multiple completions dishonestly.

Conclusions

Simultaneous production of two reservoirs through a single string of tubing will in many wells result in a significant reduction in completion and lifting costs and increase in current income and ultimate recovery. The Multiple Completion Choke Assembly will maintain separation of reservoirs and control the rate of production from each. Test procedures have been developed which provide an acceptable method of determining the production from each zone. All requirements imposed by the State regulatory agencies can be satisfied.

Well	Field	Depth, Ft.	Static Bottom Hole Pressure, Psi	Bbl Liquid Per Day	Gas-Oil Ratio Cu Ft Per Bbl
Unkel #1	Kinder, La.	8,067	2,575	6 Oil	22,100
		8,448	2,460	19 Cond	18,466
Miami B.S. #2	Bayou Sale, La.	14,025	5,870	20 Oil	1,000
		14,236	6,533	75 Oil, 75 SW	7,750
Houston #3	Kinder, La.	7,678	3,263	64 Oil	784
		8,379	3,371	37 Cond	19,100
B.I.U. #3-5	Belle Isle, La.	13,958	6,500	129 Oil	735
		13,983	6,500	129 Oil	945
K. C. "A" #2	Kinder, La.	7,394	3,290	7 Oil, 15 SW	643
		8,390	3,485	64 Cond	16,188
B.I.U. #1-56	Belle Isle, La.	12,840	5,670	115 Oil	906
		13,398	5,781	129 Oil	423
State Lse 1337 #22	Bateman Lake,La.	10,154	4,538	71 Oil	2,929
		11,700	5,060	65 Oil, 10 SW	3,354
Carpenter #4	Sour Lake, Texas	4,710	814	Gas	-
		4,788	1,093	14 Oil	649
State Lse 1337 #15	Bateman Lake,La.	11,749	5,335	120 Cond	29,300
		11,828	5,331	132 Oil	1,060
Dishman-Lucas #1	Sour Lake, Texas	9,610	4,340	Gas	-
		9,800	3,778	21 Oil, 325 SW	1,143

Table 1.--Sun Oil Company Wells Using Multiple Completion Tool

Well	Field	Depth, Ft.	Static Bottom Hole Pressure, Psi	Bbl Liquid Per Day	Gas-Oil Ratio Cu Ft Per Bbl
Jones #2	Conroe, Texas	3,790	1,634	Gas	-
		5,043	2,100	28 Oil, 298 SW	893
Chachere #2	Kinder, La.	6,680	3,290	Sanded Up	-
		8,062	2,300	2 Oil	54,049
Regan #2	Egan, La.	9,855	3,636	12 Cond	26,250
		10,067	3,850	121 Oil, 684 SW	995
LeBlanc Pool #1	Egan, La.	9,360	4,169	17 Cond	130,000
		9,872	4,195	48 Oil, 912 SW	1,271
Hankamer #2	Stowell, Texas	7,337	Not Meas.	10 Oil, 240 SW	2,100
		7,452	3,242	Dry Gas	-
State Lse 2620 #10	Lake Pelto, La.	15,532	8,018	196 Oil	2,200
		15,574	7,032	130 Oil	2,400
State Lse 2620 #11	Lake Pelto, La.	15,537	8,173	132 Oil	6,200
		15,576	8,099	84 Oil	4,040
Sun Fee "B" #6	Hull, Texas	9,904	5,500	100 Oil	750
		9,992	5,500	27 Oil	800
B.I.U. #1-61	Belle Isle, La.	13,478	5,441	142 Oil 37 SW	1,027
		14,392	6,500	159 Oil	1,410

Table 1 cont'd.--Sun Oil Company Wells Using Multiple Completion Tool

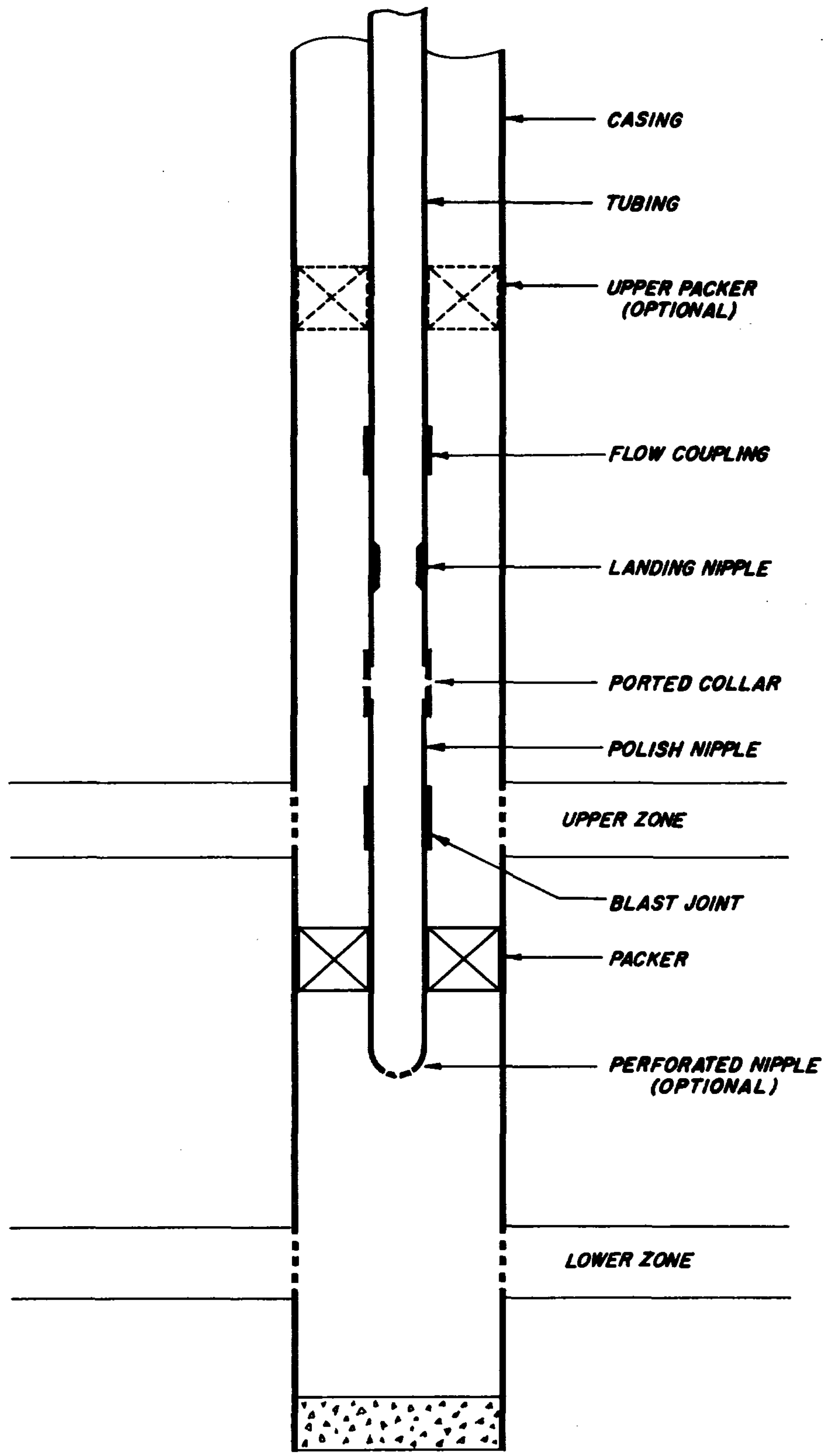

Fig. 1--Well Properly Equipped for Multiple Completion Choke Assembly

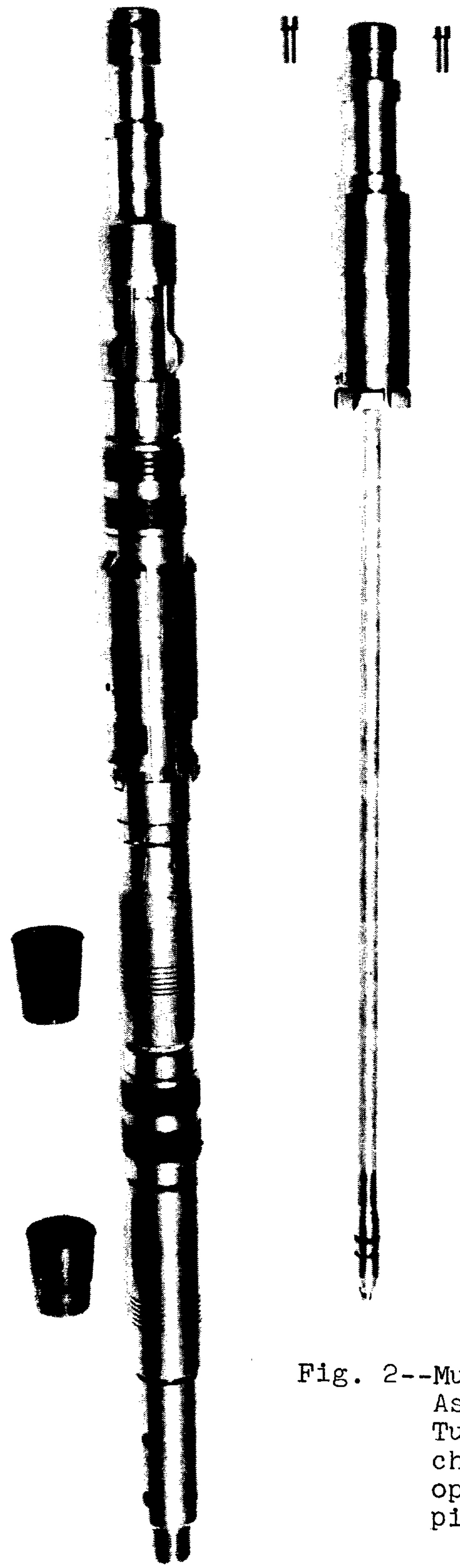

Fig. 2--Multiple Completion Assembly for 2-3/8-in. Tubing. Check valves and choke beans are shown opposite position occupied within tool.

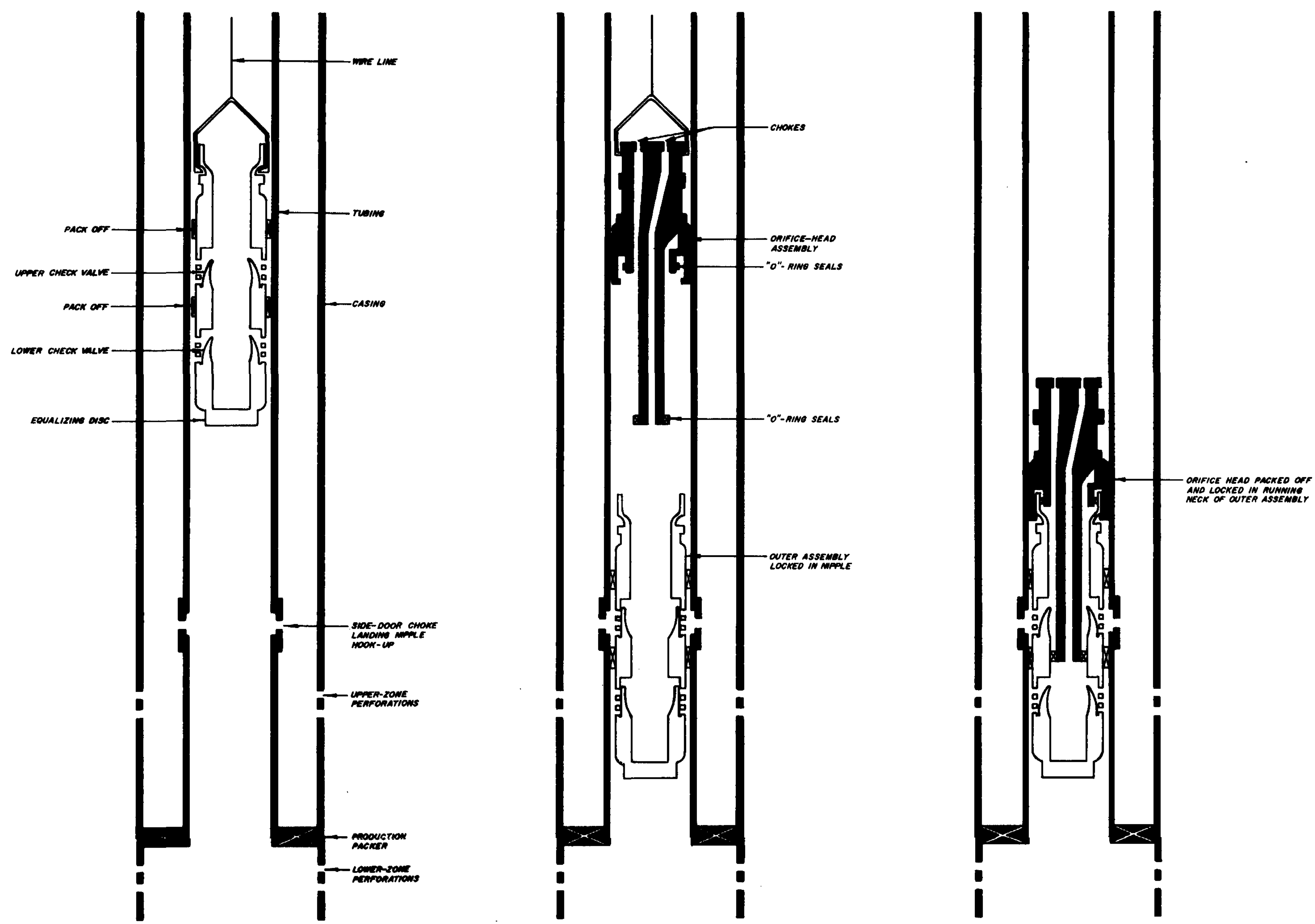

Fig. 3--Method of Running Inner and Outer Assemblies

Note in center drawing that check valves prevent inter-zone flow.

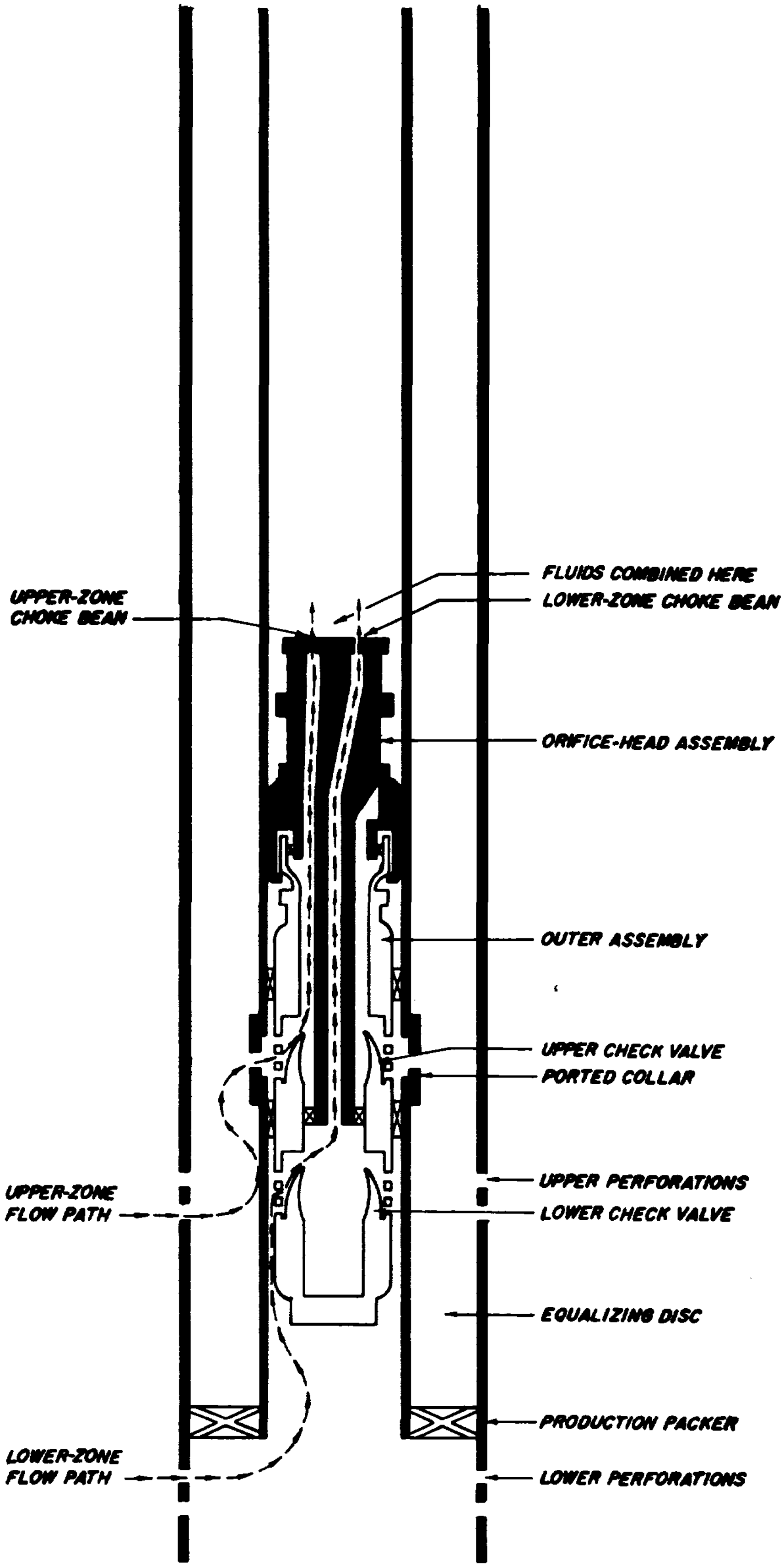

Fig. 4--Schematic Drawing Showing Operation of Multiple Completion Choke Assembly

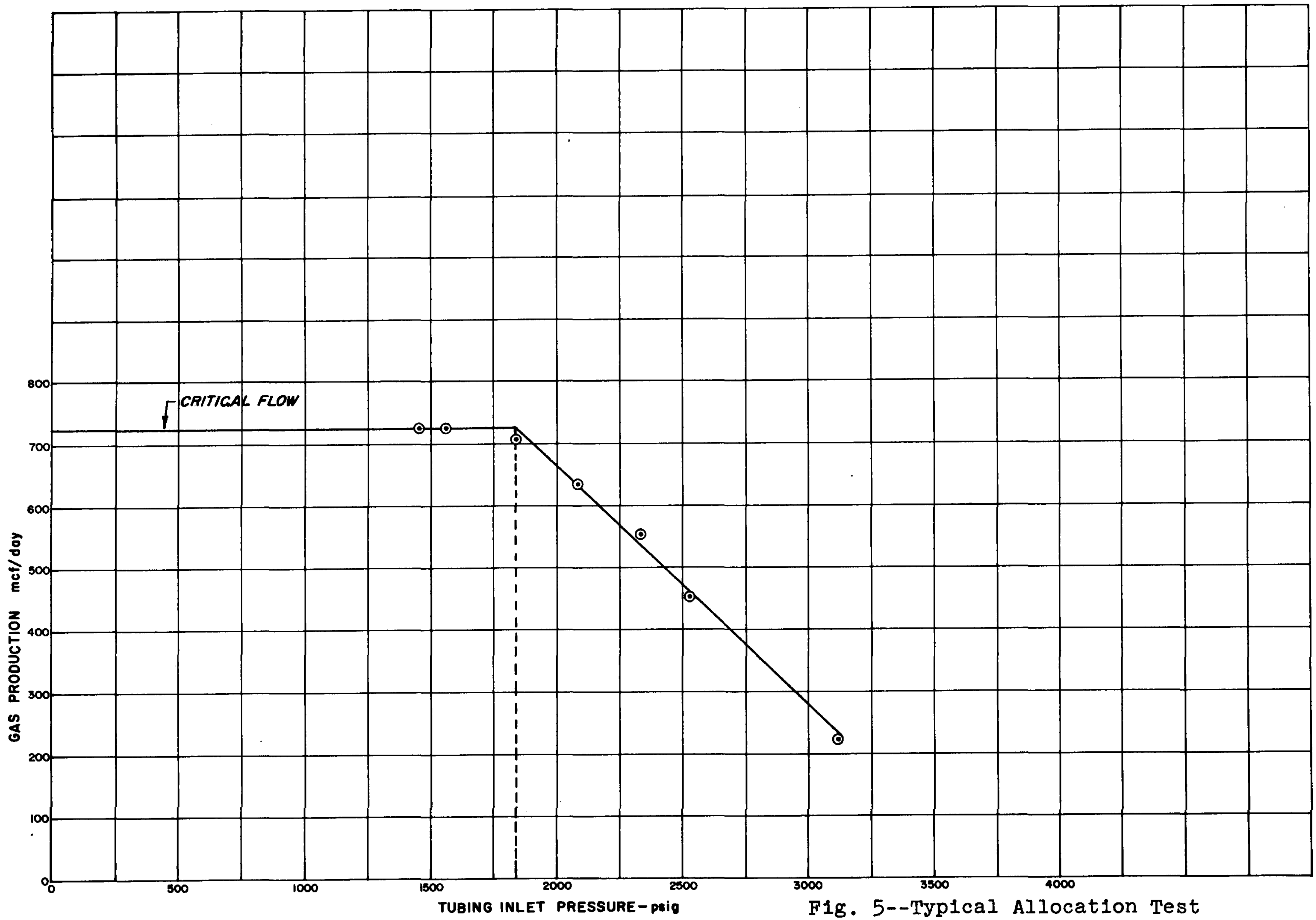

Fig. 5--Typical Allocation Test

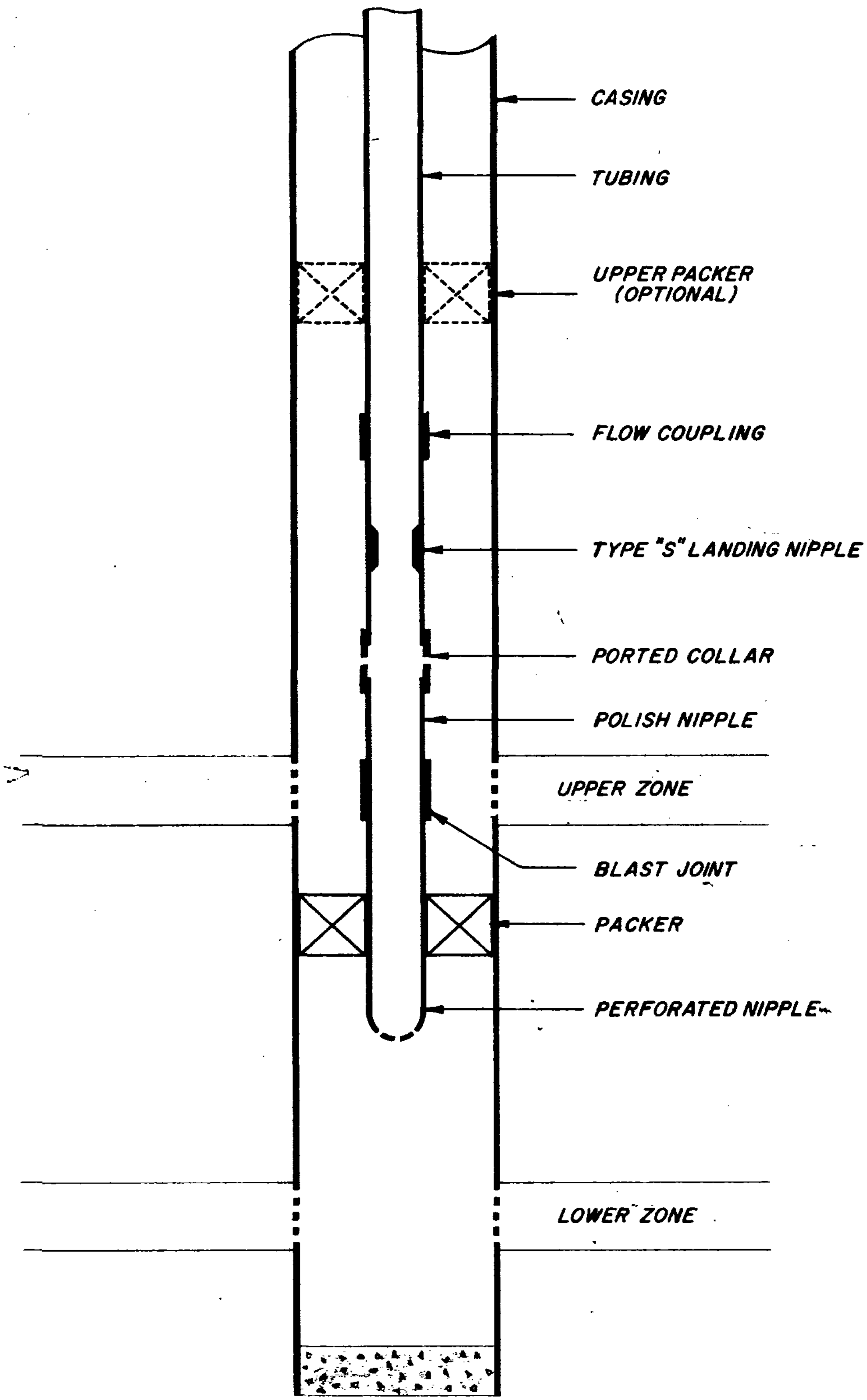

FIGURE I

WELL PROPERLY EQUIPPED FOR MULTIPLE COMPLETION CHOKE ASSEMBLY