Dual-Zone Pumping with Two Pumps Actuated by One Rod String

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ABSTRACT

This paper reviews our experience, dating from 1953, with dually completed wells equipped with tandem pumps (two pumps actuated by one rod string). In this span of time newer designs in dual-zone equipment and packer-tubing combinations have antiquated the initial installation. Subsurface schematic drawings depict seven deviations in equipment installed in various wells, which encompass most of the major techniques and assemblies. Commentaries on each method, which include installational and operational problems and production results from specific wells, give an insight into the applications and limitations of each assembly.

INTRODUCTION

The installation and operation of artificial lift equipment in dually completed wells often involve many problems not necessarily associated with single-zone producers. Many of these problems can be minimized or avoided if the operator will give some thought during initial completion to the type and size of future pumping equipment to install after one or both producing zones have ceased to flow. Sometimes one may find that it is feasible to equip a well in such a manner that dual-zone pumping equipment can be installed at a later date without disturbing the tubing. This fact may be especially true if the flowing life of one or both pays is anticipated to be rather short.

Perhaps the most important single item affecting dual-zone pumping, for consideration during the initial completion of a well, is the design of a casing program that will permit adequate clearance for passage and hanging of future tubing strings. Sometimes, however, the reverse may occur, and the casing in a well may limit the type and size of artificial lift equipment. This condition could prevent the installation of equipment best suited for the depth, productivity, corrosiveness, and other operating conditions prevailing in a well, thereby causing inefficiencies by increasing installation costs and/or operating costs and possibly by reducing production.

Casing Design

Currently, Gulf's West Texas District installs 7-inch OD production strings swaged to 7 5/8-inch OD casing near the surface in order to give more clearance for tubing hangers. This casing design is compatible with most artificial lift methods, and permits considerable flexibility in the selection of future dual-zone artificial lift equipment.

Our experience with tandem pumps began more than four years ago in 1953. Considerable improvements in equipment and methods have occurred in this span of time. This evolution has been chiefly in the direction of improved flexibility and simplicity. Several installations cover most of the major changes that have taken place. Currently, fourteen wells have some form of equipment for this type of pumping. Operational and production histories, supported with schematic subsurface drawings from some of these dually pumped wells, reflect the applications and limitations of seven major deviations in equipment.

DOUBLE-PACKERS, SINGLE-STRING

Fig. 1 schematically shows a dual-zone pumping system that represents our first endeavor to produce

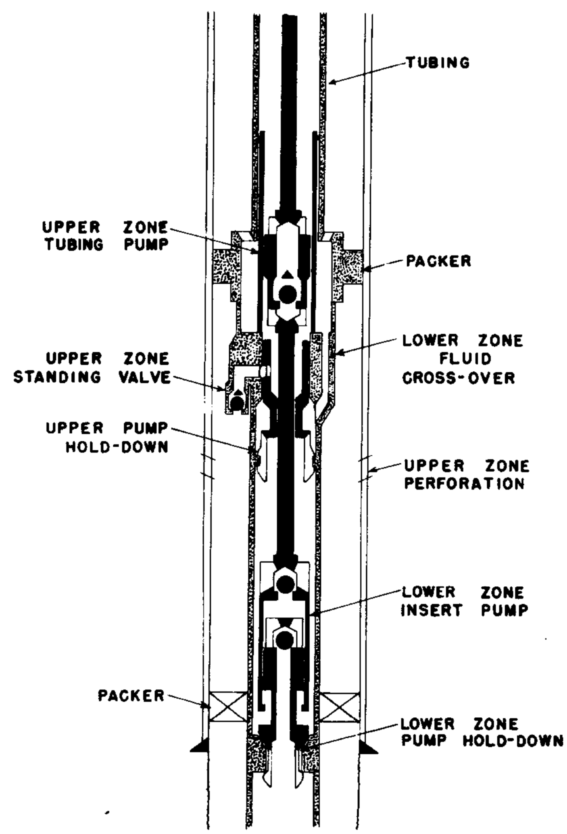

FIG. 1 DOUBLE-PACKERS, SINGLE STRING DUAL-ZONE-PUMP INSTALLATION WITH TUBING PUMP AND INSERT PUMP

Production Tests - Table 1							
Pay	Depth-Feet	Date	Hours Tested	Production - Bbls. Oil	Production - Bbls. Water	GOR	Pump Efficiency-Percent
5600'	5447	11-10-53	24	47	1	3745	23.1
Clearfork	6235	10-28-53	24	68	0	294	40.5

both zones of a dually completed well with tandem pumps. This equipment was installed in Well A in October, 1953. Only one string of 2-inch tubing was run. A retainer-type packer was set in the casing between the two producing zones in order to prevent commingling of their fluids around the tubing, and a hook-wall packer was set above the upper zone. A conventional insert pump and a tubing pump were used to produce the respective lower and upper zones. The upper-pump standing valve, composed of three API balls and seats recessed in the crossover shoe, was run as an integral part of the tubing string. The lower rod string and pump were actuated by a polished rod attached to the plunger of the upper pump that stroked through a pack-off assembly below the upper pump. The upper-zone fluid was taken into the pump suction at the crossover shoe and was pumped up the tubing. The lower-zone fluid was conducted through a jacket around the upper pump and was discharged above the upper packer into the annulus between the tubing and casing.

Locking Device

During the installation of this equipment the locking device on the pack-off assembly between the two pumps proved troublesome to latch. This device was held in an upward position until the pumps had been lowered to the desired position in the well. Then, jarring of the rod string was supposed to dislodge the positive lock permitting it to fall downward and lock the pack-off assembly into place in the tubing string. Three round trips with the rods and pumps were required to accomplish this.

Typical tests using this equipment are listed in Table 1.

New designs, in pumps adaptable to dual-zone pumping and in other dual equipment, were perfected and made available to the oil producer subsequent to this installation. A 2 1/2-inch model dual-zone pump was developed that was superior to the 2-inch model installed in Well A. It eliminated the troublesome and difficult method for latching the 2-inch model in place in the tubing and permitted the use of two insert pumps, instead of one tubing pump and one insert pump. About the same time a two-stage pump was designed. This pump is basically a stationary-barrel, bottom-anchor pump with a hollow, perforated, polished rod substituted for a pull rod and with a second traveling valve, which supports the fluid column during all or part of the downstroke. There is an annular chamber above the plunger into which all or part, depending upon the pump efficiency, of the fluid swept from the suction chamber by the plunger is displaced on the downstroke.

This two-stage pump is almost impossible to gas lock, and should continue to pump although any one of its three valves has failed. If the upper traveling valve should fail, it would revert to a conventional pump; if either the intermediate traveling valve or the bottom standing valve should fail, it should continue to pump with reduced efficiencies. The new 2 1/2-inch model equipped with a two-stage pump alleviates to some extent two major problems inherent in the pumping equipment shown as Fig. 1: (1) all produced gas from both zones must pass through the pumps, (2) the recovery of the working barrel and standing valve for the upper pump for repairs requires a tubing job.

Conventional Pumps

In March 1954, the equipment in Well A was converted to the newer 2 1/2-inch model shown as Fig. 2, except conventional pumps instead of two-stage pumps were

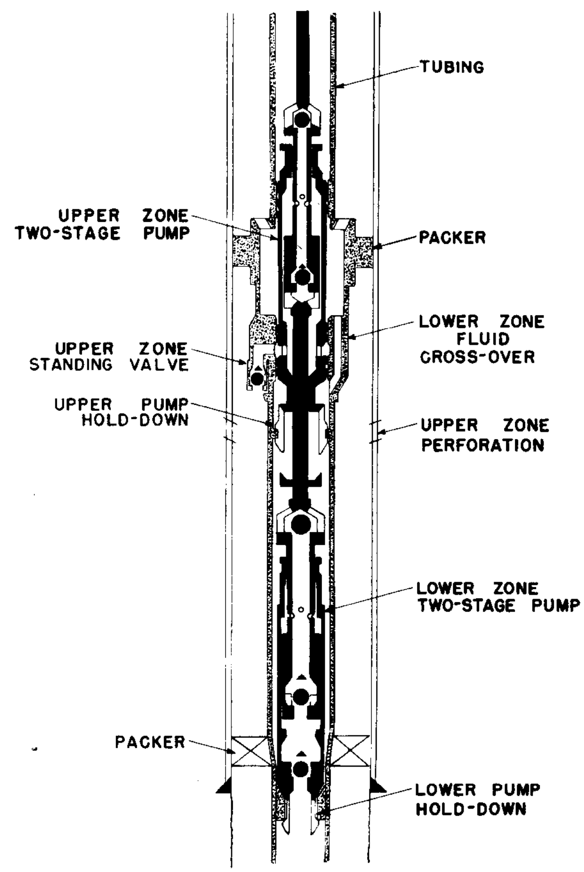

FIG. 2 DOUBLE - PACKERS, SINGLE STRING DUAL-ZONE-PUMP INSTALLATION WITH TWO TWO-STAGE PUMPS

Production Tests - Table 2									
Well No.	Pay	Depth Feet	Date	Hours Tested	Production - Bbls. Oil	Water	GOR	Pump Efficiency Percent	Remarks
A	5600	5447	8-25-54	24	21.2	0.4	3726	10.4	Unvented
	5600	5447	1-17-56	24	27.0	0	6667	20.2	Unvented
	5600	5447	7-26-57	18	23.2	0	1897	23.1	Unvented
	Clearfork	6235	7-21-55	24	10.4	0	14423	6.7	Unvented
	Clearfork	6235	8-9-57	24	8.9	0	33208	5.7	Unvented
B	5600	5317	1-12-55	24	13.6	0	3382	12.5	Unvented
	5600	5317	7-30-57	12	6.1	0	5410	11.2	Unvented
	Clearfork	6339	11-26-54	24	19.0	0	1684	15.0	Unvented
	Clearfork	6339	9-11-57	10	8.0	0	1625	15.1	Unvented

used. Following this installation production from both zones was lower than had been anticipated. The 5600' pay (upper zone) produced a daily average of 22 barrels of clean oil with a gas-oil ratio of 2200 to 1, and the Clearfork pay (lower zone) produced a daily average of 10 barrels of clean oil with a gas-oil ratio of 5000 to 1. Due to the high gas-oil ratios, gas locking of the pumps appeared to be a possible cause for the low production. In May 1954, the conventional insert pumps were replaced with two-stage pumps in an attempt to alleviate this condition. After stabilization of production, the 5600' pay produced a daily average of 45 barrels of clean oil, and the Clearfork pay produced a daily average of 26 barrels of clean oil. This is an increase in production, attributed to the installation of two-stage pumps, amounting to 205 and 260 percent from the respective 5600' and Clearfork pays.

Similar equipment to that shown in Fig. 2 was also installed in Well B in August, 1954. Representative tests using this combination of pumping equipment are shown in Table 2.

Both wells pump off, which accounts for the low pump efficiencies. Production is generally comparable to the yield of nearby single-zone producers.

The pumps in Well A have been pulled a total of four times since installation of the converted equipment in March, 1954. Each of these pulling jobs was necessary for annual bottom hole pressure measurements of the upper 5600' pay according to the Railroad Commission orders; the pumps were serviced at these times. In order to obtain a true bottom hole pressure of the upper zone, a wireline retrievable plug is set in the lower-pump shoe, thereby blanking off lower-zone fluid.

Operation In Well B

In Well B during the first 1-1/2 months of operation the sucker rods and pumps only were pulled three times, and the tubing, sucker rods, and pumps were pulled one time. Debris from jet shots, swab rubbers, packer rubbers, lost circulation materials, and cuttings plugged the pumps and the tubing crossover. Since the well was cleaned of this debris approximately 3-1/2 years ago the pumps have not required servicing. The pumps were pulled three times for annual bottom hole pressure measurements and once when the sucker rods unscrewed.

The dual-zone pumping equipment in both wells has given excellent service since removal from the well bores of debris deposited during initial completion and during the flowing life of the wells. Possibly, production would have been slightly improved if both zones could have been vented. However, the relative displacement of the pumps, compared with the fluid yield from the pay zones, is great enough that considerable pump displacement can be sacrificed to the production of gas without a loss in oil production. The large volume of the tubing-casing annulus, which serves as a conduit to transmit lower-zone fluid to the surface, proves somewhat troublesome. Since lower-zone production has been 19 barrels or less per day and the tubing-casing annulus will hold approximately 180 barrels, it is sometimes difficult to determine whether the lower-zone pump is functioning properly or not.

The two-packer combination, which currently can be obtained in the newer model in both the 2-inch and 2 1/2-inch sizes, still is applicable for some wells. For instance, it usually results in the smallest initial investment since it only requires one tubing string. This equipment can also be run in small-bore casing, which may prevent the installation of some other methods.

This subsurface hook-up imposes a number of restrictions on each zone due to its lack of flexibility. For example, neither zone can be treated with hot oil, corrosion inhibitor, or paraffin solvent; nor can fluid be circulated, gas be vented, or fluid level measurements be taken from either zone.

SINGLE-PACKER, DOUBLE-CLAMPED-STRINGS

A dual-zone pumping installation of the type schematically illustrated in Fig. 3 was installed in Well C in October, 1954. This installation differed from the double-packer, single string method in that parallel strings of 2 1/2-inch and 1 1/4-inch tubing were clamped together and run in place of a 2 1/2-inch tubing string and packer. The remainder of the equipment was identical. Fluid from the lower zone is produced up the 1 1/4-inch tubing, thereby leaving the tubing-casing annulus available as a gas vent for the upper zone.

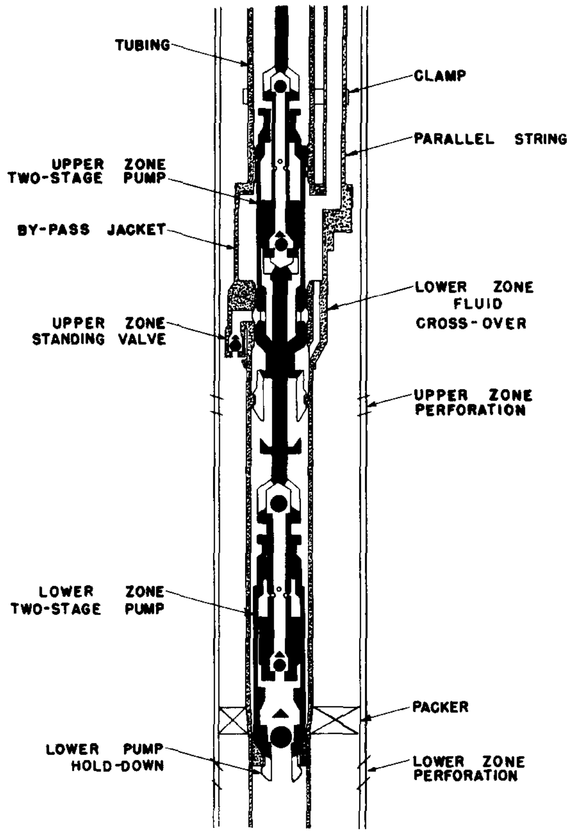

FIG. 3 SINGLE-PACKER DUAL-ZONE-PUMP INSTALLATION WITH DOUBLE-CLAMPED-STRINGS

These parallel tubing strings were preferred rather than the double-packer, single-string method, in order to provide a means for control of severe paraffin deposition from the lower-zone fluid. Hot oil is injected periodically into the casing, with paraffin accumulations from the interior of the tubing being successfully removed by the heat transfer. With this method of hot-oil treatment the pumping equipment is not shut-down, since its operation is desirable during treatment in order to remove melted paraffin.

Sand, suspended in the produced fluid from the lower pay, caused trouble immediately upon completion of this installation. The sand stuck the lower two-stage pump, which is not designed for sand production. A three-tube pump was run for a short time to clean up lower-zone production.

Representative tests from this well are listed in Table 3.

The decline in production during these tests was caused by a similar decline in the productivity of the pay zones. The production rates are very similar to those of nearby single producers.

The dual-zone equipment in Well C has undergone a total of 20 malfunctions in 38 months of operation, which is an average of 1.9 months operation for each service job. Operation of the dual equipment has therefore been extremely expensive. There have been 12 rod jobs to service the pumps, 4 fishing jobs to recover parted rods, and 4 stripping jobs to recover stuck dual-zone equipment. Eighty-five percent of these service jobs occurred during the first 16 months of operation with 15 percent occurring during the next 22 months. Produced sand seems to have been the main source of trouble causing worn pumps, stuck pumps, and stripping jobs. The dual-zone equipment has five locks or seals exposed to well fluids (three to the lower-zone fluid and two to the upper-zone fluid). The rod-string failures were possibly caused by its over stress during attempts to loosen stuck equipment and by over pumping of one or both zones.

When the equipment in Well C was converted in March, 1957, to the popular, independent-string method of dual-zone pumping, the clamps were still firmly attached to the tubing. Clamped-parallel-string installations, however, are hazardous since the buckling of the tubing by pump action could cause the clamps to loosen, fall, and stick the tubing.

SINGLE-PACKER, DOUBLE-UNCLAMPED-STRINGS

Fig. 4 shows a typical schematic drawing of this type of installation. In this subsurface combination only one packer is used to separate the two pay zones. The long string is run and latched into the retainer-type packer. This string is set with sufficient tension to avoid excessive tubing buckling and attendant sucker-rod abrasion during pump action. The short macaroni string, with beveled coupling edges, is then run and landed in the parallel-string landing head integral with the long string of tubing. Two insert pumps are used as in the other installations, with fluid from the lower pump passing up the macaroni string and fluid from the upper pump passing up the long string. This equipment is available in both the 2 1/2-inch and

Production Tests - Table 3

Pay	Depth Feet	Date	Hours Tested	Production - Bbls. Oil	Production - Bbls. Water	GOR	Pump Efficiency Percent	Remarks
Glorieta	4570	3-27-55	24	51.1	1.4	391	31.5	Vented
Glorieta	4570	1-13-56	22.6	56.1	16.6	446	51.5	Vented
Glorieta	4570	1-8-57	24	20.3	1.8	985	11.5	Vented
Fusselman	7574	10-20-54	24	92.5	5.5	714	50.5	Unvented
Fusselman	7574	10-18-56	24	24.9	5.5	803	22.5	Unvented
Fusselman	7574	10-9-57	24	16.4	0.2	433	14.2	Unvented

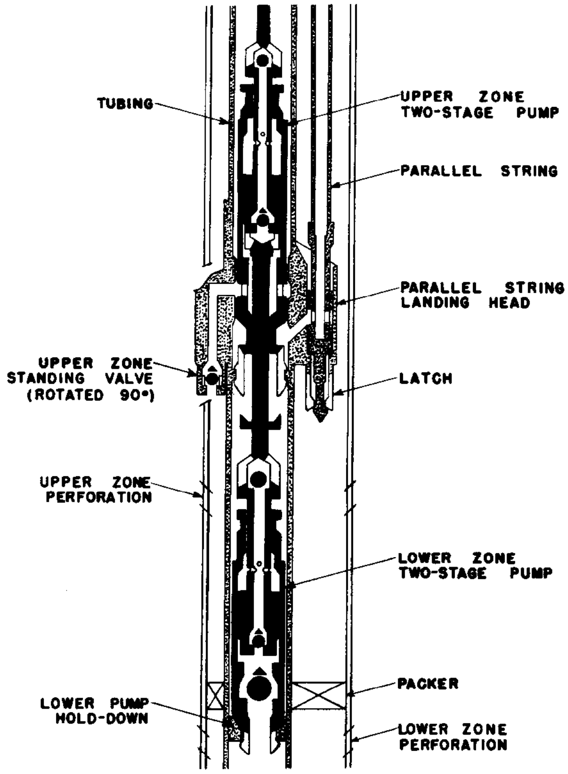

FIG. 4 SINGLE-PACKER DUAL-ZONE-PUMP INSTALLATION WITH DOUBLE-UNCLAMPED-STRINGS—BOTH ZONES PUMPING

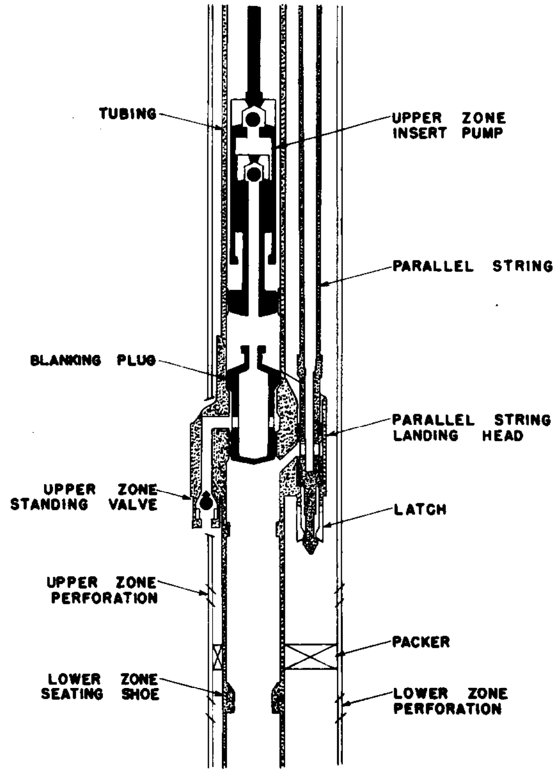

FIG. 5 SINGLE-PACKER DUAL-ZONE-PUMP INSTALLATION WITH DOUBLE-UNCLAMPED-STRINGS—UPPER ZONE PUMPING, LOWER ZONE FLOWING

2-inch models.

This arrangement of subsurface dual-zone pumping equipment was first installed in Well D in April, 1956. The inadvertent installation of a 5 1/2-inch landing head in 7-inch OD casing caused trouble during installation. The clearance between the landing head and the casing permitted the landing sub on the 1-inch macaroni string to miss the landing head and to wedge between the anchor and the casing. Shoulders were welded on the landing head to correct this condition. Before satisfactory operation of this equipment was obtained the rods, pump, and both tubing strings were round tripped once; the macaroni string alone was round tripped once; and the rods and pumps alone were round tripped twice. Since this installation was completed satisfactorily, it has given nearly 2 years of maintenance-free operation.

A similar installation was performed in Well E in July, 1956. This installation was completed without any trouble whatsoever. It has currently given 1-1/2 years of satisfactory service without a single shutdown to service the subsurface equipment.

Most Economical Approach

Many times the most efficient and economical approach to dual-zone pumping is the installation of separately-landed, parallel-tubing strings with appropriate dual-zone equipment during initial well completion. This procedure eliminates the expenditure to kill and re-enter the well at a later date when one or both zones have ceased to flow. The additional investment required at well completion is especially justifiable and profitable if the flowing lives of the two zones are anticipated to be rather short. Fig. 5 is a subsurface hook-up of an installation of this type. It permits both zones to flow or one zone to pump and the other zone to flow merely by the installation of the proper wireline tool in the crossover shoe. During installation of this equipment, an accurate measurement of the distance between the lower and upper pump shoes must be made and kept available for future reference when tandem pumps are run.

Gulf has six installations of this type. In one well both zones are now pumping; in four wells the upper zone is pumping, and the lower zone is flowing; and in one well the upper zone is flowing, and the lower zone is pumping. Both zones have pumped in Well F since July, 1957. The rods and pumps have been pulled twice to permit servicing of the pumps and packing between the pumps. On one occasion steel shavings damaged the upper pump, and in another instance the metal-to-metal packing between the pumps froze. In wells where only one zone is pumping, the troubles encountered have been common to that of nearby single-zone wells.

Compiled in Table 4 are results from tests on three wells equipped with the single-packer, double-string method of dual-zone pumping.

These single-packer, double-unclamped-string methods are rather versatile and trouble-free because (1) the need for clamps is eliminated, thereby speeding up rig time and removing the hazards associated with clamps, (2) the upper zone can be vented, (3) hot oil, paraffin solvents, and corrosion inhibitors may be injected into the casing, (4) sonic fluid level measurements can be taken for the upper zone, (5) the tubing strings may be run in and pulled out independently, but only in

Production Tests - Table 4									
Well No.	Pay	Depth Feet	Date	Hours Tested	Production - Bbls. Oil	Water	GOR	Pump Efficiency Percent	Remarks
D	5600	5750	8-1-56	24	48.8	5.4	3074	39.1	Vented
	5600	5750	9-27-57	3	9.5	0	2000	55.0	Vented
	Clearfork	6239	8-1-56	15	22.1	0	1312	24.3	Unvented
	Clearfork	6239	8-1-57	12	9.7	2.0	2062	16.1	Unvented
E	5600	5683	9-27-56	24	23.1	0	5195	17.4	Vented
	5600	5683	9-28-57	5	9.7	0	2062	35.1	Vented
	Clearfork	6246	9-8-56	24	13.2	0.6	5303	9.9	Unvented
	Clearfork	6246	7-26-57	24	5.5	0	11455	3.9	Unvented
F	Tubb	4900	9-11-57	24	80.1	21.3	325	66.1	Vented
	Tubb	4900	12-5-57	24	79.7	28.0	289	70.0	Vented
	Wolfcamp	6300	9-11-57	24	63.4	12.0	804	46.6	Unvented
	Wolfcamp	6300	12-6-57	24	51.2	34.1	645	52.7	Unvented

a certain order: the long string must be run first, while the short string must be pulled first, and (6) one or both zones may be allowed to flow and may be placed on pump at a later date without disturbing the tubing.

SINGLE-PACKER, DOUBLE-UNCLAMPED-STRINGS WITH DOUBLE-BYPASSES

This unique installation is shown schematically as Fig. 6 and was installed in Well G in August, 1956. When this equipment was installed, considerable doubt existed as to whether it would perform satisfactorily; however, the design appeared sound from an engineering standpoint. This design is an adaptation of the usual dual-zone equipment, which permits the shoe for the upper-zone pump to pass into a 5-inch OD (18#) liner in order to attain complete depletion of the upper zone.

This subsurface arrangement utilizes a double by-pass, 550 feet of hollow sucker rods, one retainer-type packer, and two unclamped tubing strings. The hollow sucker rods act as a conduit for upper-zone fluid to a point just above the 5-inch OD liner where a cross-over directs the production into a 1-inch macaroni string. The lower-zone fluid produces through the 2-inch tubing for the entire distance from the pump to the surface, except that it must traverse two bypass shoes.

The only source of trouble during this installation occurred when the macaroni string, which originally was set in tension, became unlatched. This string was reset and left in compression.

This equipment has not required any repairs since its installation 1-1/2 years ago. Table 5 shows some representative production tests from this well.

The production from Well G is comparable to the production from nearby single-zone producers.

This type of installation would rarely have an application. It is shown merely to illustrate how standard dual-zone equipment can be deviated to suit any unusual conditions existing in a particular well. The principle

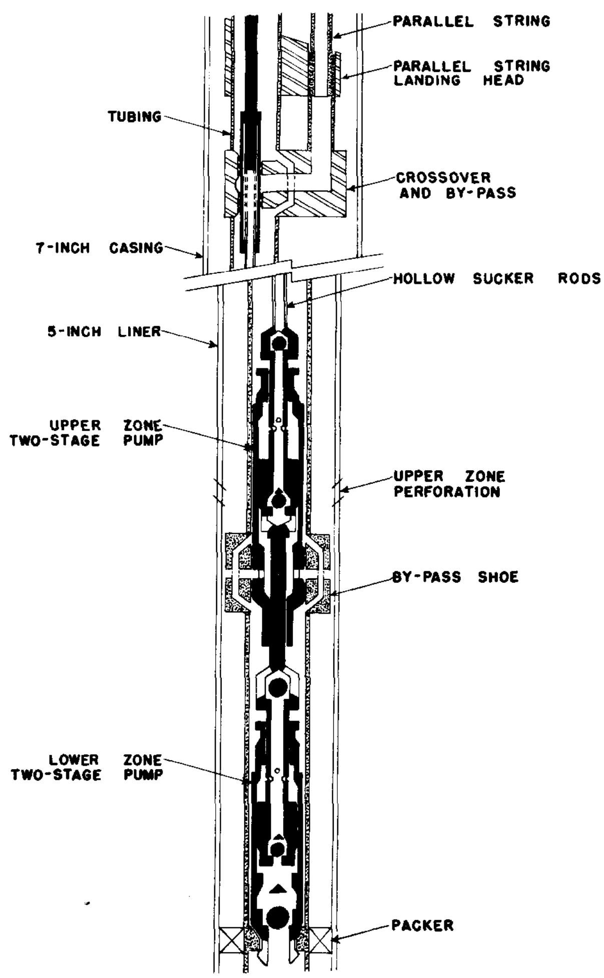

FIG. 6 SINGLE-PACKER DUAL-ZONE-PUMP INSTALLATION WITH DOUBLE-UNCLAMPED-STRINGS, DOUBLE BY-PASS, AND HOLLOW SUCKER RODS

Production Tests - Table 5								
Pay	Depth Feet	Date	Hours Tested	Production - Bbls. Oil	Water	GOR	Pump Efficiency Percent	Remarks
5600'	5810	2-15-57	24	46.1	0	3471	65.0	Vented
5600'	5810	8-2-57	24	6.8	0	19118	9.6	Vented
Clearfork	6050	3-5-57	24	15.2	0	4934	15.3	Unvented
Clearfork	6050	7-19-57	17	11.3	0	2566	16.0	Unvented

application of this hook-up would likely be in a well, similar to the one shown, containing a small-bore liner. The "double bypass" arrangement might prove applicable where it is desirable for the lower zone to produce up the long string and for the upper-zone production to divert into the parallel string.

SINGLE-PACKER, TRIPLE-STRING

Fig. 7 is a schematic drawing depicting the latest dual-zone tubing assembly installed in two wells during initial completion. The upper zone is equipped to pump, while the lower zone is flowed. When the lower zone ceases to flow, a second pump will be run and seated in a shoe provided in the tubing string.

This arrangement consists of the standard dual-zone equipment and two parallel strings of 2-inch tubing with 1-inch vent tubing extending beneath the shorter string downward through the packer. The crossover shoe with landing head is run on the long string and a landing sub is run on the bottom of the short string. A ball-and-seat arrangement with a fishing neck attached is installed in a seat on top of the 1-inch vent tubing. This valve remains closed except when the pressure buildup below it exceeds the fluid head. At a later date, should the lower-zone pump gas lock, the ball-and-seat arrangement can be pulled and a 3/4-inch vent string can be substituted inside the shorter tubing string.

In this system the long string conducts upper-zone fluid to the surface. The parallel string conducts the lower-zone fluid from the crossover shoe to the surface, while the 3/4-inch concentric string, when installed, will conduct the lower-zone gas from below the packer to the surface. The casing serves as a vent for the upper zone.

Landing Sub Leaked

In both installations of this type the landing sub on the bottom of the short string leaked. There was considerable money expended to locate the leak in each well and to pull and rerun the short string. The cause of these leaks was apparently not due to faulty equipment but to insufficient weight being set on the short string. This was the only trouble experienced with one installation. In the other installation, however, the sealing elements in the retainer-type packer also leaked. A successful completion of this well was obtained after several months had expired, in which large expenditures were incurred in testing and service work.

Since the single-packer, triple-string method requires an extra string of 2-inch tubing, it is usually more expensive than any of the other methods mentioned. Otherwise this installation has all the advantages of the single-packer, double-string model, plus some additional ones. The advantages of the single-packer, triple-string assembly over all other methods are made possible by the 3/4-inch vent string. This vent string (1) provides a means for venting lower-zone gas, (2) can serve as a conduit for corrosion inhibitor injection to the lower-zone pump when it is not used to vent gas, and (3) permits circulation of lower-zone production if such action is desirable to avoid overproduction.

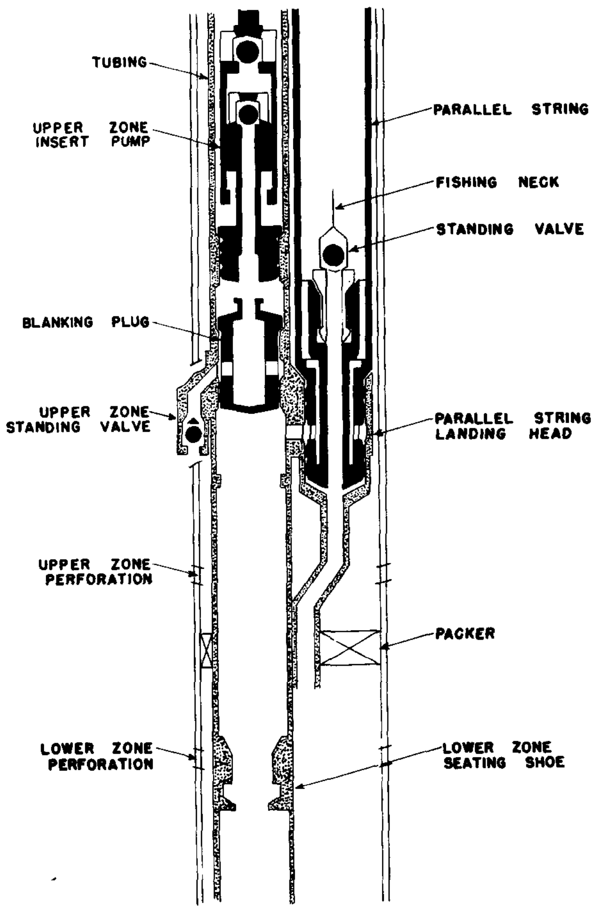

FIG. 7 SINGLE-PACKER DUAL-ZONE-PUMP INSTALLATION WITH TRIPLE -UNCLAMPED-STRINGS — UPPER ZONE PUMPING, LOWER ZONE FLOWING

DISCUSSION AND CONCLUSIONS

Our experience with tandem pumps indicates that as a general rule this equipment will give satisfactory service. The newer designs should eliminate or minimize some objectionable features of earlier models. However, problems and difficulties are usually inherent qualities of dually completed wells with out without pumping equipment. Dual-zone pumping certainly involves more problems than single-zone pumping.

Most dual-zone pumping equipment problems have occurred during installation or immediately thereafter. In some wells the installation was made without mishap. In other wells random difficulties developed, usually attributable to failure of a latch to lock into place or a seal to hold. Possibly the greatest overall source of trouble was caused by the plugging and sticking action of debris and sand during the cleaning-up period immediately following a dual-zone installation. Thorough circulation of the well bore prior to the installation of dual-zone pumps might minimize this difficulty.

In one well, in which the lower zone and possibly the upper zone produce fluids that contain small amounts of suspended solids, the operational costs have been extremely high. The equipment malfunctions experienced in the operation of dual equipment in this well, and the difficulties resulting from the production of solids during and immediately following the completion of other installations, suggest that a concerted effort should be made to keep the production of sand and debris at a minimum. Newer designs in tubing assemblies and associated equipment have reduced the number of seals exposed to well fluids, which should decrease to a small extent the possibility that sedimentation of solids might stick the pumping equipment.

Subsurface Repairs

Disregarding the aforementioned well in which the production of sand caused excessive repairs, the remaining six wells equipped with tandem pumps have suffered very little downtime for subsurface equipment repairs. These installations, following a short clean-up period, have operated a total of 150 months with only three pulling jobs that were solely the result of equipment malfunctions. Unscrewed rods caused one of these service jobs. These installations, therefore, have averaged 50 months of operation for each pulling job. The rods in two wells, however, were pulled several times for annual bottom hole pressure measurements, and the pumps were serviced on these occasions.

The two-stage pump has proved its value in the production of foamy or gassy fluid. This feature is particularly advantageous when all produced gas must pass through the pump (pumping from beneath a packer). Since the two-stage pump will usually operate with a faulty standing valve, it is also very useful as an upper-zone pump where it may minimize or eliminate the need for a standing valve integral with the tubing string. This pump, however, should not be used in wells where the produced fluid contains suspended sand.

The most logical conclusion regarding pump efficiencies is that tandem pumps will yield efficiencies comparable to single-zone pumps operating under similar conditions. With one exception the wells utilizing tandem pumps have been low producers in which the productivity of each zone has been considerably less than the pump's displacement. Under these conditions the productivity of each zone, and not the pump, usually governs the pump efficiency, accounting for most of the low efficiencies.

Advantages and Disadvantages.

Dual-zone pumping using tandem pumps has distinct advantages and disadvantages. Some advantages are: (1) smaller initial cost in comparison with other methods, (2) compatibility with casing designs in most wells, and (3) elimination of upkeep of two pumping units. The main disadvantages are: (1) lack of simplicity compared to some methods, (2) inability of equipment to handle suspended sand as well as some other methods, (3) loss of production from both zones due to the servicing of down-hole equipment for one zone, (4) pumping depth and quantity of production limited by strength of rods, and (5) lack of flexibility even in the most advanced models.

The flexibility has improved considerably in the last few years mainly through deviations in tubing assemblies; however, the pumping speed, pumping time, and length of stroke are by nature of this equipment still the same for both zones. This condition sometimes makes difficult the regulation of production from the two zones, since one zone may overproduce while the other zone is underproduced. Some means for varying the production from one zone are: (1) changing the pump size, (2) circulating production, (3) unseating pump (applies only to the lower pump), and (4) allowing the pump to pump through itself by use of a traveling overload valve on the pump.

The tandem pumping method has demonstrated its value as a means for producing dually completed wells. Like any type of oilfield equipment, however, it has its limitations, and should be thoroughly engineered to suit conditions existing in each specific well.