Rod-Counterbalanced Hydraulic Pumping Units–A Progress Report

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INTRODUCTION

The purpose of this paper is to supplement the one presented at last year's Oil Lifting Short Course when rod-counterbalanced hydraulic pumping units were discussed in detail. A brief review plus new data on design and case histories will follow.

Rod -counterbalanced hydraulic pumping has as its purpose the utilizing of the long, slow stroke inherent in the hydraulic pumping unit, at the same time effecting substantial economy in first cost with no sacrifice in subsequent operating costs.

The basic principle of the system is the balancing of the sucker rod string in one well with the sucker rod string in a second well. It can be applied to dual, parallel completions or single wells on offset locations. Only one power unit is required for the two wells.

DESCRIPTION AND OPERATION

Figure 1 shows the control piston on upstroke. The slave piston is pumped down by the power pump, while the control piston is urged upward by the balance oil, while the upper end of the control cylinder is vented to the atmospheric reservoir. The booster, or makeup, pump feeds a small volume of oil into the balance line to make up losses such as in valve operations reversal, piston blow-by, and the like.

Figure 2 shows the control piston on downstroke. It has passed the upper valve port and has caused the reversing valve to shift, and has effected the "crossover" in the reversing valve so that the slave cylinder is now vented at its upper end and the power pump is forcing down the control piston. The booster pump continues to inject oil into the balance line.

Also shown in Figure 2 is the "dumping" action, which gets rid of any excess oil injected by the booster pump. This excess oil passes through the dump port, and causes the slave piston to "wait" until the control piston has passed the valve port, with the two pistons automatically keeping in phase and with a constant amount of oil between them in the balance line. After the control piston passes the lower valve port, the reversing valve shifts to its Figure 1 position and the cycle commences once more as in Figure 1.

Figure 3 shows the starting procedure, which is completely automatic. Obviously, before operation starts, both pistons will be at the bottom of their respective cylinders. When both power and booster pumps are

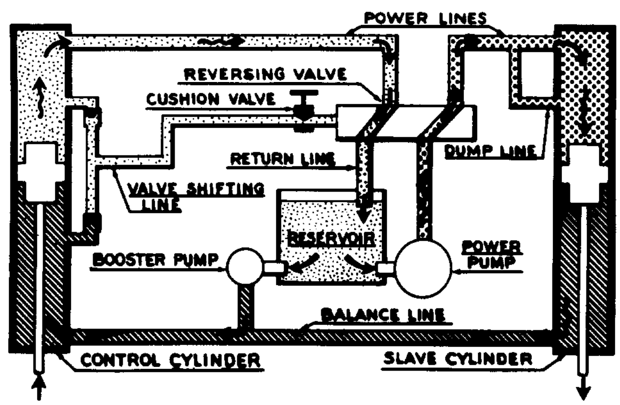

FIG. 1. CONTROL PISTON ON UPSTROKE

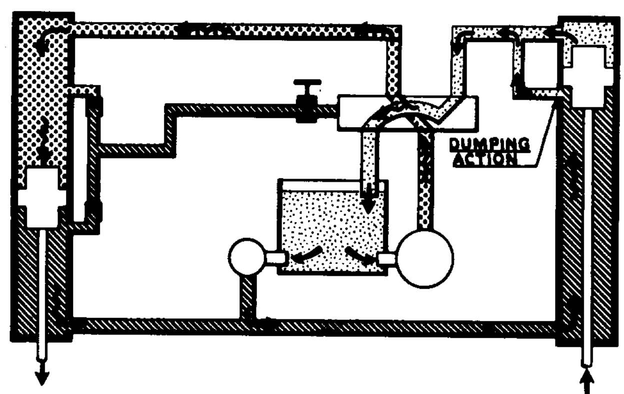

FIG. 2. SLAVE PISTON ON UPSTROKE

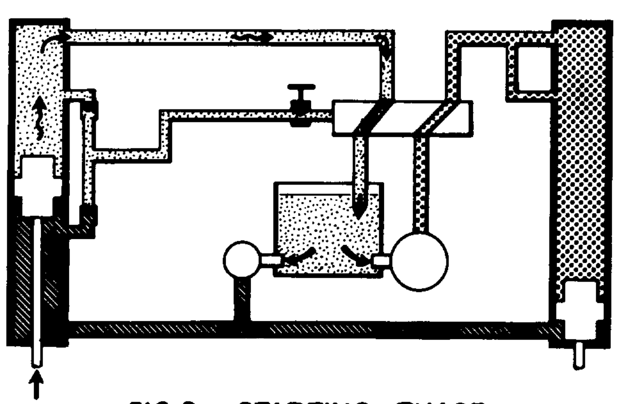

FIG. 3. STARTING PHASE

BALANCE PRESSURE: HYDRAULIC FLUID UNDER PRESSURE DUE TO COMBINED WEIGHT OF RODS AND WELL FLUID ON UPSTROKE PISTON.

POWER PRESSURE: HYDRAULIC FLUID UNDER PRESSURE DUE TO WEIGHT OF WELL FLUID ONLY ON UPSTROKE PISTON.

RESERVOIR PRESSURE: HYDRAULIC FLUID AT ATMOSPHERIC PRESSURE.

DIRECTION OF HYDRAULIC FLOW.

FIG. 4. LEGEND FOR FIGS. 1, 2, and 3.

started, the reversing valve automatically takes the position shown, so that the upper end of the control cylinder is vented to atmospheric pressure and the power pump is pumping into the top of the slave cylinder, and holding the slave piston against the bottom of the cylinder, while the power pump by-passes through a relief valve (not shown). Since the booster pump feeds into the balance line, the control piston is caused to move upward, although at a very slow rate of speed. After the control piston has passed the upper valve port, the reversing valve shifts to the Figure 2 position, and normal operation begins.

A look at Figure 4 will show the oil pressures involved in Figures 1, 2 and 3; thus a brief analysis can be made of the power requirements. In the balance line, the pressure is that required to lift the string on upstroke, and is equivalent to the weight of rods and fluid weight on net plunger area. It is assumed that there is no friction; the power oil pumping against the downstroke piston will have a pressure required to lift the fluid weight on net plunger area on the upstroke pump, for the rod strings, being designed to have equal weight, will cancel each other.

In designing a unit, the worst condition is assumed: the condition is that the upstroke well is pumped off and that the downstroke well is not. This condition substracts the buoyancy of the downstroke rods from their counterbalancing effect, and the actual effect is that the well fluid weight on the gross plunger area in the upstroke well is being lifted. On a single counterbalanced unit, only one-half the gross fluid weight is lifted, but the rod counterbalanced unit is pumping two wells.

A more detailed discussion of operation and description may be found in the previous paper.

FIELD INSTALLATIONS

Following is a discussion of various field installations, some of which were included in the previous paper, and some of which have been installed since. They serve to illustrate the two basic types of rod-counterbalanced installations (dual and offset) as well as the various types of mounting over the wells. Also they afford evidence of the wide variations of conditions to which they may be applied

Figure 5. Offset Unit in Nebraska, Support Cage Mounted.

The wells are 50 ft apart, with 1-1/4 in. and 1-1/2

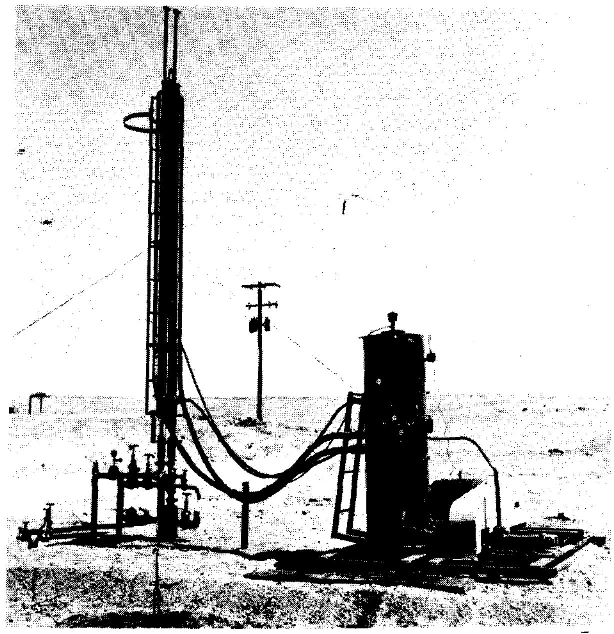

Fig 6

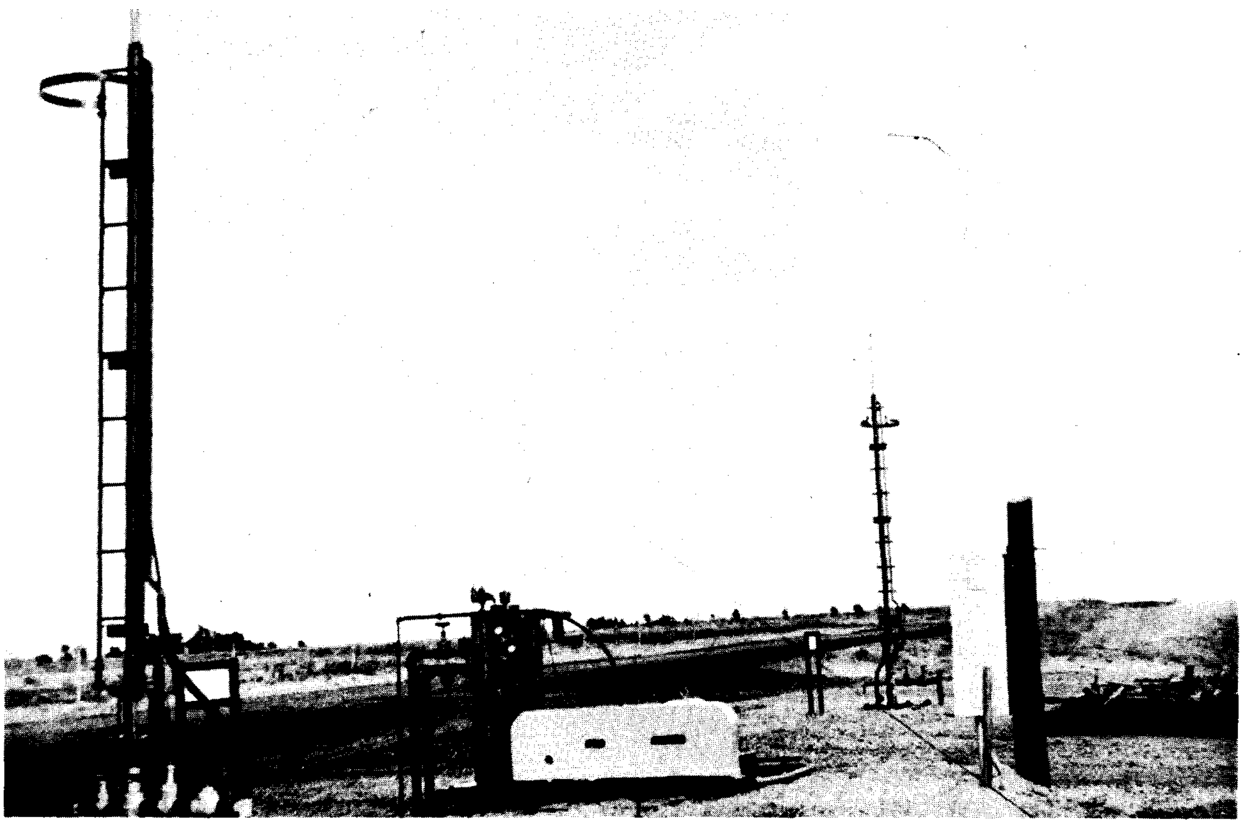

Fig. 5

in. pumps set at 3500 ft. The unit has a 10 ft stroke and is operating at 6 SPM and producing at rates of about 100 BPD and 135 BPD respectively; and was powered by 30 hp electric motor. This unit has been in service for approximately one year, and is owned by an independent.

Figure 6. Dual Unit in Nebraska, Support Cage Mounted.

This unit is one of five duals owned by the same company as is the previous offset unit. Well tubing centers were such that the cylinders could be mounted on the support cage. With a 2-in. bore pump set at 3500 ft in each zone, the unit is operating on a 10 ft stroke at 7 SPM and giving a production rate of 250 BPD from each zone. Power is furnished by a 30 hp electric motor. The operator estimated a 40 per cent overall saving in initial investment, as against conventional equipment.

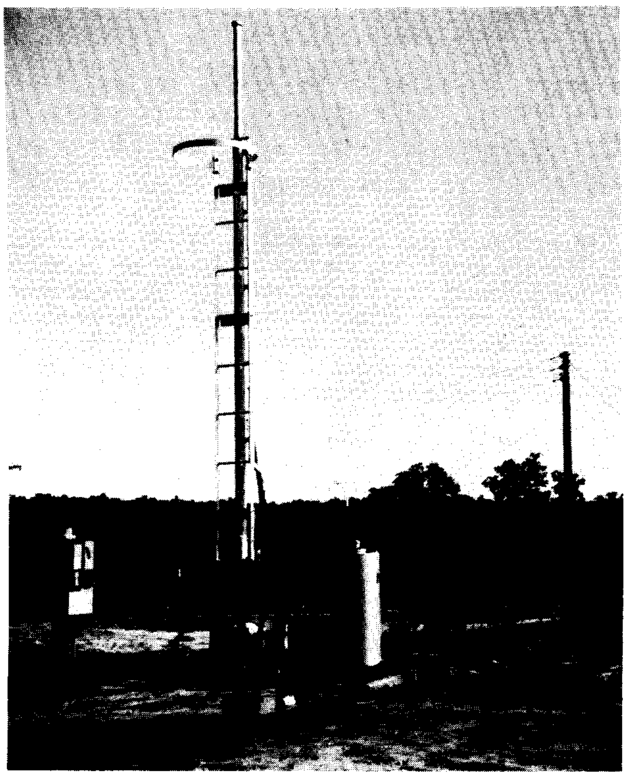

Fig. 7

Figure 7. Offset Installation in Southern Oklahoma, Support Cage Mounted.

This installation is on a major company waterflood. Wells are 350 ft apart and connected with 2-in. hydraulic lines, buried underground. Pump depths are 1200 ft, with 2-in. bore pump in each. The unit is operating on a 9 ft stroke at 7 SPM, and is producing fluid at about 300 BPD from each well. The unit uses a 20 hp electric motor. By resheaving and using 2-1/4-in. pump, this same unit can produce nearly 600 BPD from each well. Alternate conventional equipment would have cost almost twice the installed price in this case. This unit has been in operation about five months.

Figure 8. Dual Installation in South Texas, Quadrupod Mounted.

This unit, owned by the same major oil company as is the previous offset, makes a 3 ft stroke at 7 SPM.

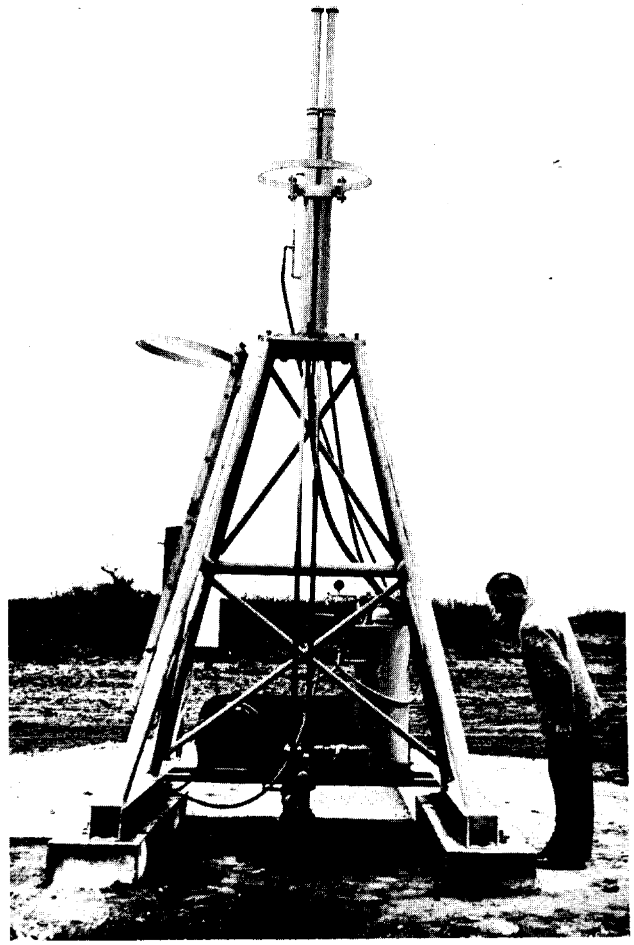

Fig. 8

A 1-1/4 in. pump is set at about 2200 ft in either zone and uses 1/2 in. sucker rods. Approximate production rate is 40 BPD from each zone. A power test showed an average demand of approximately 3 hp, or 1-1/2 hp per well. The unit has been in service about 1 1/2 yr, with no down time reported. Cylinders are mounted on a quadrupod to allow polish rods to drift, for cylinder centers are somewhat further apart than well centers.

Figure 9. Dual Uint Near Healdton, Oklahoma, Pedestal-Quadrupod Mounted.

The zones in this well are at 9000 ft and 8500 ft, and about 100 BPD are produced from each. The unit will make 7 SPM on a 12 ft stroke, with 1-1/4 in. pumps. It has been in service for about nine months, and is one of four owned by independents in this area. All are powered with multi-cylinder engines.

One of these is somewhat different and makes an interesting example of the flexibility of this system. The operator had two strings of 1-1/2 in. tubing in the well during its flowing life. When the zones died, it was felt that the tubing should be "changed out" to 2-in. in order to use 3/4 in. sucker rods, for the zones were at 8500 ft and 8000 ft. Required production was 50 BPD from each zone. After a study was made, it was found that, without changing the tubing strings, the zones could be pumped at that rate with the hydraulic unit; but by using 1-1/16 in. bore pumps and 5/8 in. high-tensile sucker rods with slim-hole couplings, they could be pumped at a rate of 4 SPM on a 12 ft stroke. The maximum rod stresses calculated 42,000 psi in one zone

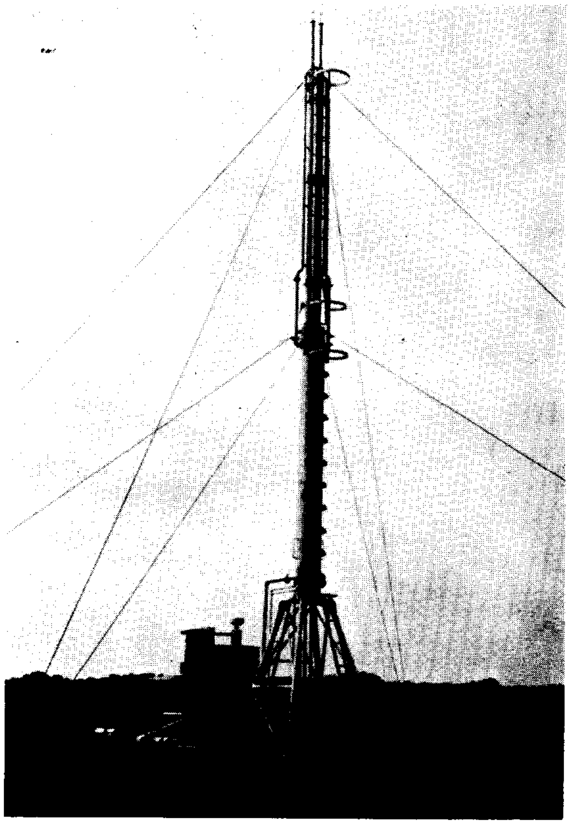

Fig. 9

and 40,000 psi in the other. The unit itself was nearly half the cost of conventional equipment, and an even substantial saving was made in not having to "change out" the tubing strings. This unit has been in operation for about six months, with no rod trouble reported.

Figure 10. Offset Installation Near Healdton, Oklahoma, Support Cage Mounted.

These wells are on 40-acre spacing (1320 ft apart), and originally had a dual zone pump in each well, with zones at 9500 ft and 9000 ft, but one well has had upper zone pump removed, for this zone did not continue to produce. Producing rate is about 100 BPD from each well. The unit has a 16 ft stroke and is operating at 3 SPM. Connecting hydraulic lines are 3-1/2 in. OD electric weld pipe. The total cost of the installation, with multi-cylinder engine, was almost exactly half that of the conventional units which were originally on the wells and which were moved to single locations. This unit has given satisfactory service and has been operating for about 18 months. At this writing, the independent owning this unit has placed orders for additional hydraulics.

CONCLUSION

The system of rod counterbalancing has been under test now for nearly two years, and has proven practical and satisfactory in all cases where used. At present, there are in excess of three dozen wells being produced in this manner, and it is expected that the economics and advantages discussed in the foregoing paragraphs will cause the continued spread of the system.

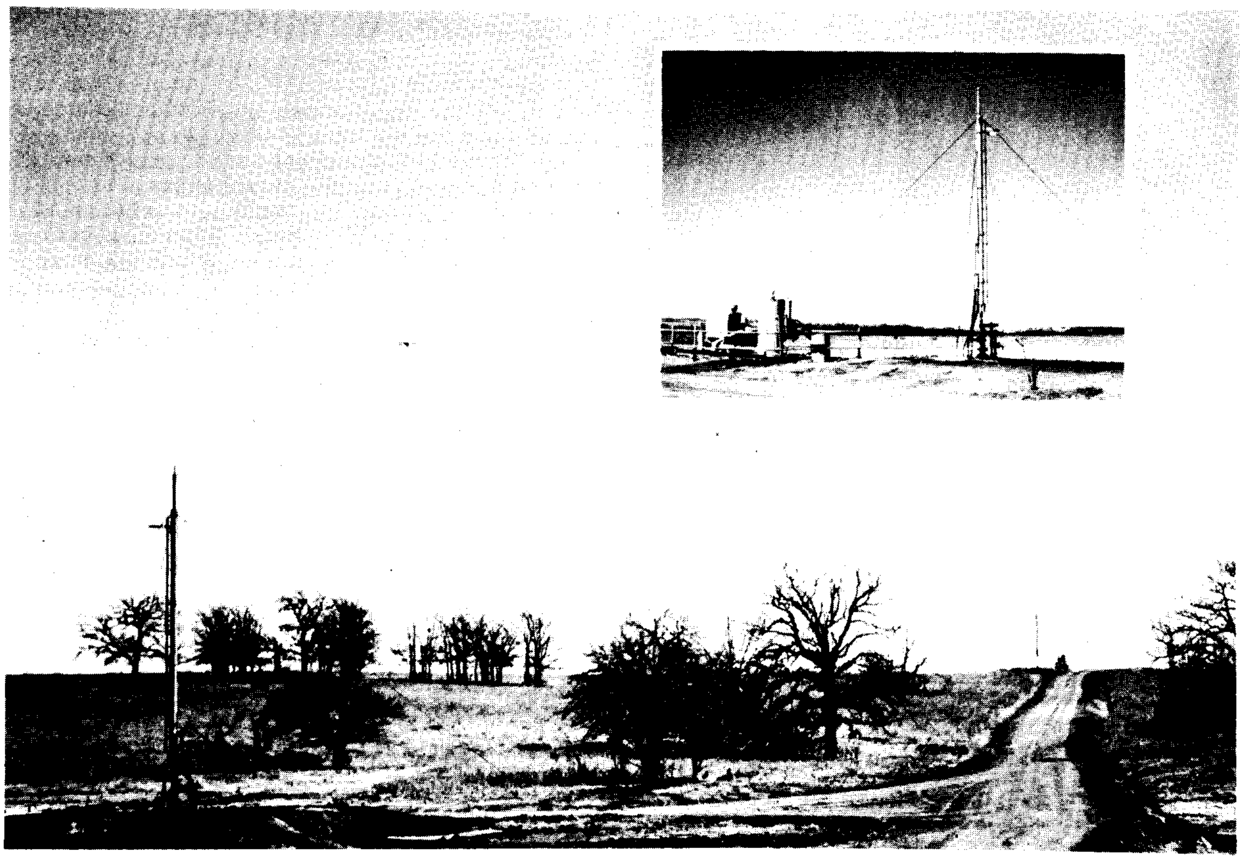

Fig. 10