Fluid Production by the Free-Travel Plunger Method in Low Pressure Gas Wells

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ABSTRACT

The water-logging of low pressure gas wells is a serious problem in some areas, and tends to become more grievous as field pressures drop. The free travel plunger, an old idea in the petroleum industry may prove in some instances to be more economical than any other known method of meeting this problem.

This paper explains the theory of the free travel plunger, presents a few case histories, and generally compares the economical and operational aspects of this method with the more popular siphon string and pumping methods.

THEORY

The theory of the free travel plunger is fairly simple. A gas well is equipped as shown in Fig. 1-A, the casing connected to the sales line and the tubing connected to a line to the salt water pit. The casing feeds gas continuously to the sale line, but the tubing is opened and closed intermittently by a clock controlled motor valve.

A metal piston is free to travel up and down the tubing, being stopped at either end by the shock absorbing spring in the bottom of the tubing and a lubricator or catcher with a similar spring at the top of the tubing. A shut-off trigger in the lubricator, which is tripped by the piston, completes the equipment installation.

Fig. 1-A also shows the first portion of the cycle. The plunger is resting at the bottom of the tubing with some water above it. The pressures of the casing and the tubing are approximately equal. Fig. 1-B shows the next step; the clock operates the motor valve, opening the tubing to the pit and beginning to bleed it down to the atmosphere. As the pressure in the tubing lowers, the casing pressure forces the piston with the load of water above it up the tubing.

In Fig. 1-C, the piston has arrived at the surface, forcing the water out to the pit. The buffer spring breaks the shock of the piston's arrival. A trigger mechanism built into the lubricator is tripped by the piston, closing the motor valve. After the valve closes the piston falls back to bottom of the tubing, there to begin another cycle.

The frequency of these cycles is set on the clock according to the daily water production of the well. This frequency ranges between one and 70 trips per 24 hour period.

CASE HISTORIES

Case histories of the following five wells are presented in order to give a more accurate idea of the actual operation of free travel plunger in low pressure gas wells. All these wells are in the West Panhandle or Hugoton gas fields. The total depths range from 3,200 to 3,400 feet, and the operating pressures range from 130 to 170 psi.

Well No. 1

This Moore County gas well was completed June 12, 1945 with an initial rock pressure of 339 psi, and an initial potential of 7,000 Mcf per day. A siphon string (one inch upset tubing) was run into this well in July, 1953. By blowing this string intermittently to the atmosphere, the well continued to produce its allowable, an average of about 15,000 Mcf per month, until January, 1955.

At that time the well began loading up with water, oil and some paraffin until the siphon string was overloaded and ceased functioning. A pulling unit was called out and the well was cleaned up enough for the siphon string to begin working again. This process continued until September, 1957. Figs. 2-A and 2-B compare the production with the allowable for this period of time. During the 6 months previous to the installation of the plunger lift, the well was underproduced a total of 18,683 Mcf.

In the 15 months immediately following the installation of the lift, the total allowable has been 229,833 Mcf, and the well produced 229,379 Mcf. The estimated production for this period without the plunger lift is 157,000 Mcf. According to this estimate, an additional 72,000 Mcf has been produced from the well due to the installation of the plunger lift during those first 15 months.

The cost of this project may be broken down as follows:

Initial cost	
Tubing and fittings	$2,830.00
Pulling Unit	560.00
Plunger lift	2,050.00
Total	$5,440.00
Operating expense	
Labor	$ 750.00
Transportation	250.00
Replacement parts	220.00
Pulling Unit	420.00
Total	$1,640.00
Monthly average	$110.00

Figuring the gas at 10¢/Mcf, the installation was paid out in 14 months and the gas produced due to the plunger lift is giving an average net profit of $370.00 per month.

This well has presented very few operating problems. The plunger now makes only one trip per day, bringing up about ten gallons of black, heavy liquid. Normally it is necessary to check this well only twice per week.

Well No. 2

This gas well in Sherman County was completed June

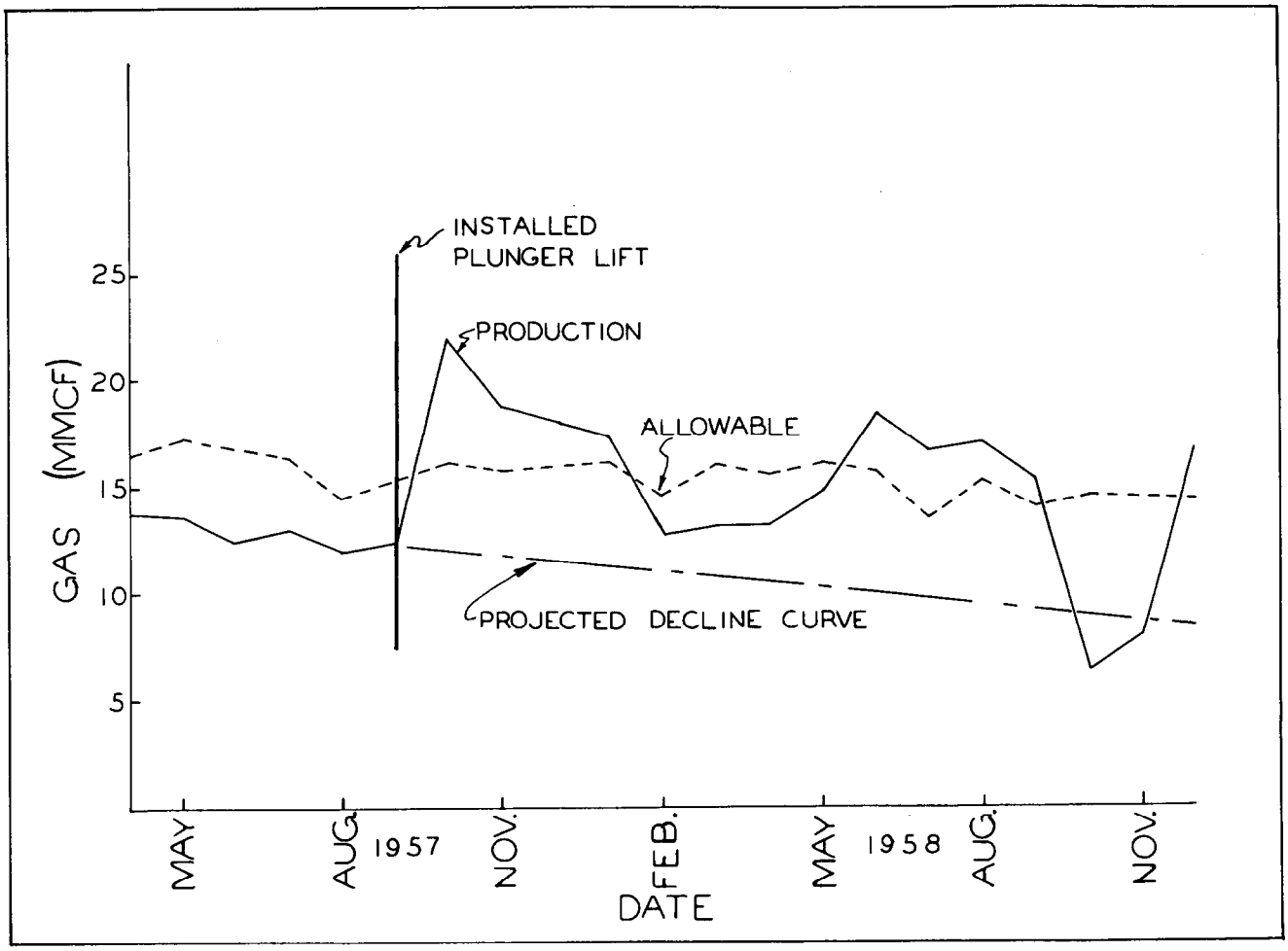


FIGURE 2-A

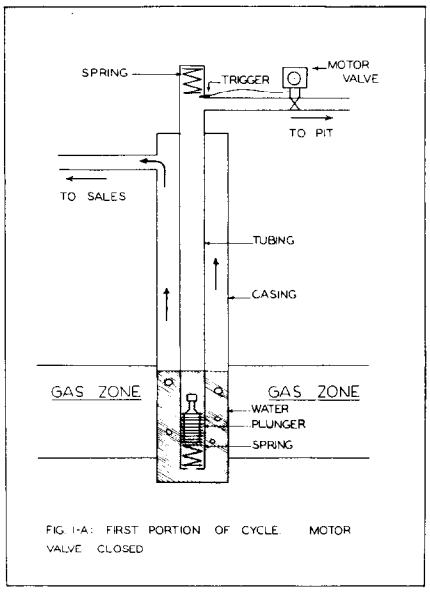


FIG. 1-A: FIRST PORTION OF CYCLE. MOTOR VALVE CLOSED

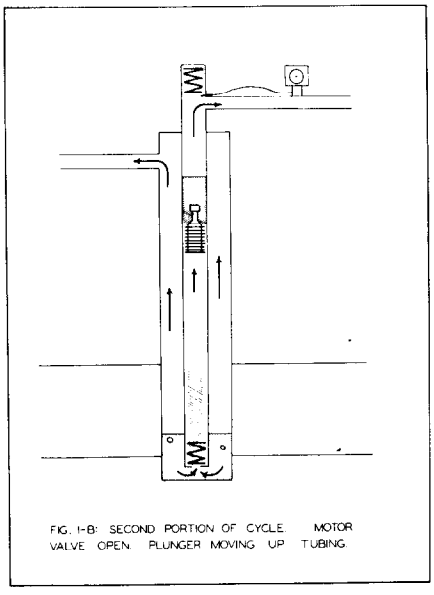


FIG. 1-B: SECOND PORTION OF CYCLE. MOTOR VALVE OPEN. PLUNGER MOVING UP TUBING.

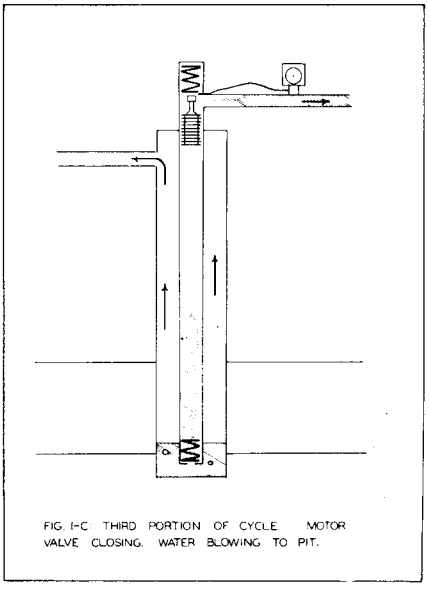
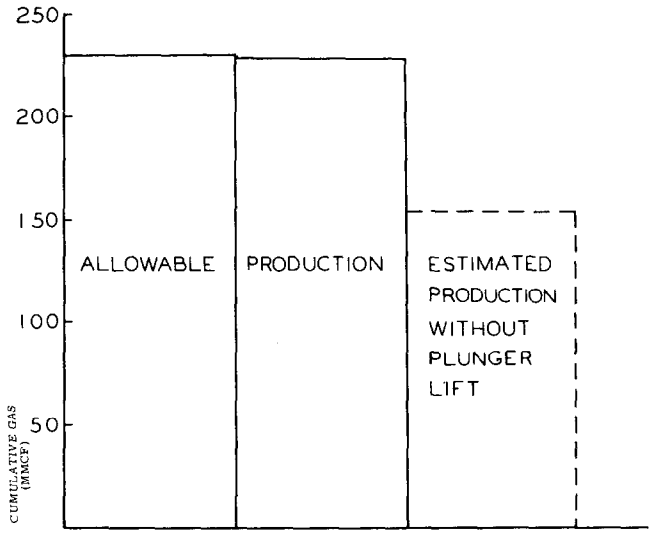


FIG. 1-C: THIRD PORTION OF CYCLE. MOTOR VALVE CLOSING. WATER BLOWING TO PIT.

FIGURE 2-B



5, 1951 for 3,352 Mcf per day with an initial rock pressure of 383 psi. During June, 1956, the well was reworked in an unsuccessful attempt to shut off the salt water. A one inch siphon string was run into the well immediately after the rework, but by February, 1957 the salt water had increased until this tubing could not handle it. In July, 1957 a plunger lift was installed on this well. Figs. 3-A and 3-B show the results.

For the seven months immediately preceeding the installation of this equipment the cumulative allowable was 155,486 Mcf, while the cumulative production was 118,981 Mcf. For the 17 months following this installation, the cumulative allowable was 398,241 Mcf, while the cumulative production was 380,930 Mcf. The projected production decline curve indicates that only 136,000 Mcf would have been produced during that 17 month period if the plunger lift had not been installed. Thus, 245,000 Mcf have been produced due to this installation.

The expense of this plunger lift is broken down as follows:

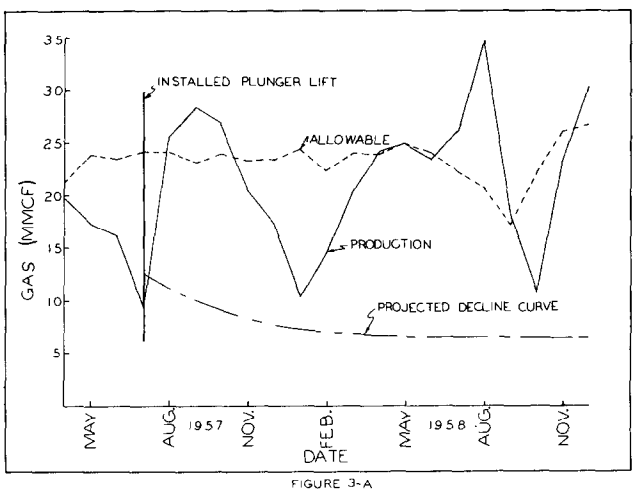


FIGURE 3-A

Initial cost

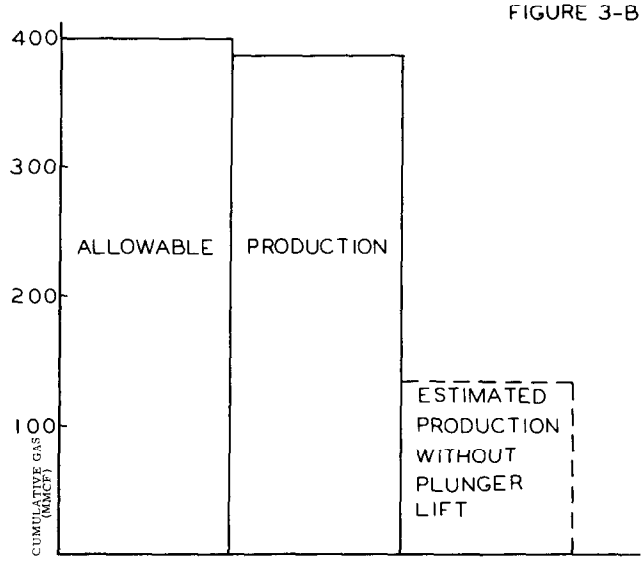
Tubing and connections	$1,120.00
Pulling unit	700.00
Plunger lift	2,260.00
Total	$4,080.00

Operating expense

Labor	$2,500.00
Transportation	2,000.00
Replacement parts	860.00
Pulling unit	600.00
Total	$5,960.00
Monthly average	$350.00

Using 10¢/Mcf for the gas price, this installation was paid out in 4 months and is now making a net profit of $1,100 per month. However, these figures are not representative of the present operation of this plunger lift. The total operating expense during October, November, and December, 1958 was only $450.00, a monthly average of $150.00 which gives a net monthly profit of $1,300.00. This decrease in expense is due to improved

FIGURE 3-B



operation of the equipment.

One serious operating problem has been encountered in working with this installation. Variations in sales line pressure cause variations in the rate of gas flow, which in turn controls the amount of water coming into the well bore. When too much water comes into the well, the plunger is overloaded and will not come up. When too little water comes into the well, the plunger runs dry.

Without a load of water to cushion its arrival at the surface, the plunger may damage itself or the catcher. During one 30 day period, four plungers were torn up in this way. This trouble was alleviated by using a lighter plunger and choking back the flow of gas from the tubing to the atmosphere, thus slowing the travel of the plunger.

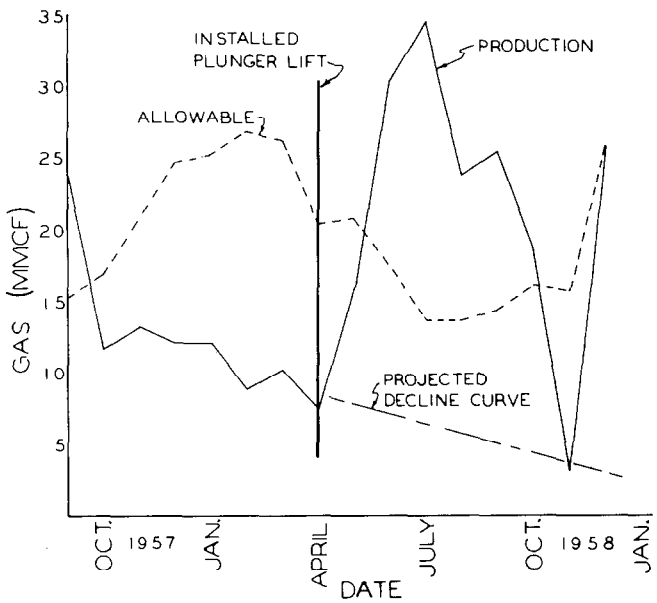
A minor problem, the freezing off of the control gas, was solved by installing a drip pot.

At present this well is being checked every other day.

Well No. 3

This Moore County gas well was completed on March 16, 1945 for 12,200 Mcf, with an initial rock pressure of 305 psi. On February 12, 1953 a spudder was moved in and the water was sealed off with hydromite. This rework was only temporarily successful, and on April 30, 1953 a 1 1/4 inch siphon string was run into the well. This installation would not function with the 150 psi working pressure present on the well. Another un-

FIGURE 4-A



successful attempt was made to shut off the water by reworking the well. A plunger lift was installed on this well on April 24, 1958. Figs. 4-A and 4-B indicate the results.

The cumulative allowable for the seven months before this installation was 177,470 Mcf, and the cumulative production for that period was 100,825 Mcf. For the eight months immediately following the installation of the lift, the cumulative allowable was 136,779 Mcf, and the production was 178,712 Mcf. The projected production curve without the plunger lift indicates that the well would have produced 38,000 Mcf during that period. According to this estimate, an additional 141,000 Mcf has been produced due to the plunger lift installation during the first seven months of operation.

The cost of this plunger lift is broken down as follows:

Initial cost	
Tubing and connections	$2,640.00
Pulling unit	300.00
Plunger lift	1,100.00
Total	$4,040.00
Operating expense	
Labor	$ 350.00
Transportation	140.00
Replacement parts	150.00
Pulling unit	-
Total	$ 640.00
Monthly average	$80.00

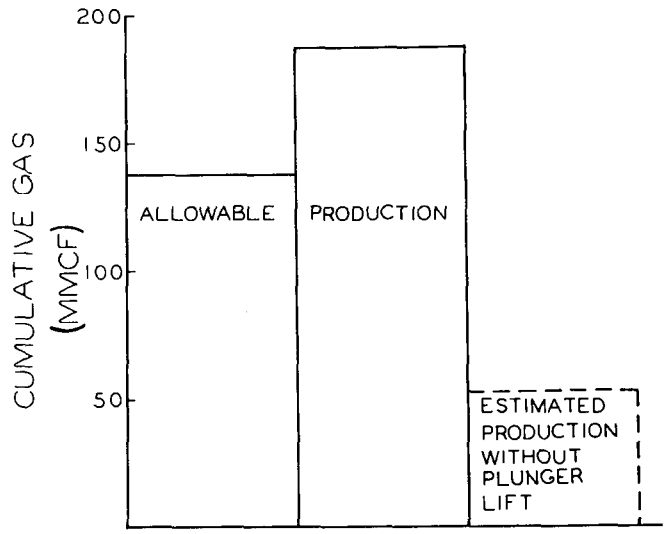
Using a gas price of 10¢/Mcf, this installation was paid out in 2 1/2 months, and is now making a net profit of $1,670.00 per month.

The only operating problems on this well have been due to the controls sticking due to corrosion or salt. During normal operation this well is checked every other day.

Well No. 4

This Moore County gas well was completed on December 10, 1935 for 25,000 Mcf, with an initial rock pressure of 400 psi. During July, 1948 the well ceased to be able to produce its allowable because of water accumulation in the well. At that time the well was reworked and recompleted for 6,900 Mcf per day. In February, 1953 the well was reworked again in an unsuccessful attempt to shut off the water. On April 1, 1953 a 1 1/4 inch siphon tring was installed and operated successfully until June, 1956. By that time the operating pressure had dropped below 150 Psi, and the siphon string ceased to function. It was pulled and rerun with gas lift valves,

FIGURE 4-B



but still would not operate successfully. On October 3, 1958 a plunger lift was installed on the well. The results are shown in Figs. 5-A and 5-B.

The cumulative allowable from September 1, 1957 until October 1, 1958 was 247,706 Mcf, while the cumulative production for that 13 month period was 87,805 Mcf. From October 1, 1958 until January 1, 1959 the cumulative allowable was 39,988 Mcf, and the cumulative production was 26,586 Mcf. The projected production curve indicates that the well would have produced 3,000 Mcf during that time. By this estimate, an additional 24,000 Mcf was produced during that three month period due to the plunger lift.

The cost breakdown of this installation is as follows:

Initial cost	
Tubing and fittings	$2,540.00
Pulling unit	110.00
Plunger lift	1,100.00
Total	$3,750.00
Operating expense	
Labor	$ 225.00
Transportation	35.00
Replacement parts	150.00
Pulling unit	40.00
Total	$ 450.00
Monthly average	$150.00

Again figuring the gas at 10¢/Mcf, this plunger lift will pay out in six months, and will then show a net monthly profit of $650.00.

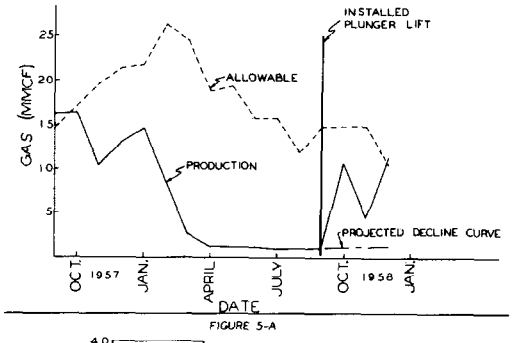


FIGURE 5-A

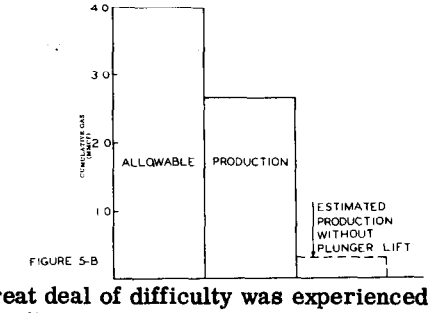


FIGURE 5-B

A great deal of difficulty was experienced in regulating the gas flow on this well. A small increase in the rate of gas flow will pull enough water into the well the kill the plunger, while a small decrease in gas flow completely halts the water production. This problem was at least partially solved by installing a 3/8 inch copper tubing bleed line between the tubing and the sales line. This keeps the tubing bled down to sales line pressure, which is about 40 pounds below the casing pressure, thus insuring that any water in the well will be pulled into the tubing and provide a cushion for the plunger. A check valve on this bleed line keeps that sales line gas from feeding back into the tubing while the tubing is blowing to the atmosphere.

At present this well is being checked every other day.

Well No. 5

This Moore County gas well represents a special application of the plunger lift method of fluid production. This well was completed in 1950. The monthly allowable is about 15,000 Mcf, and until recently it was capable of feeding over 30,000 Mcf per month against 120 psi line pressure. In March, 1958 a leak occurred in the casing and fresh water from the Glorieta sand ran down into the producing formation. The leak was packed off and the well was bailed for several days. The well was then pumped through 2 inch tubing with an 1 1/2 inch insert pump for four months.

It was nearly impossible, however, to keep a bottom hole pump in the well for any length of time due to the abrasive action of the Glorieta sand which kept coming back out of the producing formation. In October, 1958 the rods and pump were pulled out and the well began unloading through the tubing. The well was intermittently blown and produced during that month, and in November a plunger lift was installed on the well. The monthly gas production during November and December was nearly twice the production for any month that the well was being pumped. Although the well does not yet make its allowable, it is hoped that this method of production will eventually dry up the producing formation.

The cost of this installation is as follows:

Initial cost	
Tubing and fittings	$1,300.00
Pulling unit	-
Plunger lift	560.00
Total	$1,860.00
Operating expense	
Labor	$ 120.00
Transportation	60.00
Replacement parts	-
Pulling unit	-
Total	$ 180.00
Monthly average	$90.00

CONCLUSION

Although it has been shown from the case histories presented that these free travel plunger installations have paid out, it would give a better picture of their application and economic value to compare them with pumping or siphon string operations.

The plunger lift method has both advantages and disadvantages when compared to either the siphon string method or bottom hole pump method, both in the operational and economic aspects. Fig. 6 compares the most important characteristics of these three methods for working pressures ranging from zero to 300 psi.

The large variations in initial cost of the plunger lift are due to the brand type used. The variations in operating expense are mostly due to the location of the well and the frequency with which the well must be checked. Wells which are in remote areas or which will not operate continuously for long periods of time without frequent checking naturally have a higher operating cost.

An important problem in attempting to achieve trouble-free operations is the fact that the plunger lift equipment used on these gas wells was primatily designed for use on flowing oil wells with a paraffin problem. As a result, the plunger and other equipment are much heavier than needed. Light weight equipment and simpler, more reliable controls should improve the operation of these installations, perhaps to the extent of reducing original costs to around $2,700 and operating costs would be $40 to $50 per month.

If such improvements should occur, the plunger lift method would definitely be more economical than pumping. However, at present it appears that the use of the free travel plunger method of producing liquid from gas wells is limited to wells wih 75 to 150 psi working pressure and less than 15 barrels of water per day. Under these conditions it will usually compete favorably with pumping the well because of the higher initial cost of the pumping equipment.

	Minimum Operating Pressure (psig)	Maximum Water Production (Bbls./day)	Initial Cost ($)		Operating Expense ($ / Month)			Gas/Water Ratio (Mcf / Bbl.)		
			Max.	Min.	Max.	Min.	Normal	Max.	Min.	Normal
Siphon String	150	10 (at 150 psig WH)		1900	40	20	25	20	8	12
Plunger Lift	70 (Estimated)	20 (at 150 psig WH)	5500	3250	350	80	120	20	4	8
Pumping Unit	2	40		6900	320	60	100	0.4	0.04	0.1

FIGURE 6 - A Comparison of the operational and economical characteristics of two siphon string, plunger lift, and pumping methods of producing fluid from low pressure gas wells.