Two Years of Operation with a Hydraulic Power Water System

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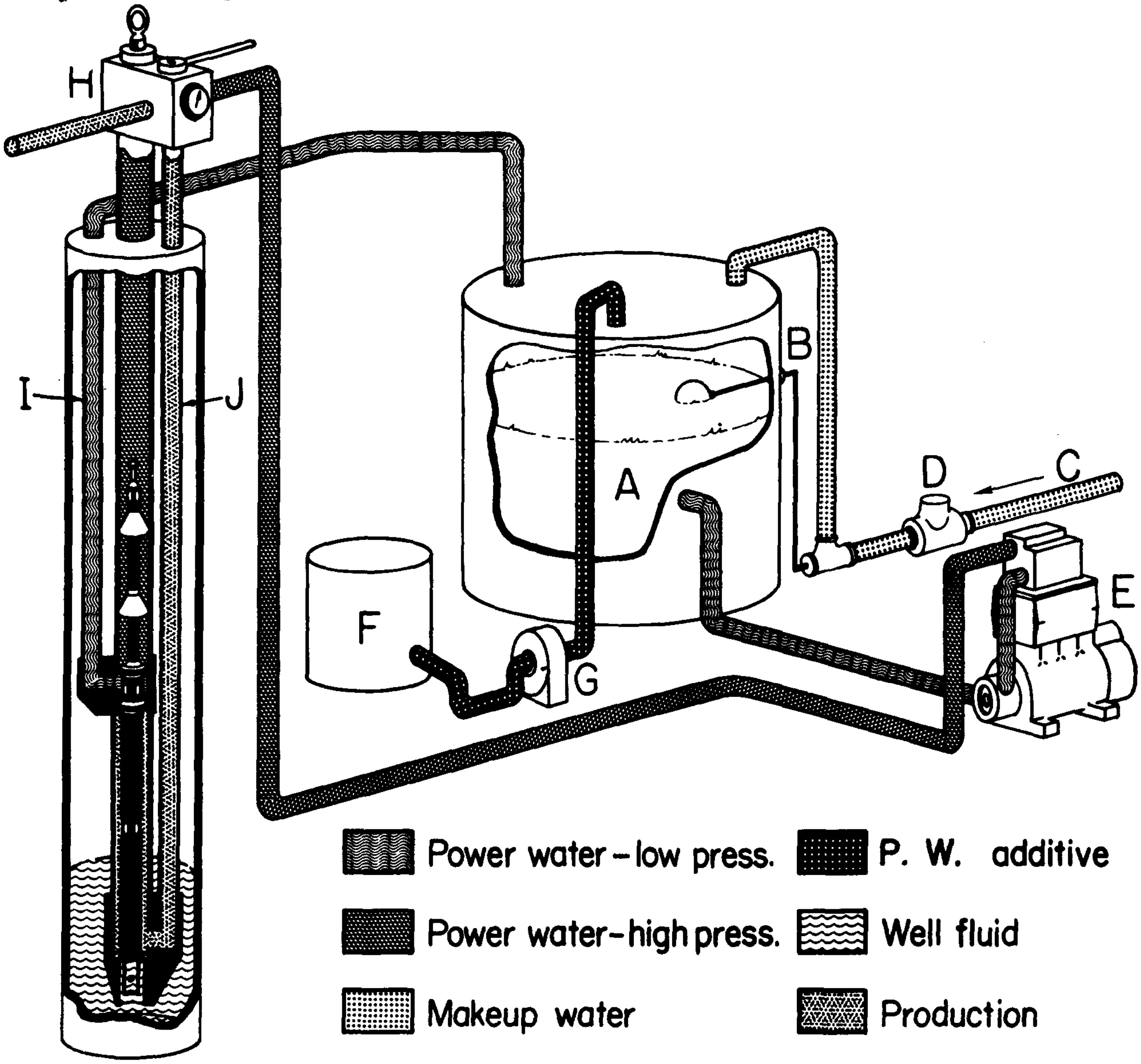
In 1964 the Company, as Operator for the City of Long Beach under a 25-year contract, opened a new parcel of the Wilmington Field to develop non-unit production. Producing by means of a hydraulic power water system, as shown in Fig. 1, was initiated on Pier "G" in September, 1964. A year later a second system was in operation on Pier "J". It is the purpose



Schematic Flow Diagram of Power Water System

FIGURE 1

of this paper to acquaint the reader with (1) the considerations which resulted in the decision to produce both Pier "G" and "J" wells by means of a hydraulic power water system, (2) a description of the power water flow through the system, (3) the surface plant installation costs and the installation costs of the surface equipment, (4) the direct costs of operation and maintenance through October, 1966 and problems encountered with the systems and (5) the approaches to potential areas of cost reduction.

SELECTION OF A HYDRAULIC POWER WATER SYSTEM

The Company had operated a closed power oil hydraulic pumping system since 1952. Experience during those 12 years indicated that this type of system was as economic to operate and maintain as other lifting systems and therefore would be an ideal system for Piers "G" and "J".

Water was selected as the power fluid on the basis of lower capital investment. If crude oil were used as the power fluid, pipelines would have to be laid to Piers "G" and "J" since the crude oil produced from these piers would be low gravity and not suitable as a power fluid. Also, additional facilities for retention and cleaning the power oil would have to be constructed. Other considerations such as safety from fire hazards and less potential damage from surface leaks were also involved.

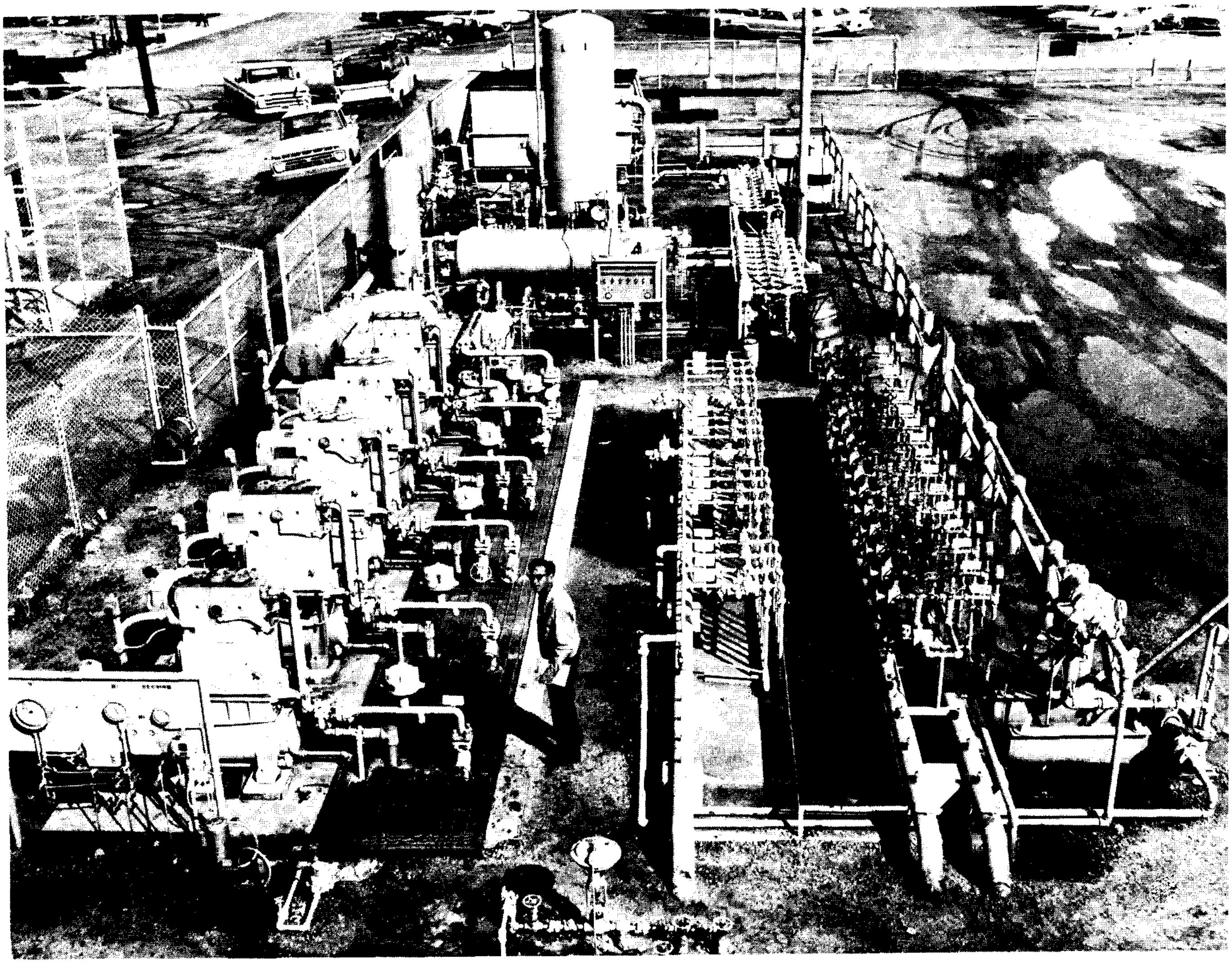


FIGURE 2

A controlling condition in the selection of pumping equipment was the desire of the City of Long Beach to carry out a policy of keeping all pumping units below ground level in this general area. This policy immediately removed all rod pumping equipment from consideration. Submersible pumping was eliminated because of limited experience and this experience indicated that the operation and maintenance would be more expensive than hydraulic pumping at the anticipated well rates.

THE PHYSICAL SYSTEMS

Power water (lease fresh water) starts from a 500-bbl galvanized, uncoated circulating tank. Because of wellhead and down-hole leakage, make-up water is added to the circulating tank through a felt cartridge filter. A water lubricant is added to the circulating tank in proportion to the make-up water to maintain the lubricity. From the circulating tank the power water is fed to the prime movers via charging pumps. On Pier "G" (see Fig. 2) the prime movers consist of five triplex pumps and one quintiplex pump, and on Pier "J" (see Fig. 3) seven quintiplex pumps are used. Power water from the prime movers is discharged through flow splitters and regulators to balance the output of the prime movers against the needs of the down-hole hydraulic pumps. The pressured power water then flows to centralized flow control headers (see Figs. 4 and 5) from which each well receives a metered amount of power water necessary to

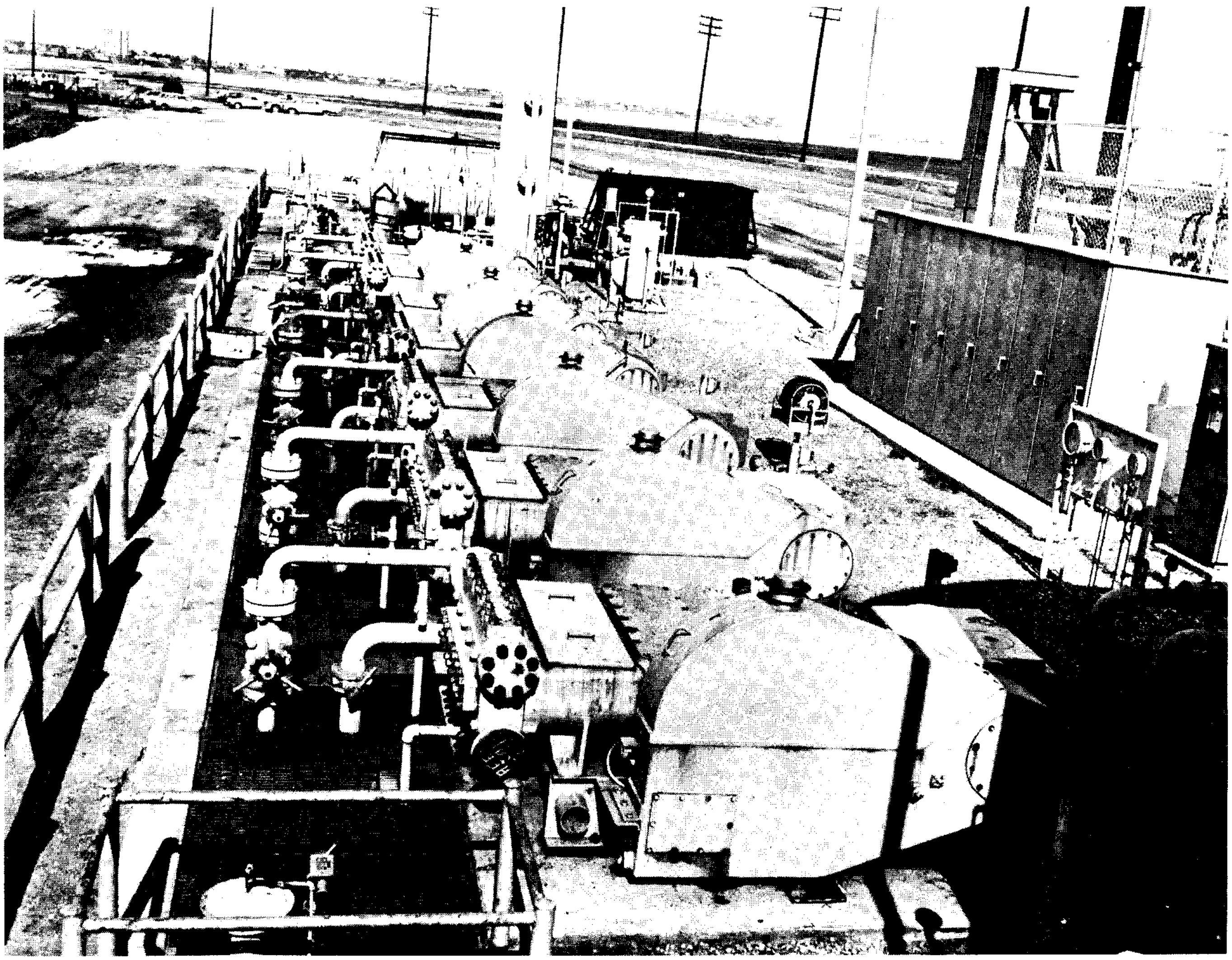


FIGURE 3

drive the down-hole hydraulic engine to the well's potential. Power water returning to the surface flows through a centralized metering station (see Figs. 4 and 5) and is then returned to the circulating tank.

Wells are equipped with three strings of tubing; a 3-in. power water-in string, a 2-in. production return string and a 1-1/2 in. power water return string. The bottom-hole hydraulic pumps are 3-in. high volume single pump-end. The four-way valves and controls for surfacing and running the pumps are located on the wellhead on Pier "G" and either at the cellar wall (see Figs. 6 and 7) or at the flow control headers (see Fig. 8) on Pier "J". On Pier "G" the unseating of the hydraulic pumps is accomplished by pumping down the production return string and the pump-out is accomplished with the power water return string. On Pier "J" the unseat and pump-out operation is the same except that on half of the wells the unseat operation is accomplished by pumping down the power water return string.

CAPACITIES AND OPERATION OF THE SYSTEMS

The Pier "G" plant capacity is 18,300 BPD at 2500 psi. Current output is 15,000 BPD which supplies 14 producing wells. Current power water loss is 1100 to to 1200 BPD or an average

FIGURE 4

of 82 BPD per well. The Pier "J" plant capacity is 31,500 BPD at 2500 psi. Current output is 22,000 BPD which supplies 27 producing wells. Current power water loss is 700 to 800 BPD or an average of 28 BPD per well.

DIRECT COSTS OF INSTALLATION

The cost to complete the Pier "G" power water plant including all facilities to the well-head was $8.8/bbl of daily plant capacity. The cost of the Pier "J" plant was $7.8/bbl of daily plant capacity. The average installation of well-head and down-hole equipment which includes the 4-way valve, three 2800-ft tubing strings (3-in., 2-in. and 1-1/2 in.), pump (average 1000 BPD capacity), and pump cavity was estimated to be $21/bbl of daily pump capacity.

DIRECT COSTS OF OPERATION AND MAINTENANCE

On Pier "G" the direct operation and maintenance cost (O & M) from start-up through October, 1966 for all wells was 3.54 cent/gross bbl. The direct O & M for all Pier "J" wells was 3.12 cents/gross bbl. Power water plant O & M based on gross production allocation was 3.80 cents/gross bbl. Thus, the total O & M for Pier "G" was 7.34 cents/gross bbl and 6.92 cents/gross bbl for Pier "J".

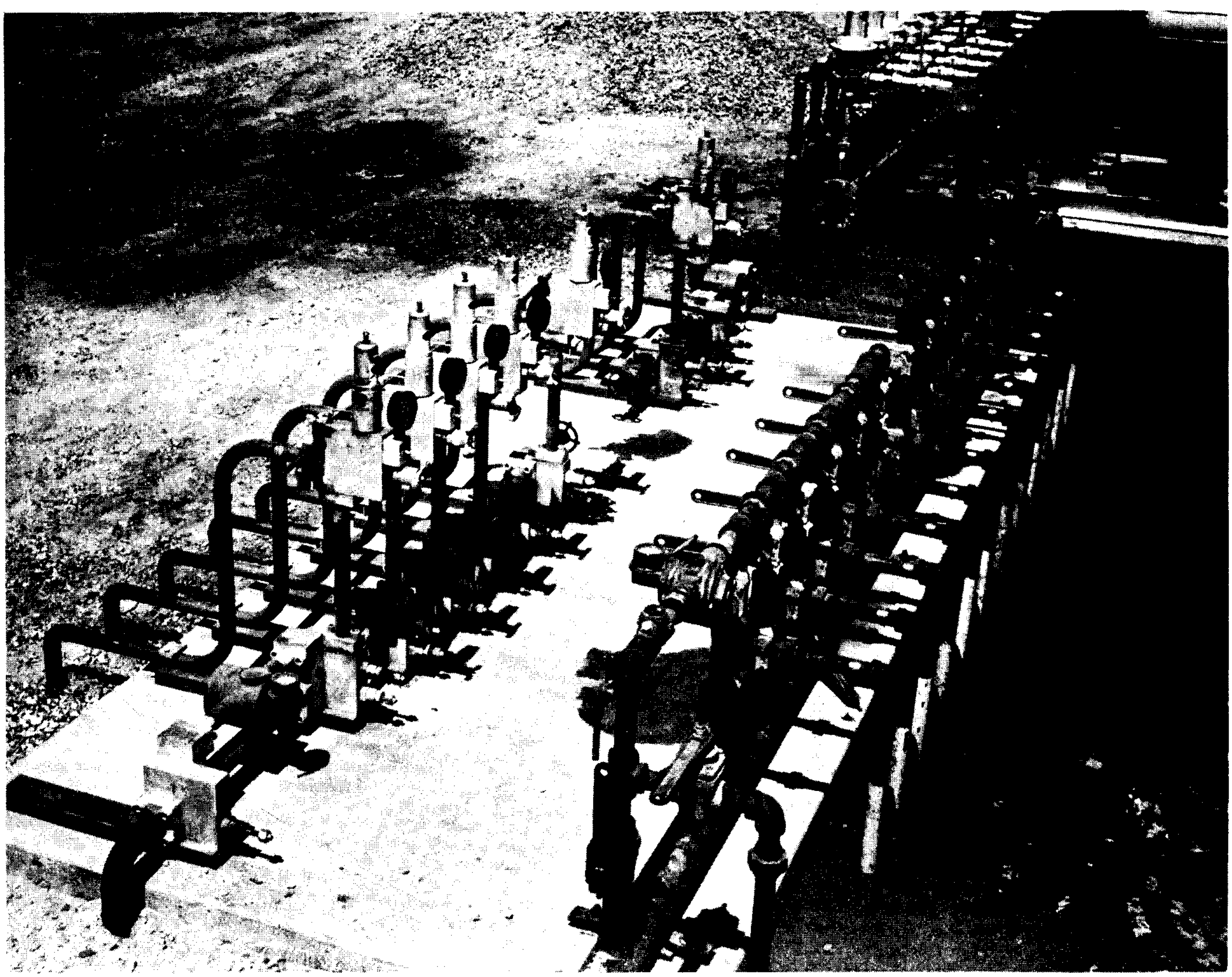


FIGURE 5

OPERATING PROBLEMS

Prior to discussing specific operating problems it should be stressed that the Piers "G" and "J" hydraulic power water systems were the first commercial systems to be installed. As can be anticipated with any new application, there are necessarily higher initial operating costs which stem from development problems.

Power Water Loss

It is suspected that there are two major sources contributing to power water losses; leakage at the collars of the 3-in. high pressure power water-in tubing and leakage in the four-way valves. Weekly salinity tests are run on the produced water from each well. From these tests an estimate of power water loss can be made for each well. The correlation between test losses and make-up requirements is good. Where the loss is excessive the four-way valve, power water-in tubing and power water return tubing are pressure tested to 2500 psi under static conditions. The pressure tests of the four-way valve readily indicate leakage but tests of the power water strings very rarely indicate the magnitude of leakage which must be occurring under dynamic conditions.

As was stated in a previous paragraph the average power water loss per well on Pier "G" is more than three times that of Pier "J". The

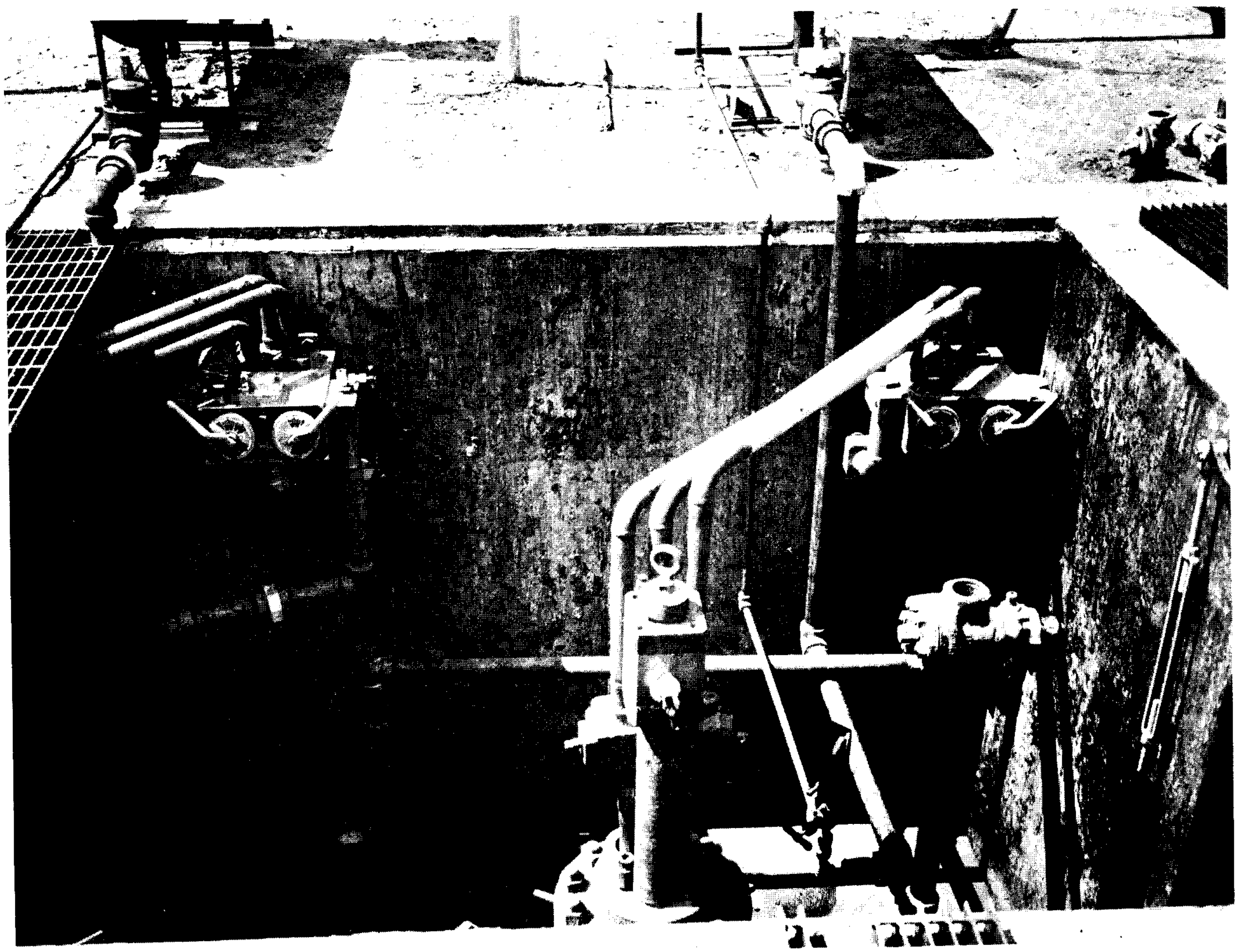


FIGURE 6

primary differences between the two systems that may account for the smaller power water losses on Pier "J" are that the Pier "J" system is a newer system and that the four-way valves used at Pier "J" are of a design which is more compatible with the use of power water.

Average power water losses for both Pier "G" and "J" amount to 1900 BPD. The cost of lubricating this amount of make-up water at the recommended concentrations is \$5300/month. During the month of October, 1966 gross production for all 41 wells was 443,021 bbl, resulting in a lubricant cost of 1.2 cents/gross bbl.

Solids In The Circulating Power Water

On Pier "G" recent tests indicate 55.7 PPM of solids in the combined power water return line and 44.8 PPM of solids leaving the circulating tank. On Pier "J" 64.0 PPM were found in the return line and 54.0 PPM leaving the circulating tank. These solids are silts, sands and clays with minor parts of corrosion products which range in particle size from 100 microns or greater to less than 100 microns.

It is assumed that solids may enter the power water system during the pump-out operation. Since many of the pumps are unseated by pumping down the production return tubing, one or more barrels of production are pumped into the pump cavity and 3-in. tubing and thus into the power water system. Furthermore, those few barrels of production will most likely contain all the solids from the column of fluid in the production return tubing. As the contaminated power water reaches the surface it should be

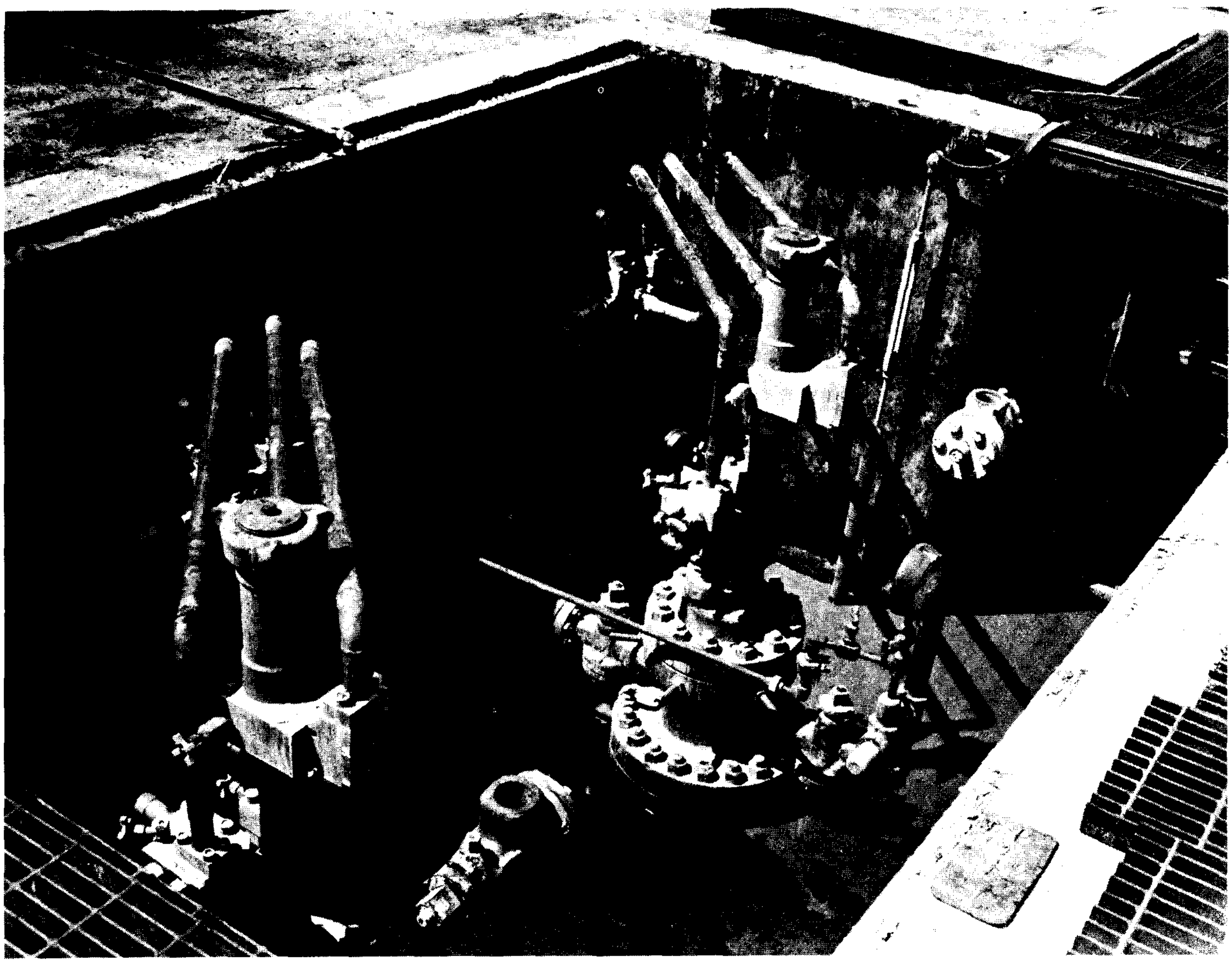


FIGURE 7

switched over to the production return system and thereby eliminated from the power water system.

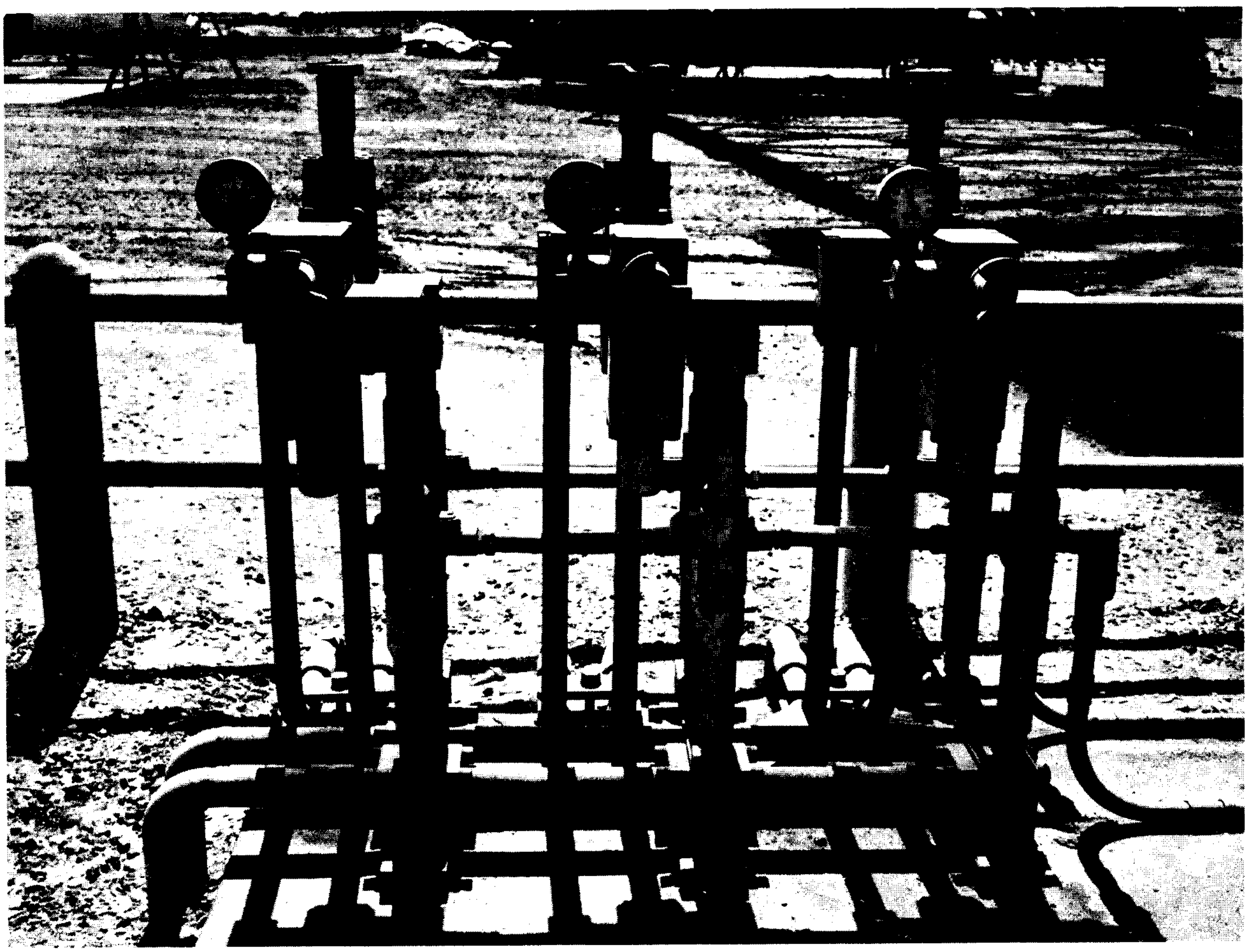
These solids have resulted in greatly reducing down-hole engine life, have hampered the proper producing of the well by cutting out surface flow controllers and have certainly aggravated the power water loss problem.

Sludge At Pier "G"

It now appears that some sludge is forming at the Pier "G" power water system. From analysis this sludge seems to be a combination of the aforementioned clastics, iron oxide, iron sulfide, crude oil and water lubricant. Recently, the sludge has necessitated the use of a pulling rig on several wells where the pumps could not be surfaced in a normal manner.

SOLVING PROBLEMS AND REDUCING COSTS

To reduce the power water loss in the 3-in. tubing strings, the Company has installed in two wells special collars with Teflon sealing rings. As yet, data is not available to indicate if we have been successful in reducing the loss. This type collar has been used by another operator in the Wilmington Field and although their hydraulic power water system is new, the first few months of operation show very minimal power water losses. By reducing the total power water loss, direct operating costs would be reduced more than 1 cent/gross bbl. At this time the Company has contracted with an independent laboratory to test a number of power water additives in an attempt to determine if the costs of maintaining an adequately lubricated system can be reduced.



To minimize introducing formation clastics into the power water system the Company has reviewed, with the pump manufacturers, the proper procedures for round-tripping the pumps. These procedures will be distributed to the Company's field personnel and to contract well crews along with other information which will stress the importance of these procedures in maintaining a solids-free system.

The Company is currently investigating the value of installing de-sander equipment. On Pier "G" a 2000 BPD centrifugal sand separator has been installed on the power water return line. The single solids analysis on the sand separator showed a 30 per cent reduction in solids from inlet to discharge, which would indicate that other methods of removing solids must be tried. Complete elimination of solids could result in a direct cost reduction in pump engine, flow controller, and four-way valve repairs of 1 cent/ gross bbl.

CONCLUSIONS

The introduction of a radical departure in the type of power fluid for hydraulic oil well pumping has resulted in higher than normal operating and maintenance costs. Various experimental techniques and approaches are being employed in an effort to reduce these costs.

ACKNOWLEDGEMENT

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