A System of Automatic Lease Operation

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INTRODUCTION

An 87-well lease in a major West Texas oil field has been converted to automatic operations except for custody transfer. The system automatically controls the production from the wells and the periodic well testing scheduled for the lease.

All wells on the lease are pumped with standard, electrically powered, beam units. Individual well pumping cycles are scheduled by a time-clock controller located at each well.

Periodic well testing, formerly done manually, is now performed automatically by means of electrically operated time controllers which divert on a pre-determined schedule production from the well to be tested through well test units. The well test units separate, measure, and permanently record the oil, water, and gas produced on test.

Lease production is gathered at a central storage battery equipped with automatic tank switching and safety controls. When a tank is filled, production is automatically switched to an appropriate, empty tank. Safety controls guard against tank spillages and shut-down lease operations when lease storage is full or when a power failure occurs.

The pumper's work on the lease includes daily visits to the battery with the pipeline gauger to test manually the oil and to make the pipeline runs and checks of wells and equipment for routine maintenance.

GATHERING SYSTEM

Production flows from the individual wells through thirteen remotely located headers, as shown schematically in Figure 1. Well test units are located at four of these headers.

The system of headers existed on the lease virtually as shown in Figure 1 before complete consolidation and auto-

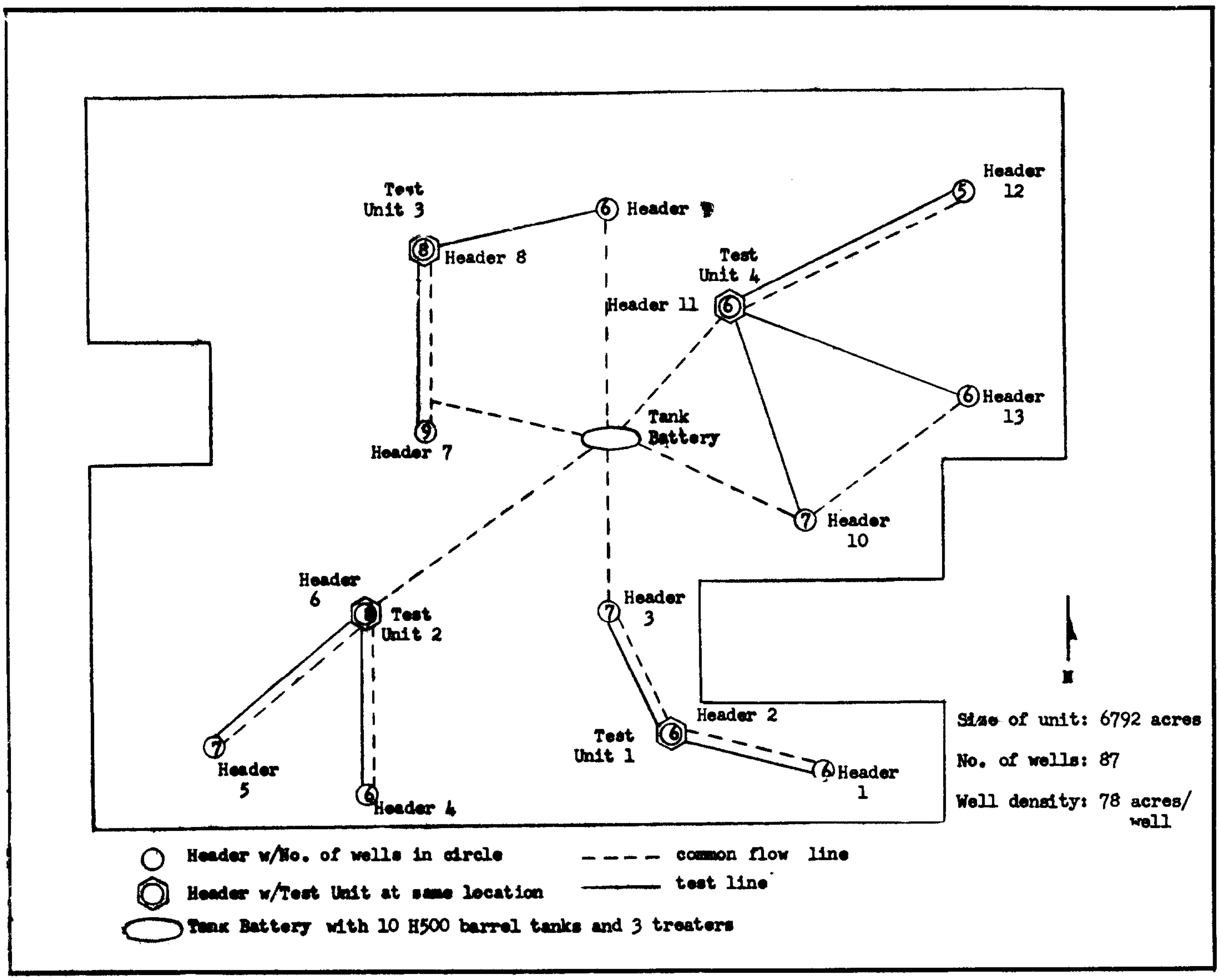


Figure 1

mation. By way of explanation, the lease had experienced intermittent development over a period of several years. Production was gathered into five batteries scattered over the lease through the header arrangement. Economics dictated the use of the existing field gathering system with minor modifications in the consolidation.

The headers handle production from six to eight wells. Each header consists of a manifold of three-way, two-position valves and a panel of a like number of electric timers or well test controllers. The valves are of the spring-loaded diaphragm type, actuated by a combination electro-pneumatic control. The spring load holds the valve open in the "non-test" or "production" position. With the valves in this position, the production flows from the wells through each header to the central battery through the production trunk lines.

To test a well, the appropriate well test timer is manually set for the day of the test and for the number of test hours. At the proper time, the timer actuates the automatic header valve to the "test" position. The timer sends an electric signal to energize the solenoid-actuated pilot valve, which opens, permitting gas pressure to be applied to the diaphragm and to overcome the spring load. With the header valve in the "test" position, the production from the appropriate well is routed through the testing system and to the central battery.

AUTOMATIC WELL TESTING SYSTEM

Well test units are located at four convenient headers on the lease. The location of each of the test units was dictated, again, by the gathering system installed before consolidation and thus was considered the most economical.

Each test unit is an integral, skid-mounted unit consisting of four parts:

1. Horizontal separator
2. Metering vessels
3. Gas measuring and computing system
4. Recorder.

The three-phase horizontal separator is shown schematically in Figure 2 as E. The separator is equipped with a 125-psig relief valve and a safety valve. The components of production are separated in the horizontal separator before being measured. The oil and the water, having been separated, are measured by two metering vessels--a one-barrel oil metering vessel (G) and a 1/4-barrel water metering vessel (I). Each metering vessel is equipped with a torsion tube liquid-level controller, shown as J. The controller is connected to a four-way relay valve which operates the inlet and the outlet valves (K) on the metering vessel. The pilot-operated valves control the filling and dumping of the metering vessels. They are designed to interlock so that when one is open the other is closed and to operate in a sequence such that the one which is to open cannot do so until the other one closes. This precautionary procedure prevents the possibility of the vessel's receiving fluid at the same time that it is dumping. The dumps of the metering vessels are recorded as marks on the strip-chart recorder, shown as (L). The same principle of operation applies to both the oil and the water meters except that the latter measures 1/4 barrel with each dump. The gas pressure is equalized between the horizontal separator and the metering vessels to facilitate dumping the measured fluid.

Produced gas, coming off the top of the horizontal separator, is measured through an orifice shown at the orifice flange (M). The static and the differential pressures from the orifice flange are converted to electric impulses by means of transducers (N). These electric impulses from the transducers are fed into the gas computing system (O). This electronic computer integrates the static and the differential pressure readings and computes the flow of gas through the orifice, using the orifice flow equation. The volume of gas is recorded on the strip chart in the recorder (L) in standard cubic feet per hour. The gas computing system has a variable dial which may be adjusted to compensate for temperature, gravity, or other variables which may be encountered and a different resistor which is plugged in for different orifice sizes. A pilot-operated, diaphragm-type back pressure valve (P) maintains a minimum pressure of 40 psig on the test unit.

The three-pen recorder continuously records the amount of oil, water, and gas measured during the test directly on the strip chart. This system eliminates computing errors in the calculation of the volume of fluid produced and enables the pumper to calculate the gas-oil ratio in the field easily.

The gas, the oil, and the water, after having been measured, are recombined into the common flow line, which goes to the tank battery.

CENTRAL STORAGE AND AUTOMATIC TANK SWITCHING SYSTEM

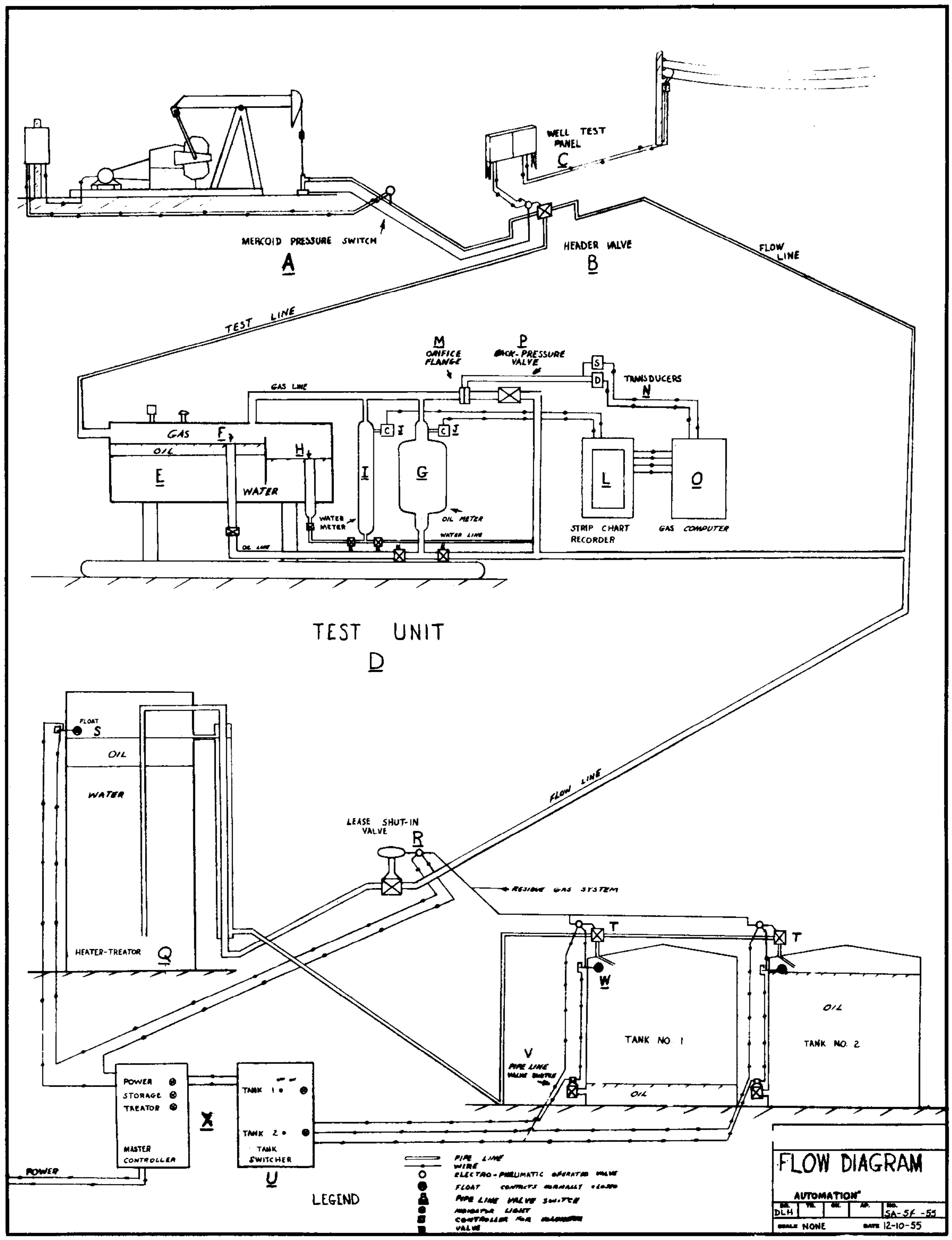
Production from the common flowlines connecting the various headers enters centralized treating and storage facilities located in the approximate center of the lease. The lease flow is separated through a manually controlled header into three streams flowing to three heater-treaters. Separation of the lease production stream is necessary to equalize the load on the treaters. The production flows to the treaters through a lease shut-in valve (R), which is an electro-pneumatically controlled, spring-loaded diaphragm valve.

The lease shut-in valve is opened by gas pressure acting against the underside of the diaphragm, overcoming the spring load. Gas pressure is applied to or released from the diaphragm through a pilot valve which is opened or closed by a solenoid. When electric current is applied, the solenoid functions to open the pilot valve, permitting gas pressure to open the lease shut-in valve. When the electric current is removed, the pilot valve closes, removing the gas pressure from the diaphragm and permitting the lease shut-in valve to close under the spring load. Thus, the lease shut-in valve "fails safe" should an electric power failure occur or the gas pressure fail.

Electric current is applied to the lease shut-in valves through float-operated, liquid-level controllers located at the high-level position (S) in the treaters. If the fluid level build up in the treaters to the high-level position, the floats actuate the level controllers to break the electric circuit and to close the lease shut-in valves. With the lease shut-in valves closed, pressure builds up in the flow lines. When the pressure in the flow lines reaches a pre-determined high value at the wells, pressure-operated mercury switches, located in the flowlines at each well, are actuated to shut off power to the pumping units of the wells that are pumping.

The above sequence serves to shut down the lease completely and will maintain it shut down until the pressure in the flow lines is lowered below a pre-determined low value, at which time the mercury switches will close the electric circuit to the pumping units.

The treated oil goes from the treaters to storage, which consists of 10 tall-pattern 500-barrel tanks. The tank fill valves (T) are two-way, two-position valves whose operation is electro-pneumatically controlled in a manner similar to that of the header valves and lease shut-in valves. The fill valves receive electric current from an automatic tank switcher (U), which is an electrically operated controller that selects the tank to be filled and, in sequence, automatically switches to the appropriate empty tank when the receiving tank is full. The electric circuit from the tank selector to the tank fill valves also includes a float-operated, liquid-level control switch (W) and a pipeline valve switch (V). When the level in a particular tank reaches or is at the float, the float switch opens breaking the electric circuit and shutting the tank fill valve to prevent producing into a full tank. When the pipeline valve is opened to run oil from a tank, the pipeline valve switch functions similarly to keep the tank fill valve closed and to prevent production from entering a tank which is "on the line". The tank fill valve circuit can



Legend for Figure 2.

A. Pressure switch
B. Three-way, two-position header valve
C. Well test timer
D. Test unit
E. Horizontal three-phase separator
F. Oil riser
G. Oil metering vessel
H. Water riser
I. Water metering vessel
J. Metering vessel controller
K. Inlet and outlet valves for metering vessels
L. Three-pen strip-chart record
M. Orifice plate and flange
N. Transducers
O. Gas flow computer
P. Back pressure valve
Q. Heater-treaters
R. Lease shut-in valve with solenoid pilot valve
S. Liquid-level controller
T. Tank fill valve with solenoid pilot valve
U. Tank switcher
V. Pipe line valve switch
W. Liquid-level controller
X. Tank switching system

also be broken manually, if so desired, to take a tank out of operation.

The tank switcher is a multiple cam switch operated by an electric motor. The cam switch is designed to energize the electric circuits to each of the ten tanks in a set sequence -- tank number one through ten. It attempts to energize the fill valve at tank number one and will do so to open that valve if the tank is not full or not "on the line" or not manually set off. Closing of the circuit to the fill valve shuts off the current to the electric motor which drives the selector cam switch. When the circuit to number one tank is open and when that tank has been filled, the motor starts and rotates the cam switch to tank number two, and the cycle is repeated. The selector switch will seek out tanks eligible to receive production until all available storage is full.

When no storage room is available, the selector switch stops, and electric power to the automatic battery system is interrupted. With all tank fill valves closed, the battery fill lines become full, in turn, causing the treaters to fill to the high-level switches. As described previously, this action causes the lease to be shut down.

The master controller (X) is connected into the lease shut-in valve, the tank selector switch, and the main power supply circuits in such a manner that it opens these when storage is full, when treaters are full, or when a power failure occurs. When any of these circuits are so de-energized, an appropriate light on the master control panel comes on, signaling the cause of the shutdown.

The tank switcher panel has an indicator light and an "auto-off" switch for each tank. The indicator light is lighted for the tank which is receiving production. In the "auto" position, the tank will be filled in sequence, if eligible. If the switch is in the "off" position, the tank is manually taken out of the automatically switching cycle to prevent filling while it is being repaired or is open for any other reason.