Automatic Lease Production

By E. F. FOREMAN, Jr.
Southwest Control Company
Odessa, Texas

The oil industry has utilized automatic controls and instruments for controlling processes and functions in the refining, natural gasoline and pipeline departments for a number of years. Only recently, though, have steps been taken to automate the handling of fluid and gas from the well head to the pipelines. Automatic lease installations now installed and operating have shown that the greatly increased economies and performance derived will provide tremendous momentum for full automation of oil and gas production.

Instruments and equipment are now available for controlling the three basic or operating phases of lease production. These phases are namely: well flow and test control, battery control with tank switching, and automatic custody transfer of the crude oil to the pipeline. The first two phases have been thoroughly tested and proven to be extremely successful. Several installations involving automatic custody transfer are already in operation in various sections of the country and numerous additional installations are now being made. The principle of automatic custody transfer has been accepted by most of the major oil companies, and this acceptance will bring to the industry a rapid transition from manual to automatic operation.

To illustrate the three basic operating phases of oil production automation, we have included schematic diagrams showing the routing and control of the fluid and gas from the well head to the pipeline. Figure 1 illustrates the phase covering automatic well flow and test control for each well on the lease. In Figure 2, battery control and automatic tank switching are shown. Figure 3 illustrates battery control where automatic custody transfer is utilized.

Automatic Well Test and Flow Control — Fig. 1

Referring to Figure 1, the numbered items are the controls and equipment used for handling the crude oil from the well head through the production and test separators. Item 1 is the high-limit pressure switch used to shut down pumping units when lead line pressure builds up due to the header valves being closed. When the header valve is opened and pressure is released from the lead line, the pressure switch causes the unit to start. This pressure controller is illustrated in Figure 5.

Item 2 is a safety valve located at the well head of a flowing well. When high pressure flow lines are used, this spring-loaded check valve is used as a safety device to shut in the well in case of flow line rupture. This high pressure safety valve is illustrated in Figure 6.

When it is desired to use low pressure flow lines, either a pressure piloted valve or an electrically piloted valve is used at the well head to shut the well in when header valves close. It is necessary to use this shut-in valve at the well head so that high shut-in pressures will be held off the existing low pressure flow lines. Figure 7 is an illustration of an electrically piloted valve used for this purpose.

Item 3 is the choke that is located at the header when high pressure flow lines are used. When chokes are installed at the header and high pressure flow lines are used, the problem of paraffin deposition in flow lines is minimized. High pressure flow lines with the choke at the header is, in effect, bringing the well head to the header location. Where low pressure flow lines are used, the choke is located at the well head. A rotary positive type choke at the header is illustrated in Figure 8.

Item 4 is the three-way valve that is used at the header to route the flow of well fluid into the production separator, the test separator, or to shut-in the well. This valve is the three-way, three-position valve. Individual well control at the header is possible when this valve is used. An alternate valve that is sometimes used at the header is the three-way, two-position valve. This valve is used when routing of fluid is desired but cessation of flow is not required. The fluid is either routed into the production manifold or the test manifold according to the pre-determined automatic test program. A master valve or lease shut-in valve is used on the production manifold to shut-in the lease if the routing valve is used. A header using the three-way, three-position valve is illustrated in Figure 9; the three-way, two-position valve and the master shut-in valve are shown in Figure 10.

Item 5 is the high level assembly that is mounted in conjunction with the float on the production separator and shuts in the lease in case of a high fluid level occurrence in the separator.

Item 6 is the metering separator through which all fluid made by a well on test is measured. This metering separator is a combination unit used for fluid-gas separation and metering fluid. It employs the dump type fluid meter. Dump type metering is used throughout the automatic leases that Southwest Control Company has in operation. This type metering is favored over the positive type fluid meter because the flashing of gas out of solution causes positive type meters to be very inaccurate in many instances where crude oil is being metered. Dump type metering is accomplished by filling and emptying a calibrated volume chamber between two closely controlled top and bottom levels. The new Dynatrol level switch that fits into a 3/4" NPT opening detects the high and low levels in two inch risers, thereby attaining accuracy heretofore impossible with conventional equipment. Where a test separator is already installed, a fluid meter is installed down stream to meter the fluid that is made by the well on test. For each barrel of fluid passing through the metering unit, a mark is made on the strip chart recorder located at the control panel. Thus a recording of production versus time is obtained. Whether the metering is done by the metering separator or the fluid meter, the basic operation is the same. The metering separator is illustrated in Figure 13 and the fluid meter in Figure 12.

Item 7 is the automatic device used to determine the amount of water that is made by a well on test. Throughout the testing period, one cubic inch samples of each barrel of fluid passing through the metering device are taken. Before the development of automatic cut detector, these samples were retained in indexed sample chambers, one for each well. After wells had been tested, the pumper would grind out the sampled fluid and record the amount of BS and W it contained. Figure 11 shows the chambers that were used. By use of the automatic cut detector, the sampled fluid is checked each time a well is tested and results are recorded on the strip chart recorder, Item 9, located at the control panel. No manual operation is required when the cut detector is used.

The gas that is made by a well on test is measured, integrated, and automatically recorded on the strip chart recorder. On the meter run of the test separator is a bellows type differential pressure transmitter. This transmitter measures the varying pressure across the orifice plate and relays the information to the electrically operated, null balance integrater at the control panel. Each MCF of gas measured is recorded on the strip chart recorder.

All well test information—barrels of fluid, MCF of gas, and barrels of water—is recorded on the strip chart recorder, Item 9. Testing information is recorded throughout the testing period; therefore, the pattern of flow is obtained. A study of the flow pattern results in more efficient and profitable scheduling of time for pumping or flowing. The information obtained by this testing procedure not only provides a more thorough study of reservoir characteristics. but also presents a much more accurate account of production than is obtainable by manual

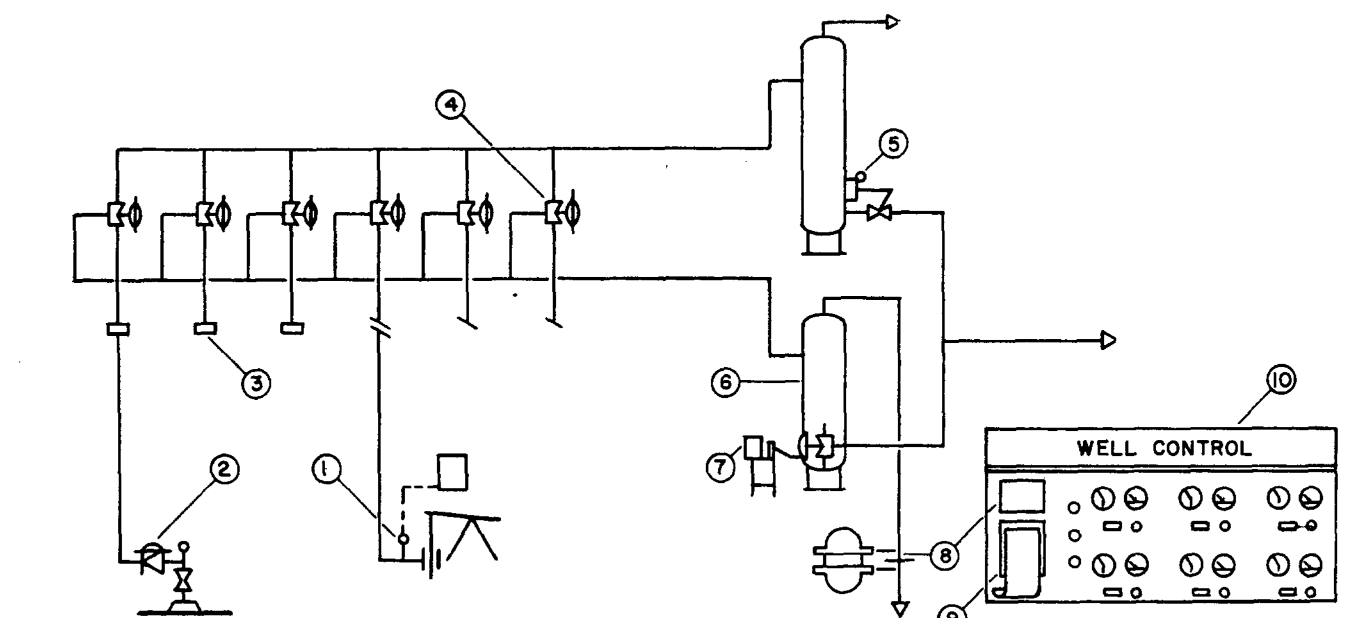

FIG. 1

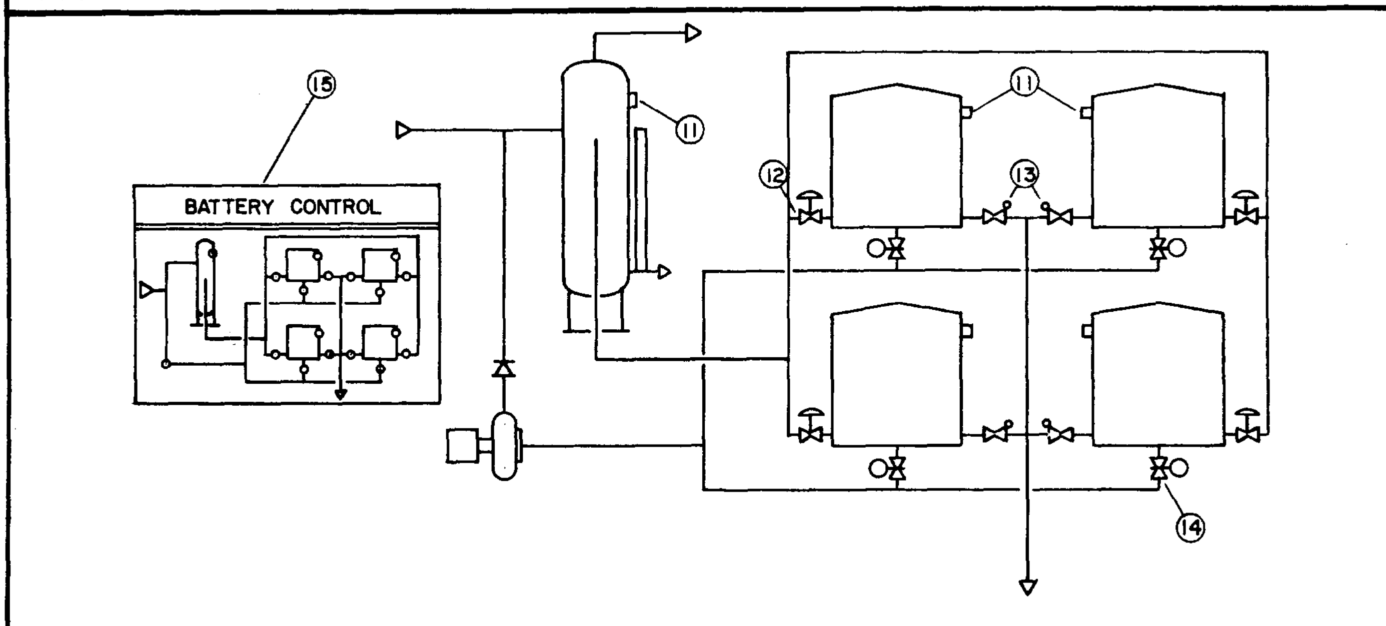

FIG. 2

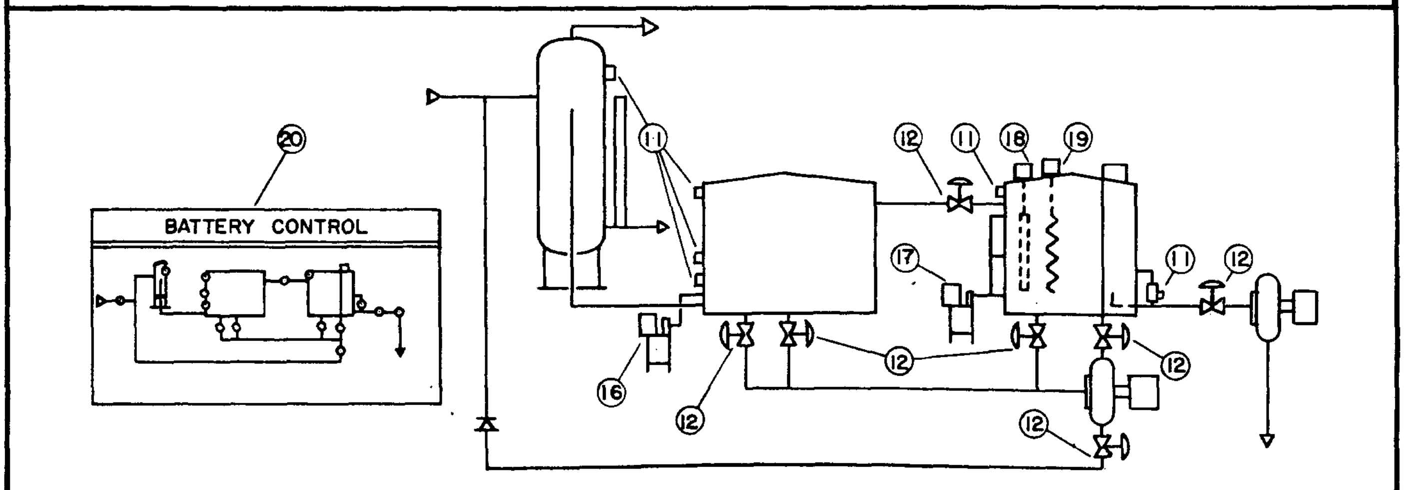

FIG. 3

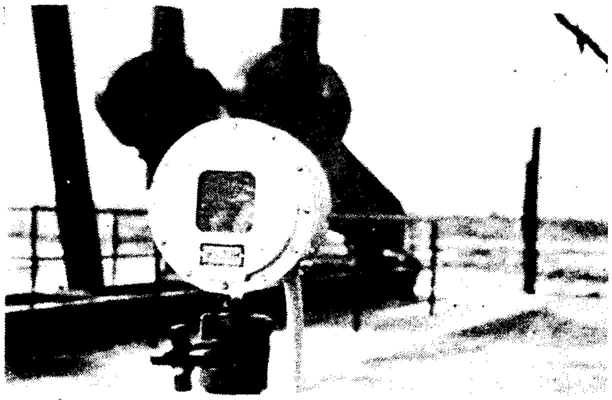

Fig. 5 High-Limit Pressure Switch

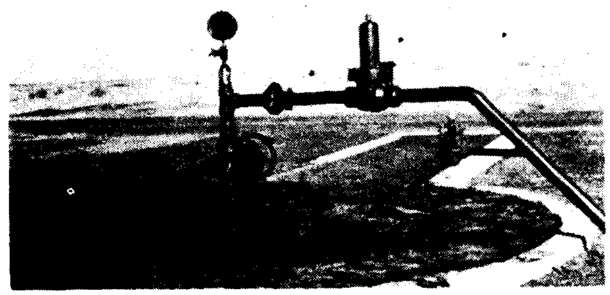

Fig. 6 Excess Flow Valve

methods.

All well test and flow control iis automatically handled through the well control console, Item 10. Wells are tested automatically on a pre-determined program with testing time individually adjustable 0-24 hours. Flow period programming is attained through this controller with individual clocks for each well. This fused, fail safe controller is equipped with on-off-auto selector switches, indicator lights, and pilots for controlling shut-down options.

Advantages of automatic well test and flow control and automatic testing over conventional methods are that by holding high pressure flow on lines, paraffin deposition is greatly reduced and higher crude gravity is obtained. More accurate testing information results in lower gas-oil ratios and conservation of reservoir drive. With the complete and detailed information compiled in this operation comes less "paper work" and less clerical labor required for the integrating, recording, and filing of individual well production reports. A reduction of man hours in the field resulting in more oil and gas produced per man-hour of labor is achieved. By the proper scheduling of flowing or pumping periods, we are able to provide a more even and constant gas flow to the gasoline plants. We get more complete and accurate engineering information than was possible before. These are but a few of the many advantages obtained under automatic operation of the wells.

Battery Control With Automatic Tank Switching—Fig. 2

There are now two basic types of battery control handled automatically. One employs automatic tank switching with manual transfer to the pipelines, while with the other arrangement, automatic custody transfer, fluid is controlled and transferred automatically to the pipeline. Automatic tank switching will be discussed first.

All battery operation—tank switching, rerouting of tank bottoms, and lease shut-in—is automatically handled through the graphic panel console, Item 15. Indicator lights for each valve and level controller in the battery give graphic indication of battery operation in the control house at all times. A typical automatic tank switching arrangement is illustrated in Figure 14.

The fluid coming from the separators passes through the treating system and fills into one storage tank at a time. Fluid passes through the diaphragm motor valve, Item 12, and into the tank until it rises to the Dynatrol level switch, Item 11. When the fluid contacts this high level controller, the fill valve to that tank closes and the fill valve to the next tank opens. Fluid will not be transferred into a tank that is already full, routed to the pipeline, or manually omitted from automatic sequence for purposes of cleaning, etc. The pipeline valve switch, Item 13, is the electric monitor that prevents the fill valve from opening if that tank is open to the pipeline.

Item 14 is the plug valve actuator that is used to automatically reroute tank bottoms after tanks have been run to the pipeline. When a tank is closed off the pipeline, the plug valve actuator opens the reroute valve, starts the recirculation pump, and the fluid in the bottom of the tank is rerouted through the treating system for an adjustable predetermined period. When this rerouting is completed, the reroute valve closes and the tank is eligible to be filled.

If all tanks fill, and there is no longer available storage space, the lease is automatically shut-in. This is accomplished by closing the master lease shut-in valve at headers where routing valves are used, or by closing individual valves where three-way, three-position valves are used. Located near the top of the treater is a Dynatrol level switch that causes the lease to shut in should a high level occur in the treating system.

All the diaphragm motor valves and Dynatrol level switches used in the battery operation are fail safe. In case of a power failure, the lease will shut in. When power comes back on, operations will start back up just as they were when the shut down occurred. The graphic panel console is a fused, fail safe controller in that nothing can happen to it to cause it to mishandle crude or run tanks over.

Some of the advantages of automatic tank switching over conventional methods are that tank bleeding losses are eliminated, tank run overs are eliminated, provisions for lease shut in in case of full storage or high level occurrence in the treating system, reduction of man hours required for control of the battery operations, and elimination of steaming of tanks because of a build up of tank "bottoms."

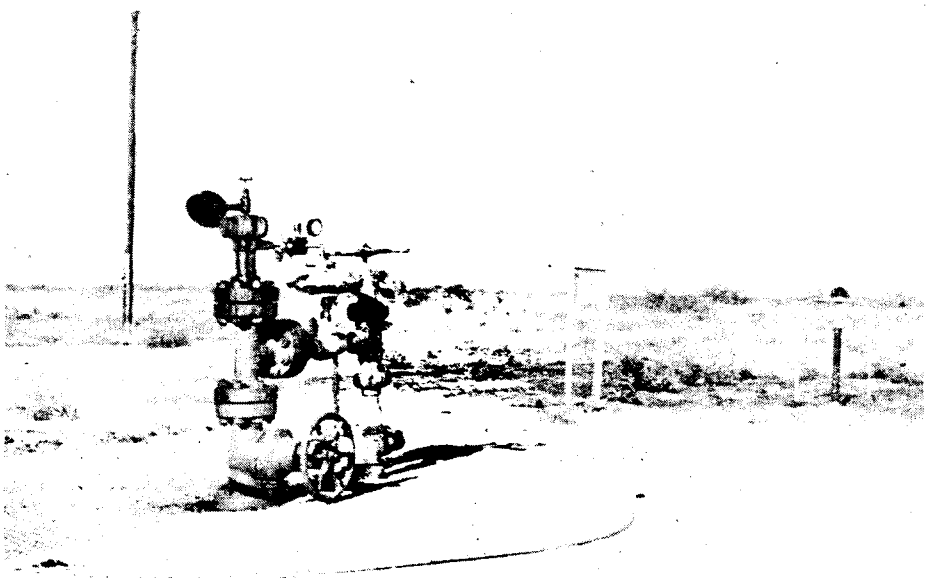

Fig. 7 High Pressure Shut-in Valve

Battery Control With Automatic Custody Transfer—Fig. 3

There are three types of automatic custody transfer batteries. One type uses two metering tanks. In this operation, one tank dumps to the pipeline while the other fills, and then the first tank fills while the second tank dumps. Another method uses one pressure type meter tank and a surge tank. The pressured meter tank is very similar in operation and design as the dump type fluid meter used in well testing except that it is usually of a one hundred barrel, or more, capacity. The third type of automatic custody transfer battery is a two tank arrangement. There is the surge tank and the weir type meter tank. The third type is the one discussed in this paper.

In this type of battery control only two tanks are required, regardless of the number of wells coming into the battery. One tank is the surge tank, while the other is used as the metering, or run tank. A typical installation of this type is shown in Figure 15.

The battery control console, Item 20, controls all battery operation. Graphic indication of operations is shown by means of indicator lights on the control panel.

Fluid passes through the treating system and into the surge tank. The surge tank is usually a 1000 barrel tank and the run tank is a 500 barrel tank, depending on the amount of production. The fluid is pumped from the surge tank into the run tank. Every thirty minutes, a sample of fluid is taken from near the bottom of the surge tank, slightly below the transfer line outlet to the run tank. This sample is checked for BS and W content, and if the content is less than a predetermined set amount, usually 1 percent, fluid transfer to the run tank continues. If a check shows that BS and W content exceeds 1 percent, transfer of fluid to the run tank is immediately stopped and the surge tank's second or lower valve opens and the fluid is routed from the surge tank bottom through the treating system until the fluid is determined clean enough to be transferred into the run tank. This process of checking the fluid being transferred is referred to as "monitoring the crude."

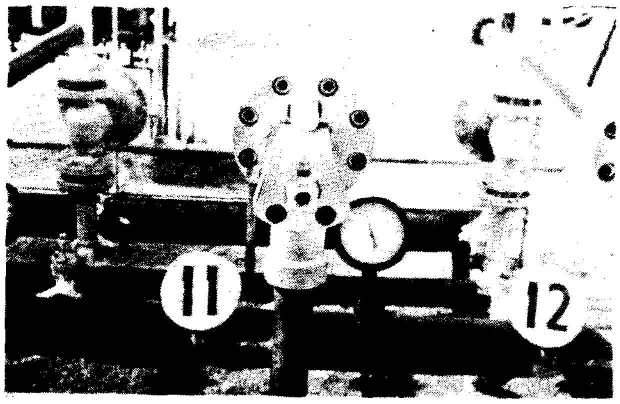

Fig. 8 Rotary Positive Type Choke

Located at three different levels on the surge tank are Dynatrol level switches. If the level in the tank drops to the lower Dynatrol, the electrically driven transfer pump is stopped until the fluid level rises to the second Dynatrol, and then it is started again. This prevents air from getting into the transfer line and pump. The Dynatrol located near the top of the surge tank is a safety control used to shut in the lease in case of a high level. The treating system is also equipped with a high level Dynatrol for shutting in the lease in case of a high level occurrence there.

When fluid rises in the run tank to the high level Dynatrol, the transfer pump is stopped. The valve located slightly below the high level Dynatrol opens and the fluid in the top of the tank, between the Dynatrol and the valve, gravities out of the run tank back into the surge tank, or in some cases, is pumped back to the surge tank. This operation insures that each tank of crude run to the pipeline will have exactly the same high level. The crude properties transmitters are started and the detection of the gravity, temperature, and cut is made.

The degrees API gravity of the crude oil about to be run to the pipeline is automatically determined by Item 18, an Automation Products Gravity Transmitter. This transmitter is a variable displacement type instrument with a ten foot displacer tube hanging down into the fluid. The electrical transducer in the upper housing of the gravity instrument gives an electrical output signal to the null balance, three circuit servo timer at the control panel, where it is measured and printed on the crude properties data printer.

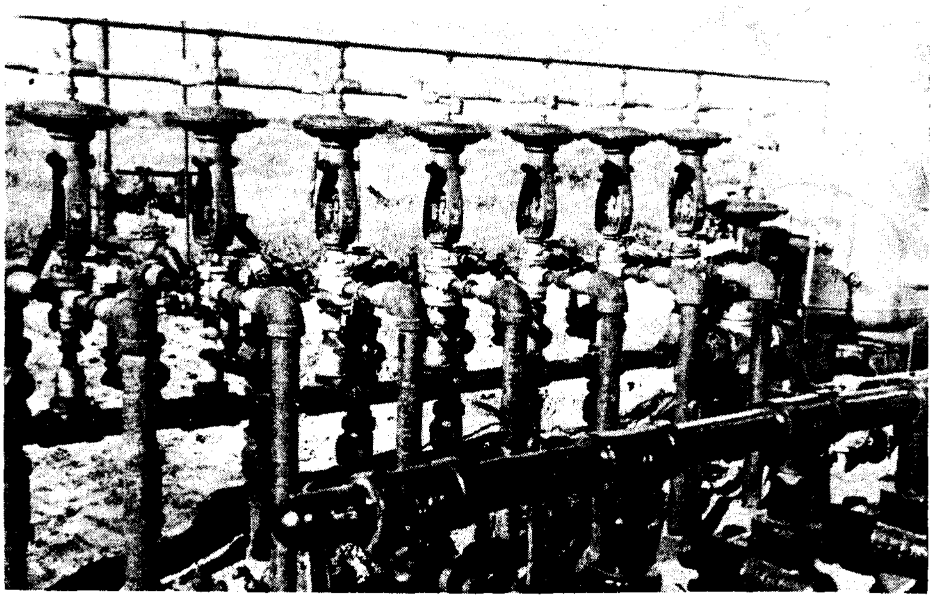
Fig. 9 Three-Way Three-Position Valve

The temperature of the crude oil is detected by Item 19, and Automation Products Temperature transmitter. This variable resistance instrument consists of a wire wound insulated core in an oil bath enclosed in a welded steel sheath. The resistance of the alloy wire varies as the temperature changes. This variation is measured through the three circuit servo timer and results, in degrees Fahrenheit, are printed on the crude properties data printer.

The BS and W content of the crude is automatically determined by Item 17, and Automation Products Cut Detector. Fluid samples are taken from three different levels on the run tank checked. The results are relayed through the three circuit servo timer to the crude properties data printer where the percent BS and W content of the crude is printed.

When the crude properties have been determined, usually requiring approximately fifteen minutes, the valve on the outlet line to the pipeline pump opens, the pump is automatically started and the fluid is transferred to the pipeline.

A weir box is mounted outside the tank, near the bottom, and as the fluid level recedes in the tank, it also recedes in the weir box. A Dynatrol is mounted into the weir box slightly below the level at which the tank bottoms out into the vertical outlet. riser. When all the fluid leaves the tank, the level in the weir box starts to drop rapidly and instantly the Dynatrol detects the low level and closes the pipeline valve. Then the lower valve opens to the transfer pump and the run tank bottom is recirculated through the treating system for a predetermined set period, to prevent a possible bottom buildup. At the end of the recirculation period, the lower valve on the run tank closes, the fill valve opens, and transfer of fluid into the run tank starts again. Thus, the automatic custody transfer cycle is completed.

Some of the many advantages realized by this type battery control are

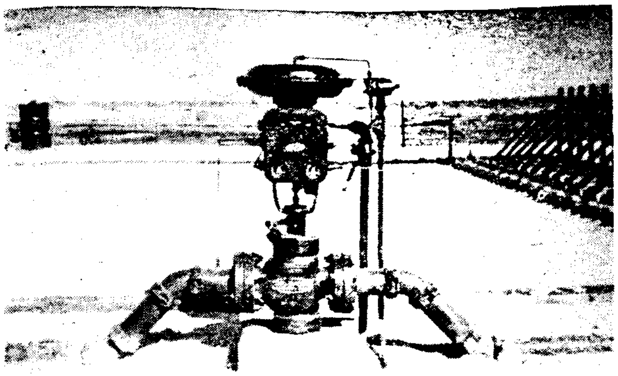

Fig. 10 Three-Way, Three-Position Valve, and Master Shut-In Valve

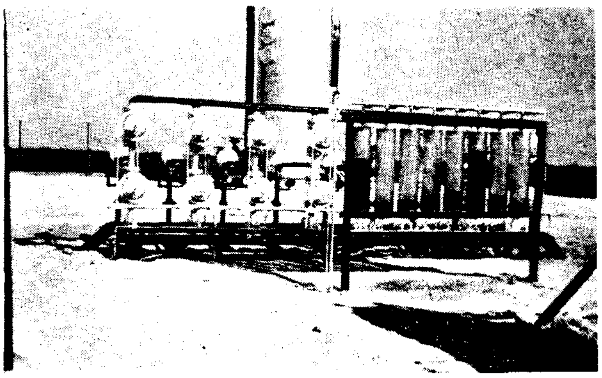

Fig. 11 Indexed Sample Chambers

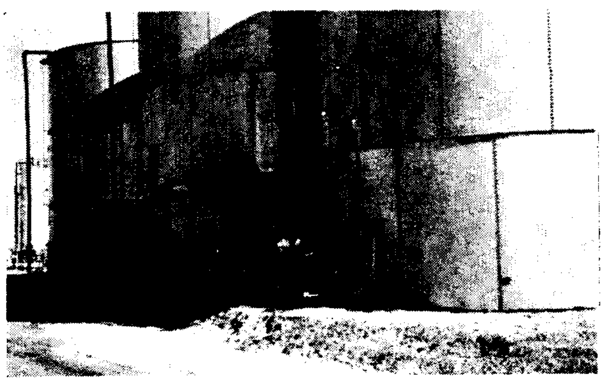

Fig. 12 Fluid Meter

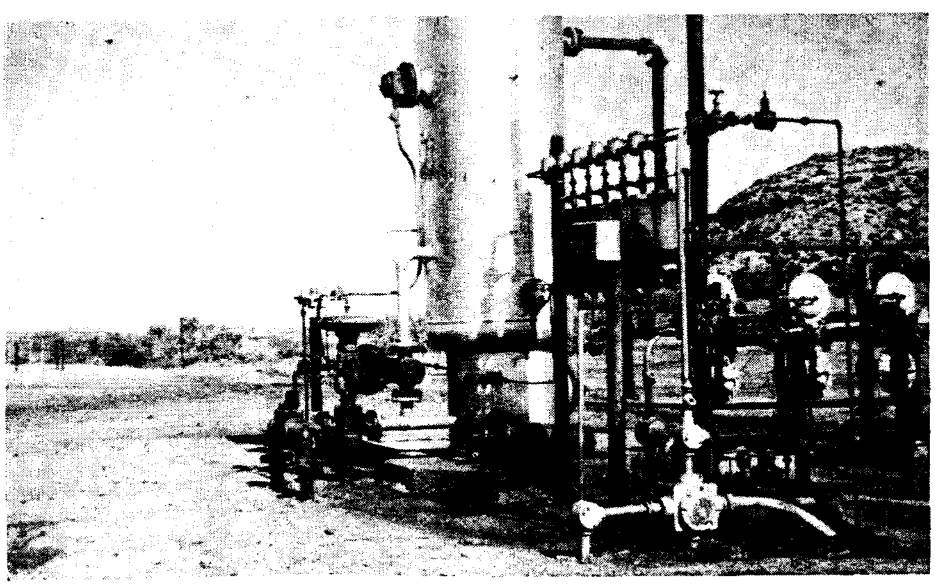

Fig. 13 Metering Separator

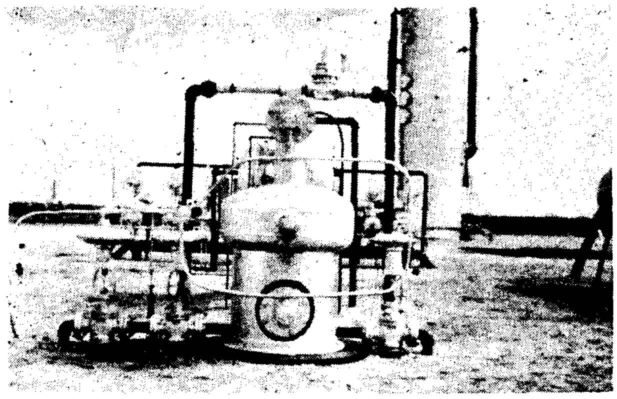

Fig. 14 Automatic Tank Switching

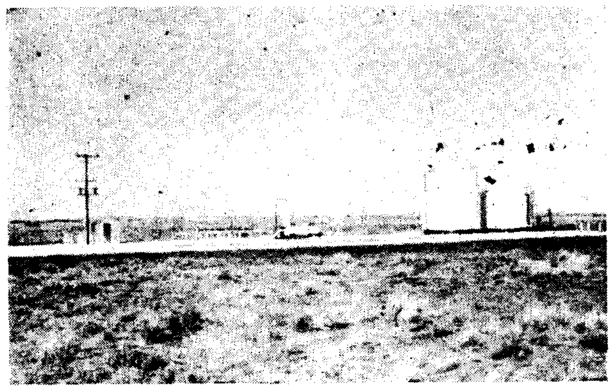

Fig. 15 Automatic Custody Transfer

that only two banks are required, thereby eliminating huge storage facilities. The closed system used in this operation provides a higher GPM of gas and higher crude gravity. The pipeline profits by this, in that there is a scheduled flow to the pipeline in contrast to the usually maximum load during mid-day and almost zero flow at midnight, thereby resulting in a reduction in required pipeline facilities. There is a reduction in man-hours required for the usual witnessed thiefing and gauging. Although this method of crude oil handling is new and considerably advanced to conventional operation, it is rapidly gaining field-wide acceptance.

A brief description of lease automation has been presented above. The best solution for your lease is a matter of opinion. Each lease has to be studied and designed to suit its particular requirements. Equipment is now available to do the job any one of many different ways.

Newest developments in automatic controls are the fail-safe Dynatrol level switch and heater-type cut detector by Automation Products, Inc., and its subsidiary, Southwest Control Company. Before the development of the Dynatrol, leases could be designed for fail-safe operation, except for high level detection in tanks. As a result, tank run-overs have been experienced due to failure of conventional type level controls. In case of failure of the Dynatrol, fluid flow is automatically diverted to the next vessel or to safe handled production. By use of this level controller, absolute fail-safe leases can now be installed. The cut detector mentioned is a self-contained, compact unit used for automatic detection of the BS and W in sample fluid. Cut detection of well test fluid and fluid being run to the pipeline can now be made and results recorded automatically.

Equipment for telemetering information from the battery site directly to a central point is operating and being experimented with on some test installations. All well test information and pipeline transfer information is relayed directly as it occurs. Experiments are being conducted with the tele-metered results to be fed into computing systems that will automatically calculate well test and production results and make out royalty payments checks for the individual leases. With this communication of production data to the centralized point, the data is computed and automatically fed back to the lease in the form of pumping and flowing programs that will give the most efficient production rates from individual wells. This example of progressive thinking and development in the field of oil production is but one of many ideas that are being expanded and becoming operating actualities.

Everyday, oil producers are proving that automatic controls and methods can work for them to save them time and money. Through the use of these new tools and operations, they are actually making possible the production of more goods per man-hour which is in itself a true measure of a standard of living. Automation is proving its place in oil production and field wide acceptance by the oil industry appears a certainty.