Automatic Lease Operation

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INTRODUCTION

Automatic lease operation fundamentally results in three basic factors which production operators always set up as primary criteria for their operation:

1. Conservation of (a) hydrocarbon resources and (b) steel
2. Increased safety and efficiency of operating personnel
3. Reduction in initial capital investment

Let us look at the basic functions we are to perform in operating a production lease:

1. Control and schedule well production
2. Conduct periodic well performance tests
3. Perform functions necessary for the separation and the storage of gas and oil production
4. Run, measure, and transfer crude oil from the lease storage to the pipe line
5. Maintain lease production records

If we perform these functions automatically, we are in a position to consider a complete new concept of a production lease arrangement.

In order to get a clear picture of this new concept of lease arrangement, we should first break down into some broad categories the types of well production as well as the size and scope of individual leases.

Certainly, the first category will be that of the unit operation. This is the combining of many small leases under the direct responsibility of one operator with the production prorated on the basis of percentage to each of the participants. This type of operation lends itself particularly to automatic lease operation in that all of the factors involved in the application of automatic operation are utilized to operate a large scale lease simply. Some of these factors are consolidation of the many individual tank batteries; the rearrangement of flow lines to consolidated flow stations; the reduction in scope of the pipe line gathering system; the centralizing of treating facilities; and the facility of handling large quantities of water, such as those found in leases in their twilight production as well as in water flood projects. Many other factors, of course, become inherent in the simplification of the performance of the various lease functions.

Another category of lease operation would be that of a single operator having numerous leases in one field with varying divided interests. Under our presently accepted production methods, each of these divided interests, or leases -- that is, the scheduling of well production, well tests, separation and treatment of the oil, storage and measurement of the oil and gas, and transfer to the pipe line connection -- is handled on the individual basis. The first phase of automatic custody transfer is a possibility under these conditions by the application of equipment now available in an advanced stage of development. Consolidation of the operation of this type of lease can be handled by co-mingling. When the oil produced from different leases is co-mingled to a central custody transfer point, the oil and gas certainly loses its identity as far as individual royalty owners are concerned; therefore, for all practical purposes, the custody of the oil has been transferred. In order to reach the end point of the simplest arrangement of flow lines, treating facilities, and consolidation of tank batteries, each lease must have the ability to measure accurately the oil and gas and must be able to allocate any BS&W produced back to the individual lease. A great deal of engineering and development work has been done in recent years with metering equipment, sampling systems, and instrumentation for the accurate and dependable performance of this function. With the ability of each lease to perform the above functions on an acceptable basis to the royalty owners and to the state regulatory bodies, consolidation of the treating facilities and pipe line connections becomes possible.

A third category would include quite a broad range of smaller lease operations over scattered areas and in remote areas where electric power is not available or where bringing a source of power to these areas would not be feasible. Equipment has been developed, and is on the market, that will completely operate these types of leases by automatic programming, using pneumatic power throughout. Many economical payout factors are involved, but we shall mention here only a few of them, such as the increased efficiency of the lease switcher activities and the safer operation of remote leases by automatic safety devices which sense malfunction and protect the wellhead equipment, the flow lines, the separation and treater equipment as well as the tank batteries.

Other categories, which obviously lend themselves to automatic operation, would be offshore production, remote swampy-area production, and far north production. These last categories all have special problems of climate and transportation in which automatic operation solves simply many difficult problems inherent to economical and safe operation of these types of leases.

Let us look at the problem of applying automatic operation to the performance of the basic functions of handling oil and gas production.

WELLHEAD CONTROL

The first, is the control and scheduling of well production. Figure 1 shows a typical wellhead installation in which a well of the high ratio type is on "stop cocking" control; the one-valve installation on the flow line performs the function of a high pressure shut-in as well as that of a pressure reducer in controlling the "heading" gas production. Other types of wellhead controls applicable are pressure-sensing devices to start and stop electric-driven pumping equipment and "Hi-Lo" safety shut-in equipment controlled by the rise in pressure in the flow lines where control is established at the manifold.

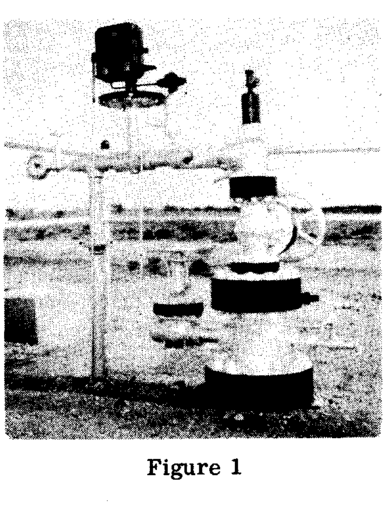


Figure 1

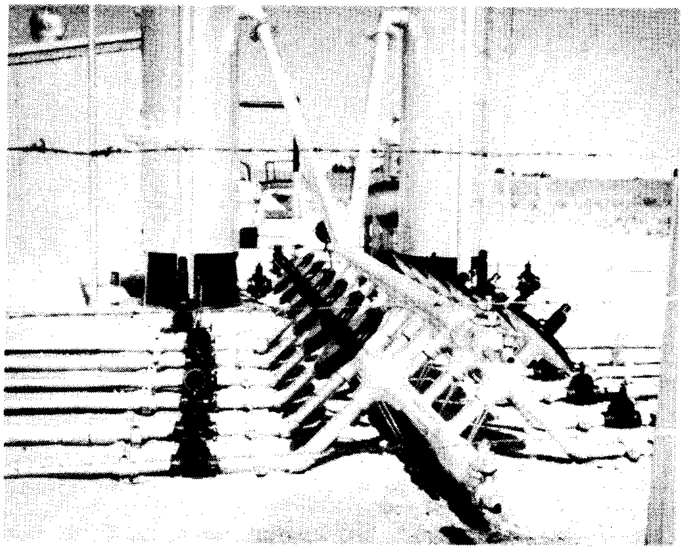


Figure 2

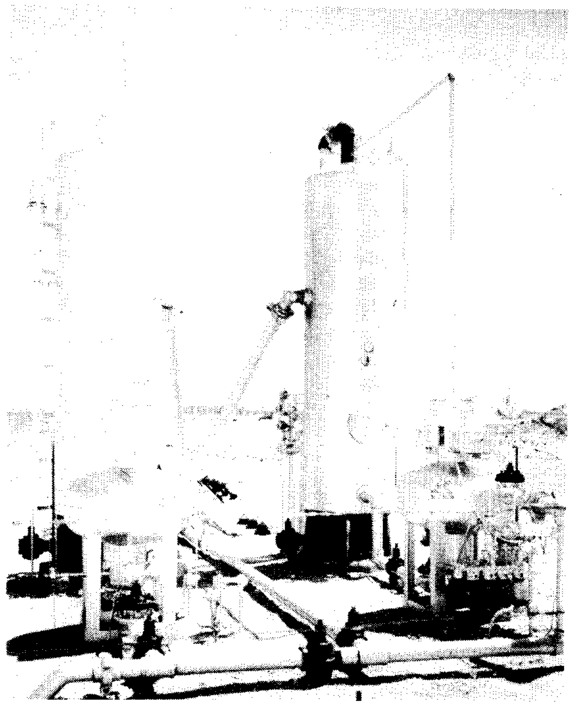


Figure 3

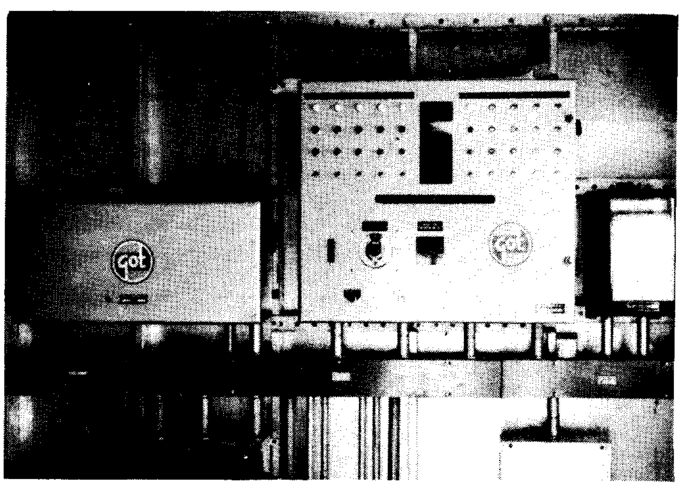


Figure 4

AUTOMATIC WELL TESTING

Figure 2 and Figure 3 show a typical automatically operated flow station with the automatic valve manifold performing the function of stop cocking and diversion from general production to test. Figure 3 is another view of the automatic flow station, showing metering equipment which meters production total fluid and well test total fluid and incorporates an automatic sampler and sample routing and storage system. Figure 4 is a view in a control house adjacent to the flow station, showing the automatic test programmer and the production programmer (stop-cocking cycle control) together with a strip chart recorder which identifies the well on test, the length of the test, the quantity of total fluid and gas produced by each individual well on test, and the total fluid produced on this lease. Figure 5 is an alternate view of the test programmer, illustrating the compactness and simplicity of this type of equipment. The well performance test and the programming of the well flowing pattern can be completely preprogrammed by these simple controllers to give complete well-performance test data. The additional equipment involved in this type of station is an integrating gas flow meter; several types on the market perform highly satisfactorily, within an accuracy range not heretofore obtained by conventional gas-metering equipment manually interpreted from differential and pressure charts. Of the several approaches other than the systems described above for the determination of well test data, one is using a test heater treater and metering separately the water leg and the oil leg by positive-displacement-type meters or the volume-blowcase-type meter.

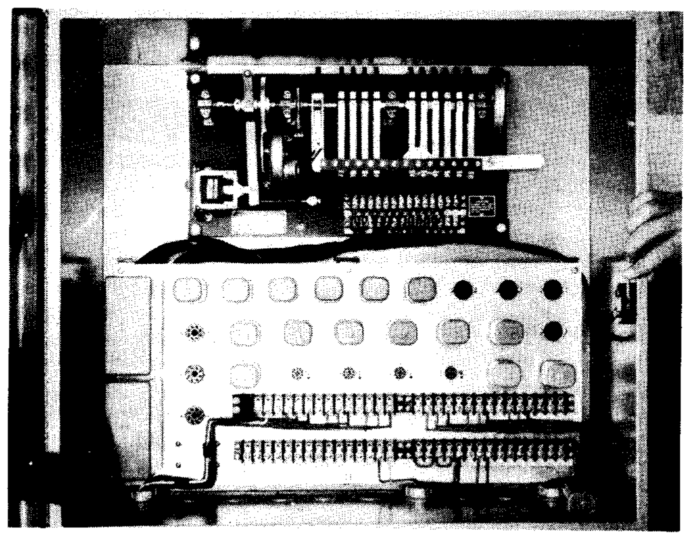


Figure 5

Development work is progressing further as requirements for this type of equipment increase to provide metering equipment with integrally built sampling devices as well as integrally built instrumentation that will analyze the water content without the necessity of sampling or separating the water from the oil for measurement. From the above discussion one can see that well tests performed automatically provide more and better well test data as well as release up to 25% of the lease switcher's time for other lease-tending operations.

TANK BATTERY

At this time we are in an "interim period" between conventional battery operation and lease automatic custody transfer. In the first concept of automatic tank battery operation, the automatic tank-switching system has been used extensively. Figure 6 shows an overall view of a typical con-

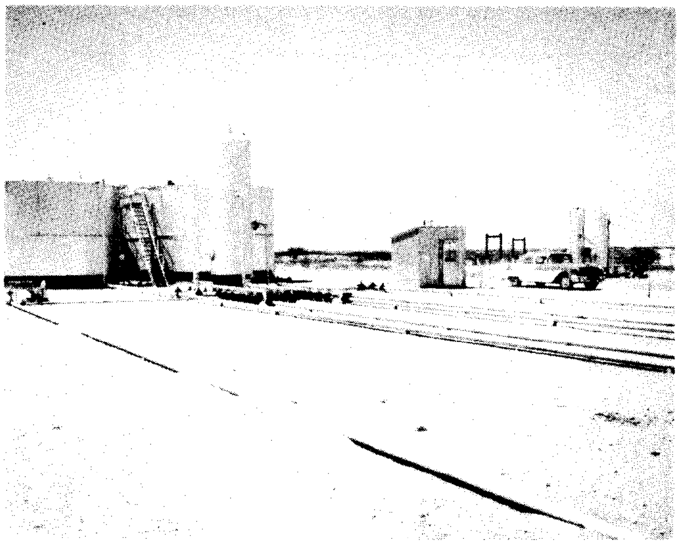


Figure 6

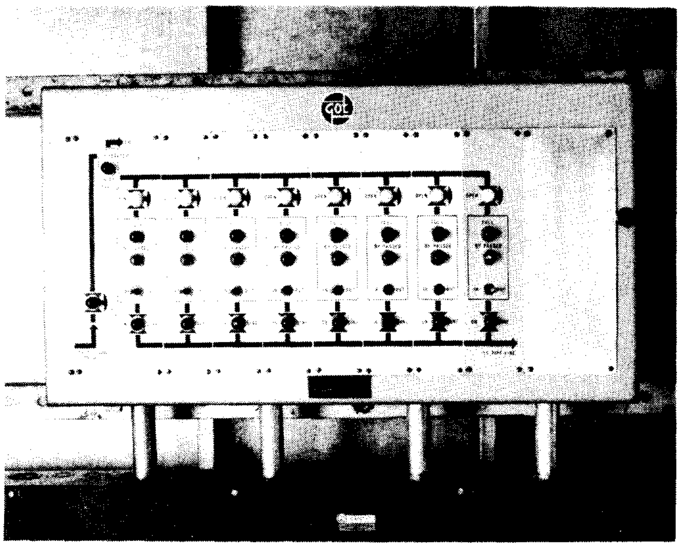


Figure 7

Figure 8

solidated tank battery, and an automatic flow station with the control house housing the automatic control equipment for the automatic function of the tank-switching system. Figure 7 illustrates the automatic control panel with graphic indication of the condition of the tank battery. This panel controls the function of automatic fill sequence and provides lock-out from the filling cycle of each tank when the particular tank is running to the pipe line. Figure 8 is a view of the tank battery, showing the automatic fill valves, and Figure 9 shows the ground level gauges which also perform the function of level control to the automatic tank-switching system. Further, Figure 9 shows the installation of the lock-out limit switches on the pipe line run valves.

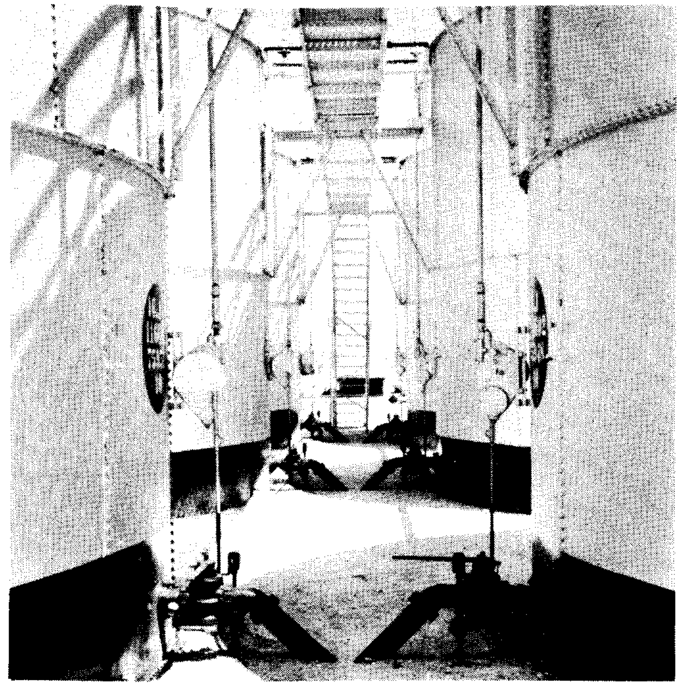


Figure 9

An additional function of automatic tank-switching systems has been built, adding the function of an automatic bottoms-recirculation system after the tank has been run to the pipe line.

LEASE AUTOMATIC CUSTODY TRANSFER

The automatic custody transfer of crude oil is the natural "end point" of the basic conception of complete automatic operation of the production lease. The benefits derived from L. A. C. T. systems are manifold. Some of these benefits are listed below:

Man Power Utilization

Lease-pumper and pipe-line-gauger transportation costs and time in the routine functions of manually turning tanks on and off, making hand measurement, and taking samples for quality determination will be reduced.

Steel Conservation

Automatic controls permit continuous or more frequent pipe line runs, reducing the tank storage time required. Further steel savings result from the overall concept of consolidation to central custody transfer points. To illustrate this point, a large unit operation in which 141 tank batteries with more than 400 tanks involved will be consolidated to 10 pipe-line transfer points is now in the construction stage. With the L.A.C.T. system installed, a total of only 30 tanks can be used. Pending acceptance of further simplified L.A.C.T. units, tankage can be further reduced.

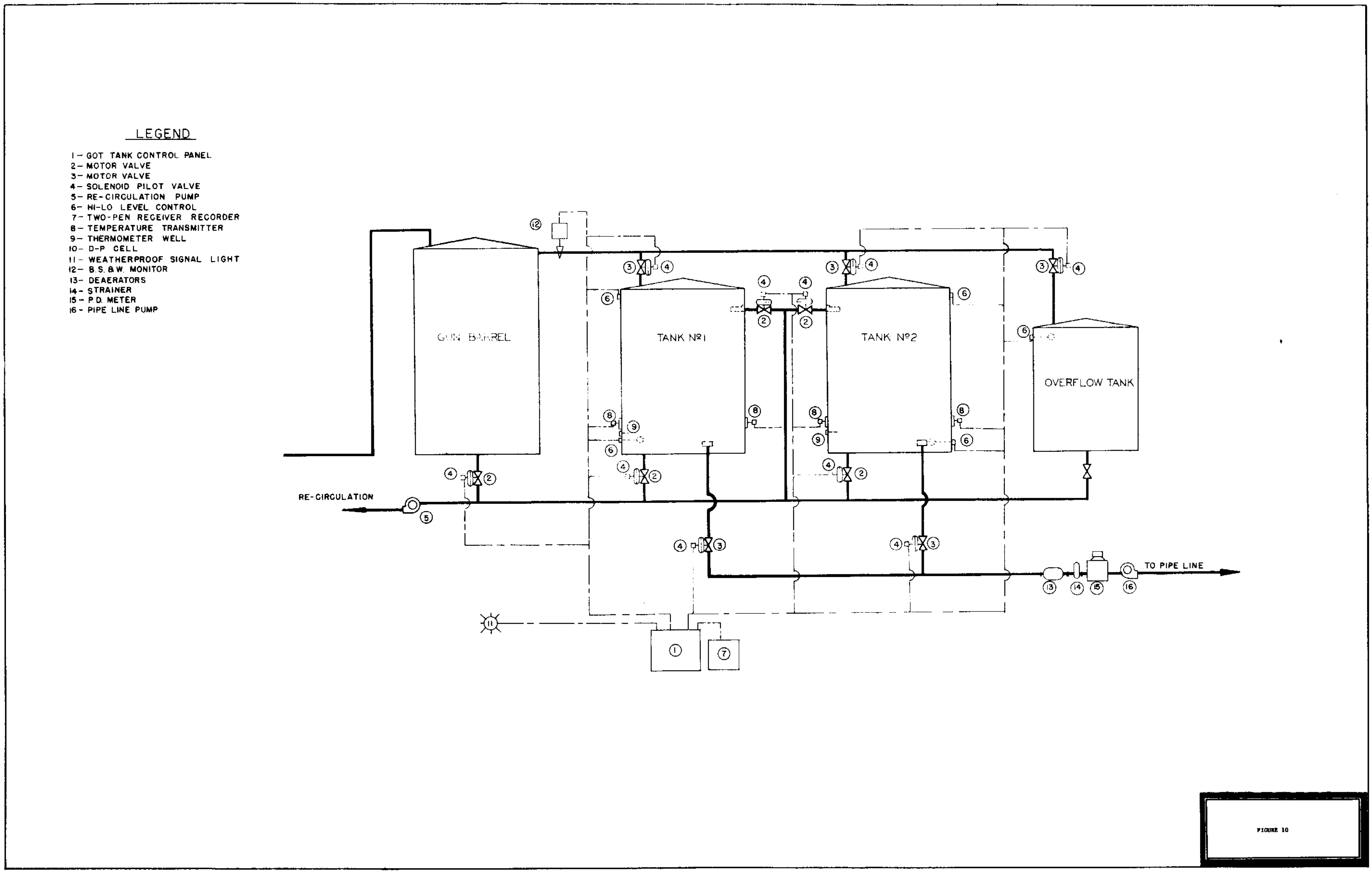

LEGEND
1 - GOT TANK CONTROL PANEL
2 - MOTOR VALVE
3 - MOTOR VALVE
4 - SOLENOID PILOT VALVE
5 - RE-CIRCULATION PUMP
6 - HI-LO LEVEL CONTROL
7 - TWO-PEN RECEIVER RECORDER
8 - TEMPERATURE TRANSMITTER
9 - THERMOMETER WELL
10 - D-P CELL
11 - WEATHERPROOF SIGNAL LIGHT
12 - B.S.&W. MONITOR
13 - DEAERATORS
14 - STRAINER
15 - P.D. METER
16 - PIPE LINE PUMP
GUN BARREL
TANK Nº1
TANK Nº2
OVERFLOW TANK
RE-CIRCULATION
TO PIPE LINE
FIGURE 10

Figure 10

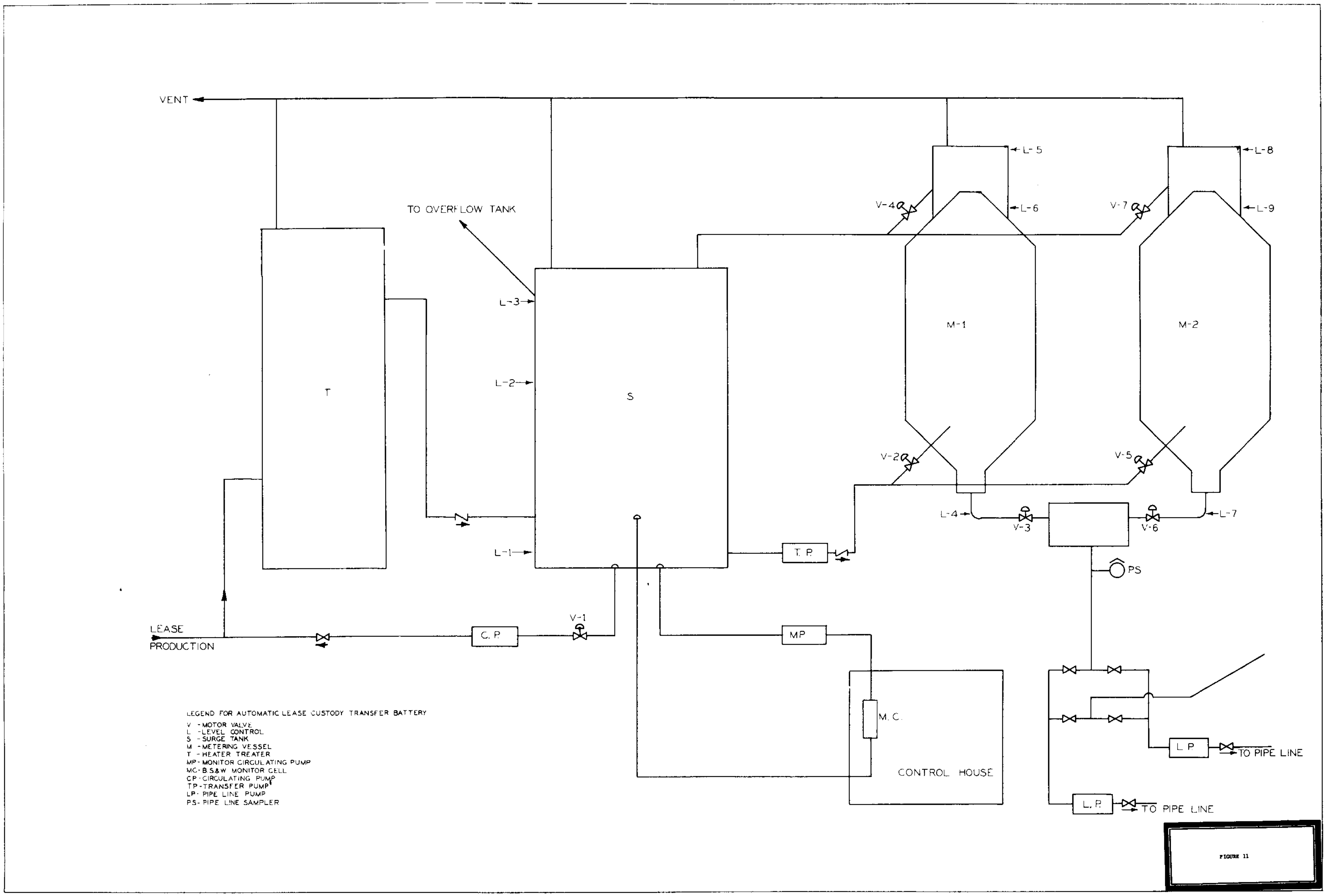
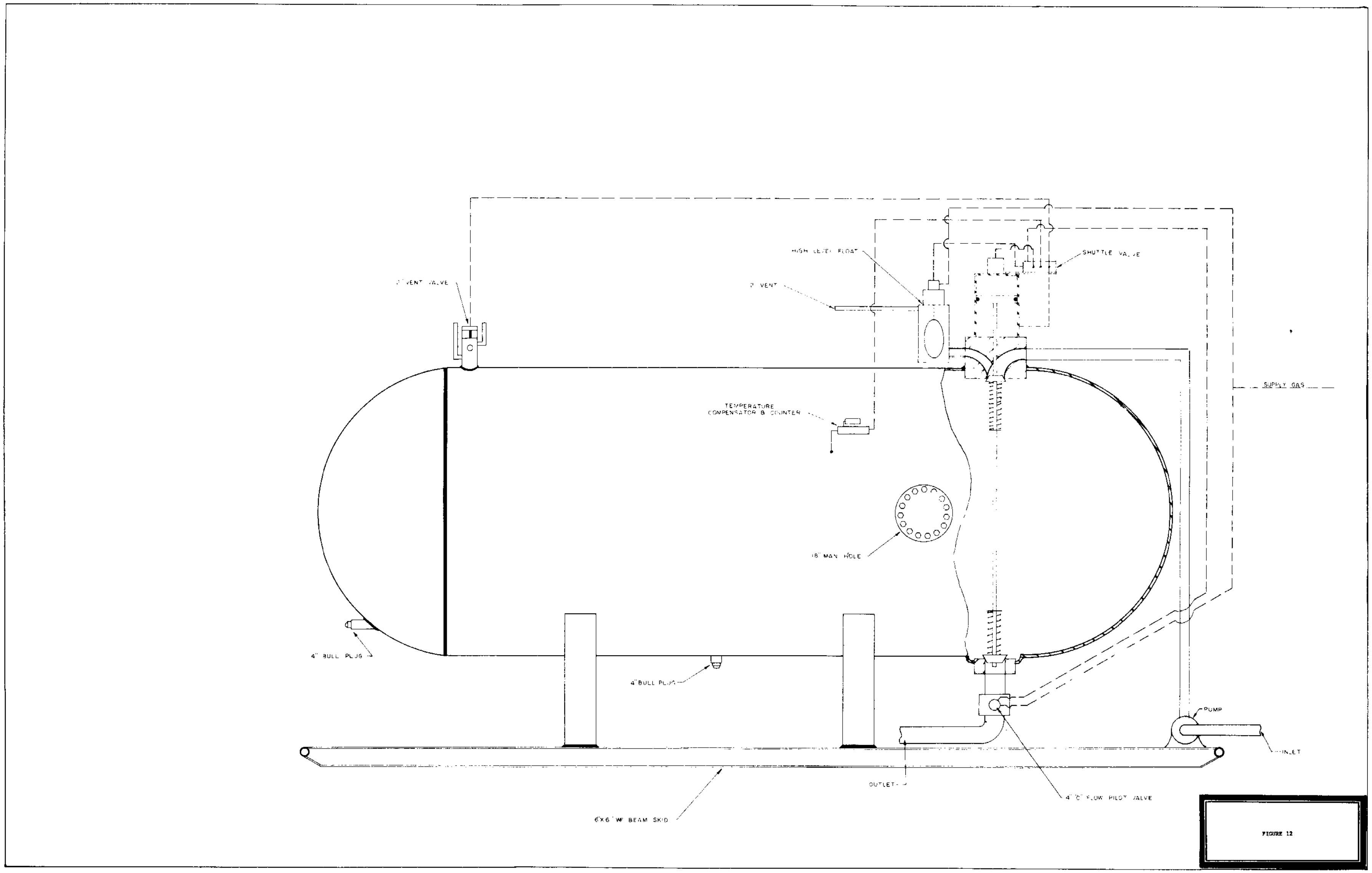

VENT
TO OVERFLOW TANK
T
S
M-1
M-2
L-1
L-2
L-3
L-4
L-5
L-6
L-7
L-8
L-9
V-1
V-2
V-3
V-4
V-5
V-6
V-7
LEASE PRODUCTION
C. P.
T. P.
MP
M. C.
CONTROL HOUSE
PS
L P
L. P.
TO PIPE LINE
TO PIPE LINE
LEGEND FOR AUTOMATIC LEASE CUSTODY TRANSFER BATTERY
V - MOTOR VALVE
L - LEVEL CONTROL
S - SURGE TANK
M - METERING VESSEL
T - HEATER TREATER
MP - MONITOR CIRCULATING PUMP
MC - B.S.&W. MONITOR CELL
CP - CIRCULATING PUMP
TP - TRANSFER PUMP
LP - PIPE LINE PUMP
PS - PIPE LINE SAMPLER
FIGURE 11

Figure 11



VENT VALVE
HIGH LEVEL FLOAT
VENT
SHUTTLE VALVE
TEMPERATURE
COMPENSATOR & COUNTER
18" MAN HOLE
SUPPLY GAS
4" BULL PLUG
4" BULL PLUG
PUMP
INLET
OUTLET
FLOW PILOT VALVE
6X6 WF BEAM SKID
FIGURE 12

Figure 12

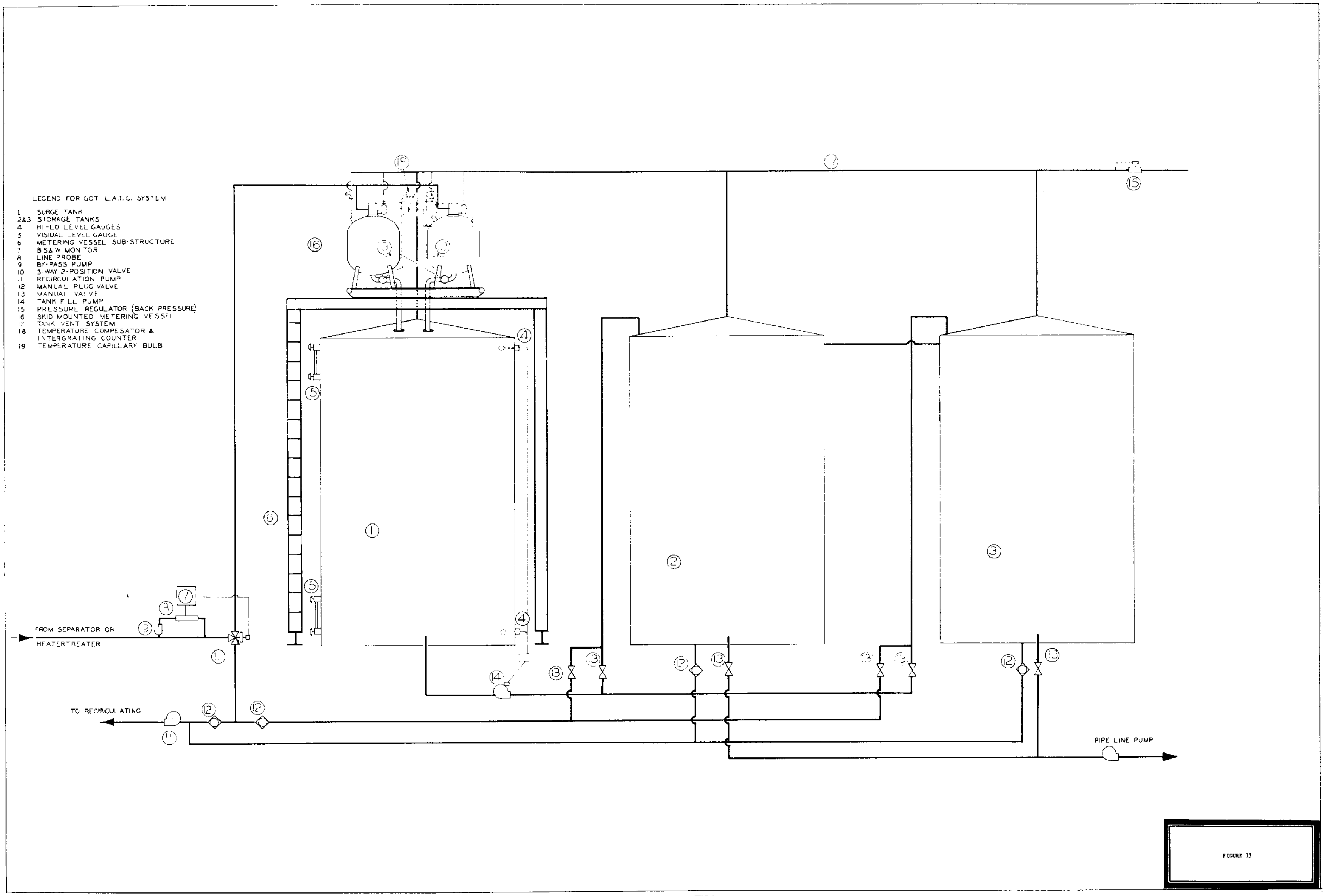

LEGEND FOR GOT L.A.T.C. SYSTEM
1 SURGE TANK
2&3 STORAGE TANKS
4 HI-LO LEVEL GAUGES
5 VISIUAL LEVEL GAUGE
6 METERING VESSEL SUB-STRUCTURE
7 B.S.& W MONITOR
8 LINE PROBE
9 BY-PASS PUMP
10 3-WAY 2-POSITION VALVE
11 RECIRCULATION PUMP
12 MANUAL PLUG VALVE
13 MANUAL VALVE
14 TANK FILL PUMP
15 PRESSURE REGULATOR (BACK PRESSURE)
16 SKID MOUNTED METERING VESSEL
17 TANK VENT SYSTEM
18 TEMPERATURE COMPESATOR & INTERGRATING COUNTER
19 TEMPERATURE CAPILLARY BULB
FROM SEPARATOR OR HEATERTREATER
TO RECIRCULATING
PIPE LINE PUMP
FIGURE 13

Figure 13

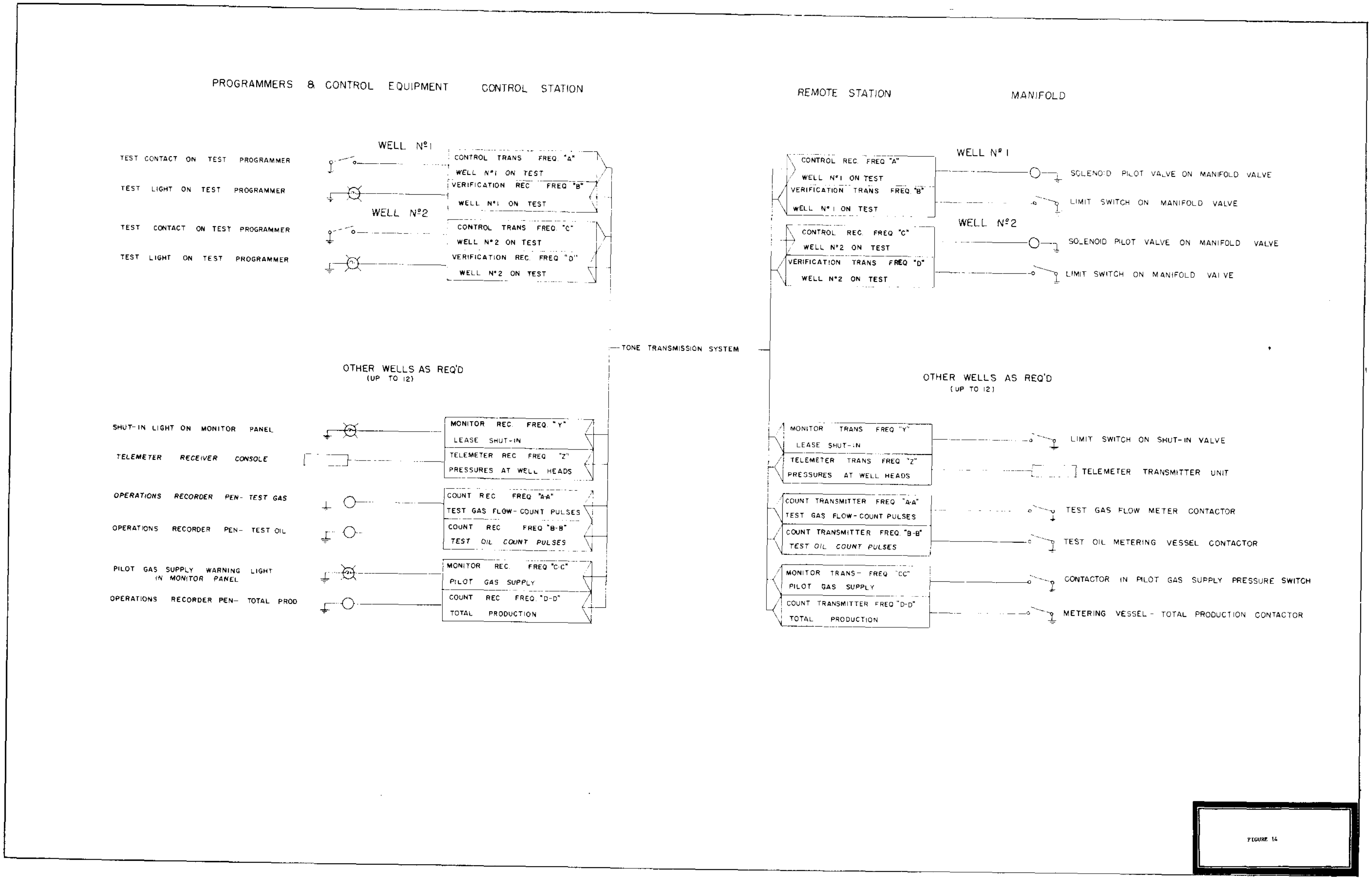

PROGRAMMERS & CONTROL EQUIPMENT
CONTROL STATION
REMOTE STATION
MANIFOLD
WELL N°1
WELL N°2
TEST CONTACT ON TEST PROGRAMMER
TEST LIGHT ON TEST PROGRAMMER
TEST CONTACT ON TEST PROGRAMMER
TEST LIGHT ON TEST PROGRAMMER
CONTROL TRANS FREQ "A"
WELL N°1 ON TEST
VERIFICATION REC FREQ "B"
WELL N°1 ON TEST
CONTROL TRANS FREQ "C"
WELL N°2 ON TEST
VERIFICATION REC FREQ "D"
WELL N°2 ON TEST
CONTROL REC FREQ "A"
WELL N°1 ON TEST
VERIFICATION TRANS FREQ "B"
WELL N°1 ON TEST
CONTROL REC FREQ "C"
WELL N°2 ON TEST
VERIFICATION TRANS FREQ "D"
WELL N°2 ON TEST
SOLENOID PILOT VALVE ON MANIFOLD VALVE
LIMIT SWITCH ON MANIFOLD VALVE
SOLENOID PILOT VALVE ON MANIFOLD VALVE
LIMIT SWITCH ON MANIFOLD VALVE
TONE TRANSMISSION SYSTEM
OTHER WELLS AS REQ'D
(UP TO 12)
OTHER WELLS AS REQ'D
(UP TO 12)
SHUT-IN LIGHT ON MONITOR PANEL
TELEMETER RECEIVER CONSOLE
OPERATIONS RECORDER PEN- TEST GAS
OPERATIONS RECORDER PEN- TEST OIL
PILOT GAS SUPPLY WARNING LIGHT IN MONITOR PANEL
OPERATIONS RECORDER PEN- TOTAL PROD
MONITOR REC FREQ "Y"
LEASE SHUT-IN
TELEMETER REC FREQ "Z"
PRESSURES AT WELL HEADS
COUNT REC FREQ "A-A"
TEST GAS FLOW-COUNT PULSES
COUNT REC FREQ "B-B"
TEST OIL COUNT PULSES
MONITOR REC FREQ "C-C"
PILOT GAS SUPPLY
COUNT REC FREQ "D-D"
TOTAL PRODUCTION
MONITOR TRANS FREQ "Y"
LEASE SHUT-IN
TELEMETER TRANS FREQ "Z"
PRESSURES AT WELL HEADS
COUNT TRANSMITTER FREQ "A-A"
TEST GAS FLOW-COUNT PULSES
COUNT TRANSMITTER FREQ "B-B"
TEST OIL COUNT PULSES
MONITOR TRANS- FREQ "CC"
PILOT GAS SUPPLY
COUNT TRANSMITTER FREQ "D-D"
TOTAL PRODUCTION
LIMIT SWITCH ON SHUT-IN VALVE
TELEMETER TRANSMITTER UNIT
TEST GAS FLOW METER CONTACTOR
TEST OIL METERING VESSEL CONTACTOR
CONTACTOR IN PILOT GAS SUPPLY PRESSURE SWITCH
METERING VESSEL - TOTAL PRODUCTION CONTACTOR
FIGURE 14

Figure 14

Hydrocarbon Conservation

Reduced quantity storage and the elimination of vapor losses by opening hatches for manual gauging and sampling increase the quantity by retaining a higher gravity of the crude oil. Increases of from .5^{o} API gravity to 1.5^{o} API have actually been shown by the use of a closed system in automatic custody transfer of the production. This conservation factor is further increased by the overall programming of a lease through the ability to control such functions as the scheduling of the casinghead gas to the gasoline plants.

Measurement Accuracy

L.A.C.T. can consistently measure at least as accurately as hand methods at their very best can. L.A.C.T. systems offer the ability to simplify oil accounting procedures. Computation by instrumentation, which can compensate automatically for the quality factors such as temperature and gravity group, and by the use of highly developed instrumentation for the monitoring of BS&W in oil and from the treating systems assures continued accuracy of measurement and quality determination.

The factors accruing to the gathering system permit constant load factors and the scheduling of pipe line runs on a predetermined basis, which inherently will make for all-weather operation on a 24-hour basis. L.A.C.T. systems can completely comply with production allowable regulations as to quality, quantity, and timing.

Safety

Intrinsically, operation of automatic custody transfer batteries serves to improve safety of personnel and equipment. The hazards involved in the pumpers' and gaugers' climbing ladders and walkways and manually gauging and thiefing in open hatches, particularly where hydrogen sulfide is present in the produced gas, are eliminated. The elimination of the routine (and the physical labor involved) of manual gauging, sampling, and recording of this information is an added safety.

The detailed arrangement of automatic custody transfer systems has caused consideration. Basically, the systems are broken down into two categories, the first of which is using tanks for the minimum amount of storage time and metering the oil through positive-displacement-type meters. This type of meter can be temperature-compensated and, with the use of a line sampler, the quality determination can be made. The second general category of automatic custody transfer utilizes primarily two tanks used as volume meters.

Many different systems of physical arrangement are taking shape in test installations. In one system two tanks are used with high and low weirs, and measurement is made by pumping to the pipe line the oil between these two weir levels. Figure 10 shows a typical flow diagram of this system. Of course, there are many minor arrangement variations within the basic system of weir control.

Another system uses the truncated or cone-shaped metering vessel. Figure 11 illustrates schematically this system. A third system, in the development stage at the present time, uses a volume-meter principle operating under gravity head conditions. A schematic of a vessel of this system is illustrated by Figure 12. Figure 13 illustrates another system operating on the volume-meter principle under gravity head conditions. This system uses two small-volume meters and a pipe line surge tank built integrally. It also has the ability to provide automatic temperature compensation within the gravity group in which the oil being handled falls. Further, the system incorporates a capacitance BS&W monitor and a "bad oil" diverting system, as well as a provision for storage tankage. The measuring system requires no surge tank capacity ahead of the unit, except the capacity of standard separator or treating units.

REMOTE-DATA TRANSMISSION AND FUNCTION CONTROL

A typical remote control system is illustrated in Figure 14. The remote control signal is an audible tone transmitted between the master and the remote station by means of a telephone line or a microwave radio. Information to be recorded or observed is transmitted in the same manner from the remote to the master station. A total of 48 control or monitor channels is available over a single telephone line or over one two-way microwave channel. Control is accomplished by a receiver at the remote or the master station which is sensitive to only one tone. A relay in the receiver operates the valve, the pump or the recorder associated with it. Pressure, flow rates, or levels may also be sent over a system of this type by using equipment which translates the information into a code. This code is decoded at the other end, and the information is available at a recorder or gauge. A remote-control system may be operated by automatically or manually operated supervisory equipment at the master station.

One other type of remote-control system sends a coded signal for each operation to be accomplished. This system is in general use on pipe line and railroad systems.

The end point of remote-data-transmission systems will be a complete data handling system. The equipment for this system is available for many other business operations such as accounting, cost and production control, and others. Many of the business machine manufacturers are building this equipment that will be completely compatible with receiving, storing, and translating these data automatically into a usable form for oil field accounting purposes as well as for engineering reservoir studies.

CONCLUSION

The scope of this paper has not allowed us to go into the details of all of the individual components that are available to perform reliably all of the functions of a complete lease automatic operation. The experience obtained, however, with many hundreds of leases with varying degrees of automatic operation installed and from some five years of continuous operation of these leases, points out clearly the very dynamic development which has been made.

The definite advantages that have been shown to producers and pipeliners who have installed some degree of automatic operation are pointing up the way for an industry-wide investigation of advantages that are to be accrued by operators who have not had their first experience with automatic lease operation.