HYDRAULIC PUMPING - PHASE III

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Phase I for the hydraulic pumping method of artificial lift was the initial development of the first commercially successful hydraulic pumping installation in 1932. Phase II followed with the introduction of the "free pump" in 1948. Phase III covers the relatively recent development of the unitized, skid-mounted Power Fluid Conditioning Unit which was conceived in 1969 and placed on the market in 1970. The acceptance of the concept of using a PFCU for taking well fluid and making it suitable for power fluid had resulted primarily from overcoming the disadvantages of the established central system concept - specifically, the high cost of treating and storing power oil combined with cost of long, high-pressure power oil lines.

The "Unidraulic" Hydraulic Pumping System eliminates these disadvantages by moving the power fluid system back to the well site. The Power Fluid Conditioning Unit removes solids from the produced well fluid with a cyclone separator. The cyclone converts the pressure energy of the fluid into centrifugal force to increase the settling velocity of the suspended solids. These solids are carried by the force to the discharge point at the bottom of the cone. The liquid phase, being lighter, moves upward in the cone as a spiralling vortex to the liquid discharge connection at the top of the cyclone. Solids-free power fluid, either water or oil, from the reservoir provides suction to the multiplex pump which returns the power fluid at the required pressure to the wellhead to again operate the subsurface production unit to start the lift cycle all over again. Lease treating facilities are needed to process and treat only that volume of oil, water or gas that is actually produced from the well; the same as for a sucker rod pumping well. Therefore, well testing procedure is performed exactly as a sucker rod pumping well.

Figure 1 is a schematic drawing of the flow diagram for the first Unidraulic System. This was a single-vessel unit which received the total volume of returned power fluid and production from the well. Water from the lower section of the reservoir was then forced into the inlet of the cyclone separator at an optimum pressure to give the appropriate pressure drop across the cyclone for the particular well requirement. The solids separated by the cyclone were discharged from the cyclone with the underflow to join the well production for the trip to the lease treating facilities. The clean water was discharged out the upper end of the cyclone through the gas eliminator into the suction of the multiplex pump where it was pressured to operate the subsurface production unit.

The first system was designed specifically for using water as the power fluid. However, after making the first few installations in 1970 it became evident that the flexibility of operating with either water or oil would be a big advantage, so dual-flow piping was added. For oil operation, the well fluid was directed through the cyclone separator for cleaning and then to the reservoir vessel for gravity separation to take place. The appropriate piping and outlets were installed so oil or water could be present at the suction of the multiplex pump to be used as power fluid.

The first major change in the Unidraulic System was the addition of a second vessel - a horizontal tank located below the reservoir and referred to as a pressure charging accumulator as shown schematically in Fig. 2. The charging accumulator serves both as a primary gas separator and as a surge chamber to absorb volume fluctuations and to provide a relatively constant head to the cyclone. Most of the gas separates from the fluid in this accumulator and is discharged through a back pressure valve into the flow line.

The underflow rate of the cyclone is continuous and controlled so that a rate equal to approximately 25% of the production rate of the well is discharged to the flow line carrying entrained solids with it.

The clean overflow from the cyclone goes to the reservoir which serves basically as a free water knockout. In this version, it is designed to (1) provide adequate retention time to effect the needed gravity separation of oil, water and gas; (2) provide enough gas capacity to maintain a stable pressure in the system; and (3) provide enough storage capacity to displace the volume of gas trapped in the tubulars for pump-in and pump-out of the free-type pumps.

By opening one valve and closing another, the Unidraulic unit can be changed from power water to power oil operation. With water as the power fluid, the produced fluid outlet is near the top of the tank so that, except for a thin layer of oil on the top, the tank remains filled with water. With oil as the power fluid, the produced fluid is removed from the bottom so that, except for a thin layer of water on the bottom, the tank remains filled with oil. In either instance the riser to remove suction fluid to the multiplex pump is normally about one-third of the way up from the bottom of the tank but may be adjusted up or down if desired. The float valve controls the production discharge to the flow line maintaining a constant level in the tank. A back pressure valve controls the discharge of gas to the flow line, maintaining a constant pressure on the vessel.

Figure 3 schematically represents the Unidraulic unit equipped with a vertical accumulator. This is probably the most reliable arrangement for any type producing well and is the preferred model when a high GOR is anticipated.

The evolution of the Unidraulic through the above changes was an effort to make the equipment perform more effectively and efficiently on a greater number of wells. This modification of handling power fluid, in an artificial lift system that has been used by the industry many years, has been received with much enthusiasm during the last four years. During this time, over 400 units have been placed in service. Currently over 50% of the wells being placed on hydraulic lift are being equipped with the Unidraulic hydraulic pumping concept. The PFCU concept has found use also in multiwell installations and especially on platforms or production island-type installations.

Figure 6 shows a schematic drawing of the surface equipment of a complete "Unidraulic" Hydraulic Pumping System.

Phase III of hydraulic pumping, which resulted in the development of the Power Fluid Conditioning Unit, permits economy to be added to the advantages of hydraulic pumping. The Unidraulic concept permits portability, flexibility, accurate and simple well testing, and safety.

One real advantage in today's operation is the minimum of down-time to re-place a well on production when the subsurface pump needs repair. With the demand and price of oil increasing, down-time waiting on service rigs or actual time and cost of pulling and running rods compared to circulating out and in the hydraulic pump is a real and significant consideration. We recommend you give consideration to a Unidraulic Pumping System on any artificial lift requirement before reaching a decision on the method to be used.

About this same time a differential valve was adopted as standard to control the differential pressure between the accumulator and the reservoir. This maintains a constant differential pressure across the cyclone separator. Since the cyclone has flow characteristics similar to an orifice, a constant differential will establish a constant flow through the cyclone. Then with the proper feed nozzle size, vortex trim, and bladder diameter the optimum cleaning of the power fluid is obtained. Previously, a back pressure valve was used on each vessel.

An optional feature of the vertical accumulator is the addition of a liquid level control in this vessel to maintain a constant fluid level. This option is shown in Fig. 4. The excess fluid of that fluid required to enter the reservoir tank for proper cleaning and power fluid selection is dumped directly to the flow line through a dump valve controlled by the liquid level control in the vertical accumulator. This arrangement allows the fluid and gas to be separated and an optional auxiliary gas line may be used for more accurate well testing. This optional feature is especially desirable where a large volume of gas is produced with the well fluids. An additional advantage of this arrangement is the ability to retain the primary fluid to be used for power fluid (water or oil) in the accumulator. Figure 5 illustrates this hook-up in the flow diagram.

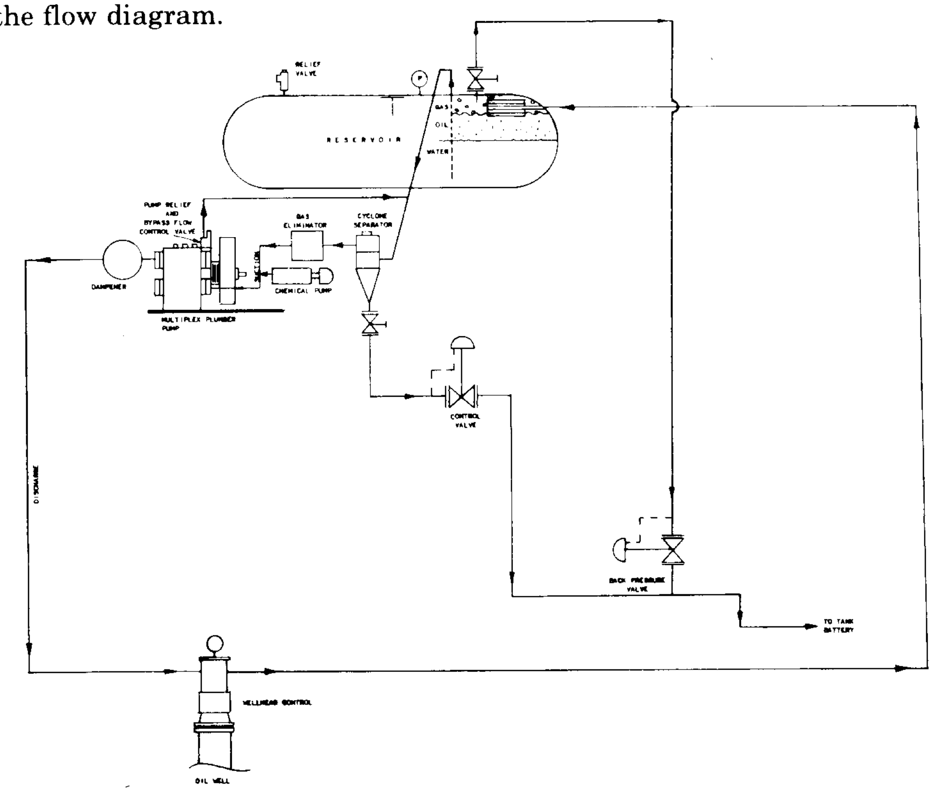

FIG. 1—FLOW DIAGRAM - SINGLE VESSEL UNIDRAULIC UNIT

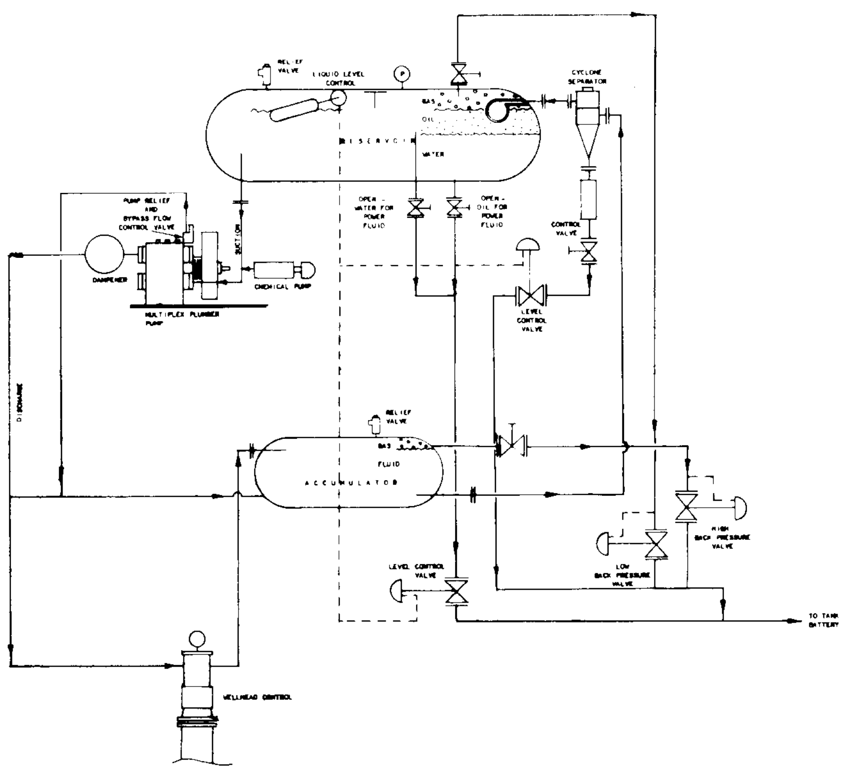

FIG. 2—FLOW DIAGRAM - UNIDRAULIC UNIT WITH HORIZONTAL ACCUMULATOR

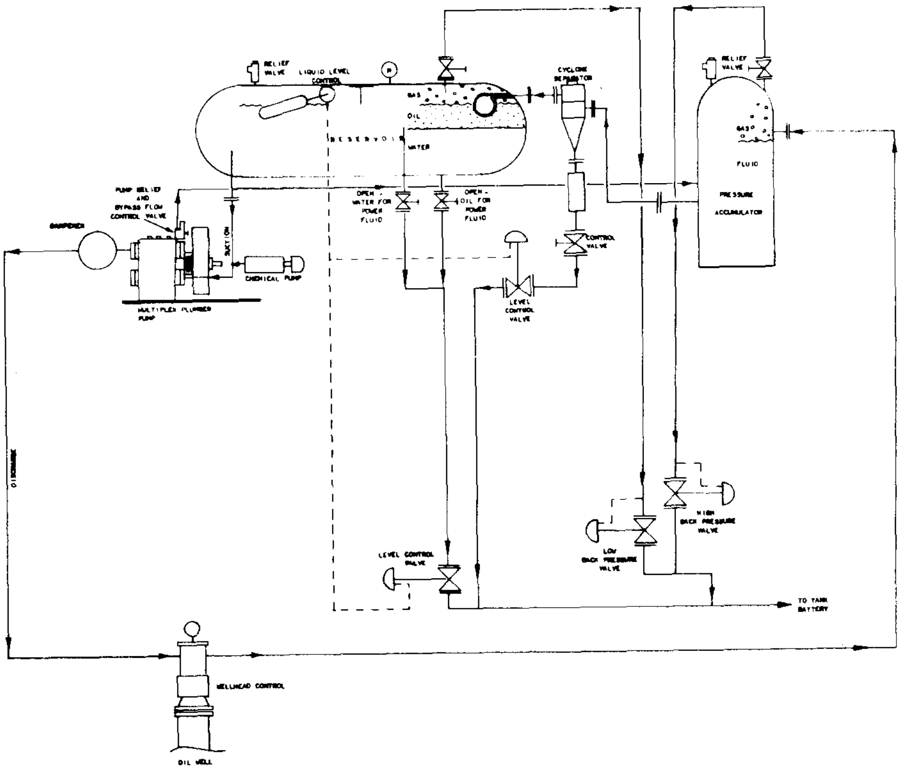

FIG. 3—FLOW DIAGRAM - UNIDRAULIC UNIT WITH VERTICAL ACCUMULATOR

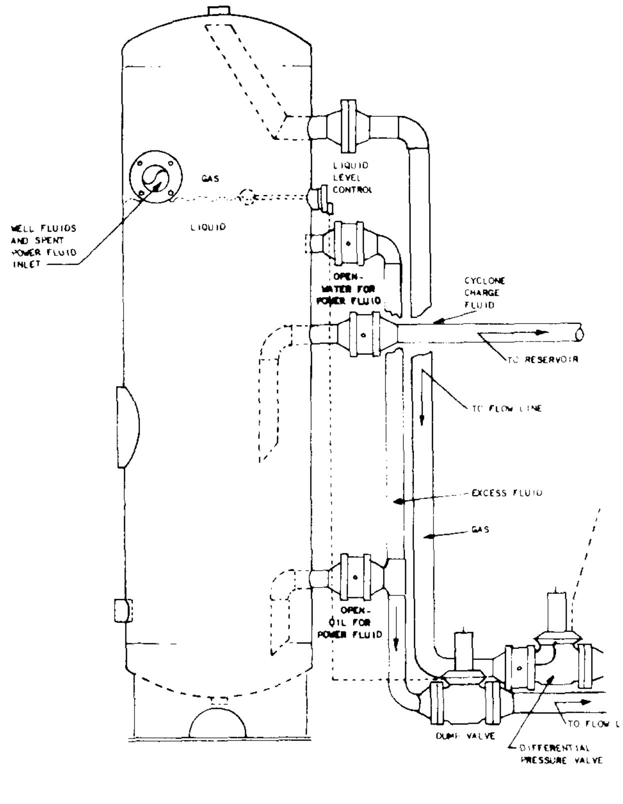

FIG. 4—VERTICAL PRESSURE CHARGING ACCUMULATOR WITH OPTIONAL LIQUID LEVEL CONTROL AND DIAPHRAGM-OPERATED VALVE

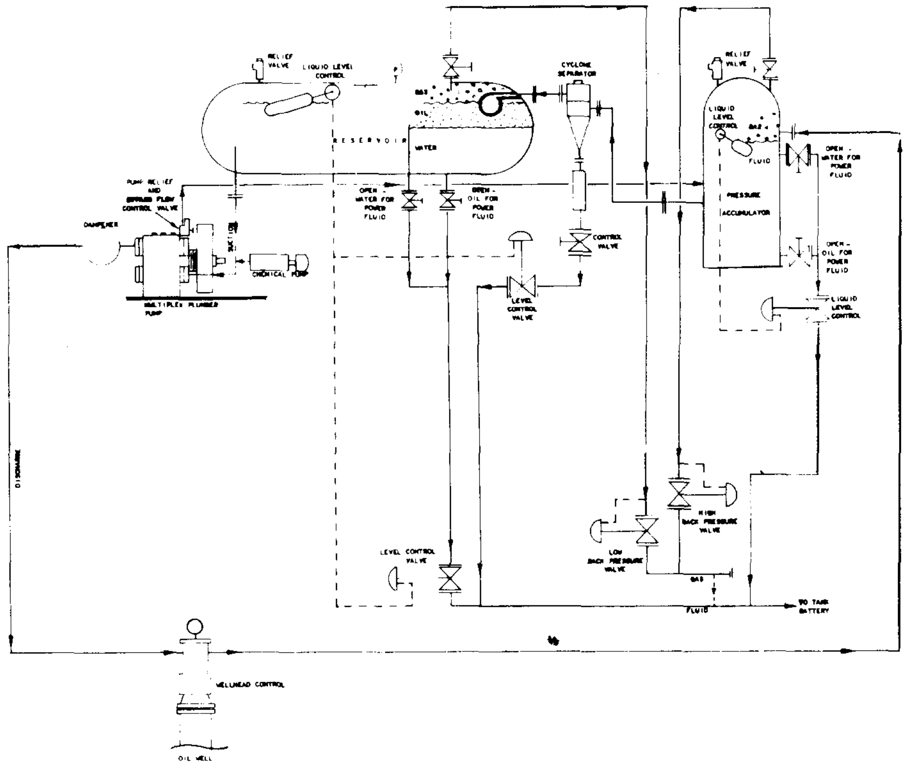

FIG. 5—FLOW DIAGRAM - UNIDRAULIC UNIT WITH VERTICAL ASSUMULATOR AND OPTIONAL ACCUMULATOR CONTROLS

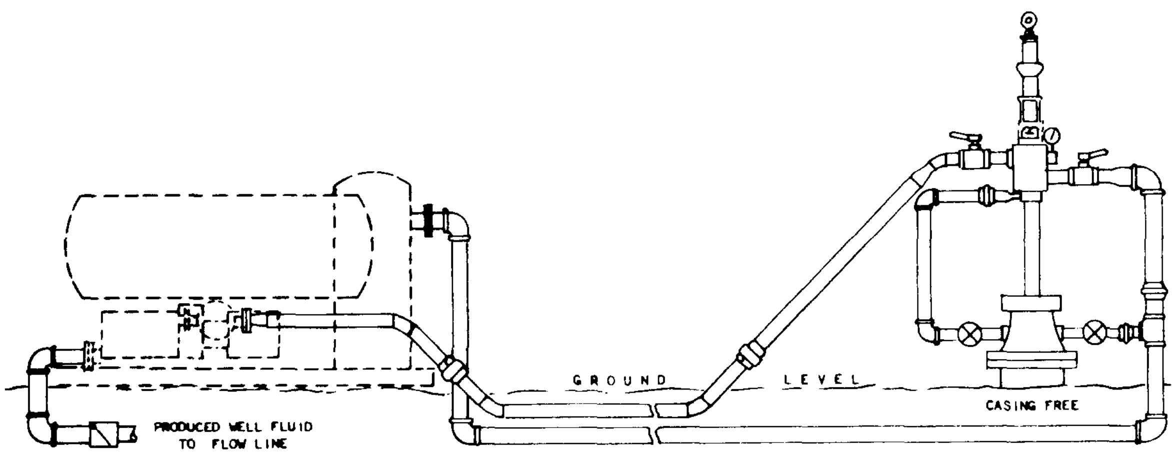

FIG. 6—COMPLETE UNIDRAULIC HYDRAULIC PUMPING SYSTEM