Some Modern Aspects Of Electrical Submersible Pumps

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Reda Pump Company

DESCRIPTION

General

An electrical submergible pump is essentially a multistage centrifugal pump, the shaft of which is directly connected through a protector section to a submergible electric motor. The entire assembly, as a unit, is of such outside diameter that it can be installed in wells completed with standard size casing. In operating position the unit is suspended on tubing, submerged in the well fluid, with a cable from the surface supplying electricity to the motor. The installation may be for any depth, since the unit is designed to function under any submergence pressures encountered. The installation is illustrated in Figure 1. The cross section of the assembled unit is illustrated in Figure 2.

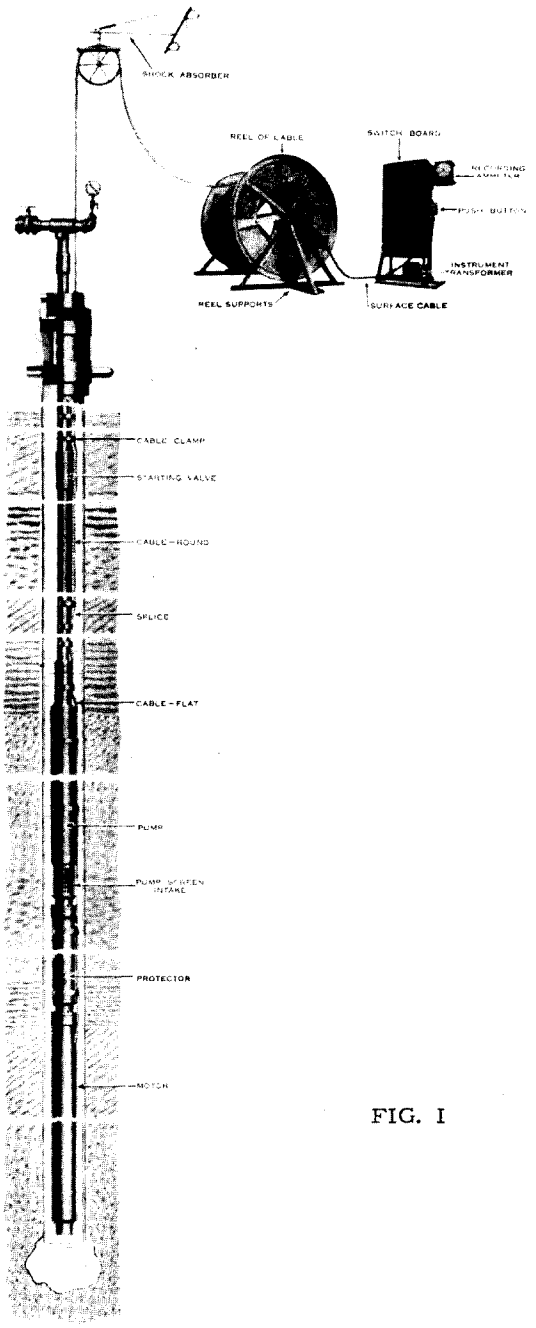


FIG. I

Pump

The multistage centrifugal pump is manufactured in a wide range of capacities to provide the desired head-capacity in each particular installation. The pump section consists of a series of stages, each composed of an impeller and diffuser, keyed to the pump shaft. This shaft is close-coupled through the protector section to the motor.

The characteristics of a centrifugal pump are quite different from those of a reciprocating or positive displacement pump -- its capacity varies inversely with the head (feet of lift or pounds per square inch of pressure). This is shown by the head-capacity curves in Figures 4 and 5 (100-Stage D-16 and I-300).

The above curves are for 2 different capacity pumps. These are but 2 of nearly 20 pump designs for capacities from 250 BPD to over 20,000 BPD. From curves such as these it is possible to calculate the head value of one stage at a given producing rate. When the required head is known the number of stages can be determined for a pump to meet the head-capacity requirements.

Gas Separator

The gas separator makes possible the production of fluid from gaseous wells and forms an intergral part of the submergible motor-pump assembly. It is interposed between and connects the protector of the motor with the pump unit (Figure 6). The connecting shaft extends through the separator unit. These gas separators are available in any desired capacity for a given diameter of well. Because of its design advantages the gas separator can be built of any desired length for effective gas separation of the mixture of any gas-oil ratio.

In operation, when the pumping starts, gassy fluid is rapidly raising in the well where it passes by the ledges of the separator (Figure 7). (a) The liquid content of the mixture reverses its direction (b) and flows downward (c) into a reservoir in the separator tube (d) and is then, by action of the screw impeller, pumped upward (e) into the intake of the centrifugal pump while the gas keeps on raising and escapes out of the well.

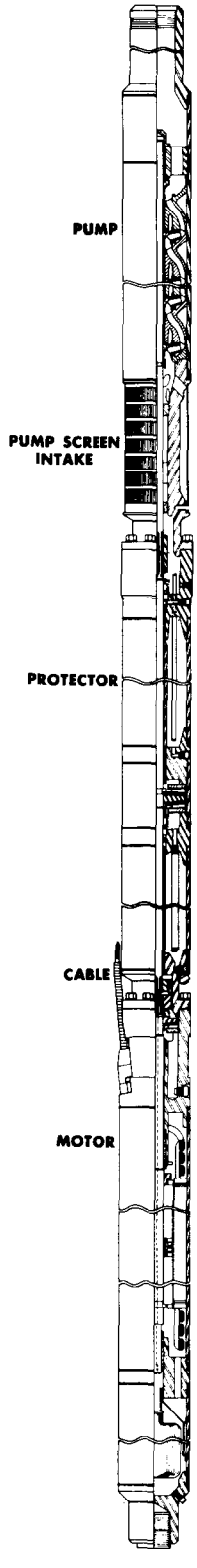
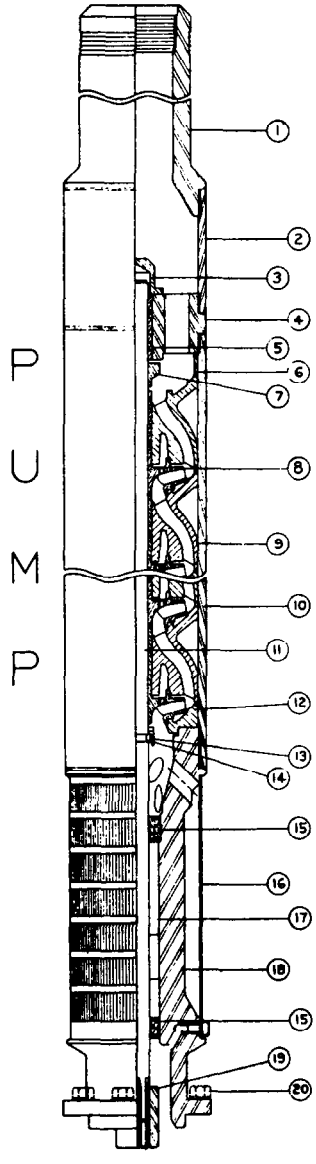


FIG. 2



NO.	DESCRIPTION
1	HEAD
2	EXTENSION - HEAD
3	CAP - SHAFT
4	BEARING - UPPER
5	BUSHING
6	TUBE - COMPRESSION
7	STOP - KEY
8	IMPELLER
9	DIFFUSER
10	HOUSING
11	SHAFT
12	DIFFUSER - LOWER
13	RETAINER - RING
14	RING - TWO PIECE
15	BUSHING
16	SCREEN - INTAKE
17	PACKING
18	BASE
19	COUPLING
20	HEX. HD. CAP SCREW & LOCKWASHER

FIG. 3

[redacted]

REDA PUMP PERFORMANCE CURVE
100 Stage, Type D16AE, 60 Cycle
3450 R.P.M.

Reda Pump Company
Bartlesville, Oklahoma
2-1-63 - HLP

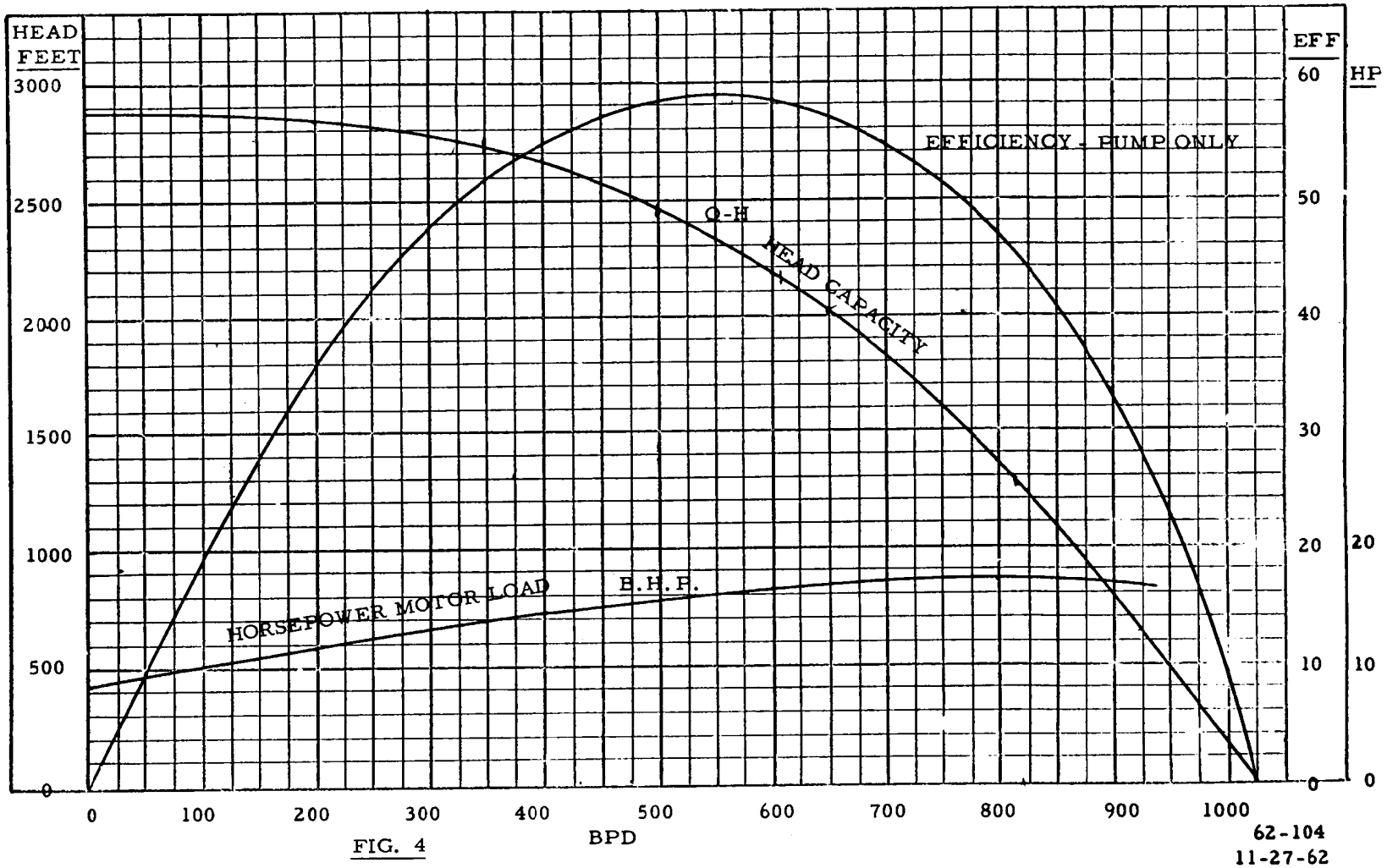


FIG. 4

62-104
11-27-62

Reda Pump Co.
Bartlesville, Oklahoma
4-20-62 - TBE

Reda Pump Performance Curves
100 Stage, I-300, 60 Cycle

Minimum Casing Size:
8-5/8" OD, 38 Lb.

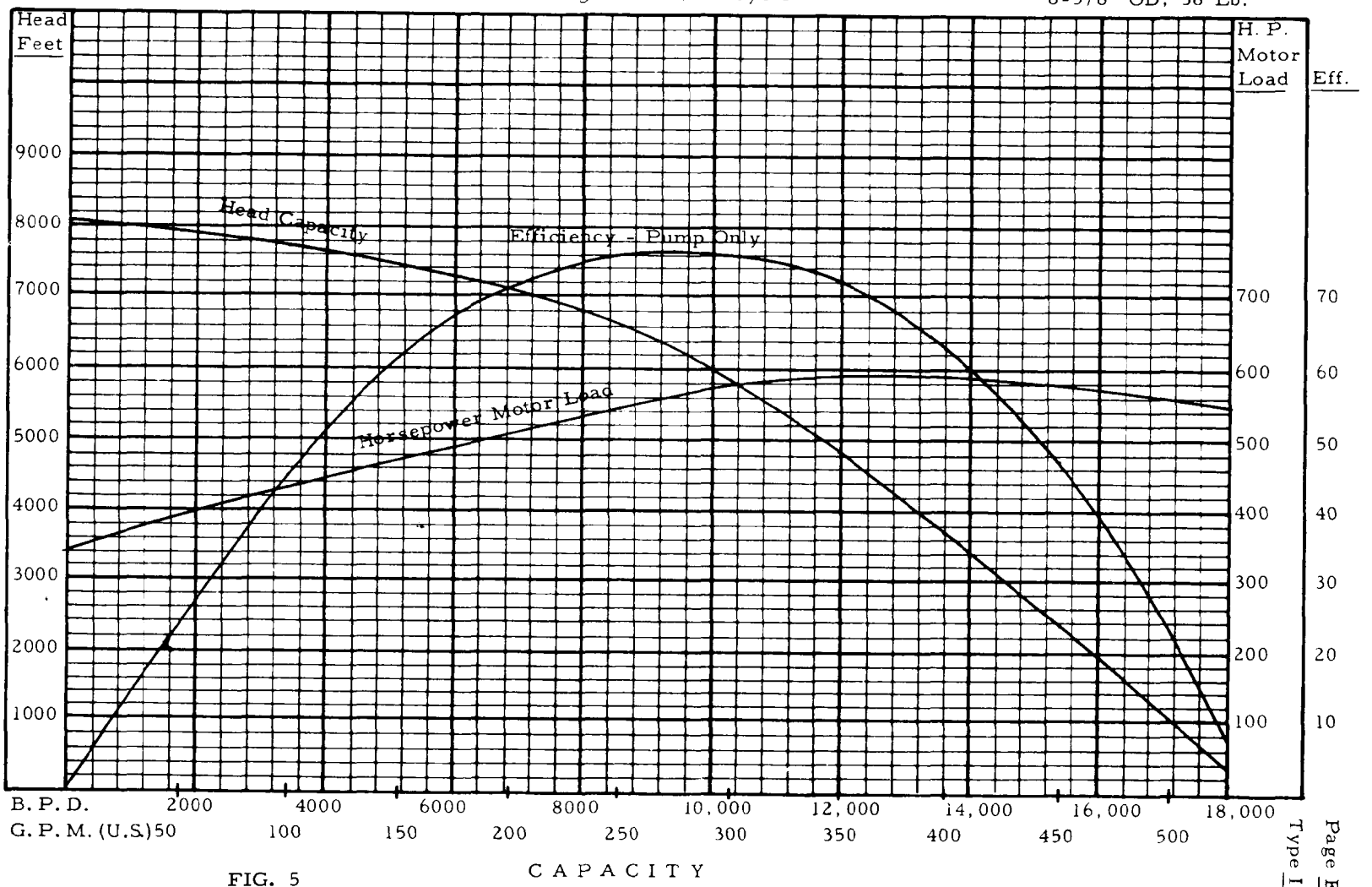


FIG. 5

Type I-300 Page E-13A

Type I-300 Page E-13A

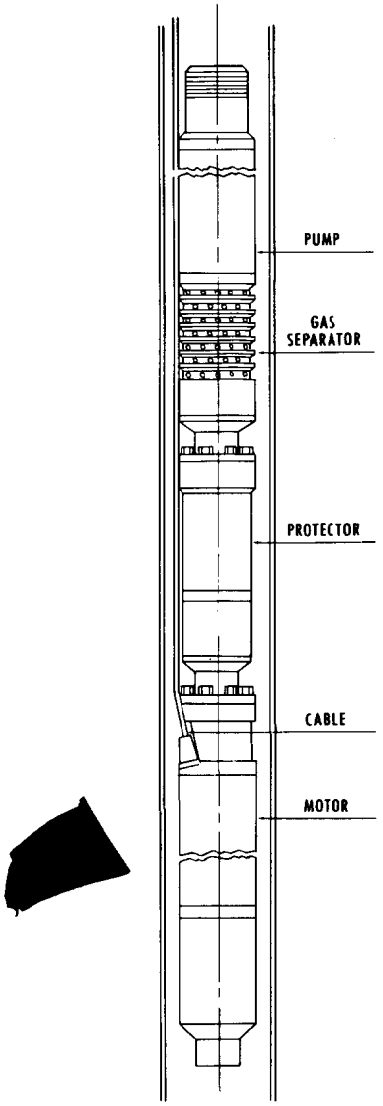
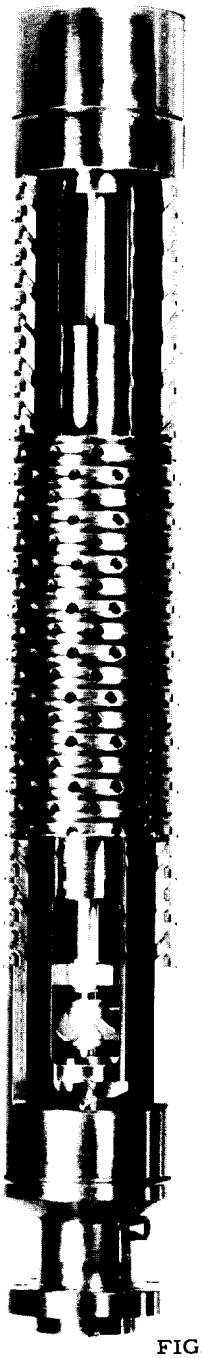


FIG. 6



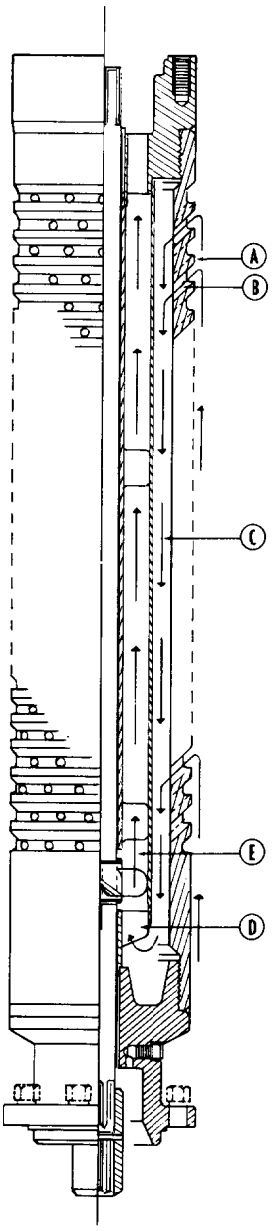


FIG. 7

Centrifugal pumping units equipped with this gas separator, the most efficient gas separator available, have made possible economic recovery otherwise not obtainable from highly gaseous wells. In the high gas/fluid ratio wells employment of a gas separator more than doubles the production.

Protector (Figure 8)

The protector section, located between the pump and the motor, serves to equalize internal pressure in the motor with submergence pressure in the well. A tandem arrangement of two oil chambers, each containing a mechanical seal, serves to exclude well fluid from the motor while because of the alternate heating and cooling of the motor, permitting expansion and contraction of the motor oil.

Motor (Figure 9)

The submergible motor is of the squirrel cage induction type which was designed and developed by our company. It is filled with a special dielectric oil to insure lubrication and proper cooling and operates at approximately 3450 rpm. Maximum motor horsepower ratings are controlled by casing size:

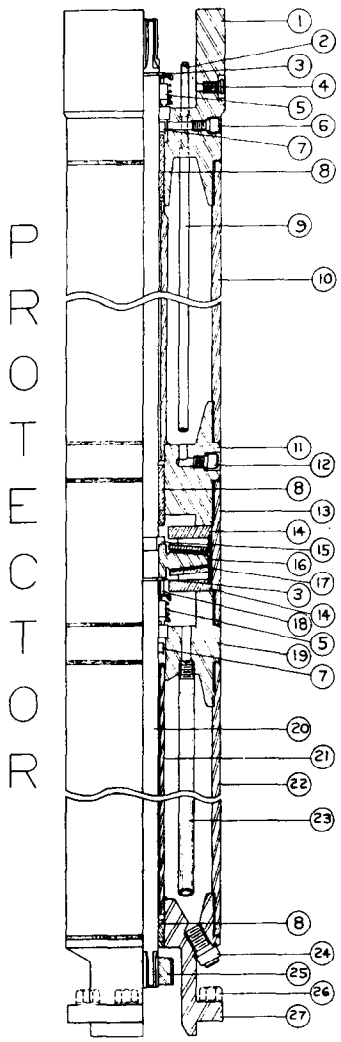
	Horsepower	Multiple Motors
4-1/2" O.D. Casing	25-1/2	76-1/2
5-1/2" O.D. Casing	74	119-1/2
7" O.D. Casing	180	240-300
8-5/8" O.D. Casing	240	480

Cable

The electric cable supplying power to the pump-motor assembly is manufactured in various sizes and is oil and water resistant and capable of operating under the most severe well conditions. Mechanical protection is provided by interlocking steel, bronze, monel or polyethylene as dictated by the corrosive aspects of the well fluid. The cable is clamped to the tubing at approximately 15 ft intervals during the installation and is available for temperatures up to 250° F.

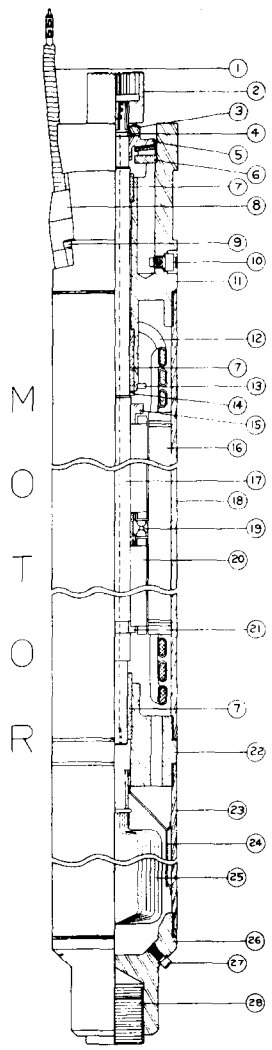
Switchboards and Controls

The controls vary from simple pushbutton magnetic contactors with overload protection to switchboard assemblies with devices such as fused disconnects, recording ammeters, under-voltage and overload protection, signal lights, timers for intermittent pumping



NO.	DESCRIPTION
1	HEAD
2	TUBE - BREATHER
3	RING - SNAP
4	VALVE - RELIEF
5	SEAL
6	PLUG - VENT
7	SHEDDER
8	BUSHING
9	TUBE
10	HOUSING
11	BODY - BUSHING
12	VALVE - DRAIN
13	HOUSING - BEARING
14	BEARING - THRUST
15	RING - TWO PIECE
16	RUNNER - THRUST
17	SPACER - BEARING
18	SPACER - SEAL
19	BODY - SEAL
20	SHAFT
21	TUBE - BASE
22	HOUSING
23	TUBE
24	VALVE - DRAIN & FILL
25	ADAPTER - COUPLING
26	HEX. HD. CAP SCREW & LOCKWASHER
27	BASE

FIG. 8



NO.	DESCRIPTION
1	FLAT CABLE
2	COUPLING
3	RING - RETAINER
4	RING - TWO PIECE
5	RUNNER - THRUST
6	BEARING - THRUST
7	BUSHING
8	FLANGE - CABLE
9	HEX. HD. CAP SCREW & LOCKWASHER
10	VALVE - DRAIN & FILL
11	HEAD
12	LEADS - MOTOR
13	GUARD - LEAD
14	WASHER - UPTHRUST
15	NUT - ROTOR COMPRESSION
16	STATOR
17	SHAFT
18	HOUSING
19	BEARING - ROTOR
20	ROTOR
21	RING - TWO PIECE
22	SUPPORT - BEARING
23	HOUSING - FILTER
24	JACKET - HEAT EXCHANGER
25	BAG - FILTER
26	BASE
27	PLUG - VENT
28	PLUG - PIPE

FIG. 9

and instruments for automatic remote control operation.

The more simple controls are for 440 v operation and may be equipped for 550 v Accessories include undercurrent relay, automatic restart, float switch operation and recording ammeter.

For operating voltages between 762 and 880 v, a 60 and 100 amp switchboard is available. This has low voltage protection and is equipped with a fused disconnect switch. Recording ammeter and automatic controls can be added if required.

Larger switchboards are available for voltages up to 1200 and 2300 v -- all with automatic controls, disconnect switch, under-current, over-current and under-voltage protection, and recording ammeter.

POWER SOURCES

The common source of electric energy is the utility power company but in remote locations electric power may be generated on location. Engine generators of various capacities are available on a rental basis for testing the productivity of wells or for permanent installations where commercial power is not easily obtained.

Auto transformers, capable of operating with motors as large as 120 hp, and larger, may be used where a power source of 440 to 480 v is available. Where the primary power is 2400, 4160 or 13,200 v, large OISC type transformers are available to provide the correct surface voltage to operate the motor.

FIELD OPERATIONS

Probably one of the least known capabilities of the electrical submergible pumping equipment is in lower capacities for this type equipment. There are a number of installations where the D-16 type pump, with a capacity of 300 to 500 BPD, has been operating successfully in wells in Texas, Oklahoma, Wyoming and California. Two wells in Texas have been equipped with this pump. They have a setting depth of approximately 4450 ft and a PFL of 4400 ft. They are using a 24-1/2 hp motor and one is delivering close to 500 BPD with 93 bbl of oil. The other is pumping 300 BPD with 50 bbl of oil. One has been installed for 2 yr and has never been pulled, while the second one has had 1 pump only change-out since originally installed.

In Oklahoma there is a 458 stage pump setting at 8900 ft, producing 400 BFPD with a high percentage of oil. Previous to submergible pump installation the well had been produced by another method at the rate of only 125 BFPD. The oil increase on submergible was almost 13 times the amount previously recovered.

SPECIAL EQUIPMENT

Submergible pumps have been used extensively in wells with 4-1/2 in. casing to produce the maximum amount of fluid possible from wells with this small diameter. This is accomplished by using a bottom intake pump delivering fluid above a packer and then using the casing annulus to bring the fluid to the surface (Figure 10). The pump is located at the bottom in order that the maximum diameter pump can be installed to give the maximum capacity of up to 2700 BPD. The motor being above the pump allows the cable to bring power to the motor without a flat cable having to go past the pump. There are pumps available with capacities up to 500 BPD and a total lift of 3400 ft arranged in the conventional manner with the motor below the pump. (This same bottom intake design can be made for wells with larger casing). In this case, a housing is placed outside the motor to allow the fluid to be directed past the motor into the tubing and then to the surface. This arrangement is recommended in wells of low bottom hole pressure but of relatively high capacity. This allows for maximum amount of fluid withdrawal with maximum draw-down and could

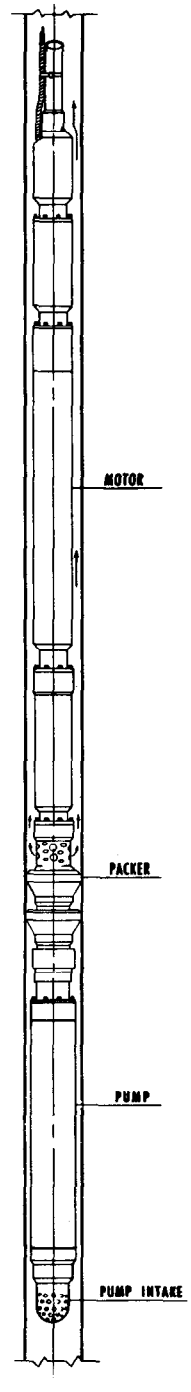


FIG. 10

be used in producing wells where it is desired to reduce the bottom hole pressure to the lowest point. This type of bottom intake would be of advantage where the upper section of the formation carries considerable gas that might interfere with good pump operation. The fluid would be pumped from the lower part of the formation, while the gas would be brought to the surface through the casing annulus.

WATER SUPPLY PUMPS

Submergible pumps have been and are being used extensively to produce water for water injection in waterfloods. Another growing and accepted use of submergible pumping equipment is to combine the water-producing pump and injection pump in one unit in the supply well. A conventional unit is used, but designed with enough pumping head and horsepower to overcome the injection pressure at the input wells. For example, the supply well will give up the required 2000 BPD from a pumping depth of 1500 ft. This would require a 40 hp, 40 stage pumping unit of a certain type, costing around $7500. If the injection pressure is about 650 lb, this would then require a pump to deliver 2000 BPD against a head of 1500 ft and a discharge pressure of 650 lb, or approximately 1500 ft, making a total of 3000 ft. This would require a pump of 79 stages with a 70 hp motor, but the installed cost would be around $12,000, or only about $4500 more than a pumping unit capable of lifting the required water just to the surface.

Still another arrangement can be made using submergible pumping equipment to produce a lower zone of a dually completed well (Figure 11). In this arrangement the centrifugal produces the fluid from a lower zone through a cross-over packer to the casing annulus and thence to the surface. By an arrangement of packers the upper zone is pumped by conventional rod pump through the tubing to the surface.

SUMMARY

There are many advantages of submergible pumping equipment that are being accepted more and more every day. In the range of 250 to 500 bbl of total fluid the results have been demonstrated to be equal to or better in economics than previously installed equipment of other types. As the capacaties become greater, no other lifting method can successfully compete with the electrical submergible pumping unit. It has always been our claim that the lifting cost of a barrel of fluid will be one cent or less per 1000 ft of lift. This is based on a power cost of one cent per kilowatt and the produced fluid being relatively free of sand or other foreign material.

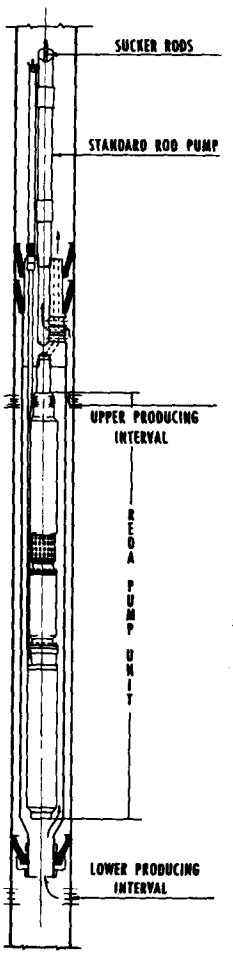


FIG. 11