Some Good Operating Practices For Electrified Lease Pumping

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The principal causes of motor failures in the oil fields are:

(1) Lightning strikes or surges on the line.

(2) Single-phasing of power system supply.

(3) Overload or high current conditions due to—

(a) Low voltage conditions on line; voltage drop on long feeder runs; or transformer bank or conductor sized too small for load.

(b) Voltage unbalance on 3-phase power supply caused from single-phase power tap-offs; or operating unbalanced loads on open-delta transformer bank.

(c) Motor incorrectly sized to load.

Are these problems the result of design or of equipment specifications? Further, what can be done to lessen equipment failures from these causes?

In lease pumping today, as in most electrified industrial applications, maximum automation and maximum equipment protection are high on the list of requirements. The degree of automation and equipment protection attained is, of course, a compromise between ideal engineering practices and economics—with experience usually dictating what is acceptable. Too often, however, equipment standards and selections are based with economics—particularly first cost—being the prime consideration. Additional features or modifications to the basic equipment are sacrificed that would provide the additional protection or functional action to prevent a costly shutdown or equipment failure, or al-

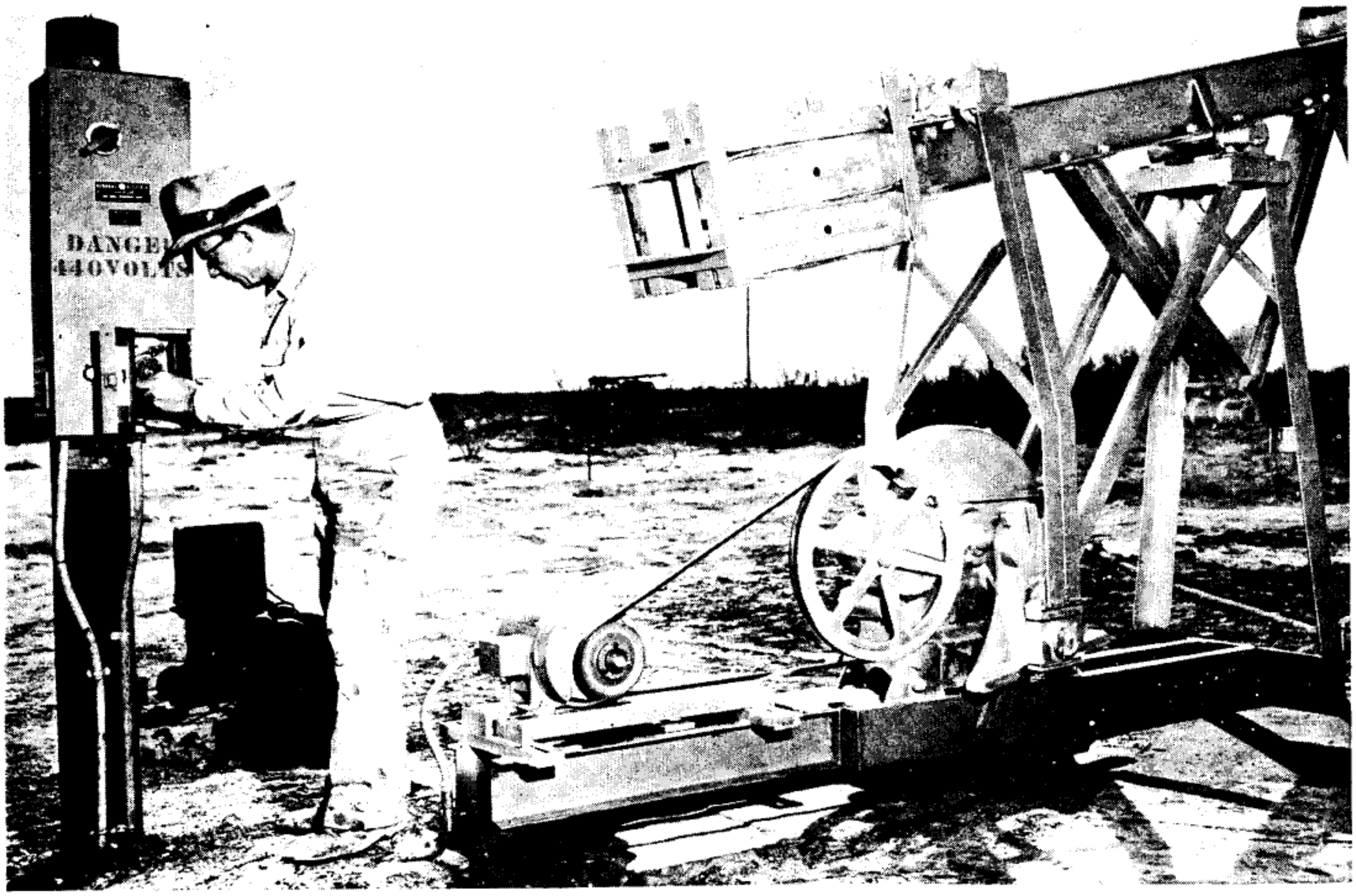

Fig. 1—Typical electrified oil well beam pumping installation.

low realization of maximum operating economy.

There are a few requirements for the motor and controller that are now accepted as being basic and essential. Figure 1 illustrates a typical electrified oil well beam pumping installation. The motor as a prime mover must be suitable for use out of doors in all kinds of weather, generally of the high-starting torque normal-slip variety, and complete with rodent screens, lifting eye-bolts, and other accessory features as normally required. Figure 2 shows a typical high-torque, dripproof motor as used for oil field pumping service.

The starter or controller on the other hand, in addition to starting and stopping the motor either manually or automatically on some pre-selected time cycle basis, should suitably protect the motor both from instantaneous faults — such as lightning and sustained faults — such as overload conditions or undervoltage conditions.

In addition to performing these necessary functions, the starter, like the motor, must be suitable for oil field pumping construction-wise. The devices must be unit-assembled for ease and economy of installation, and the enclosure must be weather-resistant—preferably dust tight, particularly where dust is a problem. It should have means for padlocking to prevent unathorized entry, and ease of setting if program pumping is to be employed. Figure 3 shows a typical oil-well pumping controller equipped for automatic or unattended lease pumping.

In addition to these basic requirements, there are several "extra" or additional features which should be strongly considered when specifying or installing electrical equipment for oil well pumping applications. At a moderate price addition, the following items will prove to be an investment well worth while in eliminating the causes of many motor failures and considerably reducing downtime, repairs to the quipment, and operating costs:

(1) Increased lightning protection by use of supplementary lightning arresters.

(2) More effective lightning protection by proper grounding.

(3) Increased overload and single-phase protection by use of 3-element overload relay.

(4) Increased undervoltage and single-phase protection by use of voltage sensitive undervoltage relay.

(5) Improved operating conditions and economics by use of capacitors.

1. *Use of Supplementary Lightning Arresters*

The probability of equipment in the oil fields being subjected to damage from lightning depends on several factors, chiefly:

(1) Recurrent thunderstorm activity in the area.

(2) Exposed power lines—particularly over hills or high terrain.

(3) Length of secondary lines.

(4) Lightning protective apparatus installed.

(5) Grounding—both power system and equipment.

Standard practice is to provide a

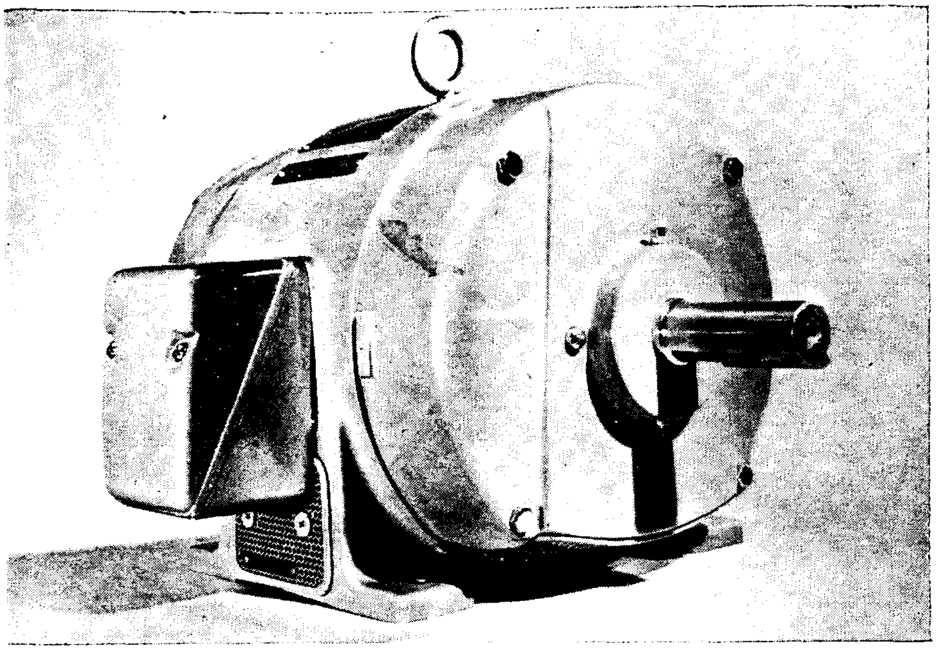

Fig. 2—Typical high-torque, drip-proof motor for oil field pumping service.

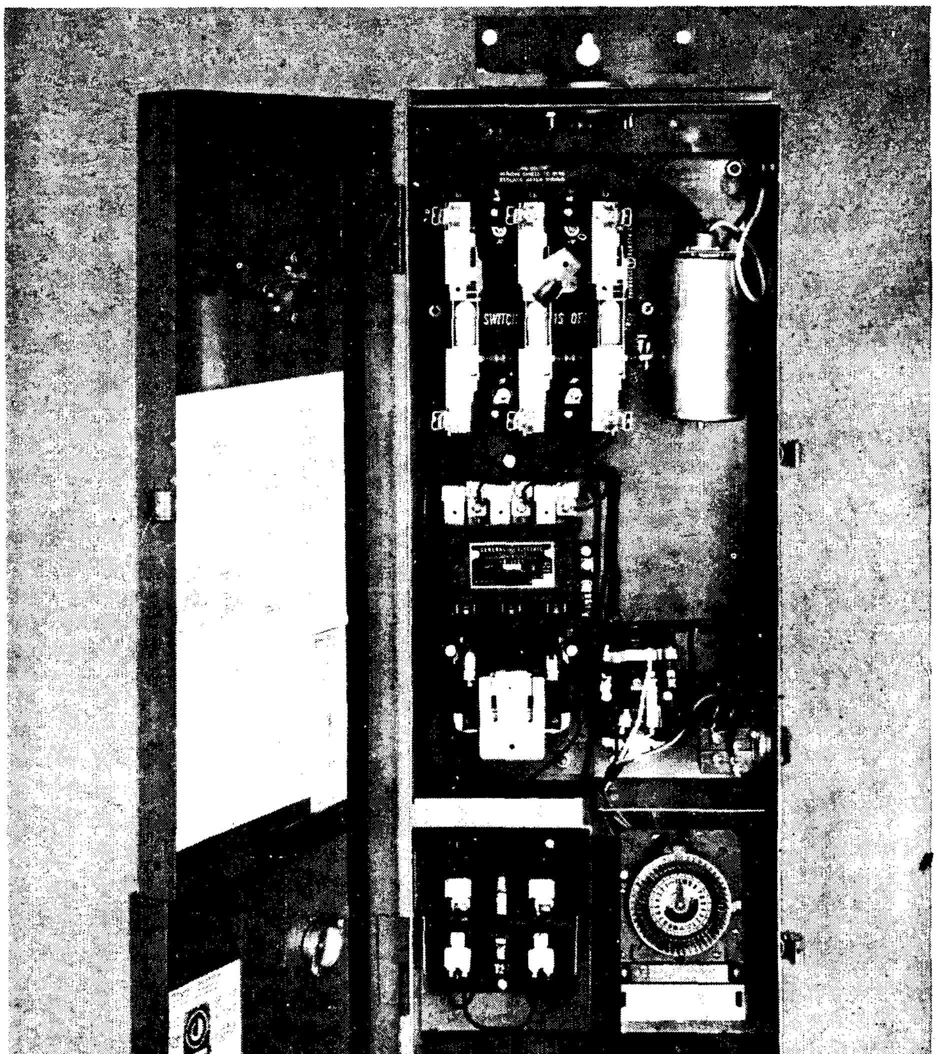

Fig. 3—Typical oil well pumping controller equipped for automatic or unattended lease pumping.

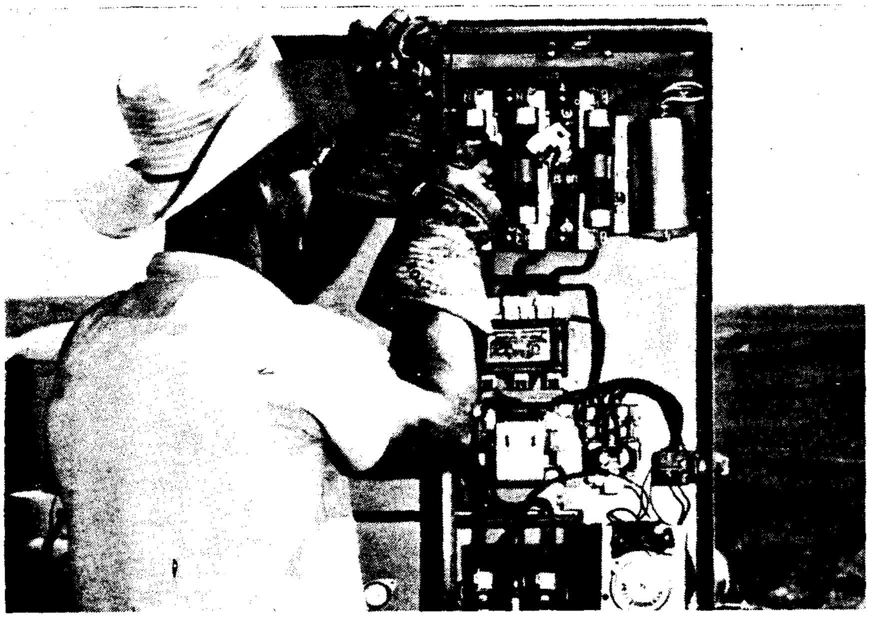

Fig. 4—Lightning arrester (Upper right corner of case) is a 3-phase Thyrite type connected ahead of the primary disconnect switch.

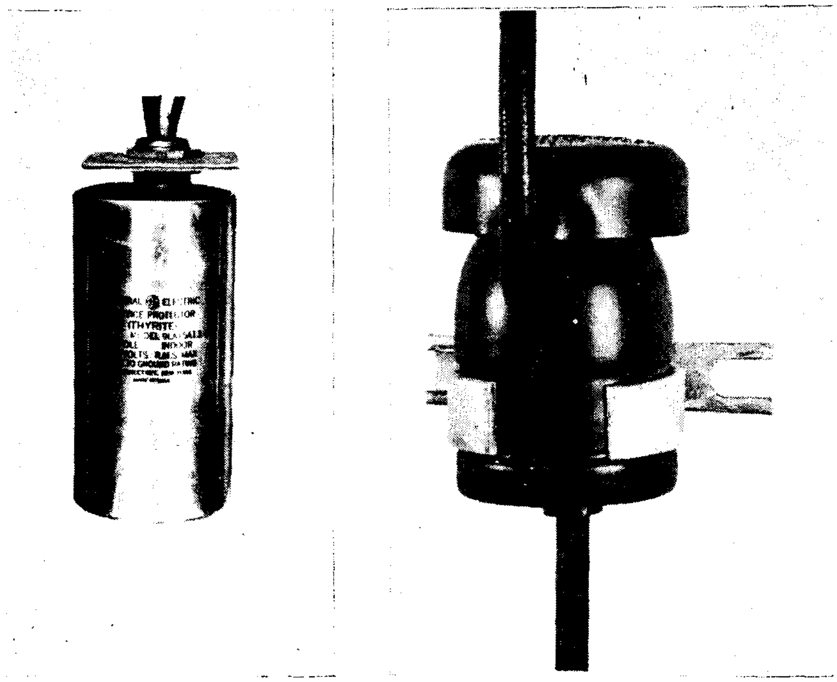

Fig. 5—Typical Thyrite (left) and pellet-type lightning arresters.

lightning arrester (usually a 3-phase Thyrite* type) in the controller, connected ahead of the primary disconnect switch or circuit breaker as shown in Fig. 4. Many operators have instituted a practice of connecting an additional lightning arrester ahead of the motor starter, particularly on leases with long secondary runs. This second unit is generally 3 single-pole pellet-type arresters, pole mounted, and connected one in each phase of the incoming power line. Figure 5 shows typical Thyrite and pellet-type lightning arresters.

This valve-type pellet arrester should be located on the pole cross-arm at the junction of the overhead line with the cable circuits as shown in Figure 6.

It should be spaced one pole span length (at least 100 feet) away from the controller to permit this arrester to spark over to ground before the peak of the surge reaches the second arrester in the controller.

The addition of the pellet-type arrester (which is a relatively inexpensive item) will greatly increase the protection to the starter and motor from lightning surges by providing additional parellel paths to ground. In other words, the second set of arresters on the pole will act as the first line of defense to help discharge severe surges that may not be safely handled by the Thyrite arrester in the starter, which has a lower discharge voltage rating than the pellet-type arresters.

When secondary exposure justifies it, it is felt that the installation of this second lightning arrester will greatly cut down on outages and downtime due to lightning strokes, as well as help prevent costly repair of equipment.

*Reg. trade-mark of General Electric Company.

2. *Proper Grounding*

The overall protection afforded by lightning arresters depends upon effective grounding. In order to provide a suitable ground, it is strongly recommended that the grounding stud of the starter-mounted lightning arrester be connected to the well-head or casing, preferably by solidly welding on. Although grounding of both starter case and motor frames are important safety practices, the grounding of these devices and the lightning arrester to machinery frames or base plates or to surface pipelines is not considered to provide a safe or reliable ground. Furthermore, in particularly dry areas like West Texas (or most of the Southwest, for that matter), grounding rods cannot be relied upon to provide an acceptable ground. It is to be emphasized that a proper low-resistance true ground is both necessary and desirable from the standpoint of safety to personnel and proper protection of the equipment from lightning. Many operators who have adopted the practices of solidly grounding to the well-head or casing have reported a drastic reduction in outages and failure of equipment from electrical storms.

In the past, there has existed some misconception in regard to ground connections causing increased electrolytic action or corrosion resulting in the eating away of the well casing. In the first place, it should be stated that no current should flow through the ground connection except under fault or emergency conditions. And, secondly, A-C current being cyclic in nature cannot cause electrolysis, as battery action depends upon D-C current flowing between the two electrodes. Therefore, unless rectified, A-C current cannot contribute to increased electrolytic action. Most operators today agree that the chief cause of electrolytic action on well casing is due to salts, acids and other chemicals in the earth, and is increased by the different properties of the different strata through which the casing passes. Figure 7 indicates proper grounding procedure. (Editors Note: this opinion is not shared by corrosion engineers and consideration should be given both sides before installation is made.)

3. *Use of Three-Element Overload Relay*

A typical elementary wiring diagram for oil-field starter is shown in Figure 8. Standard practice on both industrial-type and oil-field starters is to provide a 2-element or 2-pole overload relay, usually with provisions for the addition of the third-pole overload element. It is unfortunate that industry requirements in oil-field pumping have not established the 3-element overload relay as standard, with an allowable omission price if only 2-element overload protection is known to be adequate.

As is generally known, it is possible for a 3-phase induction motor to continue to operate, particularly if lightly loaded, after the primary of a wye-delta or delta-wye transformer has been single-phased. Under this condition, the theoretical double-current may occur in the secondary line without an overload element, if 2-pole overload protection is employed, while motor action on the peculiar oilwell cycling load may attempt to partially re-establish the voltage in the secondary phase reflecting the open primary. Thus, the motor will continue to run with the primary single-phased.

To provide maximum overload and single-phase protection, it is recommended that 3-element overload protection be adopted as standard control on all oil-well pumping motors—particularly size 2 and larger starters (i.e., above 7 1/2 H. P., 440 volts). Compared to the total costs of the pumping unit, this additional small investment cost-wise certainly seems justified.

4. *Use of Voltage Sensitive Undervoltage Relay*

Many oil-field controllers depend upon the voltage pickup and drop-out characteristics of the main line contactor coil for low voltage protection. While some degree of low-voltage is thus afforded, most line contactors, not functioning primarily as a voltage sensitive device, have considerable variance in their coil pick-up (seal-in) and drop-out characteristics. Pick-up values as low as 65 to 75 percent of rated line voltage, and drop-out as low as 45 to 60 percent of line voltage are sometimes obtainable. If the contactor tips kiss or chatter during near pick-up or near drop-out conditions, this, of course, causes considerable pitting and wearing of these parts. Even depending upon the overload relay elements to trip out on the high currents during low voltage conditions is not considered positive low voltage protection, particularly if there is any power regeneration during the pumping cycle, or if the overload heaters are not properly sized to the motor actual full-load current.

To assure positive drop-out and pick-up at high values of low voltage

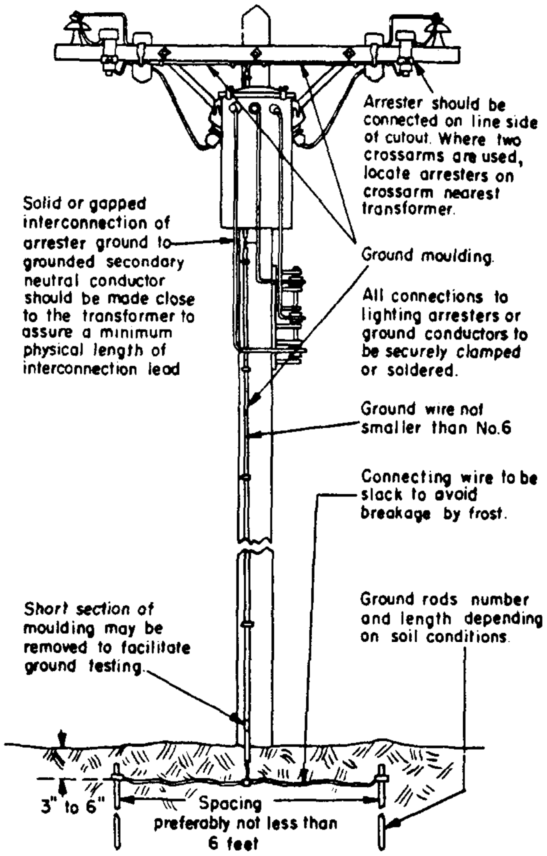

Fig. 6—Pole installation indicating normal location of lightning arresters on cross-arm and proper method of grounding.

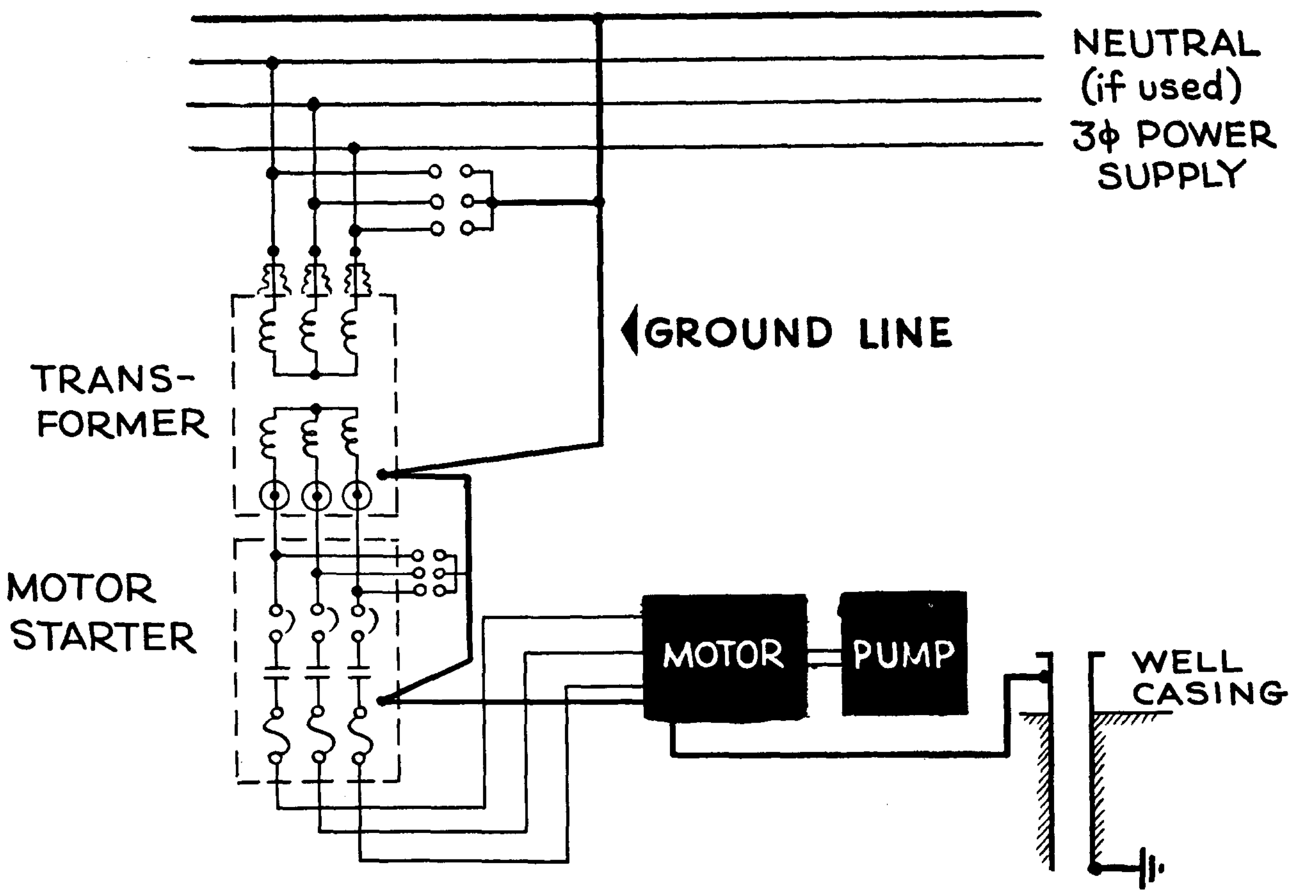

Fig. 7—Proper grounding procedure.

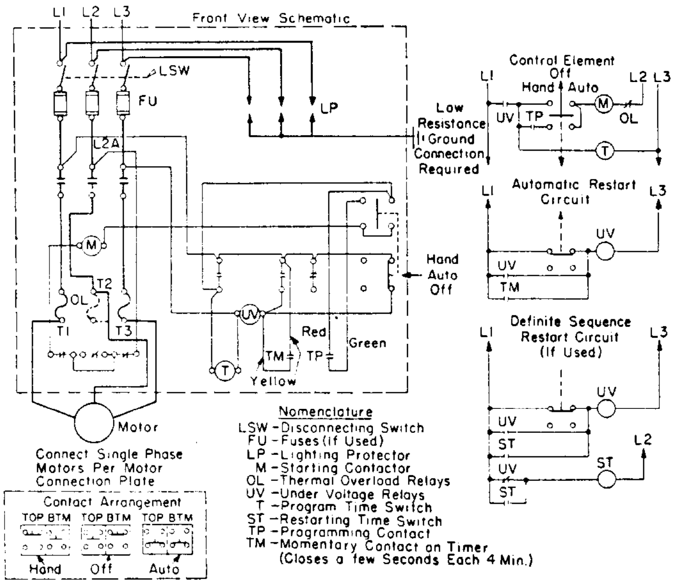

Fig. 8.—Connection diagram for oil well pumping controller.

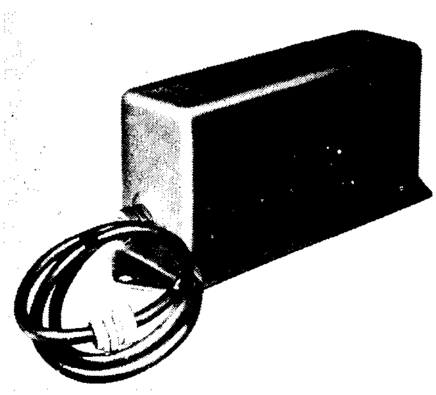

Fig. 9 — Typical oil-field capacitor.

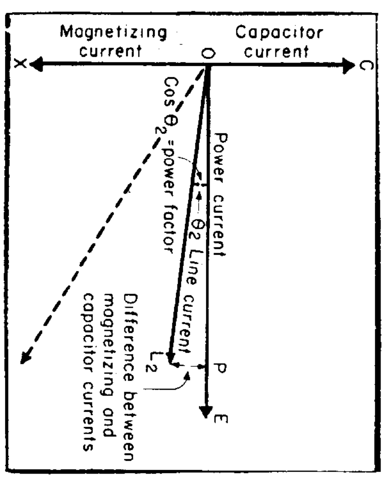

Fig. 10—How a capacitor reduces the line current.

conditions, it is recommended that a voltage-sensative relay be employed in the control circuit. The coil of this relay should have definite high pick-up and high drop-out characteristics, in order to provide the maximum degree or low voltage protection. And, as an added advantage, the coil of this undervoltage relay should be connected in a phase different from the coil of the main line contactor to also provide definite secondary single-phase protection. The proper connection of this device in the control circuit is shown in Figure 8.

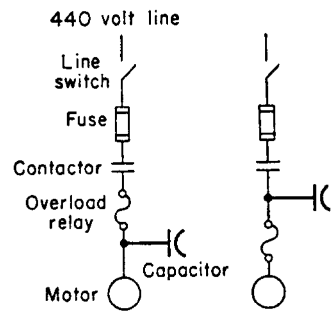

Fig. 11 — Location of capacitors when switched with the motor.

Recommended Capacitor Ratings for Switching with Nema Design C, Open, 1200 RPM, Oil Well Pumping Motors.

Motor Horsepower	Capacitor KVAR
5	2
7.5	3
10	4
15	5
20	6
25	8
30	9
40	12

Figure 12

Here, again, a relatively inexpensive device may make considerable difference in downtime and equipment maintenance costs.

5. *Use of Shunt Capacitors*

The use of motor-switched capacitors has greatly increased in the oilfield during the past 7 or 8 years, so that today there generally is not much doubt as to their economic justification. It has been proven that in addition to raising the overall system power factor (which can save considerably on power bills if a power factor clause is in the power contract), capacitors will greatly reduce line losses, and thereby permit considerable reduction in transformer and conductor capacity requirements, as well as the motors. In addition, some degree of lightning protection is afforded. A typical oil-field type capacitor is shown in Figure 9.

Low operating power factor and high reactance distribution systems can result in:

(1) Excessive voltage drop on the line.

(2) Oversized distribution equipment.

(3) Unnecessarily high power losses.

With the resultant reduction in line current and secondary losses, capacitors usually will pay for themselves in about two years or less. If a power factor penalty clause is enforced, the time would be considerably shorter — perhaps around six months. And, of course, the operating benefits of more efficient motors, greater torques available, and reduction in power bill costs will continue long after the first cost of the capacitors has been amortized. Figure 10 demonstrates the effect of capacitors in reducing motor line current.

In using and applying capacitors, some word of caution should be taken into consideration. First, the recommended practice is to connect the capacitors in the motor line to be switched with the motor, located between the line contactor and the motor but ahead of the overload relay heater elements. This is done to enable the same overload heater elements and standard heater table sizes to be used. Capacitor connections are shown in Figure 11. Secondly, to avoid dangerous transient torques and over-voltages due to self-excitation, the KVAR capacitor sizes selected should not exceed those listed as corresponding to the various horsepower ratings shown in the application table. These values will improve power factor to 85-95 percent for the load, depending upon the initial overall power factor for the system. Recommended capacitor ratings for use with oil well pumping motors are shown in Figure 12. Third, a time lapse, several seconds, should be allowed after switching the motor and capacitor off before personnel touch the capacitor or starter interior, to allow sufficient time for the capacitor charge to drain off. Otherwise, possible high discharge currents may "spark over," and while not necessarily harmful in itself could cause accident in frightening a man.

Conclusions

None of the above ideas are particularly new. As a matter of fact, many lease operators and producers are following all or a part of these practices. However, a great many leases—even some major projects—are being installed today without due consideration being given to the better protection and operating results to be obtained from these five basic engineering practices. Far too often, low first cost becomes the criterion for the equipment to be purchased without due regard for the extra benefits to be gained by a slightly larger expenditure of money. We should remember that in producing oil, an ounce of prevention is certainly worth a barrel of cure.