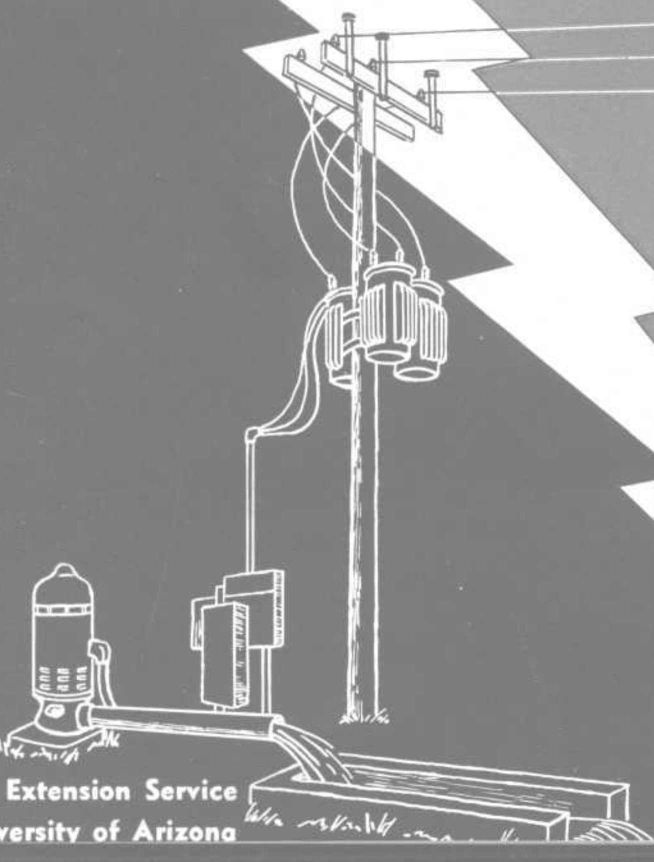
Electrical Equipment for Irrigation Pumps

Circular 271



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Electrical Equipment for Irrigation Pumps

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To Pump With Electricity

An electric motor, directly connected to a vertical turbine pump, is a common sight in the irrigated areas of the West. To keep this pumping unit working safely and economically, all of the equipment must be installed correctly and maintained and operated properly. This requires a general understanding of the electrical system and a knowledge of safety precautions.

A general understanding of the function of electrical equipment will result in an appreciation of the system capabilities and limitations.

An electrical system appears complicated but can be greatly simplified by the systematic consideration of the function of each of the parts.

Proper installation is necessary if a system is to operate safely and economically. Installation should be made by a licensed electrical contractor.

Adequate protection of electrical equipment is available and is always a good investment. The additional cost for the protective devices is small in comparison to the total cost of the equipment or the loss of crops from lack of water.

Maintenance of equipment is essential if a system is to continue satisfactory performance. A little time for routine servicing will help prevent a failure during a critical time.

Many operating problems are common to all areas. Mechanical and electrical devices are available which will minimize the difficulties.

Follow These Safety Precautions

Always make certain the switch is open before touching any part that might be connected to the power source.

Stand on a dry surface before touching electrical equipment. Use the backs of the fingers to touch equipment for the first time; reaction to electrical shock will move the fingers free of contact.

To operate a switch in the primary circuit, use a hook on a dry, wooden handle and do not stand directly under the switch. The best handle to use is one which has been dried and varnished with a nonconducting material. A horizontal pipe, mounted on the transformer poles, can be used to keep the handle dry.

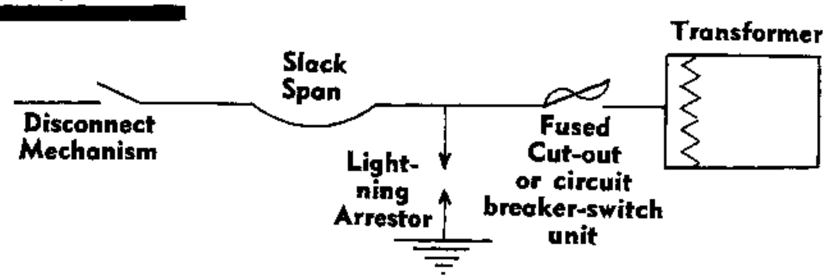
Shut the motor off with the switch intended for that purpose before operating the oil-filled switch and circuit breaker unit in the primary circuit.

Know Your Electrical System

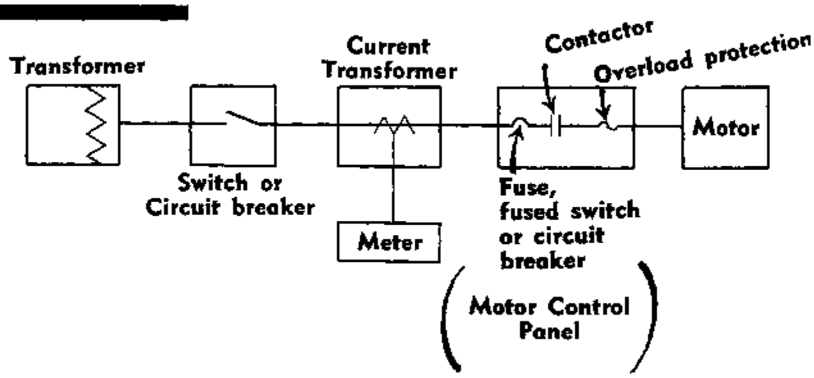
The purpose of the electrical system is to deliver power from the high voltage source to an electric motor. To do this, certain standard components are required.

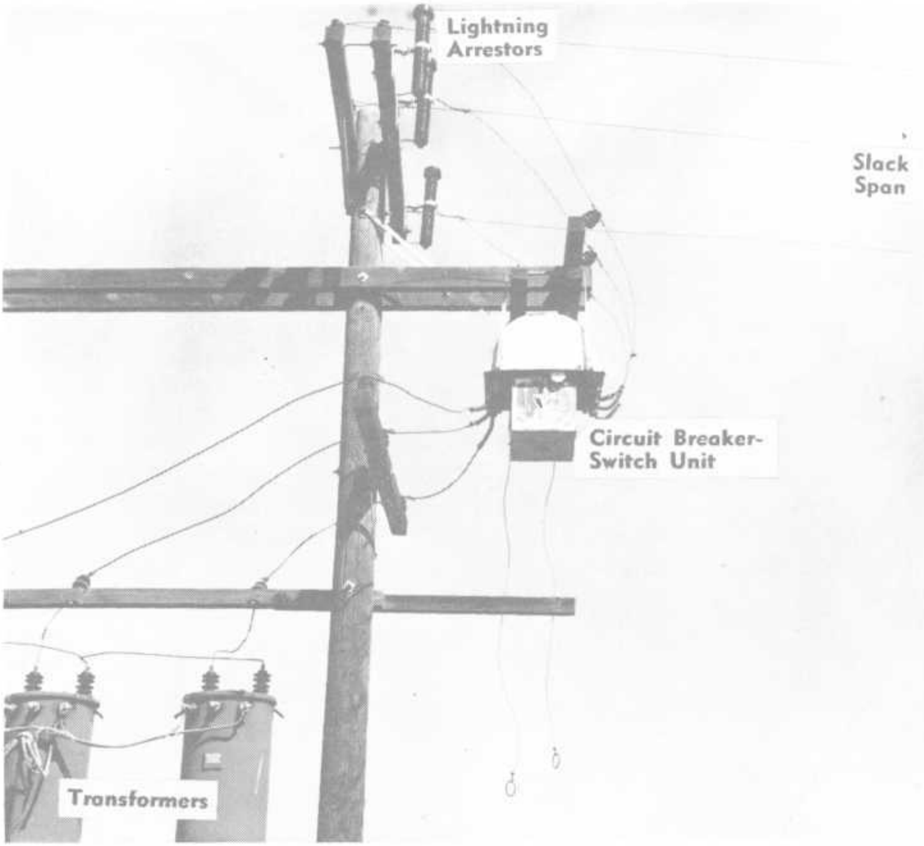
The drawings below illustrate the usual arrangement of the essential components of most systems. Under some conditions, the switch in secondary circuit is not required.

Primary Circuit



Secondary Circuit





Lightning Arrestors, Oil-Filled Switch, and Circuit Breaker Unit

Primary Circuit

The primary circuit includes a disconnect mechanism, a slack span, an oil-filled circuit breaker and switch or fused cut-outs, lightning arrestors, and one side of the main transformers. The main transformers are in both the primary (high voltage) and the secondary (low voltage) circuits.

The disconnect mechanism is located at the point where power is taken from the transmission line. It should be operated only by a representative of the power supplier.

The slack span refers to the power wires from the transmission line to the transformer poles. There are minimum standards which specify the required height of these wires over roads.

Lightning arrestors are required to lead the energy of lightning to the ground. They are constructed so that normal electric current goes to the motor—but the energy from lightning is by-passed harmlessly to the ground.

All of the arrestors should be well-grounded to a ground rod, or preferably, to the well casing. The large lightning arrestors in the primary circuit will protect the transformers but may not protect the meter or the motor windings. An arrestor may be installed in the secondary circuit for this purpose.

An oil-filled switch and circuit breaker unit is sometimes used in the high-voltage or primary circuit. The switch is operated manually and provides a means whereby the transformers may be removed from the circuit while the pump is not being used. The circuit breaker operates automatically to protect the equipment against short circuits but does not provide motor protection against overloads.

Like any other equipment, the switch and circuit breaker unit must not be used under conditions where its maximum rating may be exceeded. It should not be mounted directly over the transformers because a fire in the unit would endanger the transformers and other electrical equipment. Experience has shown that the case of the unit should not be grounded.

Fused cut-outs in the primary circuit are used on most modern installations instead of the switch and circuit breaker. Each unit consists of a fuse and a manual disconnect in series. If excess current flows as a result of a short, the fuse will blow out and remove power from the circuit.

The manual disconnect should be operated only by a representative of the power supplier or by the electrical contractor.

Secondary Circuit

The secondary circuit may be considered to begin at the low-voltage side of the main transformers and includes a switch, current transformers, meter, motor controller, low voltage and overload protection and motor windings. Lightning arrestors are sometimes used in the secondary circuit.

Most transformer banks include three transformers, one for each of the three phases. The purpose of the transformer is to convert electrical energy from the high voltage supply to 220 or 440 volts to be used by the motor. This is accomplished with very little energy loss. Under full load, a transformer consumes from one to two percent of the power for which it is rated. Under no-load conditions, the loss is less than one percent.

Transformer Bank

A main switch or circuit breaker is needed unless the oil-filled switch and circuit breaker is used in the primary circuit or a factory-built pump panel containing a switch is used in the secondary circuit. In this way, a means is provided for disconnecting equipment so tests and repairs may be made.

Current transformers are used with large motors to transform the current in the secondary circuit to a lower value. This is done to facilitate the measurement of current and power with a meter. The current transformer cabinets are usually marked "Do not break seals: no fuses inside."

Meters are used to measure the power and total energy delivered to an electric motor. The meter reading, expressed in kilowatt hours, serves as a basis for computing the charges for power.

The power being used at any time may be determined by counting the revolutions per minute of the rotating disc in the meter. This value, times 60, times the meter constant, K_h, times the current transformer ratio, gives the watts of power. This can be divided by 1,000 and multiplied by 1.34 to calculate the horsepower being used.

The procedure can be used to determine whether or not a motor is overloaded. For example:

Motor Nameplate
Horsepower.......75

Revolutions of disc
per minute.......22

Meter Constant, K_h
(taken from meter)....... 4.8

Current Transformer Ratio
(taken from meter).......10

$22 \times 60 \times 4.8 \times 10 = 63{,}300$ Watts
$63{,}300 \div 1000 = 63.3$ Kilowatts
$63.3 \times 1.34 = 85$ Horsepower Input
85 Horsepower Input $\times$ 90% efficiency $=$ 76.5 Horsepower Output

A 75 horsepower motor would be only slightly overloaded.

Fuses protect the motor windings by breaking the circuit in case of a short circuit condition. Since starting currents are five to six times the normal running current, the fuses must be so large that they do not provide overload protection.

Standard fuses consist of a metal strip which burns and opens the circuit at a specified current. Thermal-lag fuses are available which do provide overload protection.

The motor controller is used to start and stop the electric motor. Small motors may be started on full line voltage (across the line). For large motors, a method must be provided for starting with a reduced voltage in order to keep the starting current down to a low value. A reduced voltage starter may be either the manual or magnetic type.

Manual Reduced Voltage Motor Starter.

Overload protection devices are often installed inside the motor controller cabinet although they may be mounted in a separate location. Their purpose is to interrupt the circuit before the motor windings become hot enough to cause damage to the insulation. The devices must be so constructed that the circuit is not broken by the high starting current but is broken as a result of prolonged currents only slightly greater than the normal running current.

There are several different types of overload protective devices; the bi-metallic strip, the relay, and the thermal-lag fuse are common. Many of the devices are adjustable to different settings. On large motors, small current transformers with relays are usually used.

Electric motors, used with turbine pumps for lifting irrigation water, are nearly all of the three-phase, hollow shaft, squirrel-cage induction type. They have the advantage of simple construction, relatively low first cost, and are generally more rugged than other types. They have the disadvantage of requiring a high starting current.

If reduced voltage is used to decrease the starting current, the starting torque is also greatly reduced. Since the turbine pump does not require a high starting torque, the pump and motor are well-matched for this application.

Electric motors can be operated under overload conditions only at the expense of shortened motor life and the hazard of complete loss. The load on an operating motor can be computed from information taken from the meter.

Electric motor used for pumping irrigation water.

Proper Installation Is Important

Proper installation is the first requirement if a system is to operate safely and economically. The work should be done by a licensed electrical contractor who is familiar with the detailed specifications and regulations in the particular area.

The 1956 National Electric Code defines minimum installation standards for clearances, cabinet sizes and spacing, conductor sizes, and the general requirements of the system. A copy of the "1956 National Electric Code" may be obtained from the National Board of Fire Underwriters, 85 John Street, New York 7, New York.

Additional specifications are usually established by the power supplier and must be adhered to in addition to those specified in the "1956 National Electric Code."

All components of the electrical system should carry the Underwriters Laboratory label and be used within the range for which they are rated.

All equipment cabinets and cases should be grounded with one exception. The exception is that the case of the oil-filled switch and circuit breaker unit in the primary circuit should not be grounded.

Equipment Needs Protection

Adequate protection for expensive electrical installations is always a good investment. Devices are available which afford a high degree of protection. The additional cost is small compared to the cost of the equipment protected.

Lightning arrestors, of the correct rating, must be properly installed and well-grounded. Lightning arrestors may be used in the secondary circuit to provide additional protection for the meter and the motor.

Three overload protective devices (one device per phase) are required for complete motor protection. A sunshade over the cabinet may be necessary to permit the protective devices to function properly.

A sunshade over the motor is a good investment. Motor life is significantly shortened by high operating temperatures.

Other devices are available and should be considered for the additional protection which they afford.

Maintain Your Equipment

Periodic maintenance provides insurance that a properly installed system will continue to operate satisfactorily. A routine maintenance inspection should be made each year before the start of the irrigation season. For correct servicing, the recommendations of the equipment manufacturer should be followed.

Oil-filled switch and circuit breaker units in the primary circuit should be cleaned and the oil changed once a year by an electrical contractor.

Manual reduced-voltage starters contain oil. Replace this oil when it becomes dirty or filled with sludge.

Inspect electrical contacts periodically and replace them when they become worn or pitted.

At the beginning of the irrigation season, the motor should be inspected for nests of rodents or birds. The motor should be observed for half an hour after starting to make certain that it is functioning properly.

Consider Operating Problems

Falling Water Tables: Falling water tables should be anticipated by making the original installation more than adequate. On a given installation, as the water table drops, the load on the motor is decreased because of the pump characteristics. The motor overload condition develops when additional bowls are added to the pump without increasing the motor size.

High Temperatures: High temperatures cause difficulties with overload protection devices. On hot days, the sun may heat the cabinet more than the motor so that the devices must be set for a high current value to prevent repeated disconnection of the motor. In the evening, when temperatures have lowered, the motor is not adequately protected until the protective device is reset.

This difficulty can be minimized by providing a sunshade and good ventilation for the cabinet containing the overload protection devices. The exterior of both the cabinet and the sunshade should be of a color which will reflect the maximum amount of heat. Temperature compensating devices are available which automatically allow for air temperature variations.

Lightning: Lightning often strikes power lines and causes circuit breakers and fuses to disconnect motors. Sometimes transformers and motors are destroyed by the lightning or by fire as a result of lightning.

This hazard can be minimized by proper installation and grounding of lightning arrestors. The arrestor connection should be made as close as possible to the transformers. Circuit-breaker-switch units and fused cut-out connections should be between the lightning arrestors and the transformers. For additional motor and meter protection, lightning arrestors can be installed in the secondary circuit.

There is some evidence that lightning damage is more likely to occur at the end of a transmission line. At this point, the entire energy of the discharge must be diverted to the ground. Extra care should be taken to provide these installations with adequate protection.

When a pump is pulled from the well for repairs, the ground connection to the well casing is sometimes lost. This connection must be restored in order for the arrestors to be effective.

Single-Phasing: Single-phasing occurs when one line of a three-phase supply is interrupted and the motor continues to operate on two lines. The interruption may be due to a broken power wire, a blown fuse in the fused cut-out, or a blown fuse in the motor controller Under some conditions, the resulting currents will burn out a motor winding before the motor protection device is actuated. **The practice of installing motor overload protection in only two phases provides only partial protection. Three overload protection devices are required for complete protection from single-phasing.**

A phase reversal relay will protect a motor from damage as a result of a single-phase condition. The device is so constructed that, if one phase is interrupted or if the electrical connections to the motor are made incorrectly, all three phases are disconnected before damage can occur.

Backspin: Backspin of the pump impellers and rotor occurs whenever the power is interrupted unless prevented by a non-reversing ratchet. The backspin is caused by water falling in the column pipe and through the impellers. No harm is done unless power is restored during the period of reverse rotation.

If the power is restored during this time, the effort of the motor to resume the proper rotation may cause the column shaft to snap. A backspin relay will prevent the restoration of power until the reverse rotation has stopped.

Reverse Rotation: Reverse rotation is caused by the incorrect connection of the motor to the power supply. If reverse motor rotation is allowed more than a few seconds, the column shaft will unscrew entirely and ruin the threaded end.

Damage can be minimized with a motor-disengaging clutch which disengages the motor before the column shaft is completely unscrewed. A phase reversal relay will disconnect the motor if the connections are made incorrectly.

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