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Measuring Water Levels in Wells: An Inexpensive Electric Water Level Indicator[1]

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It is often necessary to measure the depth to water in a well. The depth to water influences pump selection and placement. It also determines the energy required to lift water to the surface in the pumping process and thus affects the horsepower requirements of the pumping system. It must also be measured to evaluate the efficiency of irrigation pumping systems to determine the need for pump repair or replacement.

When a pump discharges water from a well, the water level in the well drops. This occurs because friction losses prevent instantaneous water flow from the aquifer to the well to replace that which the pump has displaced. This drop in water level in the well during pumping is called *drawdown*.

Drawdown increases the depth to the water surface in a well. Because of drawdown, more work must be done to lift water to the surface, and thus more energy is used in pumping. Because drawdown changes the water level in a well, the pumping water level is the water level which most influences pump selection, placement, and power requirements.

Drawdown is not a constant, even for a given geographical location. Rather, drawdown depends upon the well size, rate of pumping, aquifer characteristics, and type and quality of well construction. Therefore, if pumping water levels are to be accurately known, they must be measured for each well and pumping conditions.

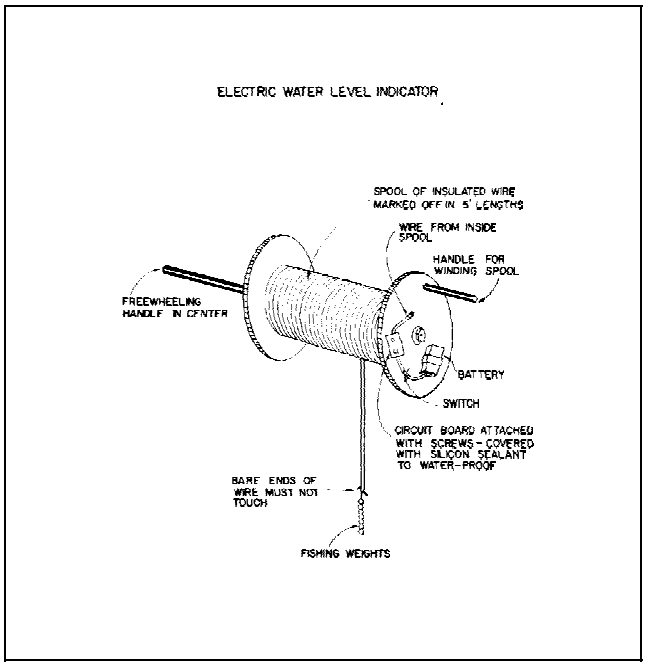

Figure 1. Details of the electric water level indicator.

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This fact sheet presents the details for construction and use of an inexpensive electric water level indicator. This instrument costs approximately $25 to construct, yet it can be used to measure water levels in a well with sufficient accuracy for the purposes previously mentioned both before and during pumping. It also is portable and easy to use.

This instrument could be used by (1) irrigation managers to measure pumping water levels for pump performance testing, (2) well drillers to determine depths to water tables and for well performance tests, (3) pump installers and consultants to determine the proper placement and selection of pumps, and to "troubleshoot" systems in need of repair, and (4) U.S. Geologic Survey, Water Management District, and other personnel to evaluate aquifer characteristics.

DETAILS OF CONSTRUCTION

The electric water level indicator shown in Figure 1 can be constructed using materials available at local electronics suppliers. A complete listing of components is given in Table 1. The total cost of the components was less than $25 when this fact sheet was published.

Reel Unit

A major component of the water level indicator is the reel of wire. A spool of approximately 22 gauge audio hookup wire is suitable for this purpose. However, any small-gauge stranded insulated wire can also be used. The wire must be long enough to reach the greatest anticipated water depth. Stranded rather than solid wire should be used because flexibility is necessary when the wire is lowered into the small space between the well casing and column pipe.

The reel shown in Figure 1 may be constructed using small diameter metal rod (threaded) for handles, and using the spool purchased with the wire. For convenience, a permanent marking pen can be used to mark the wire in five-foot increments. Alternatively, at each measurement the wire can be extracted from the well, laid out on the ground, and then measured to determine the depth to the water table.

The water level indicator operates when an electric circuit is completed by the two bare ends of the sounding wires contacting the water surface in the well. Therefore, those wires should be stripped for a short length to allow ready access to the water. Lead fishing weights can be attached to one of the bare wires to allow the wire to be lowered directly to the water table. Small diameter weights should be used to avoid lodging them in the well. However, a sufficient number of weights must be used to pull the flexible sounding wire down into the well and to ensure that the wire is straight when measurements are made.

Lead weights should be used because they are relatively soft and can often be pulled free if they become lodged between the casing and pump discharge pipe. Also, if weights come loose and drop

Table 1. Electric Water Level Indicator Parts List

1 -	**Spool on which to wind sounding wire and mount the circuit.**
1 -	**Wire-2 conductor, insulated, light gauge (~ 22 ga), stranded, about 100 to 300 feet long depending on water depth to be measured.**
1 -	**2N3904 NPN transistor, or equivalent.**
1 -	**100-ohm resistor, 1/2 watt.**
1 -	**1k (1000)-ohm resistor, 1/2 watt.**
1 -	**10k (10,000)-ohm resistor, 1/4 or 1/2 watt.**
1 -	**High-Brightness Light Emitting Diode (LED) (Cat. No. 276-066A*).**
1 -	**Buzzer (optional) (Cat. No. 273-065).**
1 -	**Single Pole-Single Throw (SPST) switch (Cat. No. 275-612).**
1 -	**Battery, 9-Volt.**
1 -	**9-Volt Battery Clip (Cat. No. 270-325).**
1 -	**9-Volt Battery HOlder (Cat. No. 270-326).**
1 -	**Experimenter's Box with PC Board (Cat. No. 270-283).**
1 -	**Tube of silicone sealant.**
-	**Hardware to make handles.**
-	**Lead fishing weights.**
*	**Catalog numbers are for Archer brand (Radio Shack) parts. Trade names of products, where given, are used for the purpose of providing specific information. Use of a commercial name is not intended as an endorsement of products named, nor as criticism of similar products not named.**

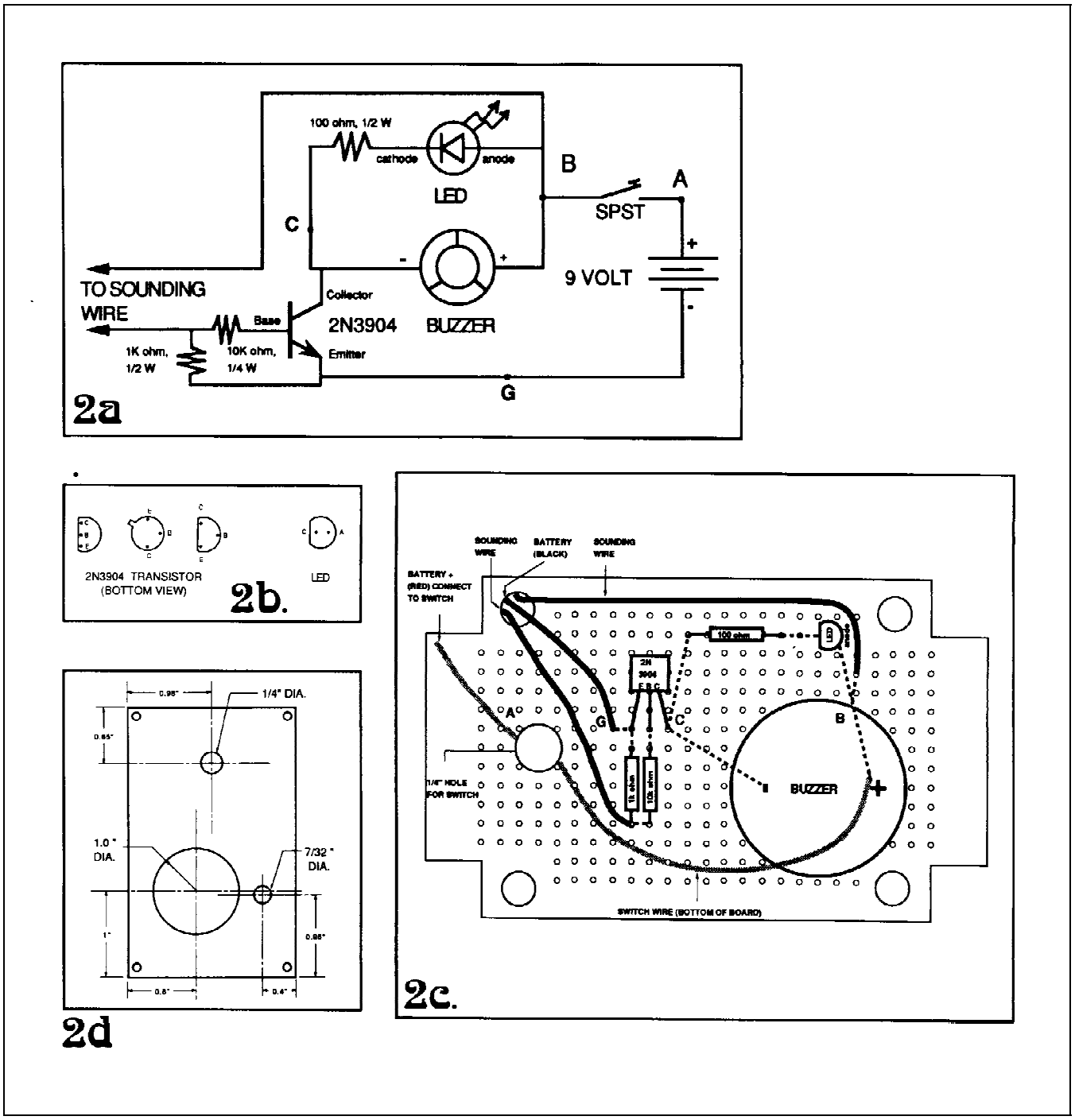

Figure 2. Electronic circuit.

into the well, they will fall to the bottom and will not interfere with the pumping operations.

Electronic Circuitry

The circuit described in this publication detects immersion of the bare ends of the sounding wire by taking advantage of the fact that water will conduct electricity better than air. When the bare ends of the wire both touch the water, current will begin to flow; however, insufficient current will flow to directly cause a LED to glow or a buzzer to sound. A transistor has been added to amplify this small current to the level necessary for the LED and/or buzzer to operate properly. Although there are many possible ways to amplify the current flowing through the leads, the circuit shown here was chosen as the simplest

alternative capable of reliably indicating water level. In order to maintain simplicity, no attempt has been made to protect the circuit from some infrequent, but potentially damaging, events. The most notable of these omissions are:

1. The circuit provides no protection from static discharge. Walking across a carpeted floor then discharging a spark into the ends of the sounding wire will very likely destroy the transistor. Static discharge is rarely a problem in the field; when working on the device indoors, merely touch a metallic surface to drain any static buildup from your body before working on the circuit.

2. A 9-volt "transistor" battery and polarized snap-on battery leads have been specified to insure proper voltage and polarity for this circuit. Additional protective measures have not been included in the design to avoid damage caused by reversed polarity or excessive voltages from "jury-rigged" power sources.

3. The circuit has not been designed to preclude electrolysis at the end of sounding wire due to prolonged submersion. The circuit shown in this Fact Sheet is designed for intermittent use—it is not suitable for continuous water level detection (such as in a sump). Continuous operation of the device with the leads submerged will result in failure to detect the water after a few days operation.

The electronic circuit recommended to detect immersion of the bare ends of the sounding wire is shown in Figure 2 (A, B, C, D). This design includes both an LED and a buzzer to indicate contact with the water. The circuit will operate properly with either omitted. Figure 2a is the circuit schematic, 2b is the pinout of the transistor and LED used in the circuit, 2c is a pictorial representation of the proper way to assemble the circuit if the experimenter's circuit box is used, 2d is the hole pattern for the cover included with the experimenter's box, and 3 is a photograph of an assembled unit.

Circuit Construction

Construct the circuit on the circuit board provided with the experimenter's box identified in the parts list or, alternatively, on apiece of bare perforated circuit board. The board provides a mounting surface and

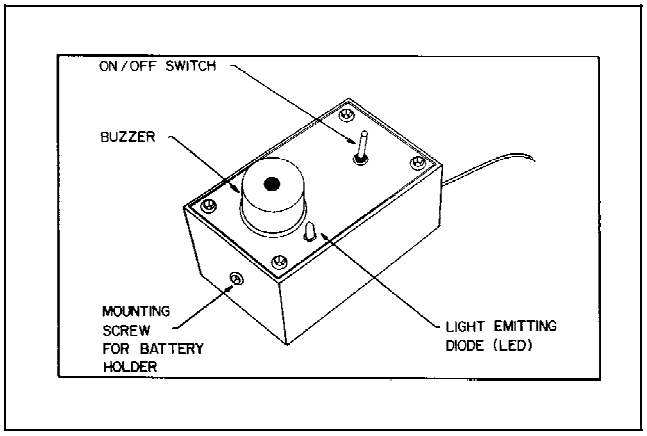

Figure 3. Sketch of assembly.

ensures mechanical stability of the components. Short lengths of insulated copper wire can be used on the bottom of the board to provide connections between the various components.

All components must be soldered to ensure good connections (use only rosin core solder). The preferred soldering instrument is a 15-25-watt pencil-type soldering iron. When soldering, be very careful to avoid excessive heating of the LED and transistor: a heat sink should be used between the electronic components and the point of soldering to avoid overheating. Heatsinking can be accomplished by gripping the component lead between the component body and the soldering point with a small pair of needlenose pliers or by attaching a small alligator clip close to the component body.

The proper orientation of the LED, transistor, and battery are critical to the proper operation of the circuit; however, the leads on the resistors, switch, and sounding wire can be reversed without affecting the circuit operation. The buzzer may or may not require a specific orientation. Refer to Figure 2b and the paragraphs below to determine proper orientation.

LED: Note in Figure 2d that the LED has one flattened side at the base. The leg adjacent to the flat side is the cathode or negative lead of the LED. Connect the negative (cathode) lead to the 100-ohm, 1/2-watt resistor as shown in Figure 2a & c, and the positive (anode) lead to the battery positive lead at point B. (Assembly hint: raise the LED approximately 0.15 inch from the circuit board surface—this will facilitate heatsinking during soldering and will made the LED more visible by

causing it to protrude through the box cover.) Do not touch the leads of the LED directly to the battery terminal to determine polarity: a fresh 9-volt battery will almost certainly destroy the LED.

Transistor: The 2N3904 transistor can take several forms depending on the package style (Figure 2b). Plastic encapsulated transistors are usually the least expensive devices and will probably have pinouts as shown in either the center or righthand drawing. Metal encapsulated transistors will have pinouts as shown on the left. Note that these drawings show the bottom of the transistor. Be careful to connect the Base, collector, and Emitter leads as shown in Figure 2a & c. (Assembly hint: lay plastic transistor flat on its back to provide clearance for the box cover.)

Battery/battery leads: The snap-on leads for the 9-volt battery are polarized such that the red lead is connected to the positive terminal. Connect the red lead to one terminal of the switch and the black lead to point G of the circuit.

Buzzer: As indicated above, the buzzer may or may not be polarized. Study the packaging carefully and look for any mention of proper orientation. If the packaging makes no mention of polarity, look at the bottom of the buzzer: some will have polarity marked with "+" and "-" (the buzzer given in the parts list is marked in this manner). Connect the positive ("+") lead to point B of the circuit. If polarity is not indicated and there is one red wire, connect it to point B. Buzzers are often specified as operable over a particular voltage range, e.g., 3-18 volts, with louder sound occurring at the high end of the operating voltage. Purchase one with an operating range bracketing 9 volts with the high end as close to 9 volts as possible. Do not use a buzzer with an upper-voltage specification less than 9 volts, because it may be damaged in this circuit.

Testing the Water level Indicator

The water level indicator may easily be tested before using it in the field by dipping the bare ends of the sounding wires into water and observing the light emitting diode (LED) and listening for the buzzer to sound. The LED should light and the buzzer should sound when the bare ends of the wire contact the water. Alternatively, the unit can be tested by touching the bare ends of the lead wire together.

If the LED fails to light (the LED is not highly visible under bright sunlight conditions — it may be necessary to shade the LED with your hand to be certain that the light is operating) or the buzzer fails to sound as a result of the previous tests, check the following:

1. Battery: Be sure that the battery is a fresh 9V transistor battery. Check that the positive and negative terminals are connected correctly.

2. Mechanical (solder) connections: An ohmmeter will be helpful for these checks. Check each leg of the lead wire to assure that it conducts electricity. The wire may be broken or connections may be improperly made. Make certain blobs of solder are not making unwanted connections. Then check all other solder connections between the battery, switch, and electronic components. Check that contact is made when the switch is closed.

3. Circuit electrical components: If the water level indicator still does not work after the previous checks, carefully check orientations of critical components (transistor, LED) to insure they were installed properly. If this does not remedy the problem, one of the parts may be defective: a component may have been damaged by overheating or perhaps was defective when purchased. These components can be tested by closing the switch to provide battery power to the circuit and shorting across leads C and E of the transistor (Figure 2c). If the LED lights during this test, then the transistor is defective. If the LED does not light during the test, replace the LED and try the test again to determine whether the transistor is also defective. Fortunately, these components are not expensive.

Once the circuit has been tested and found to be functional, coat both sides of the board with sealant to prolong the life of your water level sensor. Do not allow the sealant to get inside the buzzer; otherwise, it will not function properly, if at all. For convenience, the experimenter's box can all be mounted on one end of the reel unit as illustrated in Figure 1. This can be done with machine screws and nuts (do not allow sharp edges of the screws to project into the wire area). Care should be taken when operating the device to prevent water from getting inside the buzzer, because this will shorten its life.

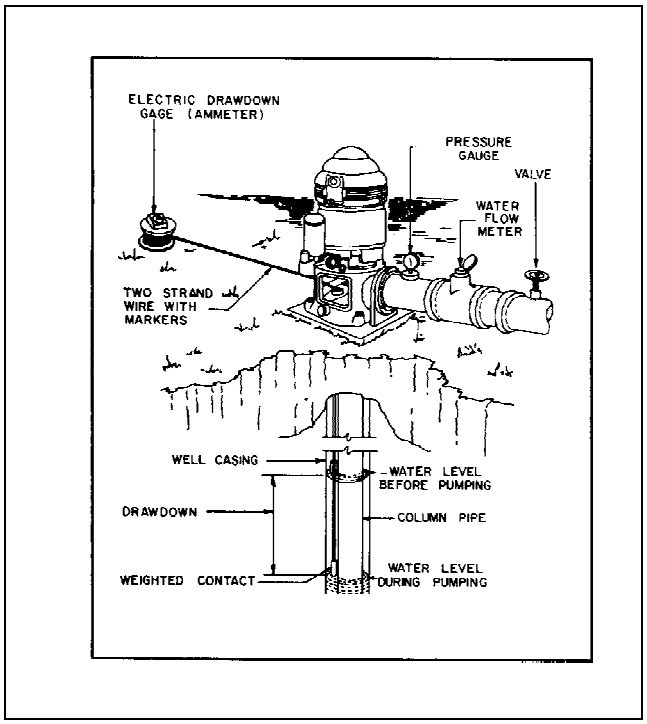

Figure 4. Field use of the water level indicator.

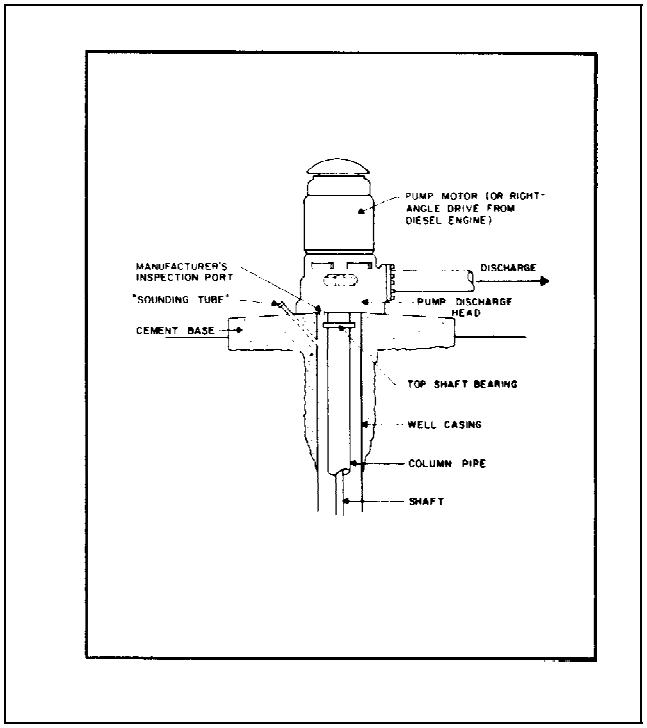

Figure 5. Sounding tube and manufacturer's inspection port locations on a turbine pump in a deep well.

USE OF THE WATER LEVEL INDICATOR

After testing, the water level indicator is ready for field use. The instrument is used by lowering the weighted sounding wire into the space between the well casing and the discharge pipe as shown in Figure 4. This space should be accessible through the well seal on commonly-used submersible, turbine, and jet pumping systems.

On deep-well turbine pumps an access port (manufacture's inspection port) on the pump discharge head should provide access to the well (Figure 5). Most manufacturers have included the access port in the design of the discharge head. Note that the port provides access to the space between the well casing and the column pipe. There may also be ports on the discharge head for access to the column pipe. Do not lower the water level indicator wire into the column pipe because it will become entangled with the drive shaft when the pump is started.

To determine whether the access port you have located is the proper one, remove the plug and start the pump without inserting the lead wire. If water is discharged from this port, it is not the correct access to the well. (CAUTION: Water may be sprayed throughout the pump house. Attach an adapter and a hose to route the water away from the area to prevent danger from electrical shock or other hazards.) If no water is discharged from the open port, then the lead wire can be lowered into the prot to measure water level in the well while the pump is operating.

Unfortunately, many pumping systems do not provide ready access to the well to measure water levels. The access port if often plugged or inaccessible due to improper pump installation. In those cases, it may be necessary to drill into the casing (perhaps through the concrete slab) to install an access "sounding" tube as shown in Figure 5.

In some cases, it will not be possible to make a water table measurement in the space between the column pipe and the casing pipe. This is true if the pipes were not properly sized and there is not enough space between the two pipes to lower a probe to make the measurement. In that case, it will not be possible to make a water table measurement using this instrument.

Water level Measurements

The water level indicator can be used to measure the depth to water in a well under either static or pumping conditions. The static water level is the level in the well when the pump is not operating and has not been operating for a period of time.

The pumping water level is that which is measured when the pump is operating. The difference between static and pumping water levels in the well is called drawdown. In Florida, drawdowns are typically 5 to 10 feet, but may range from 0 to 30 or 40 feet. Smaller drawdowns indicate better yielding wells, that is, wells which are able to supply the required flow rates more readily. Smaller drawdowns are desirable because water will not need to be lifted as far to the ground surface. Therefore, less energy will be required for pumping.

Safety

Safety should always be a consideration when working with mechanical systems. Unfortunately, the access ports for water level measurements are often near the pump drive shaft on the pump discharge head. If measurements of pumping water level are being made, the shaft will be turning at a high rate of speed. Keep hands, clothing, and the water level indicator sounding wires away from the spinning shaft. If necessary, install a shield between the shaft and the area in which you are working.

SUMMARY

Details were given for the construction, testing, and use of an inexpensive electric water level indicator for the measurement of water levels in wells. This instrument can be constructed by individuals with average mechanical skills and without in-depth knowledge of electronics. The water level indicator can be used to obtain information necessary for pump performance testing, well testing, pump selection and installation, and aquifer testing.