Part 3:
THE WATER SYSTEM

GOLD & SILVER

(This is the third and final part of our series on home water systems. Parts 1 and 2 were in Issue Nos. 58 and 59. — Editor)

By Michael Hackleman

Let's look at some examples of commonplace water systems. Three major design concepts are reflected in the Gold, Silver, and Gold-Silver systems. The Gold system is based around the "store" theme of water system design, the Silver system around the "demand" theme, and the Gold-Silver system is a hybrid of the two. [Note: Realize that these are only the base parts of a system. Water purification and conditioning equipment, if any, are additive items, and are not treated in this article.]

The Gold system

The Gold system (my own term) is built around the deep-well piston pump. Primary considerations in this setup are minimal use of energy, the application of low-yield energy sources, the variety of energy sources that may be applied, and accessibility to the pumping equipment for maintenance and repair. Though only one energy source may be applied initially, this system boasts the ultimate in "add-on" capability. Money permitting, other energy sources may be applied as the need arises to match increasing water usage or a changing energy picture.

The Gold system is a composite of systems I've seen in manufacturer's manuals. It shows the full breadth of options available for a water system based on wind power. Even if wind energy is not accessible, the system is still sound, easily able to utilize a number of other, equally good energy sources. Systems using various arrangements of these components have withstood the test of time and tough conditions.

The Gold system is composed of a piston pump, the delivery pipe, the sucker rod, a stuffing box, pump standard or hi-pipe, a pumping jack, a motor or engine, and a wind plant in various combinations. **(See figure 7 from Issue No. 59)** Let's look at each part and it's function in the system.

Deep-well piston pump: The deep-well piston pump is composed of a plunger and a stationary cylinder. **(See Fig 5 from issue #59)** This pump is sized to the energy source that powers it, the desired gpm (gallons per minute) rating, and the pumping head. Through careful selection, we can vary the cylinder diameter, stroke (length of pumping motion), and number of strokes per minute (usually not to exceed an upper limit of 40) to fulfill the pumping needs. **(See Fig. 6 from issue #59)**

Cylinders vary in size, ranging from l¼ inch to 3½ inches inside diameter, and are made from iron, plastic, or brass. The all-brass cylinder and plunger assembly with the ball type of check valves offers the longest life, particularly in pumping highly turbid water. These cylinders come in different lengths to accommodate various sizes of wind machines or pumping jacks which can additionally offer a longer stroke.

Delivery pipe: A pipe is needed to position and support the piston pump in the well, house the sucker rod (which connects the drive mechanism to the piston pump itself), and transport the water to the surface. Since it must withstand water pressure, absorb the push-pull forces of the sucker rod, and guide the sucker rod with minimal resistance losses, the pipe should be rigid and strong. Two-inch (I.D.) galvanized steel pipe is the standard.

As previously mentioned, there's a unique feature in the l7/8-inch cylinder and 2-inch delivery pipe combination: the pump innards, including the two check valves, the leathers, and the plunger assembly (the only portions of the pump that are subject to wear) may be removed up through the pipe for servicing and repair as required. Remember, it's the delivery pipe that is the real weight in this system. So, this feature makes maintenance and repair an uncomplicated affair.

When a larger size of cylinder (producing a higher pumping rate) is desired, without a corresponding increase in the size of the delivery pipe, this feature is lost. The situation is not always unavoidable. The cumulative weight of pipe becomes a problem for wells over 200 feet in depth, and a delivery pipe smaller than 2 inches may be needed for wells double this depth. Still, for wells up to 200 feet, the owner should seriously consider longer strokes and longer cylinders to increase pumping rates, rather than hasty increases in cylinder size.

Stuffing box versus pump standard: At the top of the well, one of two pieces of hardware will be needed: the stuffing box or the pump standard. **(See Fig. 8 from issue #59)** They have similar functions, but the main difference between the two is that the pump standard has a lever attached for using muscle power to pump water from the well. This assumes that you have both the muscle and the inclination. For the added fifty dollars or so in price, it's not a bad deal.

Both the stuffing box and the pump standard perform several important functions. First, they hold the in-well equipment—delivery pipe and piston pump—in position and support their combined weight. In fact, they are screwed onto the pipe end. Second, they have a watertight fitting through which the sucker rod passes and is able to move back and forth; this permits power transfer to the piston pump without spilling the pumped water. Third, the stuffing box and pump standard contain a number of fittings for attachment to the rest of the water system aboveground. And fourth, equipped with the correct type of gasket, both units provide a watertight seal over the well casing to prevent contamination of the well by dirt, insects, small animals, and surface water.

Since the primary function of either the stuffing box or pump standard is to effect a watertight seal at the point where the sucker rod emerges from the delivery pipe, an alternative to using this hardware is the hi-pipe (my term). In essence, the hi-pipe is a delivery pipe that has been extended upward to some point above the level where the water is pumped. A T-fitting anywhere between the wellhead and that point allows the water to flow out of the delivery pipe and, a few feet higher, the sucker rod emerges. Where the sucker rod is used, however, no watertight fitting is required.

The hi-pipe technique is used extensively in systems using only a water-pumping wind machine. The height of the tower might allow an easy extension of the delivery pipe to some level above that to which the water is being pumped. The tank need not be directly alongside the tower. Just as long as water storage is situated below the level of the wind machine itself, this technique can be used. However, if the delivery pipe does not extend all the way up the tower, it should be fitted with some type of cover. A watertight seal may not be required, but we'd still want to keep debris out of the well.

Sucker rod: The piston pump in the well is linked with the stuffing box or pump standard at the wellhead via the sucker rod, or pump rod. Moving up and down inside the delivery pipe, this transfers power from the energy source to the pump mechanism. The sucker rod is made up of sections of either wood or galvanized steel rod fitted with threaded ends. The required number of lengths, then, may be screwed together.

Wood is the preferred sucker rod material for three reasons. First, it's bulkier, and so a closer fit to the inside diameter of the delivery pipe. This helps to guide the rod and, on the downward stroke, keep the rod from bending or flexing over long lengths. Second, since the power stroke occurs on the upward swing of the rod, the wood's buoyancy assists this motion. With a metal sucker rod, the power source must overcome the accumulated weight of the rod, too. And, third, wood rubbing against the steel delivery pipe is silent. With a metal sucker rod, there's a chance that everyone will get to hear the repeated "clang" as the rod strikes the pipe wall during pumping operations.

The sucker rod ends just below the watertight fitting in the pump standard or stuffing box. There it is secured to the smooth rod that actually moves up and down through the seal. If a water-pumping wind machine is used in the system, sucker rod is also used to transfer its power to the pump standard or stuffing box above the seal.

Pump rod and sucker rod are used interchangeably to describe the same thing. However, a rod that works between the wind machine and the pump standard will not necessarily work in the constant wet to which a rod connecting the pump standard and piston pump will be exposed. So, irrespective of the terminology, be certain that you and a supplier are talking about the same thing.

Pumping jack: The pumping jack is a device that converts the rotary motion of a number of energy devices such as electric motors and gasoline engines into the reciprocating (up and down) motion needed to power the piston pump. Typically, the pumping jack is bolted to the stuffing box, the pump standard **(See Fig. 8 from issue #59)**, or the concrete pad surrounding the wellhead. With long lever arms, it's designed for quick connection to, or release from, the sucker rod protruding from the stuffing box or pump standard. In the wind energy-based system, then, the pumping jack is connected during low and no-wind conditions for water pumping as needed. If no wind system is feasible, the pumping jack may be the primary means of operating the piston pump.

The pumping jack is only a sophisticated conversion device. It is not an energy source. For this reason, a motor or engine must be attached. This is usually no problem. A bolt plate that will accommodate either a small engine or an electric motor is part of the assembly.

The pumping jack is designed to rotate in a specific direction—clockwise or counterclockwise—and the motor or engine you select may or may not turn in the same direction. If it does, fine. If it doesn't, there's a definite problem. With an electric motor the direction of rotation may be reversible. A local motor shop can do this in a few minutes. A gas engine is not reversible. Of course, either a motor or engine could be mounted separately from the pumping jack, but it's a hassle to align the pulleys, maintain belt tension, and keep the respective assemblies from loosening up in operation. So—get a pumping jack that rotates in the same direction as your motor or engine or be prepared to buy your way into matching the pumping jack's rotation.

Quality pumping jacks have their gears running in oil. They should provide quiet and trouble-free operation for a lifetime. Check your pumping jack frequently, replacing lost oil and occasionally draining the old and filling up with new.

Electric motor versus gas engine: Either an electric motor or a gas engine may be bolted to the pumping jack for water-pumping operation. Gas engines are considerably noisier, and they use expensive gasoline. If there's a choice, the electric motor is the preferred power source. However, this assumes that you have electricity, either utility-supplied or generated onsite. If you don't, the gas engine is the only alternative. Don't rule out the possibility of using both. If the pumping jack is normally powered by utility-supplied electricity, it's nice to have a small gas engine as backup during a blackout or other emergency.

Manufacturers' specifications clearly designate electric-motor horsepower for given conditions—the pumping head, pumping rates, cylinder size, etc. However, observe caution when using a gas engine with a pumping jack. Without using an intermediate jackshaft, the smallest pulley that may be attached to the engine will overspeed the pumping jack (which operates at a maximum 40 strokes per minute) at optimum engine speeds. At reduced speeds, the available engine HP is a mere fraction of the engine's rating—it can be as low as 1/10 the value. Hence, where a 1/3 HP electric motor is specified, a 3-5 HP gasoline engine will be needed to deliver the same performance.

Water-pumping wind machine: The deep-well piston pump is ideally suited for use with a wind machine of the type produced by the Aeromotor, Dempster, or Baker companies. Since these aeroturbines are designed for operation at low wind speed, there are few places where they cannot be used. The least that can be said about the aeroturbines themselves is that they have evolved over a long period of time (75 to a 100 years) and that the present models are time-tested. For example, the last major design change in the Aeromotor wind machine was in 1933. Finding parts for either the new or older wind machines, however, is not a problem—a definite advantage over the change-the-model-each-year syndrome that affects other commercial equipment such as cars. This is good to know when buying a new wind machine and a lifesaver when restoring a used wind machine (if, in fact, any restoration is required) .

New or used, the major expense in wind-pumped water systems is split between the wind machine itself and the tower. Which one represents the higher cost depends largely on the circumstances. Unfortunately, the best spot for digging a well is rarely the best wind site. If this is the case, the tower must extend the wind machine high enough above surrounding obstacles such as trees and houses to reach undisturbed wind. This is not only an initial problem. Since there's a tendency to site the well and wind machine near a house and also to plant shade trees in the same location, the problem may arise in later years. Many an old farmstead may be found today with the wind machine nestled deep in the trees which have, over the years, grown above it.

If wind energy is accessible, there are a number of ways to proceed. The first is simply to buy new equipment, letting the supplier size the wind machine and tower and having him install them. This is pretty painless and, not surprisingly, expensive. An alternative is to buy the equipment and install it yourself. This is particularly applicable if you're in the boonies and there's little chance that the supplier can get his baby crane in there. Don't let the size of the job intimidate you. Learn everything you can on the subject and get the necessary help or equipment.

Tactics: Any situation that meets the requirements of a store type of water system will find the Gold system a cost-effective and efficient setup, particularly when used with a low-yield energy source. Again, this type of system is still a viable alternative even if alternative sources of energy are not available in sufficient amounts. An electric motor powered from utility-supplied electricity driving a deep-well piston pump through a pumping-jack pump standard boasts a higher cost-benefit ratio than a submersible pump pumping into the same storage. Furthermore, if energy use, hardware, well capacity, system versatility, and usage are evaluated honestly, the two systems are even cost competitive. In this respect, only personal preferences will sway the decision one way or the other.

If your money is limited, a tower, wind machine, and storage tank are pretty major expenses to tackle right away. A better idea is to install the pumping jack first. If electricity (utility, wind-electric, or standby generator) is available, an electric motor is used. If electricity isn't available, a gas engine may be installed. Both get you going right now. And even if you have no storage, you get water when you want and can turn it off when you don't.

The next item to add (as money becomes available) is the storage tank. This investment will save you from having to turn on the pump every time you want water. Additionally, it will allow you to use water at higher rates than that at which water is pumped directly from the well.

Eventually, if you plan a wind-pumping setup, the tower is purchased or made, installed, and the wind machine added.

There's an alarming tendency to reverse this process. Resist it. Even if the money is available, you can't make effective use of wind-pumped water without storage. And there's no point in having storage if there's no water to put in it. It may take weeks to correctly install a tower, wind machine, and storage tank. Only a few hours are needed to complete a pumping jack installation. So get the water first, provide storage next, and then alternate means of pumping it.

Accessories: The Gold system has several additional components: a well seal, a screen and an in-tank level sensor.

Well seal: All wellheads need a sanitary seal. This seal is always watertight and sometimes airtight. In a store system, a different well seal is positioned over the wellhead casing before the pump standard or stuffing box is set atop it. It seats when either piece of hardware is bolted down to the concrete well pad.

Screen: The piston pump doesn't come equipped with a screen affixed solidly to the bottom of the cylinder. It's sold as an accessory. Why? With a piston pump assembly you can use a tail pipe. If you do, you'll want the screen on the bottom end of it.

While all piston pump installations should use a screen, many do not. Two reasons are given. One, at lower pumping rates like those exhibited by the piston pump assembly, there's not as much need for the screen. And, two, in those systems where the pipe and cylinder have been sized so the pump innards may be removed up through the delivery pipe, it's ever so much easier to replace the leathers more often than it is to lift out the entire assembly to clean a screen.

In-tank level sensor: It's nice to know the level of water in a storage tank. This can be accomplished in at least five different ways.

1. Look inside the tank.

2. Look at a pressure gauge near the house. At .433 psi per foot, there's a 4.3 psi difference of pressure in a 10-foot high tank between empty and full.

3. Rig up a wire with a float at one end and a weight at the other. Run it out the top of the tank and down the side. Paint a scale behind the hanging weight. When it's at the bottom, the tank is full. When it's at the top, the tank is empty. Points in between will tell you how much water is present.

4. Install an electronic gizmo in the tank to give you a reading of water level. You design and install the gizmo. Hint: If it needs anything bigger than a few AA size cells to operate, you'll probably electrocute someone at some point.

5. Water flowing out of the top of the tank = full. No water at the tap = empty tank. Everything else = guess.

The Silver system

The Silver system (my own term) starts its life built around the centrifugal pump **(Fig. 1)**. Primary factors in this setup are a high-yield water source, available of utility (or generator) electricity, high head, high usage rates, and the need for immediate installation.

Note: The starting block of the Silver system is a favorite of well drillers everywhere. It is also often installed by individuals who are ignorant of the existence of any alternatives to it. It is a system that best emulates the water system found in houses in the city. It is not efficient or versa-

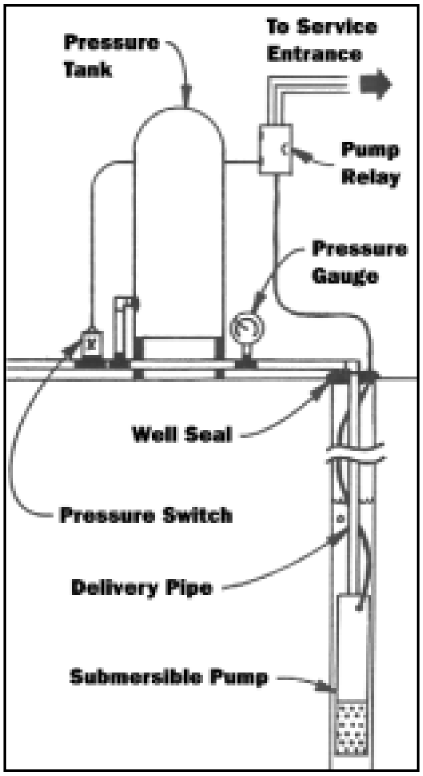

Figure 1: Components of the "demand" type system.

tile. The depth of the well in which the pump hangs is usually increased beyond the point of actually hitting water. While this helps minimize the impact of drawdown, it increases the cost of drilling the well in the first place. Despite these deficiencies, the Silver system can be modified—using a dual (parallel) or piggyback (series) arrangement of a piston pump—to increase its versatility over the basic system. (More on the Gold-Silver system soon.)

The initial setup of the Silver system is composed of a 110V or 220V AC centrifugal-type submersible pump (previously discussed). Additional components required in this system are delivery pipe, electrical wires, level sensor, pressure gauge, pressure tank, pressure switch, screen, torque arrestor, and well seal.

Delivery Pipe: In the demand system, the in-well delivery pipe (which transports the pumped water) is usually l-inch, type PE (black) plastic pipe.

Electrical Wires, Pump: Use only code-approved electrical wiring that is specially formulated for water submersion with submersible pumps. If well depth is greater than stocked lengths of wire, use code-approved connectors. Wires are strapped to the side of the delivery pipe to avoid fouling and to keep the wires from chafing against the well wall or casing.

Level sensor, in-well: If the water source is ever pumped dry, and you don't catch it right away, the submersible pump may burn out trying to pump air. The in-well level sensor is an automatic means of both sensing this condition and disabling the pump when it occurs. Two probes are lowered into the well. One is positioned just above the pump, the other some distance above it. The magnetic relay into which they connect will stop the motor when water reaches the lower sensor. It will restart power to the pump only after the well has recharged with water to the level of the upper sensor.

Pressure gauge: A pressure gauge may be added to the plumbing in the vicinity of the pressure switch (below). At this location, of course, it cannot be used for monitoring the system's operation (unless you frequent the pumphouse). It serves two purposes. Initially, when the system is installed, the gauge assists in the adjustment of the pressure switch to the correct range of operation. Later, the pressure gauge is a good visual indicator if there's some malfunction. It will let you know at a glance what is working and what is not, thereby isolating the problem.

Pressure switch: Ever wonder how the water system automatically turns on when you open a faucet? In a demand system, a pressure-sensitive switch detects the lowered pressure, closes its contacts, and energizes the pump relay, starting the submersible motor. When usage stops, the water pressure builds to a pre-adjusted value, the pressure switch's contacts open, the pump's power relay is de-energized, and the submersible pump stops.

The pressure switch doesn't open and close at one specified pressure. Instead, it closes at some low pressure and opens at some higher pressure. Typical values are 30-50, 35-55, 40-60, etc. The overall range is adjustable, but the difference between the upper (open)and lower (close) points is a built-in specification. If you want a smaller or larger difference, you must buy a different pressure switch.

Pressure tank: Water is not compressible. A water system that uses only a pressure switch will suffer from "water hammer." This is the sound of knocks like hammering as the pump switches on and off in its attempt to sustain system pressure. This also causes sputtering at a faucet when it's first turned on and uneven flow when the faucet is in use.

The remedy is the pressure tank. The pressure tank is primarily an air chamber. Unlike water, air is compressible. Inserted in-line, the pressure tank absorbs water hammer and assures an even flow to the faucets at any rate of use below the pump's capacity. The pressure tank acts somewhat like a storage tank since it is possible to get some water from the system without having the pump start up. Still, this is merely a byproduct of the pressure tank's functioning. Indeed, even a 42-gallon pressure tank is not capable of supplying more than 6.5 gallons of water before the pump restarts.

Since air mixes so readily with water, a recurring problem with older-style pressure tanks was their propensity toward waterlogging. Periodically, air had to be pumped in to replace that lost to absorption. This was usually done manually. With suitable controls, it could be automated. Newer-style tanks use floating separators, minimizing the surface area and hence the interaction between water and air. Some tanks even confine the air in a bladder suspended in the tank.

Screen: A screen is attached to the intake (upper end) of the submersible pump to filter out anything that would clog the pump. A fine-mesh screen may be added to help filter out anything that would pit the pump's impellers.

While the submersible pump may function two to fifteen years in the well without servicing, the screen may not fare as well. If pumping performance diminishes in time, the first thing that should be checked is the screen. The entire assembly—delivery pipe, wires, and pump—must be pulled for this five-second check and, if clogged, a five-minute cleanup job.

Torque arrester: Mounted on the delivery pipe just above the centrifugal pump, the torque arrester is a flexible gadget that makes contact with the well or casing wall, resisting the "twist" of the pump assembly on start-up due to motor torque.

Well seal: All wellheads need a sanitary seal. This seal is always watertight and sometimes airtight. In the demand system, the well seal is a pancaked rubber seal with holes bored through it. You buy the one that will fit the diameter of your well and pass the size of delivery pipe and electrical wires for your pump. Once these have been routed through, the seal is set on the wellhead casing. Upon tightening, it expands against the well casing to affect an impenetrable seal.

The Gold-Silver system

There's really no reason to view water systems as strictly either/or, demand versus store, piston pump versus submersible pump. Why not a combination?

There are two basic ways that the submersible pump and the piston pump may be merged into one system—side-by-side and piggyback. **(See sidebar)** Each combines the best features of both pumps (and systems) and effectively neutralizes the disadvantages of each.

Phase one: After operating a demand system for a number of years, some friends of mine realized the availability of wind energy at their site and its potential as an alternative energy source for water pumping. Their present system was ill prepared to handle fire fighting and to operate during blackouts. As water usage increased with a newly installed garden and orchard, the frustrated owners were ready to consider alternatives.

An extensive retrofit was designed—a waterpumping wind machine and tower, a piston pump, and plumbing to handle two service pressures.

Using wind energy necessitated a storage tank. While the property did elevate sufficiently to provide gravity flow from a storage tank sited at the highest point, gravity pressurization was not possible. This was not considered a major handicap since all of the

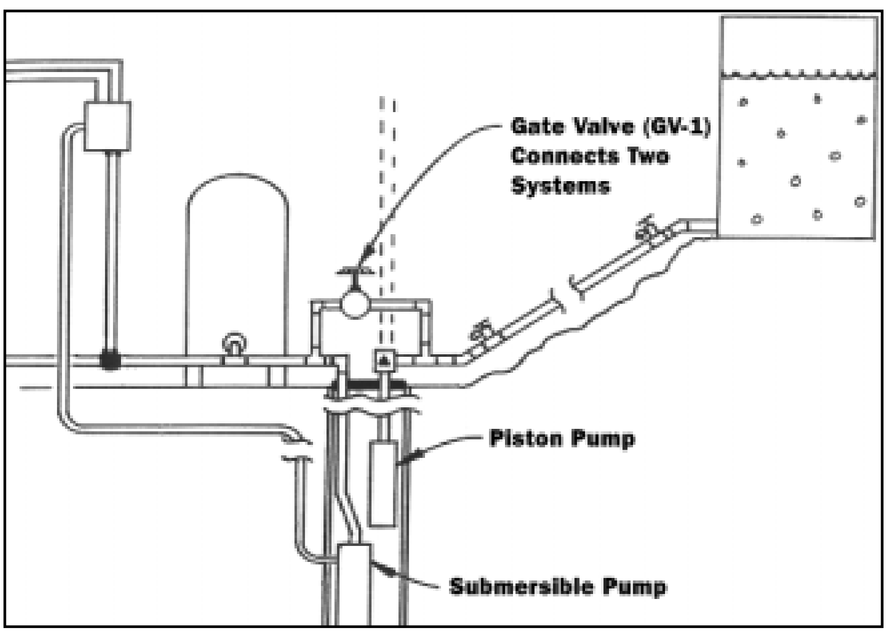

Figure 2: Demand and store type systems joined in a side-by-side method.

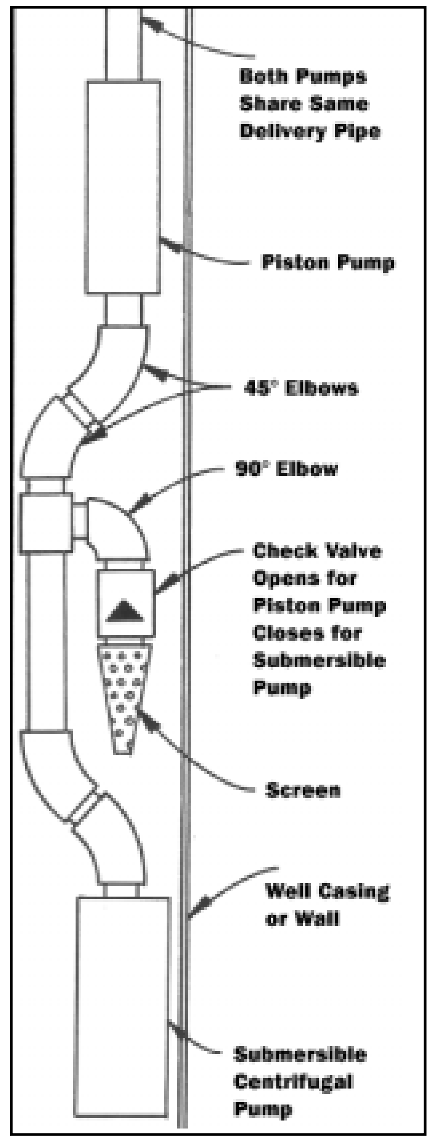

Figure 3: Demand and store type systems joined in a piggyback method.

Variations of the Gold-Silver System

A store-type and demand-type system may be combined into one system using a side-by-side or piggyback arrangement.

In the side-by-side system, each system is installed independently of the other, with the piston-pump usually positioned above the submersible (See Fig. 2). The plumbing is kept separate through the wellhead and joined, in some fashion, thereafter, in a variety of ways.

In the piggyback arrangement, the submersible pump is joined with the piston pump (See Fig. 3) to feed the same delivery pipe to the surface. While no harm would come of operating both pump mechanisms simultaneously (and, I might add, no gain either), normally only one or the other pump would be operated at a time. When the piston pump is operational, it draws water through the check valve as it would through a tail pipe. When the submersible pump is operated, it draws water through its own strainer and pumps it through the piston pump and up the delivery pipe.

The piggyback arrangement is illustrated in a number of pump manuals circulated by manufacturers. However, in practice the actual connections between the two pumps cannot be easily made inside a 6-inch well size. There just isn't the room. Instead, a number of 45-degree pipe elbows are needed to offset the interconnecting pipe to accommodate the room taken up by the check valve. It is possible to use flexible pipe between the two to surmount this obstacle, but it's not recommended. A submersible pump, on startup or shutdown, exhibits a vicious little jerk due to motor torque. Therefore a short section of interconnecting plastic pipe will fatigue in short order and break. This will necessitate pulling the entire system out of the well for repair.

Controls similar in type and function will permit the piggyback arrangement to act alternately as a demand or a store system. In reality, it is both. However, the use of this system presupposes that the owner/operator is utilizing a non-utility energy source as the power unit for the piston pump. For this reason, water pumped to storage from the submersible pump must be limited or the piston pump will have no place to put water when it is functioning.

gardens and orchards were downhill from the ideal site for the tank.

A 2,000-gallon storage tank was purchased and sited. A 20-foot wood tower was built on top of the stone pump house and a water-pumping wind machine was purchased and set atop it. A deep-well piston pump was inserted into the well in addition to the existing submersible pump. Instead of a piggyback system, a side-by-side mounting of the two pumps was chosen **(See Fig. 4).**

A new wellhead was fashioned to accommodate the unorthodox side-by-side arrangement of these two pumping systems. An overflow pipe was added to handle the well's tendency to become artesian during a few months of the year and the overflow was routed to a nearby garden. A new anti-contamination seal was made to accommodate the 2-inch galvanized pipe for the piston pump and the 1-inch plastic pipe and electrical wires for the submersible pump. A stuffing box was located at the wellhead and the needed length of pump rod and pipe was routed up through the ceiling of the pump house to the wind machine perched overhead.

The two water systems were, at this stage, wholly separate. Any water that was pumped from the wind machine to the tank was used at low pressure in the gardens and orchards. All household water was supplied by the utility-powered submersible pump. Backup hoses from the submersible pump system were routed to the gardens and orchards to take care of any watering

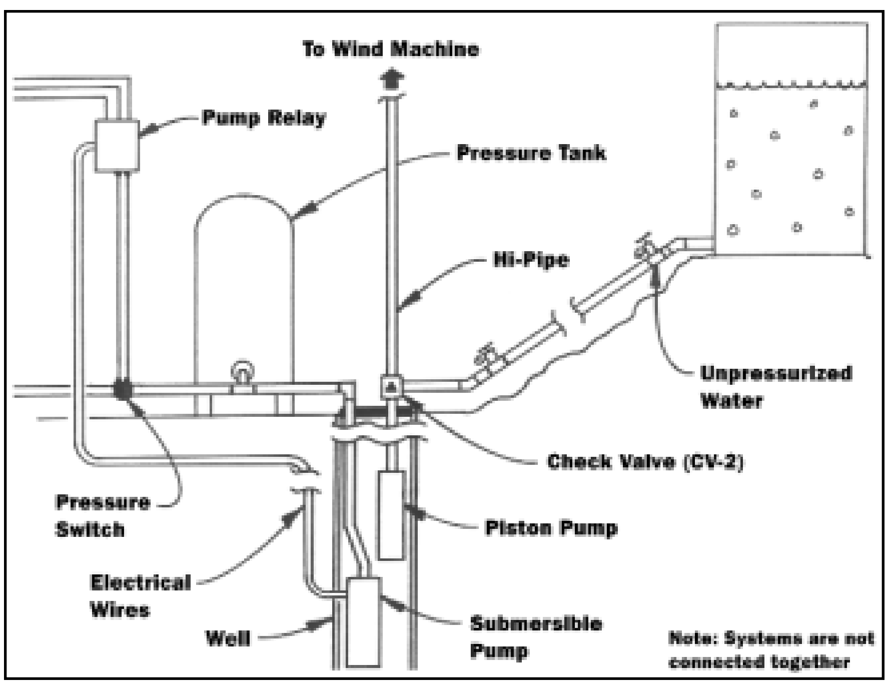

Figure 4: Phase one of the Gold-Silver system

needs beyond the capability of the wind-pumped water system. They were never used. Once the system was in and operating, it was quickly evident that the wind pump was able to handle all of the outdoor watering needs. Indeed, the system exceeded the nearby garden's water requirements, and the owners had to shut down the wind machine manually (via the handcrank in the wellhouse) again and again. Any uncertainty or disbelief on the part of the owners that the added system would handle garden and orchard and, perhaps, some of the household watering needs too, evaporated. They were ready for phase two.

Phase two: Phase two of the Silver System tied the two systems together with a gate valve between the pipes for each system at the wellhead. This served two functions. First, during a blackout, the submersible doesn't work. If there's water in the tank and there's a need for water in the household, opening the gate valve feeds water from the tank directly into the house. In times of need, water at any pressure is hardly "inconvenient."

The secondary function of the gate valve is that it provides a quick and easy way to fill the water tank to any desired level using the submersible pump. This is particularly handy if a forest fire or tornado is on its way. Simply opening the gate valve has the same effect as opening any water faucet, causing water to flow into the tank until the gate valve has been closed.

For a mere twenty dollars in parts—a gate valve, pipe, a union, and a few pipe tees—this tie-in does an awful lot.

Final comments: As simple as the Gold, Silver, and Gold-Silver systems are, it may not appear that way to the novice. I highly recommend making a system diagram. This will certainly help family, friends, and visitors to understand the system. It will help you remember, too, and will prove invaluable if something doesn't seem to be working correctly. You can't troubleshoot something if you can't remember how things are supposed to work. Clearly label all switches—pressure, level sensor, reserve bypass, etc.—in the system and key them to the drawing.

Whatever type of water system you eventually design and install, I hope it brings you and your land life, utility, and happiness.

(Some text and drawings in this article were taken from Waterworks: An Owner-Builder Guide to Rural Water Systems (Michael Hackleman, Peace Press, 1983, 172pp), The Homebuilt Wind-Generated Electricity Handbook (Michael Hackleman, Peace Press, 1975, 194pp) and At Home with Alternative Energy (Michael Hackleman, Peace Press, 1980, 146pp) For a publications list, send an SASE to: Michael Hackleman, PO Box 327, Willits, CA 95490.) Δ