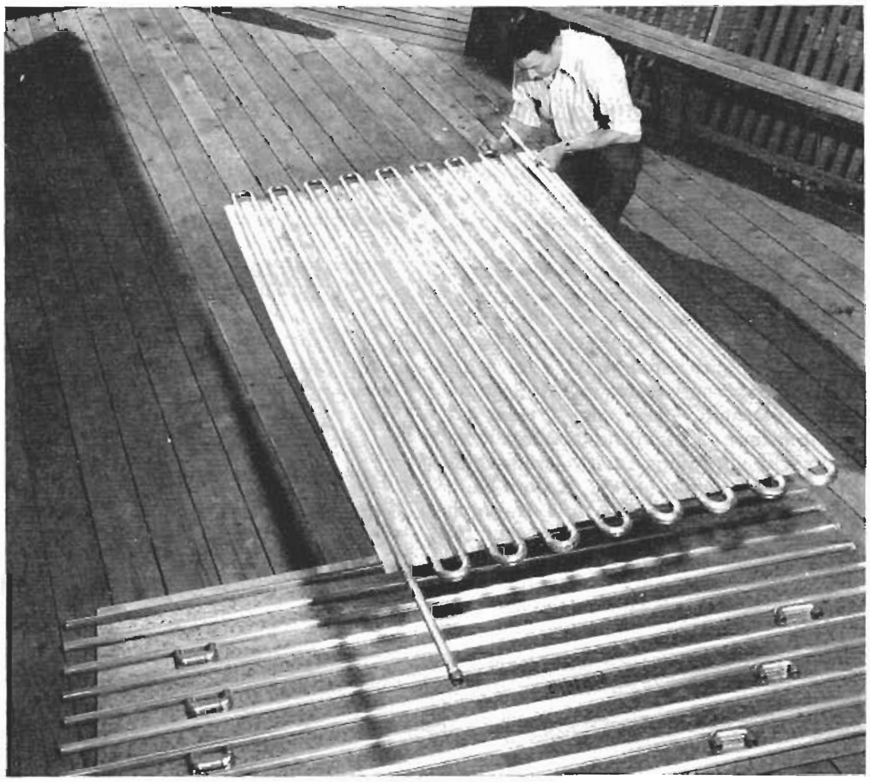
Five solar water heaters
you can build

By EDWARD MORAN

Five PS readers, in widely scattered sections of the country, share their DIY expertise in this article. Tax incentives and enlightened building codes are finally beginning to catch up with the know-how. If you don't have a "solar thumb," check out the off-the-shelf systems on page 104. For more DIY tips, see page 142.



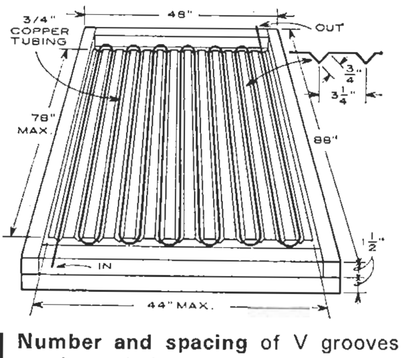
Ken Herrington: the evolution of a system

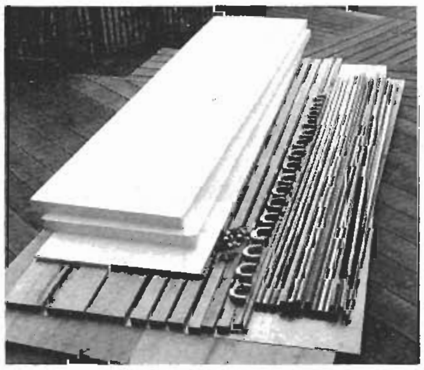
Ken Herrington just can't say no when it comes to homegrown energy. When we featured his fireplace heater in this series [PS, July '75], we weren't aware that we'd met up with an avid craftsman who is turning his ranch on a northern California hilltop into a veritable alternate-energy lab.

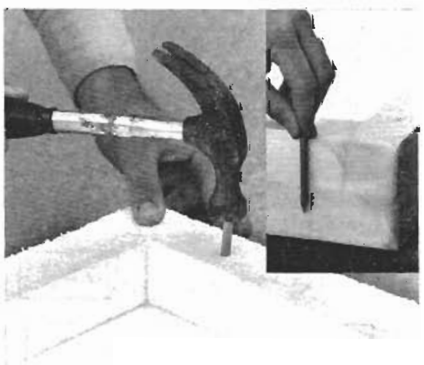
Over the months, we've been fed dozens of photos (Herrington is a

Continued

Here's a dimensioned drawing

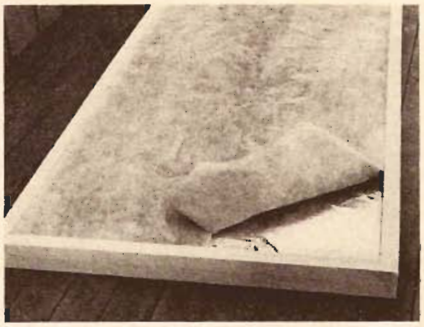




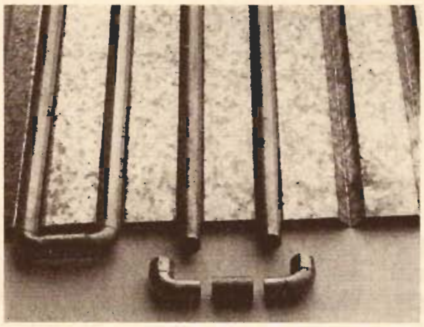


1 Number and spacing of V grooves can be varied (compare drawing and photo). Shown: 4-by-8-by-1½" beadboard panels, 17 tubes of 80-by-¾" copper; 16 sets of copper return bends and couplings, and plywood (optional). Also needed: a 78-by-43-in. sheet of 24-gauge galvanized metal, and fiberglass.

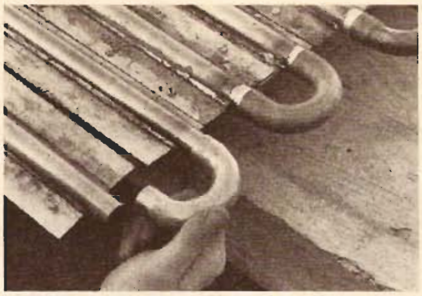
2 To form a tray for the piping, glue beadboard strips to flat beadboard panel, driving in ¼" wood dowel to hold surfaces together firmly.



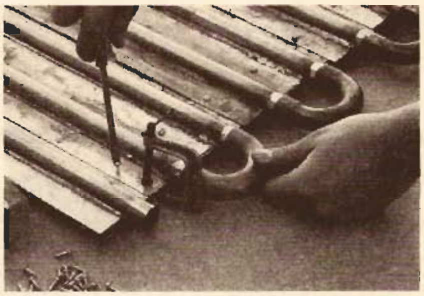
3 **After edges are set,** glue an inch of fiberglass insulation into place with butyl-rubber cement from adhesive caulking tube. Pipe grid goes on top.



4 **Pipes are soldered** into V grooves in sheet-metal plate. If the copper return bends are unavailable, use street ells and couplings, as here.



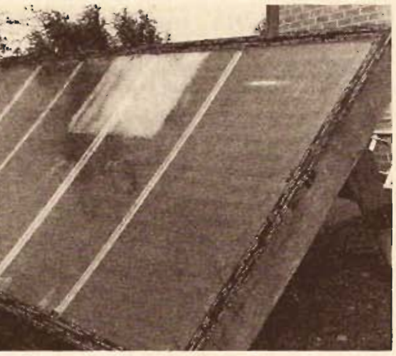
5 **Earlier version** used strips of V-grooved metal held together with sheet metal screws. You may find this easier to keep flat while soldering.

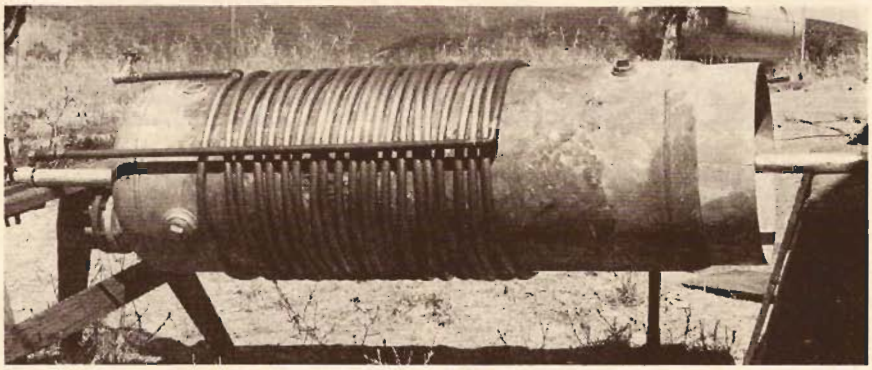


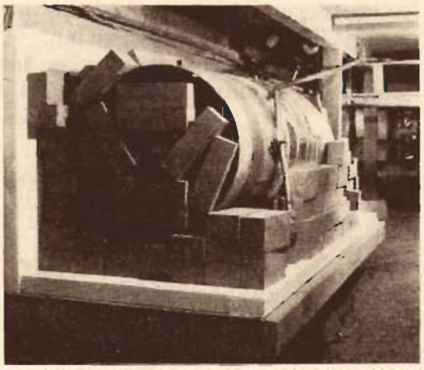
6 **Use a C clamp** to hold strips in place while screwing them together. Continuous beads of solder are run down both sides of each pipe.

7 **Seat the piping assembly** in the beadboard box. Paint flat black, then attach glazing in plywood frame; bolts along edges hold it together.

Condensation can fog single-glazed unit, reducing insolation. Herrington recommends spraying cover with moisture retardant, such as Sun Clear. In photos at right, paper mask shows effectiveness; treated area stays clear on dewy morning, next day. **Heat-exchanger tank** (bottom) holds 80 gallons. Copper tubing brings solar-heated water to heat tap water inside. Mallett-bend tubing around tank, cover with Thermon cement, **foil,** 4" foil-backed fiberglass, then brick up in basement (right) to retain heat. (Photo shows incomplete installation; bricks are later boxed in.)







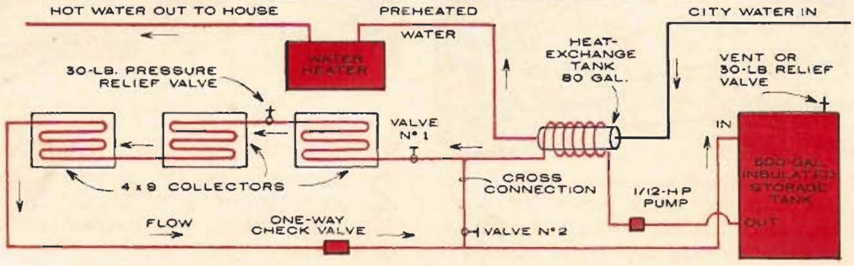


Diagram shows possible setup, linking three 4-by-8 solar panels into a conventional hot-water system for backup. Check valves permit solar collectors to be bypassed at night or on cloudy days, when you'd draw on stored water. Pressure-relief valve is necessary to prevent damage in case of steam buildup. For most American climates, heat-exchange system is recommended.

topnotch industrial photographer) of solar pool heaters, solar greenhouses, solar water heaters, storage tanks, piping, heat exchangers —each device carefully built and tested by this do-it-yourselfer.

We asked Herrington to show us plans for an inexpensive, easy-to-build collector that a typical homeowner could put together with a few tools and a little spare time. Materials for the collector shown in photo 1, cost exactly $160.73, wholesale; assembly takes a few hours.

This model is by no means Herrington's first version; and we're sure it won't be his last; he sees solar research as an evolving process, and is always making innovations. His first 4-by-8 collector, built last year, was little more than a plywood box with a flat metal plate to which copper tubing had been soldered. Later, he added fillets of heat-transfer cement to improve performance. Then he came up with the idea that's the basis for the collector described here: Instead of merely soldering pipes to a flat plate, he reasoned, why not first nestle them in V-shaped grooves?

At first, he used individual strips of metal, crimped V's down the center, then screwed them together (photos 5 and 6). A much simpler method is shown in photo 4: You can ask a sheet-metal shop to punch out a 24-gauge sheet to the specs given in our drawing.

The original plywood box has given way to one made from steam-expanded polystyrene (beadboard), which costs about $10 for a 4-by-8-by-1½" panel. (Herrington also recommends Celotex's Technifoam, slightly more expensive, but more durable.) Edging for the box is a 1½"-wide strip (cut from another beadboard panel) glued around the perimeter (see photo 2). An inch of fiberglass insulation (photo 3), avoids any danger of the beadboard melting due to the heat of the pipes.

The 4-by-8 size was chosen to take advantage of standard materials sizes. Copper pipe comes in 20′ lengths, which can easily be cut to three 80″ lengths. With return bends or street ells added (photos 4 and 5), the piping assembly should just snug into the beadboard box (photo 7). Before inserting, though, clean all surfaces thoroughly with soap and water, then cover with a flat black paint.

Herrington doesn't think double-glazing is necessary in his climate; it would prevent convective heat loss more effectively in colder areas. He single-glazes with Kal-lite premium fiberglass cover (.025″ thick), bolting it in a frame of plywood strips and sealing it with butyl-rubber silicone.

From collector to system

The diagram is Herrington's proposal of how a three-panel system might be hooked up to provide hot water for a typical household. Panels can easily be placed on a south-facing roof; or, if you have the space—as Herrington does—mount them on the ground or on a fence.

"Summer heating of hot water in my climate is simple," he tells us; "a 32-sq.-ft. collector should supply all my needs. Winter is a different matter; I need at least 90 to 100 sq. ft. of collector."

Herrington uses the heat-exchanger loop to insure a more constant supply of water on cloudy days and at night. Also, since he uses a water conditioner to prevent rust and foam (Rust Raider Heating System Conditioner), he must keep his tap water separate from the water that is pumped through the system.

Performance

In winter, the preheated water may leave the heat exchanger at 95°; on a sunny summer day, it might be as high as 130°. Space doesn't permit us to detail all the careful monitoring Ken Herrington has made on his system. He would rather err on the side of caution, so intent is he on not making any unwarranted claims.

Some figures he sent us for the middle of February are instructive. During a week in which daytime temperatures ranged from 50° to 61°, he reports tank temperatures rose by 40° to 50° each day, when the solar system was working (from 80° to 121° the first day; from 100° to 150° the next). This works out to a mean of about 180 Btu per hour per square foot of collector.

Further performance data are included in a data packet Herrington is offering for those who want more information. Send $5 to Ken Herrington, 769 22nd St., Oakland, Calif. 94612. If you want to ask a specific question (free), include a stamped, return envelope.

J. Don Field, rooftop 'trickle' collector

Not to be outdone by Ken Herginton's elaborate system, a Roanoke, Va., experimenter, working independently from previous PS articles, has also been checking out solar water heating.

Photo and diagrams illustrate the 42-sq.-ft. aluminum collectors that Field installed on his due-south-facing roof more than a year ago. It's a trickle collector: Water flows directly over a corrugated-aluminum surface backed by a slab of insulation—turn page for assembly sketch. (At press time, Field reports some success with a new copper-tube collector he built recently.)

Materials for the aluminum unit cost Field about $300. He reports average monthly savings of $7 (150 to 165 kw shaved off his power bills), so payback time is about four years.

As with Herrington's system, this setup needs a heat exchanger: If an aluminum collector is used, it's a good idea to mix in water inhibitors to prevent corrosion. Field retains his electric water heater as a backup.

Collector assembly

Field chose aluminum over copper for its lower price, and a 3′-by-16′ collector size for the convenience of using standard-cut lumber. A basic box is first made by nailing 2-by-4's to a sheet of 4-by-8-by-½″ plywood. Next, add a 1½″-thick layer of insulation. Initially, Field used Styrofoam, but

Continued

now recommends using fiberglass.

Atop the insulation goes one sheet of temper-rib aluminum roofing painted flat black. A collector pan at the lower end leads to a 3/4" PVC drain line. The entire collector is covered with double-strength window glass.

A year ago April, Field was ready to test the collector, using a temporary five-gallon tank. On a day when ambient temperature was 42°F, he was able to heat the five gallons from 55° to 120° in 90 minutes.

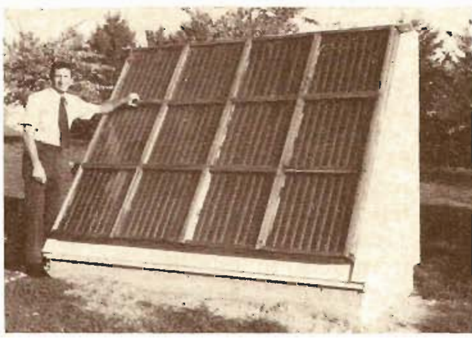
Problems beclouded him, though. Condensation blotted out sunlight, and the aluminum surface became discolored by water passing over it. Field solved both problems by pop-riveting another sheet of black aluminum over the existing one and running water between them.

What good is that sun-warmed water if you don't have it at night, or on a rainy day? Insulated storage is the answer. Field made a 100-gallon tank from two sheets of 4-by-8-by-1/2" plywood, coated the inside with fiberglass, then wrapped top, bottom, and four sides with two inches of Styrofoam. Later, he decided to add six-mil polyethylene up to the water line inside to prevent leaks. For a heat exchanger, tap water is run through coils of 3/4" copper pipe submerged in the tank; this preheated water then enters the electric heater, nearby.

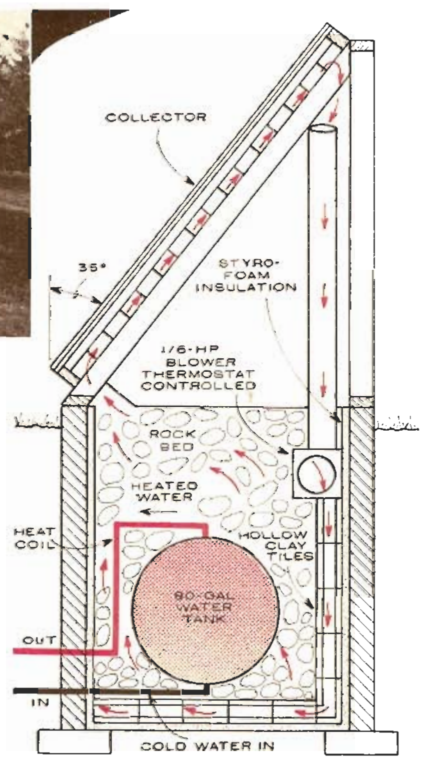
Performance varies with season, of course. In September and October, Field recorded average tank temperatures of 127° on all-sunny days, and 115° in early December. In January and February, with the new copper collector added (which doubled the original size), late-afternoon tank temperatures generally ranged from 90° to 130°, with a peak of 142° on Feb. 27 (ambient temperature, 70°). Field's electric heater was not used at all from Feb. 10-29.

For a specific question, send a stamped, return envelope to J. Don Field, 4601-A Renfro Blvd., NW, Roanoke, Va. 24017.

John Snell: circulating-air collector



If your roof isn't oriented to take full advantage of the sun, don't despair. This Nebraska DIY'er built a freestanding unit in his backyard and linked it to his home plumbing with underground piping.



This project is unique in several ways: Air, not water, is used as the heat-transfer medium; the 48-sq.-ft. collector surface is made of 600 aluminum beer cans stacked in a wood A-frame structure; beneath it, a 180-cu.-ft. underground storage pit acts as a "heat trap" for the heated water.

Economics. Snell figures he saves about 300 kwh per month (more in summer), for an average monthly electric-bill reduction of about $8 to $12. Total material costs, excluding labor, came to $3 per square foot (about $150), so Snell expects to be home free in less than two years.

Construction. The pit is 4' wide, 9' long, and 5' deep. Its walls are of hollow-core clay tiles (4"-by-8"-by-12") lined with Styrofoam insulation. An 80-gallon galvanized steel tank is buried under five cubic yards of fist-size rocks. As water leaves the tank, it passes through a 40' heat-absorption coil before entering the 50-gallon electric hot-water heater in Snell's basement.

Above ground, the collector housing is made of 2-by-4 framing lumber and 1/2" exterior plywood sheathing. Snell emptied all the aluminum cans, painted them flat black sunside, and white bottomside, then stacked them in rows with air channels in between. The housing is double-glazed with two 24"-by-24" panels of common window glass, with 3/8" air separation for each section. The collector is oriented due south at 35° from vertical, the proper angle for his latitude.

A 1/6-hp, 1725-rpm split-phase fan circulates heated air through the rock pit; it turns a direct-drive six-inch squirrel-cage blower with suction and exhaust ducts.

Performance. Snell is quite satisfied with output. "High temperatures continue to be in the 125°-135° range, depending on quality and quantity of sunshine," he reports. But after one 10-day sunless period in December, the storage temperature dropped to 55°, the same as the input water.

For specific questions, send a stamped return envelope to John R. Snell, Route 1, Gretna, Neb. 68028.

Ron Hannivig: rooftop

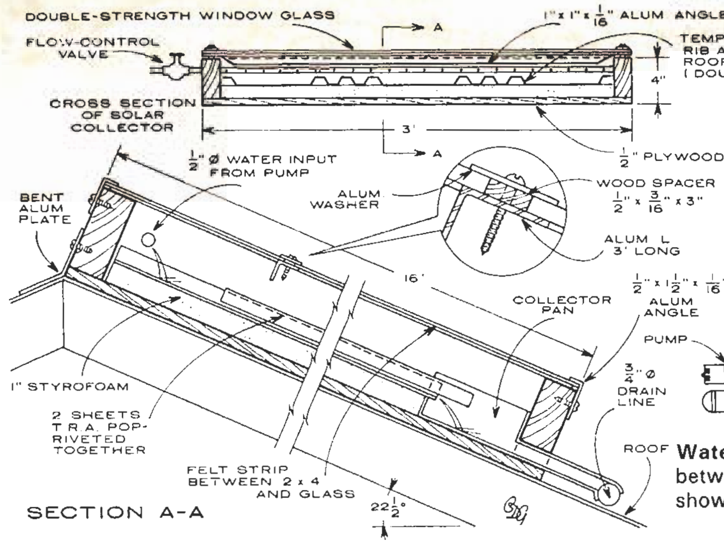
What started as a do-it-yourself project two years ago has since blossomed into a full-time solar distributorship for Ron Hannivig (turn page to next article). The tank/collector module described here is the original homemade version that anybody can try.

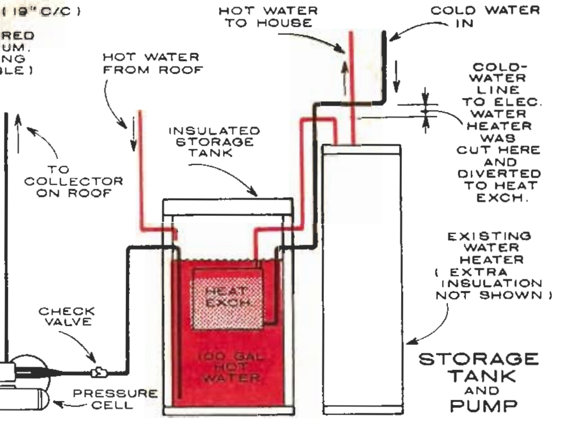
Tank and collector are exposed on the roof, so it's a natch for Hannivig's Florida climate. (For colder locations, use the heat-exchanger systems, such as Herrington's or Field's.)

This system works on the thermosiphon principle, thus eliminating the need for a circulating pump: As water in the collector is heated, it expands, rises, and passes into the storage tank. Denser cold water then fills the collector, and the cycle continues as long as the sun keeps shining.

Note that the photo shows *two* 40-gallon tanks: one standing and one lying. Local building codes made this setup more practical, though the drawing shows a single vertical tank, which can be a full 80 gallons, or as big as the system can handle.

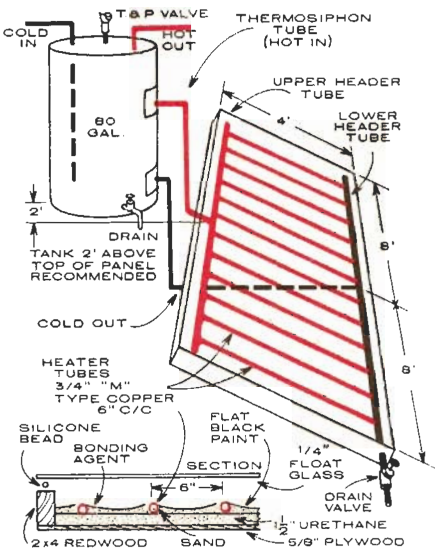
Economics. Cost of materials for the collector approximated $250, and the tanks were purchased off-the-shelf for





Water pumped up to rooftop collector (left) trickles down between two sheets of corrugated aluminum. Diagram above shows heat exchanger and tie-in with backup heater.

tank collector



$150. Estimated pay-back time is about three years. Hannivig reports that during the balmy Florida summer, his system can provide up to 95 percent of his family's hot-water requirements; in winter, up to 65 percent.

Construction. The wood-frame collector covers 64 sq. ft. (two 4′-by-8′ panels) insulated with 1½″ of urethane. Three-quarter-inch copper tubing (see diagram) is T-connected and mounted on top of the urethane. In the device shown, sand was packed around the pipes for heat transfer (see detail) and sprayed with a stucco binding agent. Assembly was then painted flat black. Finally, ¼″ float glass was silicone-bonded to the sides of the frame for an "effective weather-tight glazing." Pressure-relief valve is a must.

Performance. Hannivig set his conventional electric heater to kick in at 130°, but finds solar-heated water generally available at 135°-140° during the day.

For a specific question, send a stamped return envelope to Ron Hannivig, 2525 Key Largo La., Fort Lauderdale, Fla. 33312.

Peter West: through-the-wall collector

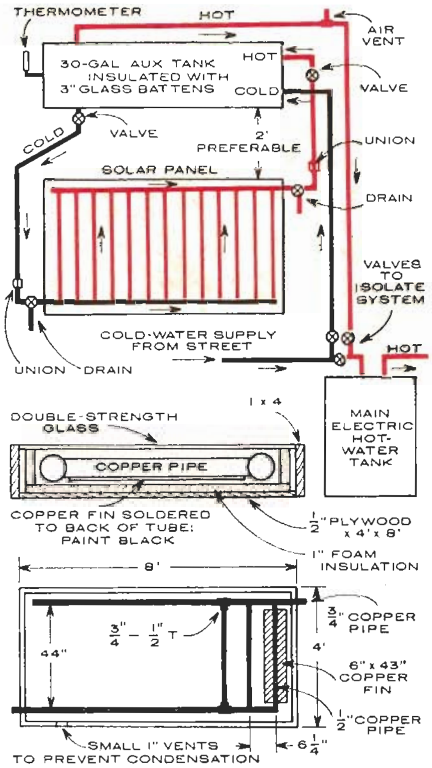
Why allow fuel bills to dampen your vacation? This "summer" heater is the least complicated of the five presented here. Specifically, it's designed to supplement an existing electric hot-water system from March through November at a vacation home on the Delaware coastline, where the mean annual sunshine totals about 2600 hours. Copper was chosen to offset the effects of salt-laden air. The system is not freeze-proof, lacking a heat exchanger.

Once again, the thermosiphon principle is the key (see Ron Hannivig's project, at left). A 4′-by-8′ collector panel preheats water that's siphoned to a 30-gallon storage tank ceiling-mounted indoors, several feet above the collector.

Economics. West invested about $200 in materials. His heating figures indicate a gain of 13,000 to 18,000 Btu per day, for a total savings of $40 from May through October. Break-even time: about four to five years.

Construction. For the collector panel, West used two ¾″ copper headers and T-soldered them at six-inch intervals to sixteen ½″ vertical copper risers. For faster water flow, the risers were designed to run the four-foot width. Pressure-test this piping before proceeding, as West did.

Next, solder 6″-wide copper flashing strips to the back of each riser, using 50-50 lead/tin solder with a good flux. Heat three to six inches at a time, and apply pressure with a wood block as the solder cools. Clean the panel and paint it flat



black. Finally, mount the piping in a 4′-by-8′ box made of ⅝″ exterior plywood to which you have added 1-by-4 sides. Paint the box and line the bottom and sides with one inch of urethane-foam insulation. A 30-gallon galvanized water tank was ceiling mounted, wrapped in four inches of fiberglass insulation, and boxed with ¼″ plywood.

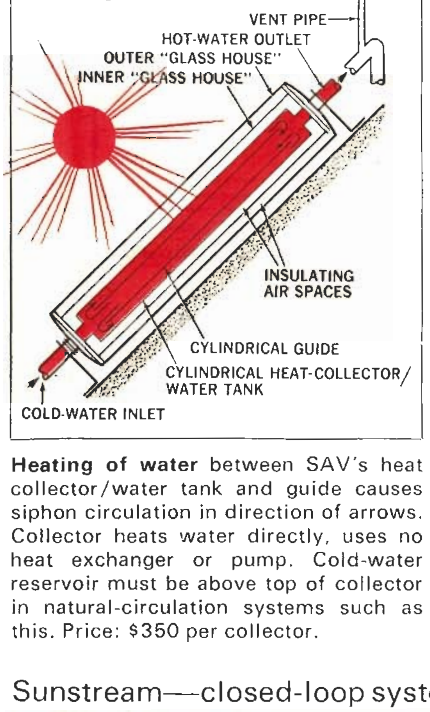
Performance. In a week-long evaluation in mid-July, when water demands were greatest, West reports that the system peaked at 115° in mid-afternoon (original water-in temperature was 70°), and stayed at 95° through 7 p.m. even with demands from washing machine, dishwasher, and showers.

For specific questions, send a stamped return envelope to Peter West, 12901 Melville Lane, Fairfax, Va. 22030.

For general installation tips and product information, turn to page 142

Solar water heaters
you can buy now

Cylindrical collector / storage tank



Heating of water between SAV's heat collector/water tank and guide causes siphon circulation in direction of arrows. Collector heats water directly, uses no heat exchanger or pump. Cold-water reservoir must be above top of collector in natural-circulation systems such as this. Price: $350 per collector.

Don't have time or tools to build your own? Take your pick off the shelf

By RICHARD STEPLER

If you can't build a solar water heating system from scratch (see preceding article), now you can buy one and have a local dealer or licensed plumber install it, or install it yourself.

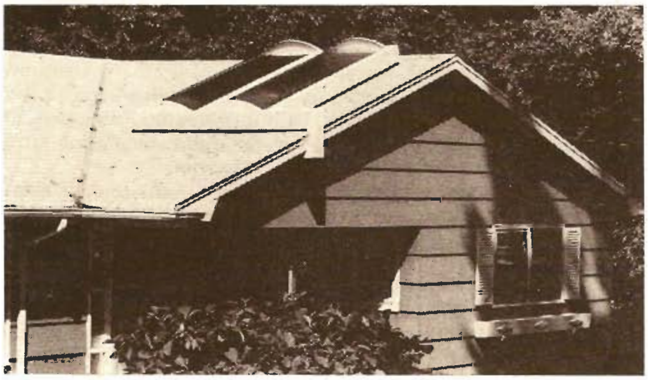
There shouldn't be anything surprising about this fact; we're really just catching up with ourselves. In the 1930's solar water heating was commonplace in Florida—before the days of "cheap" fossil-fuel energy. In other parts of the world, conventional energy sources have either been expensive, or unavailable. Water heated by the sun is a practical reality in Australia, New Zealand, Japan, Israel, and other countries.

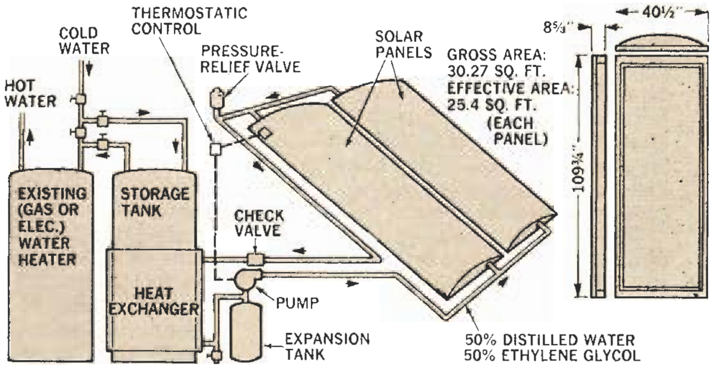
A study by the consulting firm, Arthur D. Little, Inc., notes that in parts of Australia, solar water heaters are required by law. In Japan, more than 160,000 solar hot-water units were sold in 1974 alone; there are already 5000 to 8000 solar water heaters operating in the southwestern U.S. and Florida.

The technology exists; it's tried and proven. Now that our days of profligate energy use are over, we Americans are rediscovering solar water heating. Here's a sampling:

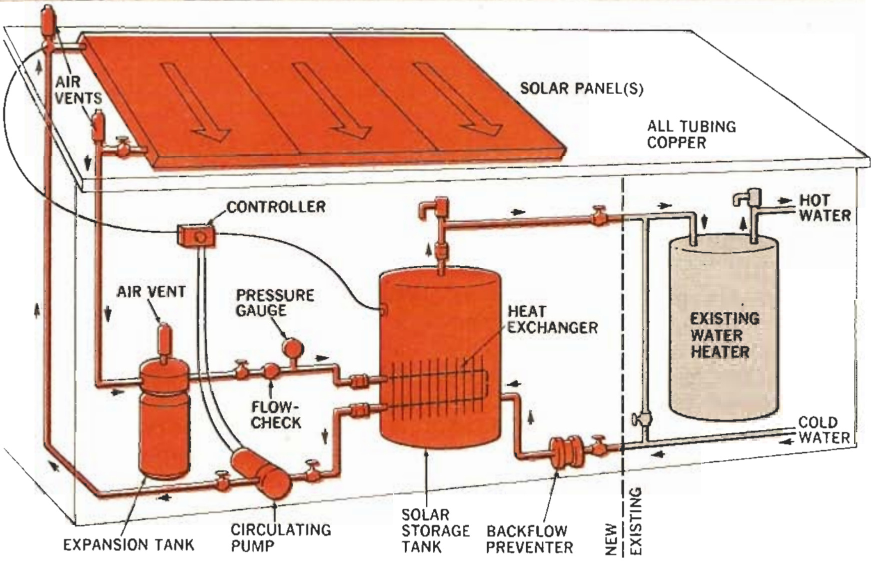
- In Florida, solar is taking off again. A recent solar trade show in Orlando was jammed with manufacturers' exhibits, including Ron Hannivig's Largo Solar Systems (see preceding article). Hannivig is both an importer (Sola-ray from Australia) and manufacturer of a solar water-heating system of his own design.
- In Hawaii, where space heating isn't needed but where water heated by expensive oil-generated electricity can push a family's bi-

Sunstream—closed-loop system with aluminum absorber plate





Curved acrylic collector covers look nicer and make snow readily slide off. Absorber plate is aluminum; maker says distilled water/antifreeze solution will not corrode. Heat exchanger is outside storage tank to prevent possible contamination of water by toxic ethylene glycol. Grumman, the maker, says two collectors give 50 gal. of hot water per day. $995.



Solar water heater for a beachhouse

Sunworks' Solector, like Sunstream, is indirect, closed-loop system, where water/antifreeze solution is pumped through collectors to heat domestic water via heat exchanger. Heat exchanger, however, is inside storage tank. Nontoxic propylene glycol is the antifreeze. Collector absorber plate, heat exchanger, and all piping is copper; absorber plate has a selective surface—a chemical treatment that darkens and microscopically pits the surface. This makes the plate absorb heat well and emit it poorly. Collector cover is single-pane 3/16-in. tempered glass, with no iron content, for high solar transmittance. Price of complete system installed with three collectors (60 sq. ft.) is $1600. This is suitable for a family of four.

monthly utility bill above $100, Sunsource Pacific is installing Israeli-made Miramit solar water-heating systems. Sunsource estimates that the system will yield a 12-14-percent return on investment.

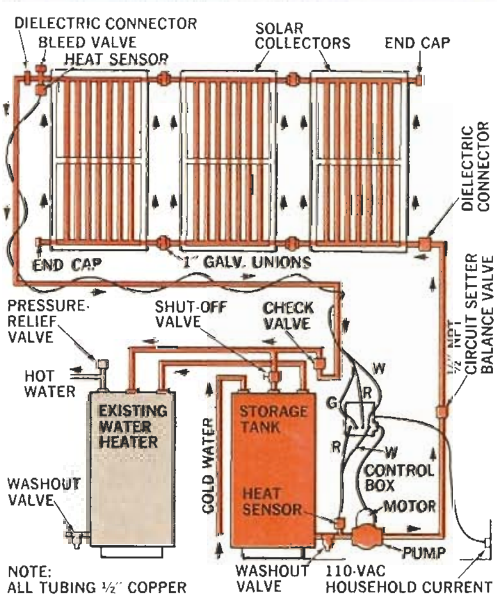
- In the northeast, which has some of the highest utility rates in the country, New England Electric is equipping 100 homes with solar water-heating systems. Cost of the systems ranges from $1000 to $1600; the homeowner pays $200 and agrees to participate in the one-to-two-year test period.
- On New York City's Lower East Side, there's a renovated tenement with a Sunworks water-heating system. The collectors are mounted in racks on the building's flat, tarpaper roof.

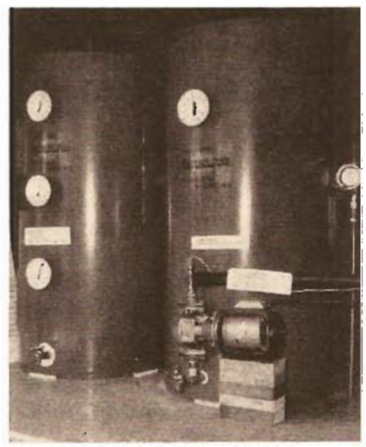
Does solar pay?

A solar hot-water system that will supply 80 to 90 percent of a typical family's needs requires only two or three collectors—unlike a space-heating system, which needs a collector area equal to one-third to one-half of the floor space being heated [PS, Mar. '75]. Of course, other factors must be considered, such as quality of insulation, orientation to the sun, efficiency of

[*Continued on page 137*]

Direct solar water-heating system





Israeli-made Miramit system circulates potable water supply through collectors so no heat exchanger is needed. Direct systems such as this work well in areas like Hawaii where freezing does not occur. Shown is installation by Honolulu-based Sunsource Pacific, local dealer for American Heliothermal. If you live in the frost zone, your direct system will need an automatic drain-down feature. The water is automatically drained out of the collectors at a preset temperature (a few degrees above freezing). Garden Way Labs and General Energy Devices (see manufacturers' list at end of article) make such systems.