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A New Breed of Solar Devices: The Freon Charged Collector

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The New Breed of Solar Devices:

# The Freon-Charged Collector

December 1985

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Most solar domestic hot water (DHW) systems installed to date have been hydronic — that is, water-filled. A mixture of water and propylene glycol, a non-toxic antifreeze, is circulated by a small pump through roof-mounted solar collectors, is heated by incoming solar radiation, is piped to a hot water storage tank where it surrenders its heat, and is then returned to the collector to be reheated. A few DHW systems use silicon or mineral oils for the heat transfer. More and more, however, Freon is being used as the transfer material.

Freon is the duPont trade name for the large class of fluorocarbons known as refrigerants — the fluids used in refrigerators, air-conditioners and heat pumps. All evidence indicates that refrigerant-charged solar DHW systems are superior in efficiency, lower in cost, simpler, require less maintenance and have a longer life span.

## How Freon-charged DHW Systems Work

In theory, all refrigerant-charged systems operate similarly. The collector is filled with liquid Freon. Solar radiation heats the Freon in the collector and changes it from a liquid to a vapor. Even though the

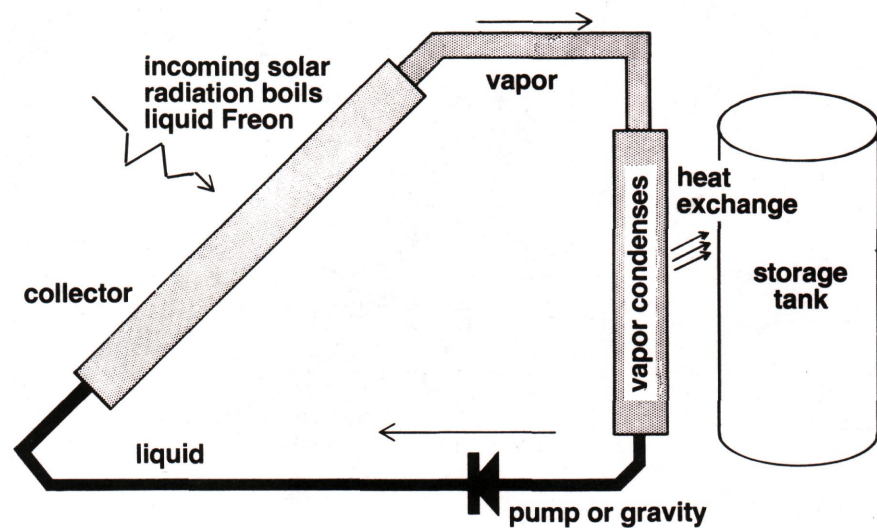


Fig. 1 Solar energy boils the liquid Freon. The vapor moves to the heat exchanger, where the Freon condenses, passing the latent heat to the storage water.

Freon temperature does not change, enormous amounts of heat are stored as latent heat by this change. The Freon vapor then moves by its own vapor pressure to a heat exchanger, where it condenses, yielding the latent heat of vaporization to the storage water. The condensed Freon liquid is then returned by pump or gravity to the collector so the cycle can begin again (Fig. 1).

In practice, there are two basic types of refrigerant-charged DHW systems: active and passive, or thermosiphoning systems. An active system requires a small pump to return the Freon to the collector; a passive system does not.

Fig. 2 shows a typical active system built around the Solaraide<sup>®</sup> tank with integral heat exchanger recently introduced by Rheem Manufacturing. Condensed

## FREON LINES

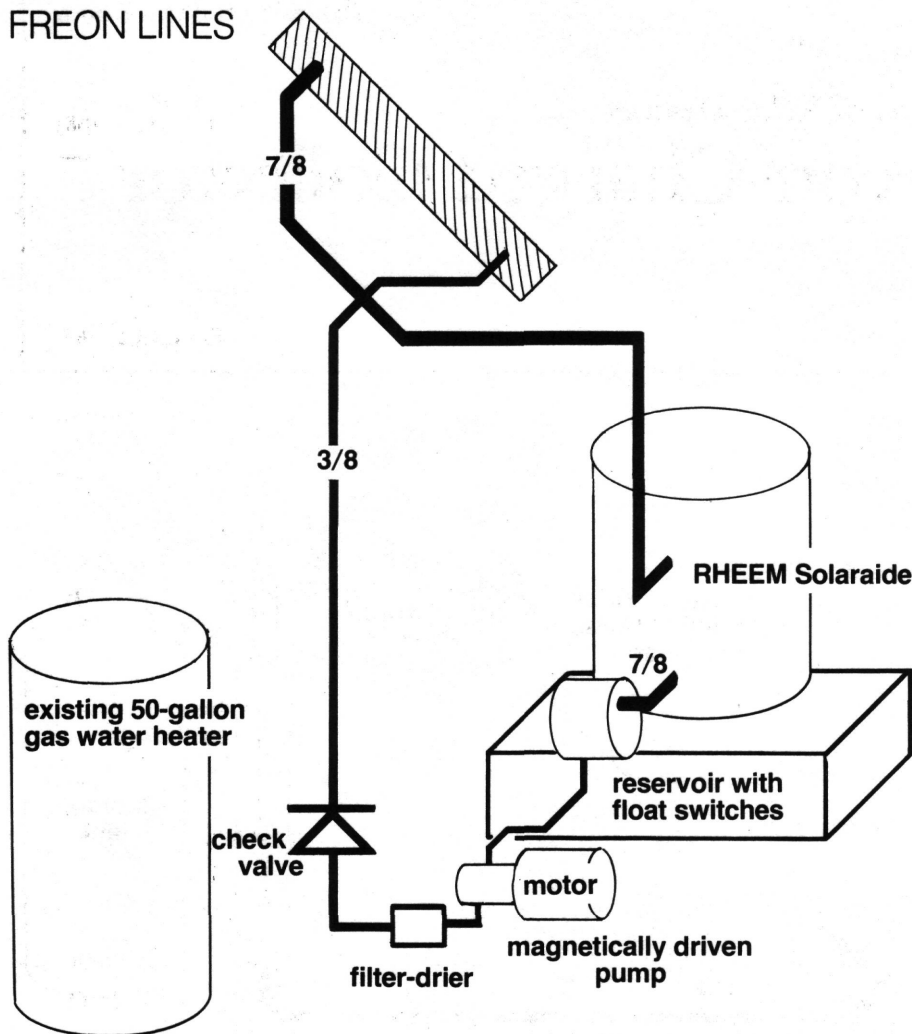


Fig. 2 An active system charged with Freon-114.

Freon-114 leaves the Solaraide heat exchanger and enters a small reservoir, where the liquid level is sensed magnetically. The pump turns on when the reservoir is full, off when empty. Electronic decision and control devices are not required.

The simplest of all solar DHW systems is the true thermosiphon (Fig. 3). In a thermosiphon, the condensate falls back to the collector by gravity. This means that the collector must be located below the storage tank. Sometimes the storage tank is located within the same enclosure as the collector — that is, mounted on the roof. Proper tank insulation and the diode action of the thermosiphon prevent the storage water from freezing. The supply and return water lines must be protected against freezing with heat tapes or by some other means.

The hybrid DHW system appears in many variations. In Fig. 4, the heat exchanger is located above the collector and the condensed Freon returns to the collector by gravity. However, the storage tank is located below the exchanger, so the storage water or some second transfer fluid must be pumped through the exchanger. Another common variation has the heat exchanger located within the collector itself — the water pump runs at a trickle during non-collection to prevent freeze-up. The disadvantage of such systems is their complexity.

**TABLE I. Manufacturers of Freon-Charged Solar DHW Systems**

Company	Code	Address
Colt Energy Sys.	P	1720 Commerce Way, Paso Robles, CA 93446
Dell Solar	H	1 Second St., New Rochelle, NY 10801
Eagle Comm. Serv.	H	P.O. Box 1100, Cottonwood, AZ 86326
Energy Engr.	A,P	4616 McLeod NE, Albuquerque, NM 87109
Golden Horizons	H	P.O. Box 1315, Ronkonkoma, NY 11779
Norsun	H	P.O. Box 760, Manotick, Ont K0A 2N0
SOESI	H	10639 S.W. 185th St., Miami, FL 33157
Solar Research	H	525 N. Fifth St., Brighton, MI 48116
Sundial	A	RD 2, Box 352, Avondale, PA 19311
Sunland Industries	H	4024 E. Broadway, Phoenix, AZ 85040
Suntime	P	1 Chase St., Bridgton, ME 04009
Urja	P	3401 W. Fordham Ave., Santa Ana, CA 92704
Western Solar	H	2506 Zurich Dr., Fort Collins, CO 80524

The above list was compiled from magazines *Solar Age* and *Solar Engineering and Contracting*.

## Advantages of Freon-charged Systems

A refrigerant-charged collector is inherently more efficient. A typical hydronic collector experiences a rise of 30 degrees F from inlet to outlet. Because Freon traps energy by changing states, not by increasing temperature, losses from enclosure and piping are lower.

Second, there is no more efficient process than condensation for heat exchange. Even a slight difference in temperature will produce condensation. In short, the exchange of heat to the storage water is very efficient.

Third, hydronic systems require electronic decision and control devices to turn on and shut off the pump, and they respond sluggishly to changing solar conditions. Worse yet, their temperature sensors drift off calibration. Freon systems respond instantly and accurately by "boiling." Therefore, more of the available solar energy is utilized.

Fourth, Freon does not degrade. The antifreeze-water mixtures used in hydronic systems break down over time and must be replaced periodically. Hydronic systems are also subject to scaling, corrosion, erosion, outgassing and galvanic action. Like a refrigerator, a properly designed Freon system should last 20 years without maintenance.

## Choosing a System

Table I lists manufacturers of refrigerant-charged solar DHW systems, coded A, P or H to denote active, passive or hybrid systems. Contact these firms for detailed information on their products and nearby installers. The required collector area will be smaller than that of comparable hydronic systems. Passive systems are, of course, less expensive because of their simplicity. Pay special attention to freeze protection with hybrid

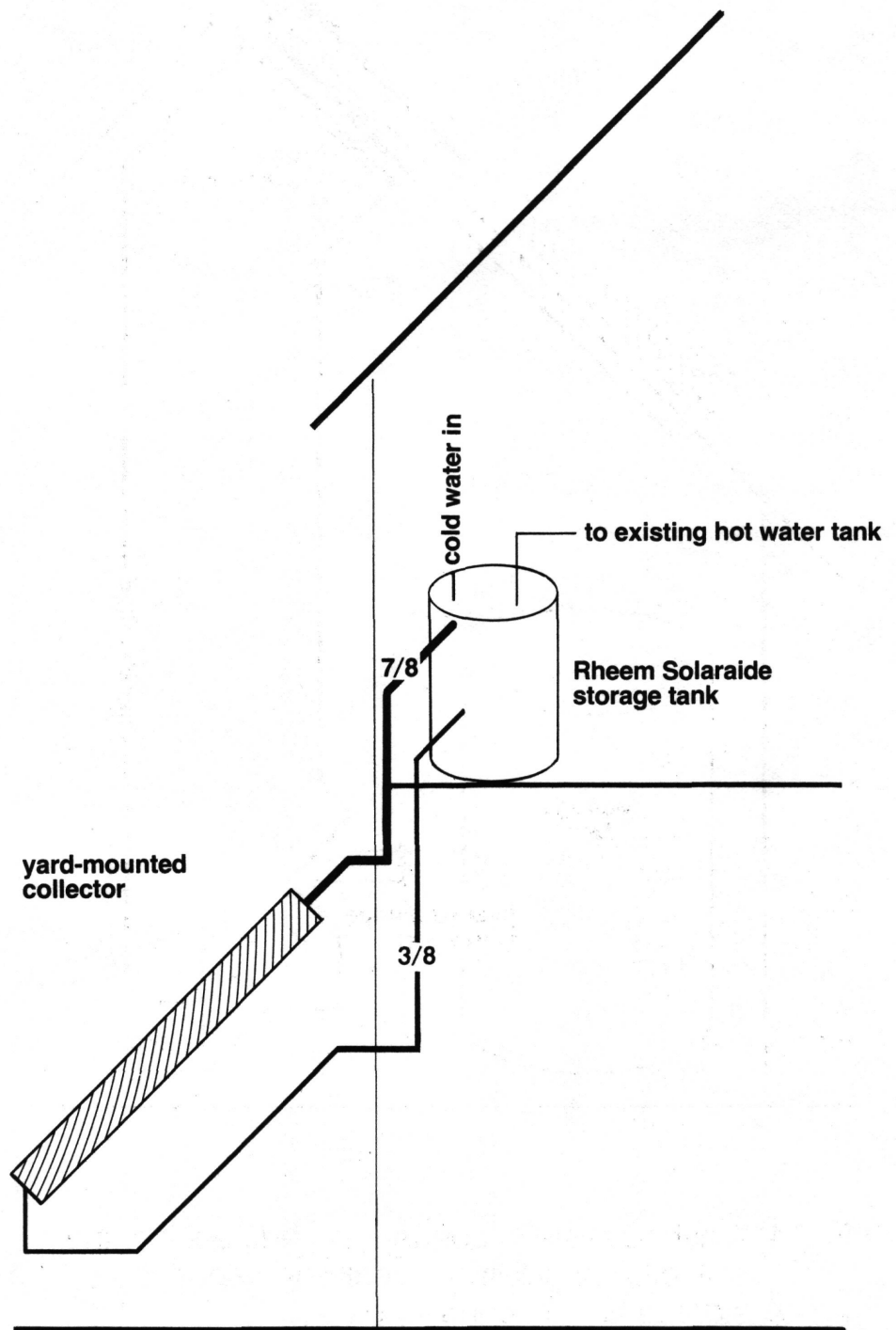


Fig. 3 A passive system charged with Freon-114.



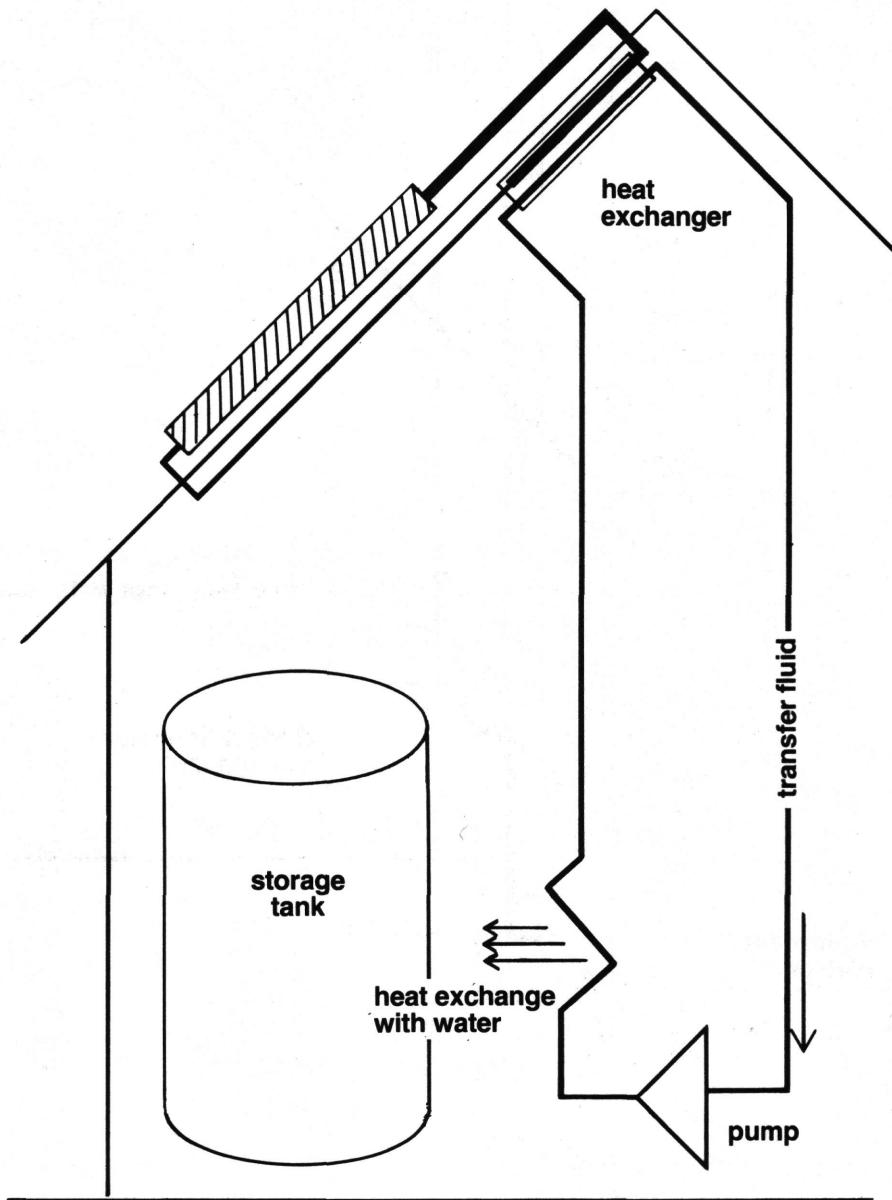


Fig. 4 A hybrid system: condensate falls back to the collector by gravity — heat is transported to storage by a second loop.

types. In the past, hybrid systems have been lost because of water pump failure — in one case, because of a blown fuse. Most of all, look for simplicity, the cardinal rule of good engineering.

### Safety

Freon DHW systems use either Freon-114 (duPont's recommendation) or Freon-11. The reason is twofold. Freon-114 and Freon-11 are low pressure refrigerants that enable the use of standard hydronic collectors, and these two Freons are two of the most benign of all refrigerants. Humans can tolerate R-114 concentrations as high as 20 percent by volume for as long as 2 hours without apparent harm. Freon systems are not do-it-yourself projects, however. Installation requires the special skills, tools and safety habits of a refrigeration technician. Homeowners eager to reduce costs might contract with a refrigeration technician and agree to supply construction labor while the technician supplies the special refrigeration skills. One-of-a-kind systems should be designed by a member of ASHRAE\* and built by a qualified refrigeration technician.

\*ASHRAE: The American Society of Heating, Refrigerating and Air-Conditioning Engineers.

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