CHAPTER 4

TYPICAL SOLAR SYSTEM CONFIGURATIONS, FLOW CONTROL AND FREEZE PROTECTION

4.0 INTRODUCTION

If a pool or spa heating system is to operate efficiently the most appropriate piping configuration, flow control method and freeze protection strategy must be chosen

4.1 PIPING OPTIONS

Solar pool heaters usually are connected to existing pool plumbing systems A schematic of a frequently used pool filtration loop is shown in Figure 4.1a. The pump draws the water from the skimmer and main drain, forces it through the filter and returns it to the pool through the conventional heater Debris-catching strainers usually are installed ahead of the pump Solar pool heating systems usually consist of 1 an array of black pipes or tiles, 2) an expanse of solar mat, 3) a number of plastic sheet or metal absorbers or 4) conventional glazed and insulated solar collectors They are interconnected to the pools filtration and circulation system in one of the following ways

4.1.1 Systems with Low Pressure Drop Across the Collector Array

Solar systems designed to operate with small pressure losses can be added as shown in Figure 4.1b. A spring-loaded check valve is installed downstream from the filter to prevent collector water from backwashing through the filter and flushing trash into the pool from the strainer when the pump is shut down. A manually operated or

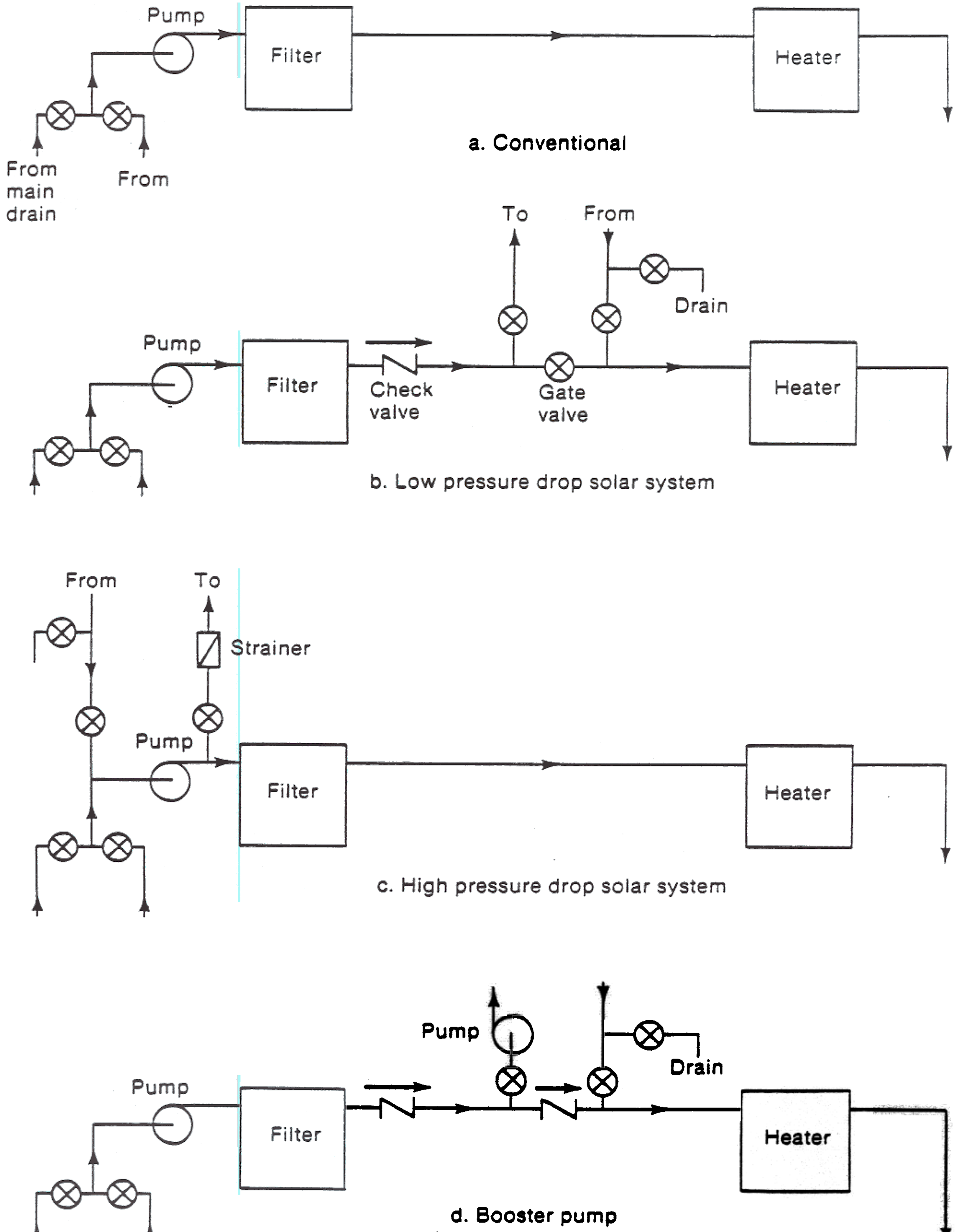


Figure 4.1

Pool Plumbing Schematics

automatic valve is placed in the main line between tee's that feed collector bank and return the solar heated water Gate valves may be placed in the feed and return lines for isolating the solar system from the pool filtration system when the filter is being backwashed or when adjustments are being made to the solar system. When solar heating is desired, the pump timer is adjusted to operate during daylight hours and the valve in the main line is closed somewhat to restrict or fully interrupt the flow and to force water up through the collectors. Valves on the lines to and from the solar system should be fully open.

Flow through the collectors may be increased by closing the valve in the main line. It may seem logical to reduce the flow rate through the solar array to make the return water warmer, and this can be done; however, it is <u>not</u> logical--the collectors will be forced to operate at higher temperatures, their efficiencies will drop (see Chapter 5) and less solar energy will be delivered to the pool. The temperature rise through the collectors should be kept low -- 10°F or less on warm sunny days -- unless the manufacturer's specifications call for a higher temperature differential.

Forcing water through the solar system uses some of the pump's power, thus reducing the flow rate through the pool filtration system. As the main line valve is closed, pressure on a gauge mounted on the filter or discharge side of the pump body will rise slightly. If valve is closed entirely, all of the flow is diverted through the solar array and the collection efficiency increases. If the pressure at the filter does not rise unduly, the solar system should be operated in this way. However, the more the pressure rises the slower the flow through the filtration system This will increase the length of time required for the entire pool's contents to be filtered Thus it may be necessary to allow some of the flow to bypass the collectors. An inexpensive plastic flow meter can be used on the main line connection to monitor flow rates through the filtration system. Check with local building officials to determine minimum filtration flow rates or pool turnover times required in your area

4.1.2 Systems with High Pressure Drop Across the Collector Array

Those solar systems which produce large pressure drops can be installed with extra pumps or plumbed as shown in Figure 4.1c The feed line to the collectors is connected to the discharge side of the pump, ahead of the filter, and the return line is connected to the suction side of the pump. The full pressure differential produced by the pump is available to force circulation through the collectors.

When solar heating is desired, valves to the solar system are opened If the pressure at the filter gauge drops substantially, or a flow meter on the main filtration line indicates that the pump is being short-circuited by excessive flow through the collector loop, one of the valves can be closed slightly to force more water through the filtration system

Since water will pass through the collectors before it goes through the filter system, a strainer is recommended on the feed line to capture medium-size particles that can clog small fluid passageways in the collectors

BOOSTER PUMPS

When the existing pool pump lacks enough power to circulate sufficient flow through the solar system and the filtration system in either of the configurations shown, a booster pump may be required It should be installed as shown in Figure 4.1d Common pool-circulating pumps with or without the strainer basket are suitable for this application

The booster pump should be placed in the line feeding the solar collectors, not in the main circulation line. In this position it can be operated (consuming electricity) only when circulation through the solar collectors is wanted. Of course, the booster pump may be operated by the same time clock as that for the filter pump, but more often it will have a separate control. If both pumps operate from the same timer, it should be set so that the pumps come on during daylight hours If the booster pump is separately controlled, the filter pump may run for a longer portion of the day, and the booster pump should turn on during appropriate periods but only when the filter pump is operating

4.2.1 Controlling the Pump's Operation

Manual flow control or control with time clocks is simple and inexpensive but has drawbacks Since clocks do not sense weather conditions, the circulating pump may be running when there is insufficient solar energy available to warm the pool water. Collectors may lose energy rather than gain it if weather conditions are unfavorable Automatic flow controls overcome this difficulty. The most common plumbing schematic for systems using these devices is shown in Figure 4.2

Accurate differential temperature control is difficult to achieve because of the small temperature rise which takes place in solar pool heaters. A sensor, tapped into the piping at a convenient place ahead

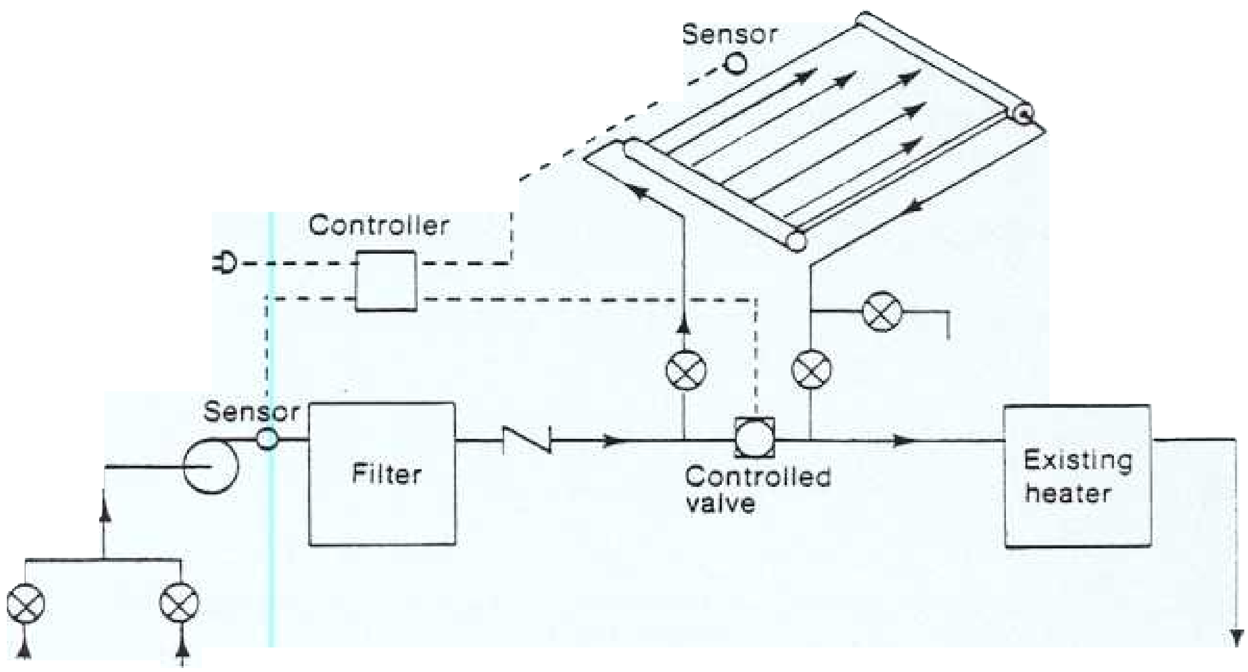


Figure 4.2

Automatic Control Schematic

of the collector return line, measures the pool water temperature Another sensor is housed in a plastic block and placed near the solar collectors (or it may be attached to the collector outlet) so that its temperature parallels that of water at the outlet of the collector When the pool water temperature exceeds the collector water temperature, the control valve remains in the open position and the flow bypasses the collector loop When the collector water temperature exceeds the pool water temperature, the valve is closed, forcing the flow through the collectors When operating properly, a differential controller automatically adjusts to changing conditions, monitoring variations in collector temperature caused by clouds, other weather factors, and the approach of evening When collector temperature drops, the control de-energizes the valve and flow bypasses the collector. Maximum pool temperature limits can be programmed into some controls In practice it has proven equally effective to control the flow through the collectors with a single solar sensor, which turns on the solar pump and/or activates the diverting valve above a fixed solar intensity level

FLOW CONTROL VALVES

Control valves may be actuated hydraulically or electrically. One of the earliest valves used, and one that is still popular today, is a hydraulically operated pinch valve consisting of a cylinder with expand-

bladder inside A high-pressure line connected to the discharge side of the pump is used to expand the bladder, pinching off the flow and diverting it through the solar system. A low-pressure line connected to the suction side of the pump deflates the bladder and allows the flow to pass unimpeded. Switching between the high- and low-pressure lines is accomplished by an automatic controller

Electrically operated valves also are common. The control signal may be used to operate a small solenoid that, in turn, activates the main valve in much the same way the the pinch valve is activated Irrigation valves are sometimes used for this purpose, but pressure drops across these valves may be excessive Specifically designed and constructed valves for solar pool heating are available in most locations

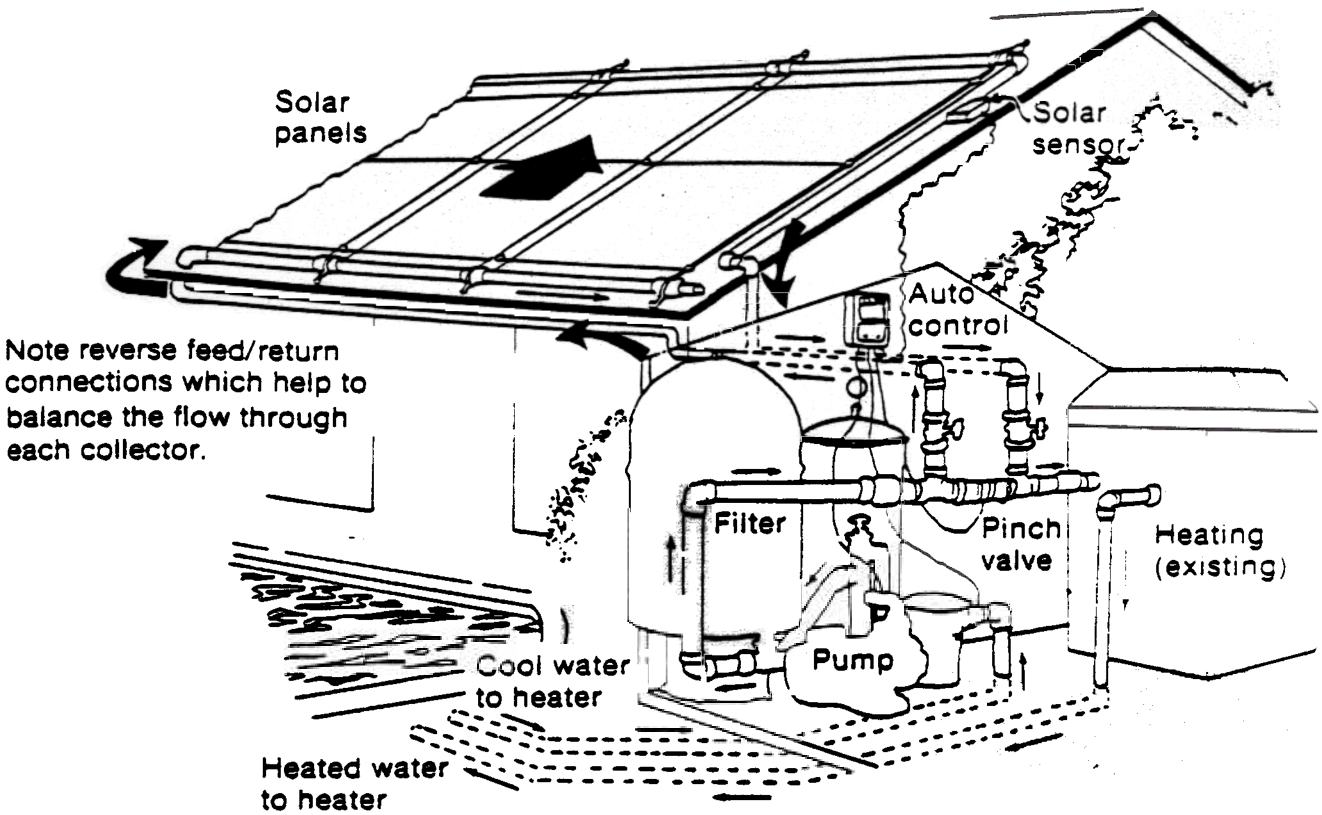


Figure 4.3

Solar Pool Heating Isometric

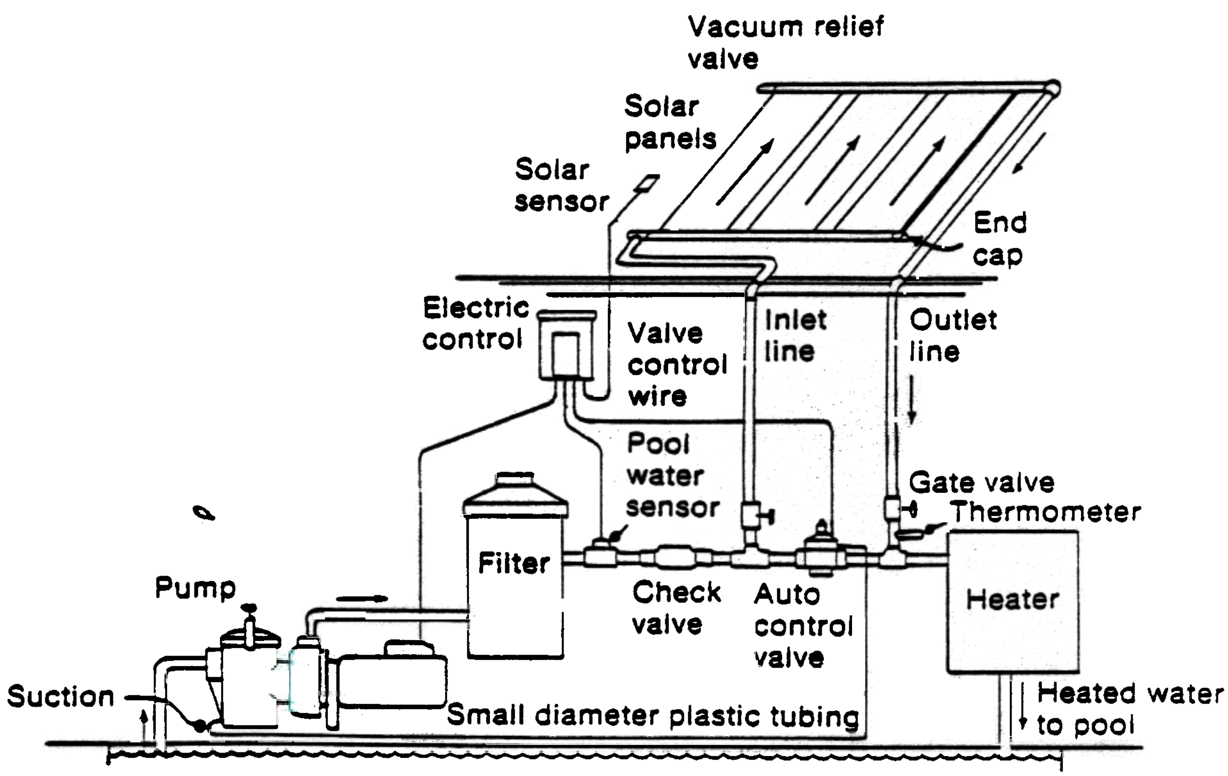


Figure 4.4

Solar Pool Heating Components

Automatic flow control schematics, taken from the installation diagrams of two low-temperature collector manufacturers are shown in Figures 4.3 and 4.4

4.4 MINIMIZING PRESSURE DROP THROUGH THE COLLECTORS

Figure 4.5 shows a method of minimizing the pressure drop across an array of black plastic piping installed to heat a swimming pool Figure 4.6 conveys the same information for plastic panels.

Component	Flow Rate (gpm)	Pressure Drop (psi)
Filter	30	5.0
100 ft. 2" connecting pipe	30	0.8
2000 ft of 1½" ABS (each 500' section)	7½	0.15x5 = 0.75

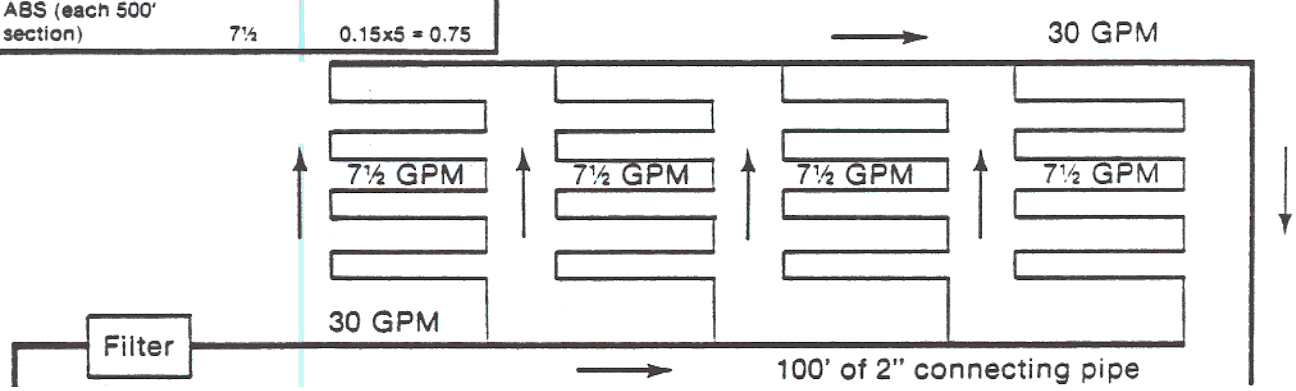


Figure 4.5

Pipe Manifold System

Component	Flow Rate (gpm)	Pressure Drop (psi)
Filter	30	5.0
100 ft. 2" schedule 40 plastic pipe	30	0.8
4 x 10 ft plastic panel (each panel)	6	0.5

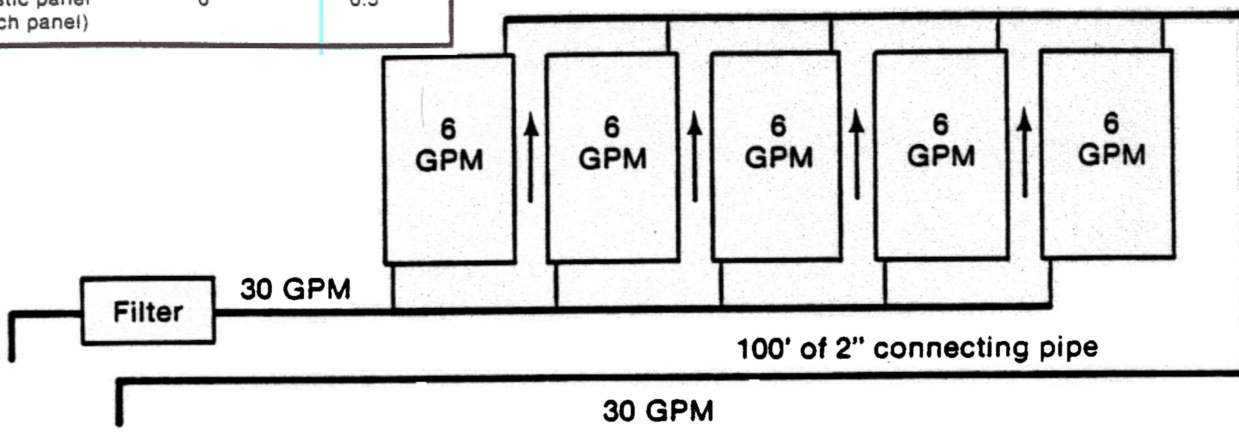
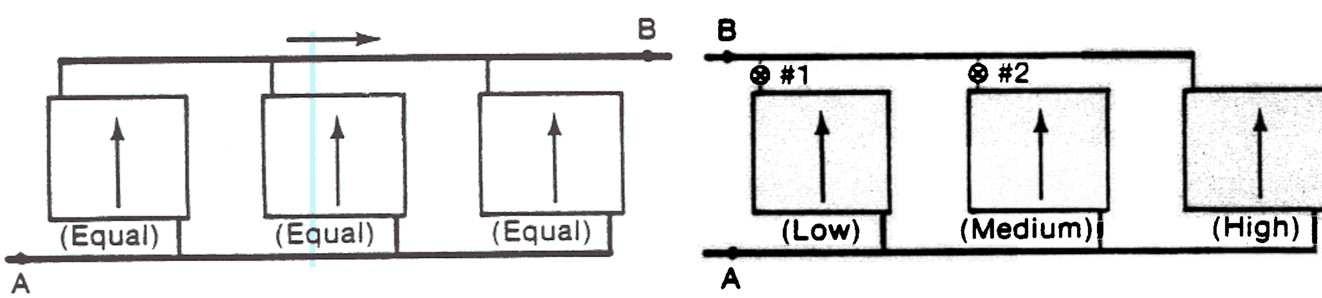


Figure 4.6

Solar Panels Manifolded to Minimize Pressure Drop

Figure 4.7 explores two methods of balancing the flow of water to an array of several collectors. If flow is unbalanced, those collectors receiving the lowest quantity of water will run "hot" and their efficiency will drop because of excessive heat losses to the surrounding air



Paths from point A to point B offer equal resistance regardless of which collector the water flows through.

Paths from point A to point B offer low, medium, and high resistance to flow. Valve #1 must be partially closed, and valve #2 must be closed slightly less in order to balance flow through the system.

Pipe balanced and valve balanced systems

Figure 4.7

Flow Balancing Method

FREEZE PROTECTION

Because solar collectors lose heat to the night sky by radiation, they should be protected when the air temperature drops below 40°F

In Florida, solar swimming pool heaters are usually protected from freeze damage by one of two methods 1) draining the vulnerable portions of the collector system and its piping or 2) circulating pool water through the collector loop during freezing weather The first method is the more popular It requires that the collectors and piping be sloped to allow for drainage Check valves must be placed so that they will interfere with the draining process In the schematic pictured in Figure 4.1b this is accomplished by opening the center gate valve between the pipes to and from the collector array

A vacuum breaker should be installed in a self-draining system to admit air, which allows complete draining of the piping. It should not be placed at the top of the solar collector loop because at that location it may admit air during periods when the pool water is circulating (because of the negative static head in the return pipe from the roof to pool). It should be placed between the circulation pump and the solar collector array. The internal hydrolic pressure at the specific location should be above atmospheric pressure during circulation of the water FSEC Installation Note #13 gives more detailed instructions for calculating an appropriate location

Systems which employ circulation of pool water for freeze protection require no special hardware other than a freeze sensor circuit to activate the circulation pump. However, their protection is afforded at the expense of cooling the pool. Thus, they are most useful in the southern-most portions of the state where freezing weather is a very occasional phenomenon