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SIMS PROTOTYPE SYSTEM 4 - DESIGN DATA BROCHURE

Prepared by

IBM Corporation
Federal Systems Division
150 Sparkman Drive
Huntsville, Alabama 35805

Under Contract NAS8-32036 with

National Aeronautics and Space Administration
George C. Marshall Space Flight Center, Alabama 35812

For the U. S. Department of Energy

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16. ABSTRACT

This document describes a pre-package prototype unit having domestic hot water and room solar heating capability that uses air as the collector fluid. This system is designed to be used with a small single-family dwelling where a roof mounted collector array is not feasible. The prototype unit is an assembly containing 203 square feet of effective collector surface with 113 cubic feet of rock storage. The design of structure and storage is modular, which permits expansion and reduction of the collector array and storage bed in 68 square feet and 37 cubic feet increments respectively. The system is designed to be transportable. This permitted assembly and certification testing in one area and installation in another area without tear down and reassembly. Design, installation, operation, performance and maintenance of this system are described herein.

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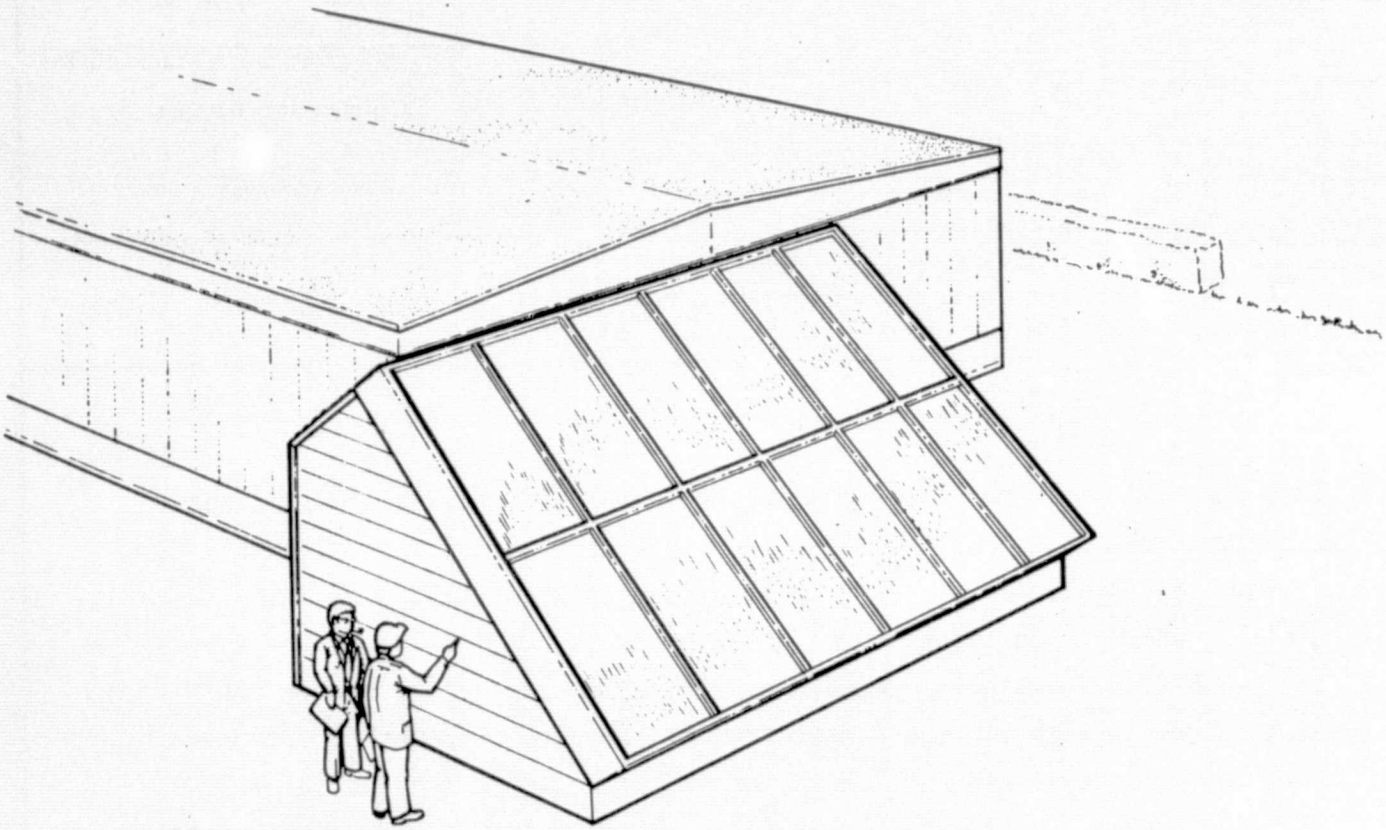

SIMS System 4

Design Concept showing Prepackaged Solar Unit

Arranged with Single Family Dwelling

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1.0 INTRODUCTION

A solar domestic hot water and space heating system using air type solar energy collection techniques is presented for a specific design. The system consists of a modular designed prepackaged solar unit containing solar collectors, a rock storage container, blowers, dampers, ducting, air-to-water heat exchanger, DHW preheat tank, piping and system controls. The system was designed to be installed adjacent to a small single family dwelling. The prepackaged unit is documented for 135, 203 or 271 square foot collector arrays utilizing a particular commercially available solar collector with appropriate storage capacity. This document describes design, performance and hardware specifications in sufficient detail to (1) fabricate a prepackaged unit, (2) to allow architectural engineers and contractor to procure, install the site oriented hardware and finally (3) to permit a contractor to operate and maintain the system.

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2.0 SYSTEM DESCRIPTION

SIMS Prototype System 4 is an air-operated solar space and domestic hot-water heating system. Eleven functional components, as described below are, configured in the system as illustrated in Figure 2.0-1.

Functional Components

(1) Solaron Corporation Series 2001 flat plate air-type solar collectors

(2) Pre-fabricated modular pebble bed, thermal storage unit

(3) One Grainger Inc. Model 7C812 air blower

(4) One Grainger Inc. Model 2C986 air blower with 5K900 motor

(5) Two Ruskin Model CD454PW/MP1161 control dampers

(6) Two American Warming Model SHB-D-1217 back-draft dampers with cohrelastic blades

(7) Two American Warming Model DAA-P-8150 balancing dampers

(8) Jackson Manufacturing Model UCO 5225 hot water tank for system preheat tank

(9) Halstead Mitchell Model SW2-18-18-8 air-to-liquid heat exchanger

(10) The conventional hot water heater

(11) The auxiliary heat source

(12) Control components (described in later section)

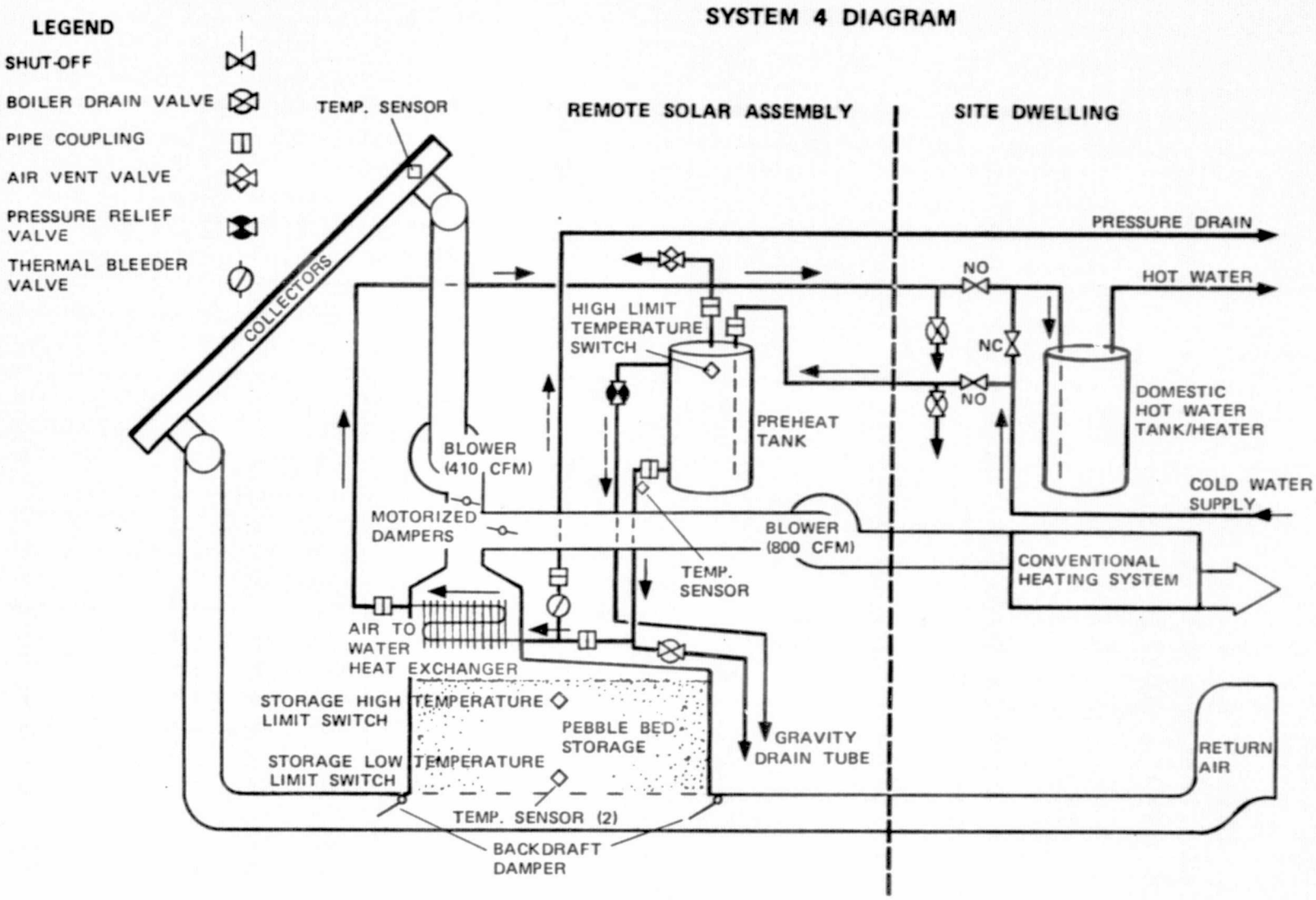


Figure 2.0-1, System 4 Schematic Diagram

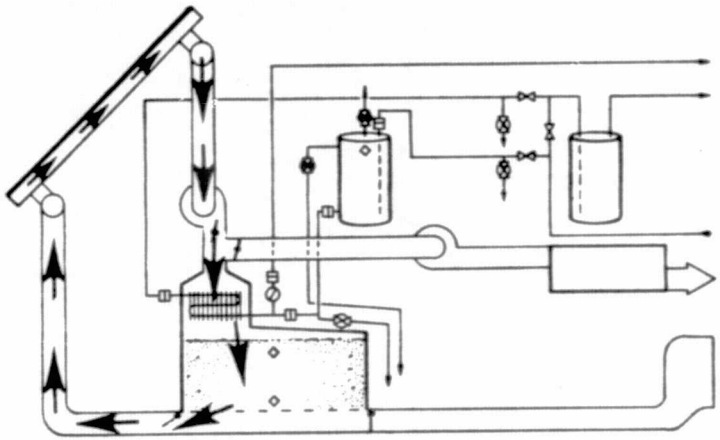
As illustrated in Figure 2.0-2, the system has three modes of operation to maintain three different air circulation loops: (1) Collector to Storage, (2) Collector to Load and (3) Storage to Load. Air flow is controlled by two blowers and two control dampers as indicated in Table 2.0-1. Solar energy is collected in modes (1) and (2). Space heating is accomplished in Modes (2) and (3).

Water is circulated in the domestic hot water preheat loop between the air-to-water heat exchanger and the preheat tank by syphon action. Domestic hot water heating is primarily accomplished in mode 1 when air temperatures to the heat exchanger are hottest; however, when air temperatures to the heat exchanger are higher than preheat tank water temperatures, water heating can also be accomplished in modes 2 and 3.

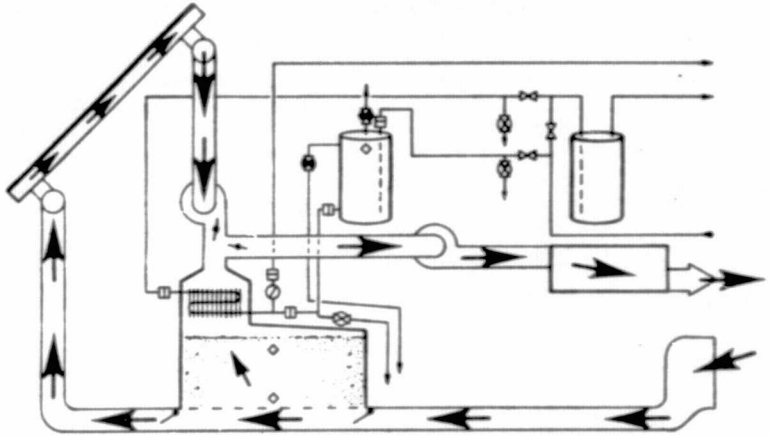
Two non-solar components (10), a conventional domestic hot water tank, and (11), an auxiliary heat source, operate in conjunction with the solar hardware to augment system heating requirements. These components are site dependent and existing items at the site. Their location in the overall system is illustrated in Figure 2.0-1. The two non-solar components (10), a domestic hot water tank, and (11), an auxiliary heating unit, are contained within the site dwelling and are connected to the Remote Solar Assembly by insulated piping and ducting.

All of the solar components (1) through (9) are assembled together in a modularized structure, to form a stand alone Remote Modular Assembly. This prepackaged unit is documented for 135, 203 and 271 net square foot collector array sizes utilizing the Solaron Corporation Series 2001 collector. Appropriately sized modular thermal storage units are included in the designs for each of the three collector array sizes. Larger Remote Modular Assemblies could be assembled using the same modular hardware, but with appropriate blower and duct changes.

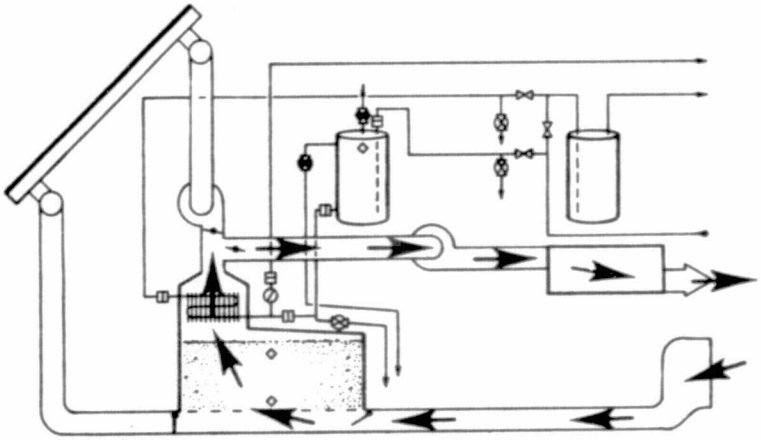
System control consists of simple on-off temperature sensitive components. These components and electrical circuits are described in the Control Subsystem, Section 2.5.



MODE 1 Collector to Storage



MODE 2 Collector to Load



MODE 3 Storage to Load

Figure 2.0-2, System 4 Modes of Operation

Mode	Collector Loop Control Damper	Collector Loop Blower	Load Loop Control Damper	Load Loop Blower
Mode 1 Collector to Storage	Open	On	Closed	Off
Mode 2 Collector to Load	Open	On	Open	On
Mode 3 Storage to Load	Closed	Off	Open	On

Air Flow Control Matrix

The system can be functionally divided into Collector, Energy Storage, Energy Transport, Domestic Hot Water, Controls and Auxiliary Energy Subsystems. Each of these subsystems is described in the following sections.

2.1 COLLECTOR SUBSYSTEM

System 4 collector subsystem consists of either 8, 12 or 16 Solaron Corporation, Series 2001, air heated collectors with appropriate mounting and flashing hardware. The basic collector is a 3 ft. wide by 6.5 ft long by 7 1/4 inches thick rectangular parallelopiped shaped unit with a 24-gage steel enclosure. The back surface insulation of the collector is 1 inch thick, 2 pounds per cubic foot fiber glass batt. The absorber is 24-gage steel with a PPG "Duracron 600" surface finish. The absorptivity and emmissivity of the absorber is 0.94 and 0.82 respectively. The weight of each collector is 153 pounds. The collector is double glazed with 1/8" thick low iron tempered safety glass (Fourco) having a total transmittance of 0.77. The Series 2001 collectors can be ganged 2-high for serial air flow. Many additional collectors can be ganged together by paralleling the 2-high collectors to form 2 by X collector array. System 4 Design Description Drawing, 7934983, shows series-parallel air flow paths for 2x2, 2x4 and 2x8 collector arrays. Air manifolding between collectors is maintained within the collectors.

The Solaron series 2001 collector efficiency is described by Figure 2.1-1. The collector parameters used in plotting this curve are defined as follows:

η	=	Collector efficiency
T_{in}	=	Collector inlet air temperature in ^{o}F
T_{amb}	=	Ambient outside air temperature in ^{o}F
τ	=	Effective combined transmittance of both glazings at normal incidence
α	=	Absorber solar absorptance
F'	=	Collector efficiency factor
F_R	=	Collector heat removal factor
U_L	=	Collector heat loss factor
W_C	=	Air flow rate test condition
I	=	Solar insolation in Btu/Hr Ft^2
$(\tau\alpha)_n$	=	Effective transmittance - solar absorptance product at normal incidence

2.2 STORAGE SUBSYSTEM

System 4 storage subsystem consists of a bed of pebbles contained in a rectangular shaped thermally insulated enclosure. The enclosure fabricated for the System 4 demonstration is 117.5" long by 70" wide by 52 3/4" high and contains approximately 5 1/2 tons of washed rounded stones 3/4" to 1 1/2" diameter.

The storage subsystem is designed and documented per 7934940 drawing for 75, 112.5 and 150 cubic feet capacities as required for 8, 12 and 16 collector array sized systems respectively. These storage capacities result in a thermal storage capacity of approximately 10 Btu/^{o}F per square foot of collector.

Air is circulated from top to bottom through the pebbles when operating in the collector to storage mode of operation. Air flow is reversed and passes up through the pebbles when operating in either the storage to load or collector to load modes of operation. In the latter mode, only a portion of the total air passes up through storage (about 1/2 of the total load).

The pebble bed enclosure is constructed by assembling side panels, end panels and top cover panels within the Remote Solar Assembly. The floor in the structure forms the base of the storage enclosure. Pebbles are supported 12 inches above the floor of the enclosure by a welded steel grating assembly. The space between the grating and the floor forms a lower plenum. The space between the top cover and the surface of the pebbles forms an upper plenum. The enclosure has three openings. One opening, 18" x 18" is located in the top center cover and provides passage to the upper plenum. The other two openings, 6" x 48" are located one each near the base of the ends of the enclosure and provide passage to the lower plenum.

Basic building - block panels have been designed to fabricate each of the three capacities described above. Larger storage capacities can be obtained in 37.5 cubic feet increments by assembling the necessary combinations of the existing design building - block panels. Panels required for a 8, 12 and 16 collector systems are defined in Table 2.2-1.

W_c = 2cfm/$_{ft}$2
τ = .77
α = .95
$(\tau\alpha)_n$ = .74
F_R = .70
U_L = .90
F' = .85

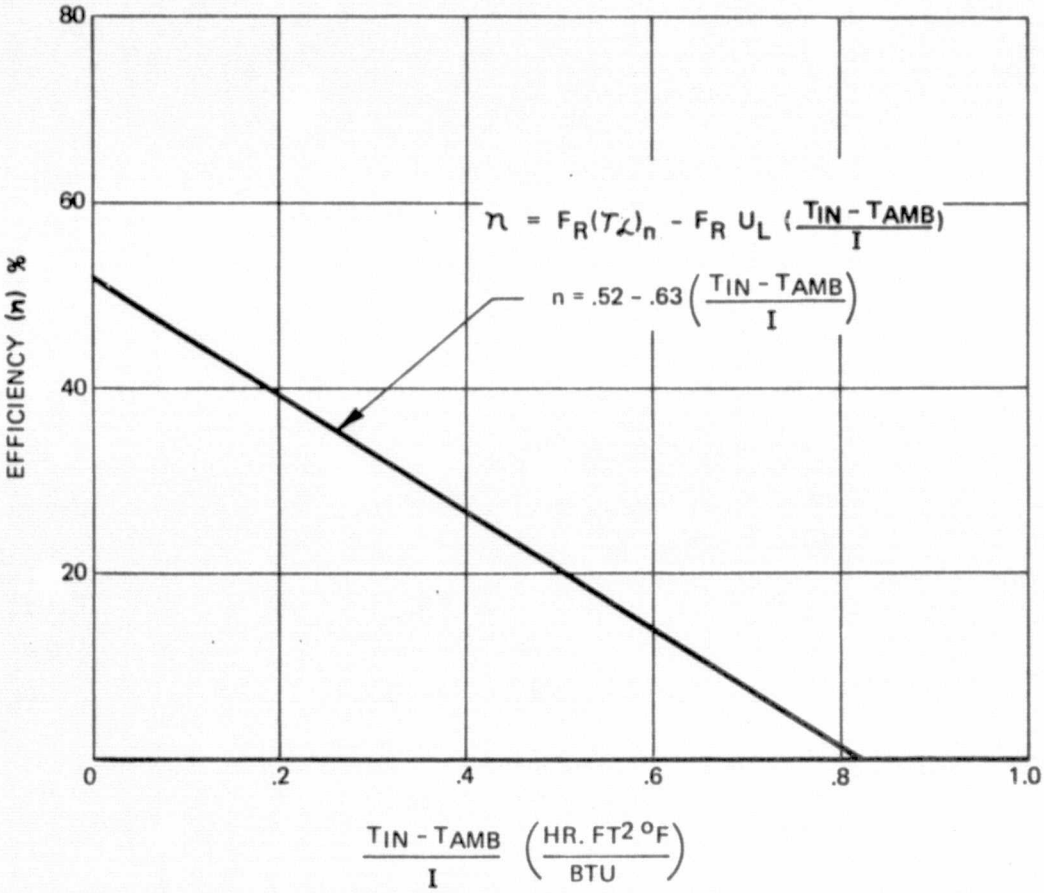


Figure 2.1-1, Solaron Corp. Series 2001 Collector Efficiency

Table 2.2-1 Rock Bed Storage Enclosure Hardware

System Description	Panel Usage	Panel Part No.	Panel Size	Qty.	Openings
8 Collector Assy					
7934940-1	Side	7934936	48"x36"x4 3/4"	4	None
7934940-1	Top	7934978	70"x40 3/4"x4 3/4"	1	18"x18"
7934940-1	Top	7934937	70"x40 3/4"x3/4"	1	None
7934940-1	End	7934938	70"x48"4 3/4"	2	6"x46"
12 Collector Assy					
7934940-2	Side	7934936	48"x36"x4 3/4"	6	None
7934940-2	Top-End	7934937	70"x40 3/4"x4 3/4"	2	None
7934940-2	Top-Center	7934939	70"x36"x4 3/4"	1	18x18
7934940-2	End Panel	7934938	70"x48"x4 3/4"	2	6"x46"
16 Collector Assy					
7934940-3	Side	7934936	48"x36"x4 3/4"	8	None
7934940-3	Top-Inner	7934939	70x36"x4 3/4"	1	18"x18"
7934940-3	Top-Inner	7934977	70"x36"x4 3/4"	1	None
7934940-3	Top-Outer	7934937	70x36"x4 3/4"	2	None
7934940-3	End	7934938	70"x48"x4 3/4"	2	6"x46"

The insulated panels are a sandwich type construction consisting of 4.25 thick isocyanurate foam, Upjohn CPR 9545, with .060 "thick polyester-glass face sheets bonded with epoxy adhesive, Dexter Corp. EA934. Polyester-glass channel, 4 3/4" x 1 5/8" x 3/16" is bonded to all edges of the sandwich panels including openings to protect the foam. Isocyanurate foam sheets are laid on the floor of storage to insulate the base.

The grating which supports the pebbles is a welded assembly that is sized consistent with the storage panel modular concept. One grating assembly is required for each 37.5 cubic feet of storage. The assembly consists of a rectangular sheet of steel grating to which four legs are welded. The grating has 3/16" x 3/4" bearing bars 1 3/16" on centers with 1/4" square cross bars 4" on centers. The legs are 2" x 2" x 3/16" steel structural angle. A 1/2" x 1/2" mesh steel wire cloth with .040" diameter galvanized wire is laid above the grating to prevent small pebbles from falling through the grating.

A piece of perforated sheet metal is placed on the top surface of the pebble bed and centered under the top center air opening. The purpose of the sheet is to deflect the air to eliminate channeling of air through the center of the pebble bed.

2.3 ENERGY TRANSPORT SUBSYSTEM

The energy transport subsystem is a two-blower system with control dampers, balancing dampers, back draft dampers and interconnecting duct work. This subsystem consists of the following hardware:

Item	Description	Qty.
Collector Loop Blower Assembly	Grainger 7C812	1
Load Loop Blower Assembly	Grainger 2C986 blower with 5K900 motor	1
Control Dampers	Ruskin CD454PB/WMP 1161	2
Balancing Dampers	American Warming DAA-P-8150	2
Back Draft Dampers	American Warming SHB-D-1217	2
Collector Loop Duct	12" Round 26 gage galv.	AR
Load Loop Duct	14" Square 26 gage galv.	AR

Air flow is adjusted in either the collector loop or load loop by varying the pulley diameters of the motor shaft pulley. The blowers are belt driven, "A" width, with motors mounted to the blower housing on a swivel base to facilitate belt tension adjustment. The motors are 115 VAC, sleeve bearing, automatic-reset-thermally protected motors. The motor for the collector loop is a 1/2 horse power, 1725 rpm, split-phase motor. The motor for the load loop is a 3/4 horse power, 3450 rpm, capacitor start motor.

The collector loop blower has a 4.35" pitch diameter pulley on the blower shaft and a 1.9" to 2.9" pitch diameter variable pitch pulley on the motor shaft. No adjustment in pulley diameter is considered necessary after the initial setting. The load loop blower has a 6.85" pitch diameter pulley on the blower shaft and a 2.8" to 3.8" pitch diameter variable pitch pulley on the motor shaft. Pulley diameter adjustment will most likely be required when the system is installed in the field so as to obtain the desired air flow. Motor current should be monitored while adjusting pulley diameters to verify that the motor rating is not exceeded.

The collectors are manifolded together in two eight (8) collector series - parallel arrays as shown in System 4 Design Description Drawing 7934983. Air is ducted to each array in two parallel loops in a "Y" configuration. Balancing dampers are installed in series with the collector arrays in each parallel loop so that the flow through the two loops can be equalized.

The purpose of the back-draft dampers is to eliminate the possibility of reverse air flow in the collector loop and load loop ducts. The dampers are the fabric vane type and are 14"x14"x1 1/2". The vane material is #1010 cohrlastic. Dampers are installed in the 14x14" ducts at outlet from storage in the collector loop and at the inlet to storage in the load loop.

Two 115 VAC motorized control dampers are utilized in the system to provide on-off air flow control in the collector and load loops. The dampers are metallic parallel blade construction. A linkage between a crank on the drive motor shaft and a crank on the damper blades provides the necessary force to open the damper blades. A helical tension spring attached to the crank of the drive motor applies the force necessary to close the damper when the drive motor is de-energized.

The collector loop ducting is mainly 12" diameter round 26 gage galvanized steel. The load loop ducting is 14" square, 26 gage galvanized steel. Irregular shaped transistion ducts are utilized at inlet and outlet to items such as storage unit, blowers and air to water heat exchanger. These transistion pieces are fabricated of 26 gage galvanized steel sheet stock.

All ducting and items in the duct such as the air to water heat exchanger and blowers are covered with 3 inches of Upjohn Inc., uthane 190, urethane foam to provide insulation with a R value of 20 or better. The insulation was bonded to the surface to be insulated with vapor barrier contact adhesive, Midwest Chemical Co. Bon-grip 169-24. The outside surface of the insulation is painted with polyvinyl chloride mastic weather barrier, WC-1 E2, which is manufactured by the Vimasco Corp., Netro, West Virginia. The paint forms a tough water proof surface over the otherwise delicate urethane insulation surface.

2.4 DOMESTIC HOT WATER SUBSYSTEM

Figure 2.4-1 is a schematic diagram of the domestic hot water system. Hot water is provided in the solar system by means of (1) an air-to-water heat exchanger in the air duct at the top of storage and (2) a 52-gallon water storage tank to preheat the water supplied to the conventional building hot water heater. Water circulates from the heat exchanger to the preheat tank by thermosyphon action whenever water in the heat exchanger is heated above the water temperature in the preheat tank. The conventional domestic hot water heater draws its supply from the preheat tank and auxiliary energy is used only if the temperature of preheat tank is below the water heater set point. Cold supply water is drawn into the base of the preheat tank when domestic hot water is used. Cold water at the base of the preheat tank is drawn to the heat exchanger while hot water in the heat exchanger rises to the top of the preheat tank through 1" diameter soft copper tubing to maintain the thermosyphon flow.

A thermal bleeder valve is installed at a low point in the thermosyphon line close to the heat exchanger to provide positive protection against freeze-ups. The valve senses the surrounding water temperature in the water line near the heat exchanger and begins to open at temperature below 40°F and is full open at 34°F. When water is bled from the system, it will be replaced by warmer city water to maintain the water temperature in the heat exchanger above freezing temperatures. Water drawn by the thermal bleeder valve may raise or lower the temperature of water in other parts of the domestic hot water system to temperatures equal to the supply water temperature which serves to protect other parts of the system from freezing.

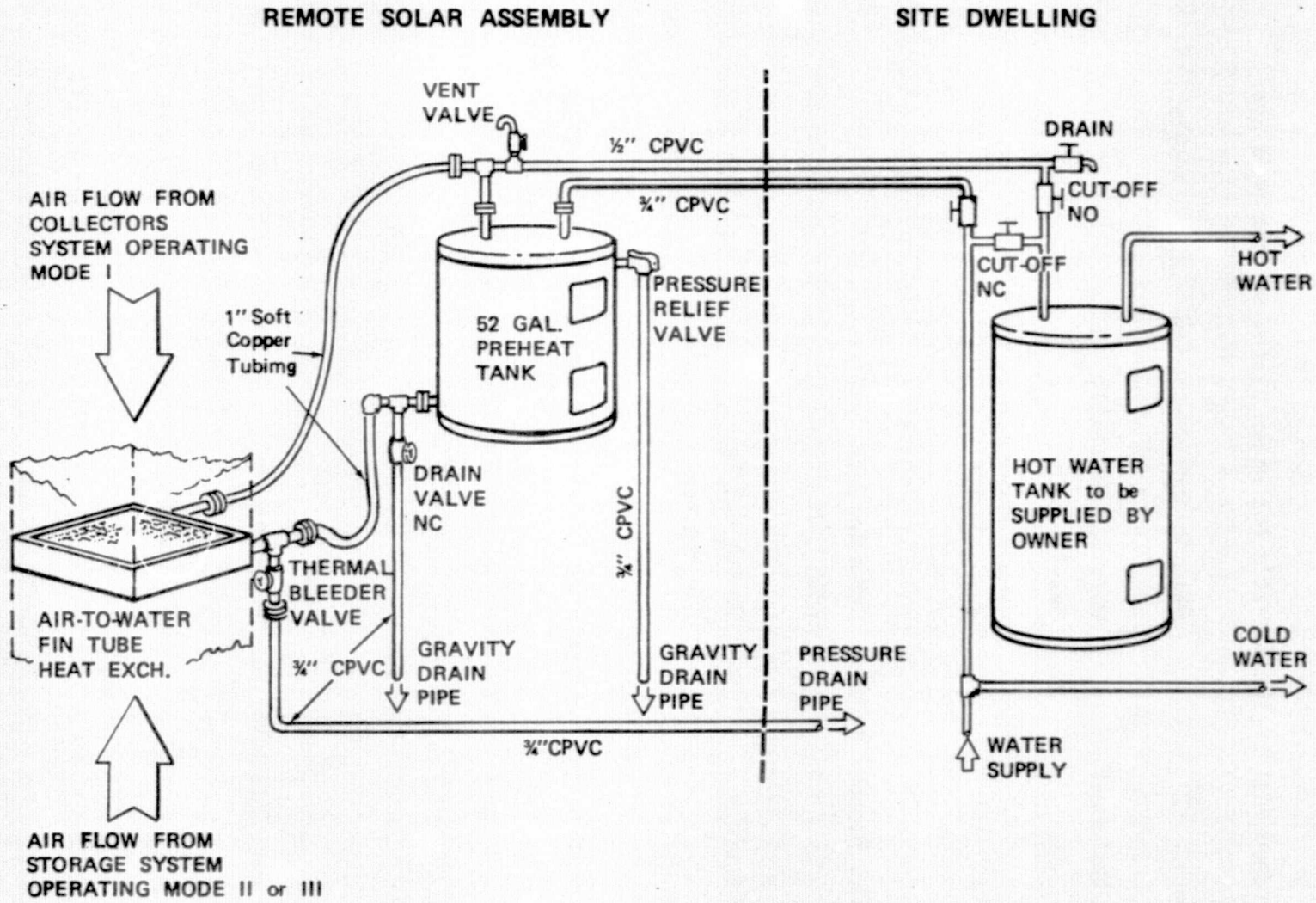


Figure 2.4-1, Hot Water Subsystem Diagram

The main components of the domestic hot water system for System 4 are:

Item	Description	Qty.
Heat Exchanger	Halstead Mitchell, SW2-18-18-8	1
Preheat Tank	W. L. Jackson, UC05225	1
Thermal Bleeder Valve	McMaster Carr, 4858 N 16	1
DHW Heater	30 gal 4.5 KW DHW Heaters *	2

* Any DHW heater available at the site is compatible with system.

2.5 CONTROL SUBSYSTEM

The control subsystem provides the means to control the collector loop blower, the load loop blower and the auxiliary heating unit. The control subsystem consists of the following component hardware:

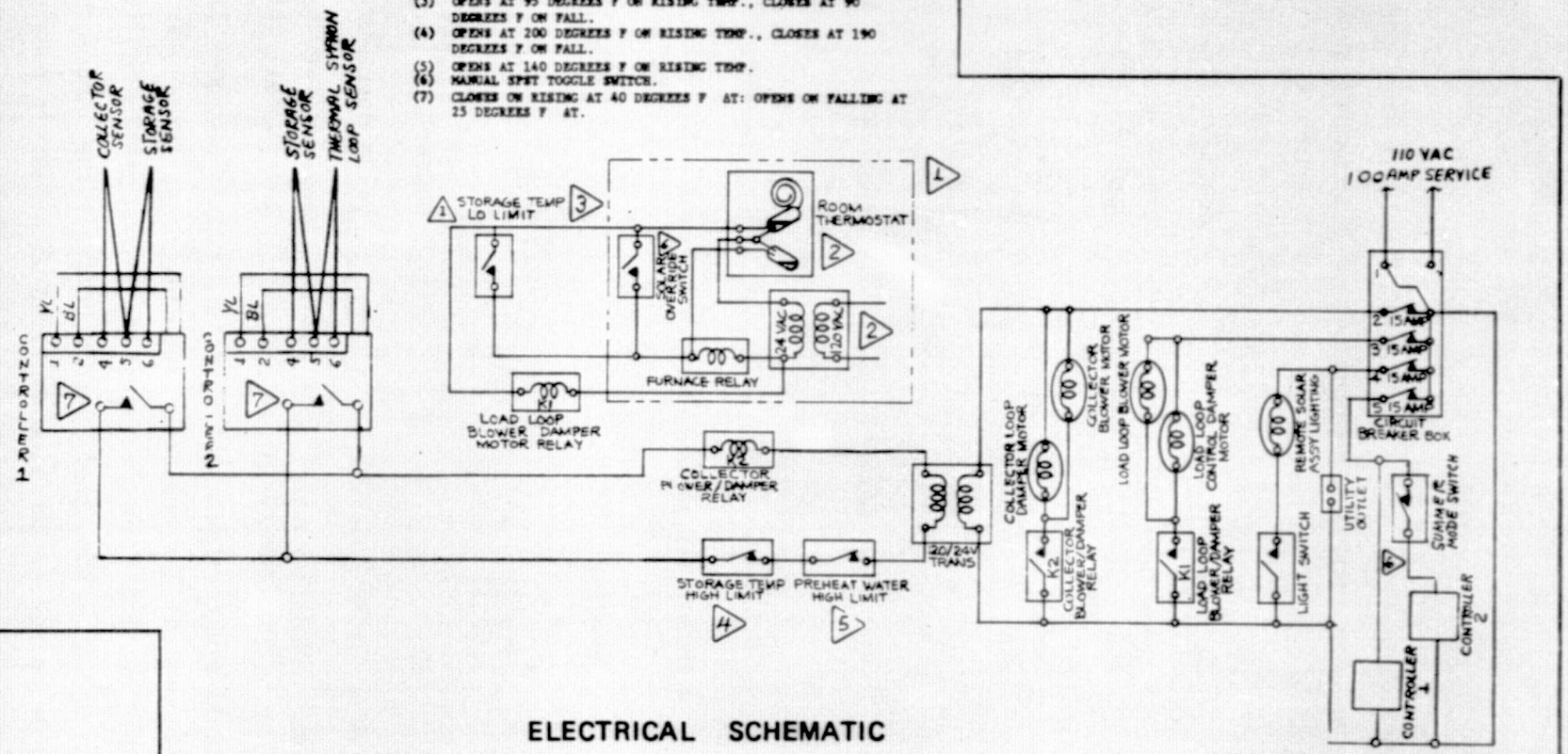
Item	Description	Function
ΔT Controller No. 1	Solar Control Corp. Mod. 77-171*	Closes with a $\Delta T > 40^{o}F$ Opens with a $\Delta T < 40^{o}F$
ΔT Controller No. 2	Solar Control Corp. Mod. 77-171*	Closes with a $\Delta T > 25^{o}F$ Opens with a $\Delta T < 25^{o}F$
Storage Temp High Limit Switch	ASCO Mod 10A/QF11A4	Opens at $200^{o}F$ on temp. rise Closes at $190^{o}F$ on temp. fall
Storage Temp Low Limit Switch	ASCO Mod 10A/QF11A4	Opens at $95^{o}F$ on temp rise Closes at $90^{o}F$ on temp. rise
Preheat Tank High Limit Switch	Grainger 2E051	Adjusted to open at $150^{o}F$ on temp. rise
Blower Relays (2)	Honeywell R8225D 1003	Coil operates on 24 VAC and switch power to the blowers
Site Dwelling Thermostat (2 Stage)	Honeywell T42H	Contacts close in sequence with temp. rise
Summer Mode Switch	Standard wall switch (SPST)	Manually operated
Transformer (2)		Converts 120 VAC to 24 VAC
Pressure Relief Valve	Watts Mod 10x6	Valve opens at $185^{o}F$ on rise
Thermal Bleeder Valve	McMaster Carr Mod 4858N16	Valve starts to open at $38^{o}F$ and is full open at $34^{o}F$

The control components are arranged in two basic circuits as shown in Figure 2.5-1. One circuit controls the collector loop blower so that solar energy can be collected when available and/or transferred from pebble bed storage to water storage on demand. The other circuit controls the load loop blower so the heat can be delivered to the site dwelling when heat is required. Table 2.5-1 shows the control component states for all possible modes of operation.

* Note: The controller is modified to eliminate the freeze and boil protection features and to energize the control relay with a $\Delta T > 40^{o}F$ and de-energize the control relay with a $\Delta T < 25^{o}F$.

NOTES:

(1) ITEMS WITHIN PHANTOM LINES ARE LOCATED WITHIN SITE RESIDENCE.
(2) EXISTING EQUIPMENT.
(3) OPENS AT 95 DEGREES F ON RISING TEMP., CLOSES AT 90 DEGREES F ON FALL.
(4) OPENS AT 200 DEGREES F ON RISING TEMP., CLOSES AT 190 DEGREES F ON FALL.
(5) OPENS AT 140 DEGREES F ON RISING TEMP.
(6) MANUAL SPST TOGGLE SWITCH.
(7) CLOSES ON RISING AT 40 DEGREES F ΔT: OPENS ON FALLING AT 25 DEGREES F ΔT.



ELECTRICAL SCHEMATIC

Table 2.5-1 System 4 Control Modes with Component States

Mode	Mode*	Cont. No. 1 (Relay)	Summer Mode (Switch	Cont. No. 2 (Relay)	Stor. Temp Hi Limit	Preheat Hi Limit	Stor. Temp Lo Limit	Room Temp. Therm.	
								1st Stage	2nd Stage
Collector	1	C	0	-	C	C	-	0	0
to	1	0	C	C	C	C	-	0	0
Storage	1	C	C	C	C	C	-	0	0
Collector to Load	2	C	0	-	C	C	-	C	0
Collector to Load with Aux. Heat 1st Stage	2	C	0	-	C	C	C	C	0
Collector to Load with Aux. Heat 2nd Stage	2	C	0	-	C	C	-	-	C
Storage to Load	3	0	-	0	-	-	-	C	0
Storage to Load with Aux. Heat 1st Stage	3	0	-	0	-	-	C	C	0
Storage to Load with Aux. Heat 2nd Stage	3	0	-	0	-	-	-	-	C

KEY: C - Switch or relay contacts closed
0 - Switch or relay contacts open
- - Switch or relay contacts in either state acceptable

* NOTE: Air flow is per mode as shown in Figure 2.0-2 on page 6.

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2.5.1 Collector Loop Blower Control

Collecting Energy

Solar energy is collected when heat is available in the solar collectors by running the collector loop blower. Energy can be collected in modes 1 and 2 with control component states as shown in Table 2.5-1. A ΔT Controller, Controller No. 1, senses the temperature difference between the outlet of collector and bottom of storage. A control relay within the controller is energized when the temperature difference is 40°F or larger. This closes the relay contacts which completes the collector blower circuit and energizes the collector blower relay. The circuit is deenergized and the blower motor power cut-off when any of the following events occur:

(1) The temperature difference between outlet of collector and bottom of storage is less than 25°F.

(2) The Storage Temperature High Limit Switch contact opens when the bottom of storage is 200°F or higher.

(3) The Preheat Tank High Limit Switch contact opens because the DHW preheat tank is 140°F or higher.

Transferring Energy

Energy is transferred from rock bed storage to the domestic hot water preheat tank when an excess of solar energy is available. This is accomplished by running the collector blower. Since hot air from storages passes through the collectors on its way to the air-to-water heat exchanger, energy will be lost through the collectors. This mode of operation is therefore not permitted in the Spring, Fall and Winter seasons.

Energy can be transferred from storage to the preheat tank in mode 1 when solar energy is not available at the collector by running the collector blower with control components states as shown in line 2 of Table 2.5-1.

In the summer mode, a ΔT Controller, Controller No. 2, senses the temperature difference between the bottom of pebble storage and bottom of the preheat tank. The control relay within the controller is energized and deenergized to control the collector blower in the same manner Controller No. 1 does. Since the control relay in both Controller No. 1 and Controller No. 2 are in parallel in the blower control circuit, either controller can activate the collector blower; however the control relay in both controllers must be open to deenergize the collector blower.

2.5.2 Summer Mode Switch

The summer mode switch controls power to Controller No. 2. When switched to the summer mode position, Controller No. 2 is capable of controlling the collector blower motor. When switched to the alternate position, Controller No. 2 is disabled.

2.5.3 Load Loop Blower Control

Heat is delivered to the site dwelling whenever the load loop blower is running provided heat is either being collected or is available in storage. Heat is delivered exclusively from storage when the first stage contact of the site thermostat closes and the Storage Temperature Low Limit Control contact is open (top of rock storage is above 90°F). When the second stage sites dwelling thermostat contact closes or the Storage Temperature Low Limit Control contact closes (top of rock storage is above 95°F) and the first stage contact is closed, auxiliary heat will be supplied in addition to any solar heat available from storage.

2.5.4 Boil Protection

A pressure relief valve is used as a safety device to limit the pressure and temperature of the water in the preheat tank. This valve will open permitting water to drain from the preheat tank if the water temperature exceeds 185°F.

2.5.5 Freeze Protection

A freeze protection valve is used to protect the DHW heat exchanger from freezing if the Remote Solar Assembly is inactive in freezing weather for an extended period as if a prolonged power failure is encountered. The valve is thermally operated and will begin to open at 40°F and be fully open at 34°F. Water will flow through the valve to a drain when the valve opens. Make-up water from the water supply system will supply the heat necessary to prevent freeze-up.

2.6 AUXILIARY ENERGY SUBSYSTEM

Since the solar system is not sized to provide 100% of the space heat required, an auxiliary source of heat is required. The auxiliary heat device is sized to carry the site dwelling load independent of the solar capability.

System 4 design incorporates auxiliary heat in series with solar storage as shown in Figure 2.0-1. Auxiliary heat in this configuration could be electric strip heat, gas or oil fired furnace. The load loop blower should be capable of moving air through the auxiliary device; however, if the pressure drop is excessive, another blower in series may be required. The operating temperature of this second blower motor in the load loop should be compatible with the solar heated air that it will operate in if it is duct mounted.

If System 4 were used with a heat pump, or if the heating ducts are also to be used for air conditioning, the heat pump or air conditioner would have to be added in parallel with the solar heating system as shown in Figure 2.6-1. The auxiliary heat in the parallel configuration would operate from the site dwelling thermostat second stage contacts.

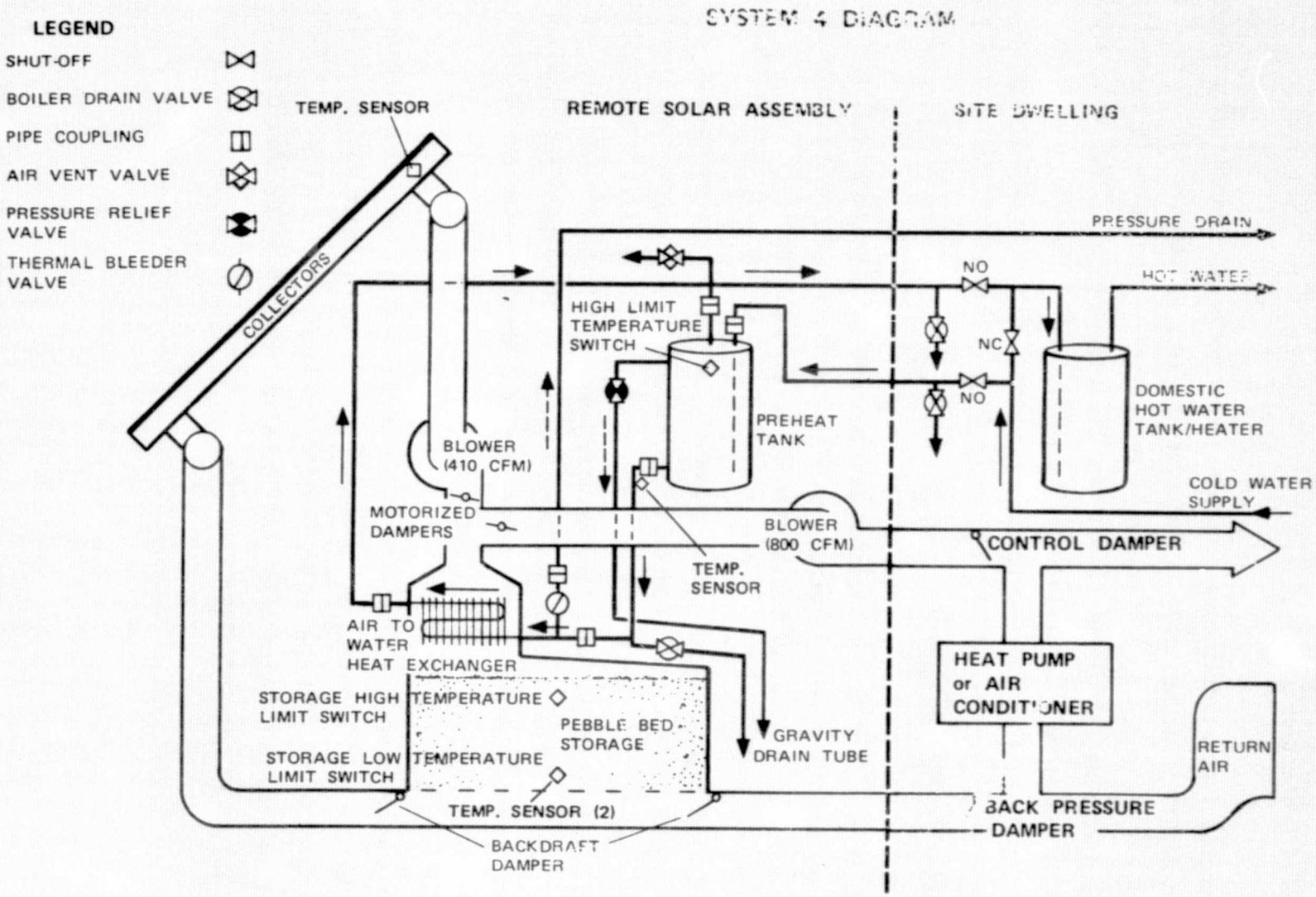

Figure 2.6-1, System 4 with Auxiliary Heat and Air Conditioning in Parallel

3.0 SYSTEM PERFORMANCE

The performance of any heating system is influenced to a large degree by the integration of the system with the total building design and construction. With solar heating systems, the type of auxiliary heating equipment will also effect the overall system performance. In this section, the expected performance for a particular Remote Solar Assembly, part number 7934940-2, when installed at a particular site with its auxiliary heating system is described. Then a technique for determining the size of the Remote Solar Assembly to obtain the desired system solar heating fraction when used at any site location will be presented.

3.1 SYSTEM PERFORMANCE AT DEMONSTRATION SITE

The Remote Solar Assembly which is to be used with the demonstration site in Clinton, Mississippi was fabricated with characteristics as follows:

Collector Area	-	203 square feet (effective)
Pebble Storage	-	113 cubic feet/5.4 tons
Collector Tilt	-	45 degrees
Collector Azimuth	-	0 degrees
Collector Loop Air Flow	-	400 cfm
Load Loop Air Flow	-	800 cfm

The optimum tilt angle for heating systems is the site latitude plus 10 to 20 degrees; however, tilt variations from the latitude to latitude plus 30 degrees will have little effect on the cost of energy delivered for heating. This suggests that System 4 with the fixed tilt angle can be used effectively at site latitudes up to 45 degrees.

Installation of the Remote Solar Assembly can effect the performance of the system. The RSA should be oriented due south in a area free of shadows. Variations of orientation up to 20 degrees from due south will not significantly effect the overall system performance. Shading of the collectors can cause a significant decrease in system performance and should be avoided.

The System 4 demonstration site in Clinton, Mississippi has a mean daily winter solar insolation of 1140 Btu/Ft^2 with heating load characteristics as follows:

Yearly Heating Degree Days	-	2300 ^{o}F day
Peak Heating Load	-	30,604 Btu
Average Annual Heating Load		
Space Heating	-	30.69 MM Btu
DHW Heating	-	28.94 MM Btu
Hot Water Demand	-	130 gal/day
Water Set Temperature	-	140 ^{o}F
Average Yearly Ground Water Temperature	-	67 ^{o}F

The auxiliary heating equipment available at the site is as follows:

One (1) 15KW Duct Strip Heating Unit
Two (2) 30 gal DHW Heaters each with 4.5KW heaters

The performance parameters of this system with the characteristics described above is as follows:

% Space Heating Load Supplied by Solar	-	35
% DHW Load Supplied by Solar	-	63
% Total Load Supplied by Solar	-	48
Maximum Electrical Energy	-	25.5 KW
Average Annual Auxiliary Energy	-	30.89 MM Btu
Domestic Hot Water Capacity	-	100 Gal
Maximum DHW Recovery Time	-	1.5 Hr.

DHW Minimum Delivery Rate	-	1.7 gal/min
% DHW Load from Auxiliary	-	37
Maximum Electrical Power to Drive Solar	-	650 watts
Maximum Electrical Power for Total System	-	25.5 KW
Maximum Average Annual Electrical Energy for Total System	-	10,720 KW Hr.

3.2 SYSTEM SIZING

The primary system parameters which determine the overall performance of System 4 design at any given site are the collector area and pebble bed size. A simplified procedure has been developed for determining the collector area required to obtain the desired solar energy contribution necessary to meet the total heating and hot water load. In this section, the development of the simplified sizing procedure is described and then two example cases are presented to illustrate its application. Sizing of pebble bed storage, blowers, heat exchanger and domestic hot water tank is also discussed.

3.2.1 Description of Collector Sizing Technique

A curve of % solar contribution vs. the ratio Solar Incidence/Load was generated by using the F-Chart analysis. Site UA values of 300 and 900 Btu/Hr. ^{o}F and collector areas of 135 and 339 square feet were used to determine the % solar fraction that can be obtain from the four combi nations of these parameters for the following cities:

City	Latitude
Birmingham, Alabama	33.34
Boston, Massachusetts	42.22
Forth Worth, Texas	32.50
Jackson, Mississippi	32.19^{o}
Mpls. St. Paul, Minn.	44.53^{o}
Nashville, Tennessee	36.07
New York City, NY	40.46^{o}
Omaha, Nebraska	41.22^{o}
Washington, DC	38.51^{o}

The curve obtained from this data is shown in Figure 3.2.1-1.

This curve can be used to either predict solar contribution for a particular system or calculate the area of the collector array necessary to obtain the desired performance. To obtain % solar contribution, the ratio Solar Incidence/Load (R) must be calculated and then the system performance (% Solar) can be read directly from the curve. To obtain the area of collector array required for the desired system performance (% Solar), the R value must be obtained from Figure 3.2.1-1; the total annual load calculated; the solar incidence/ft^2 calculated and the following equation should be used:

$$A = R \times \frac{\text{Total Annual Load}}{\text{Solar Incidence/ft}^2}$$

where

A = effective area of collector array

R = ratio annual solar incidence/total annual load obtained from Figure 3.2.1-1.

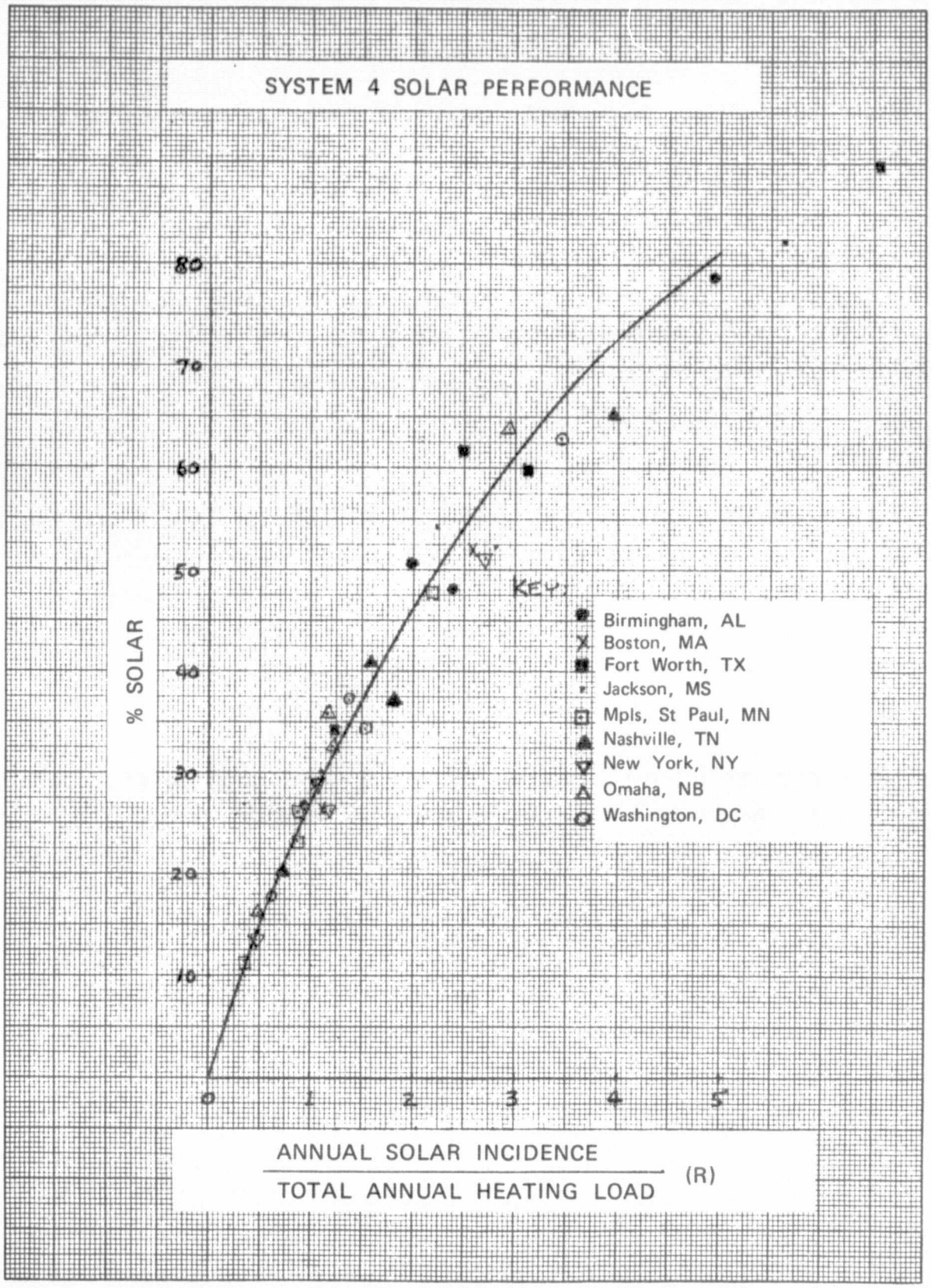

Figure 3.2.1-1, System Sizing Curve(% Solar vs Incidence Solar/Load)

This technique is intended for rough system performance estimates and system sizing. When determining a system size, the economics of system costs vs. yearly savings should be evaluated; however, this is beyond the scope of this exercise. The inaccuracies of this technique are not considered a serious problem because small variations from the optimum system size have little effect on the system economics. When economics of the system is considered critical in the sizing of the system, the use of the FCHART method as described in reference 4 is recommended.

Example 1

Let us assume that one desires to determine the % Solar contribution that can be obtained from a system with 203 square feet of collector area when used with a dwelling with a UA value of 556 (given by dwelling architect) located in Nashville, Tennessee. The average daily domestic hot water consumption is estimated to be 75 gallons per day, and the DHW heater temperature control will be set at 140°F.

The system space heating load can be calculated by multiplying the UA value times the local degree day value. Degree day value is found in reference 1 to be 3696.

$$\text{Space Heating Load} = 556 \times 3696 = 49.3 \text{ MM Btu}$$

The system DHW load can be calculated from the daily water consumption rate, the ground water temperature, and the DHW heat set point temperature. The average annual ground water temperature is required. This temperature is close to the average annual air temperature which is available from reference 3 The annual DHW load can be calculated as follows:

$$Load_{DHW} = \left[\text{Yearly DHW Consumption (\#/Yr)}\right] \times \left[\begin{matrix}\text{Specific Heat}\\ \text{of Water}\end{matrix}\right] \times \left\{\left[\begin{matrix}\text{Avg. Annual Temp}\\ \text{Deliverable Water}\end{matrix}\right] - \left[\begin{matrix}\text{Avg Annual Temp}\\ \text{Water Main}\end{matrix}\right]\right\}$$

$$Load_{DHW} = \left[75 \text{ Gal/Day} \times 365 \text{ Days/Yr} \times 8.34 \text{ \#/Gal}\right] \times \left[1 \text{ Btu/\#}^{o}\text{F}\right] \times \left[140^{o}\text{F} - 59.4^{o}\text{F}\right]$$

$$Load_{DHW} = 18.40 \text{ MM Btu/Yr}$$

The total annual heating load is found by adding the Space Heating Load and DHW load together.

Total Heating Load = Space Heating Load + DHW Load
Total Heating Load = 49.3 + 18.4 = 67.7 MM BTU/Yr.

The average annual incidence radiation can be calculated by first obtaining the monthly average daily total radiation on the horizontal surface, $\bar{I}_H$ and monthly K_t value from Table A-4 in reference 2. Knowing the collector tilt (θ = 45 degrees), the latitude of the site (θ = 36 degrees), and the monthly K_t values; monthly $\bar{R}$ values can be obtained from Table A-5 of reference 2. Monthly average daily radiation on the tilted collector array, I_T, is calculated by multiplying I_H values by $\bar{R}$ values. Columns I-IV of Table 3.2.1-1 were generated in this manner. To obtain the total average insolation per month, the monthly average daily radiation on the tilted collector array (I_T) values are multiplied by the number of days in each month to obtain the total average insolation per month (S). Columns V and VI were generated in this

Table 3.2.1-1 Incident Solar Radiation

	I	II	III	IV	V	VI
Month	$\overline{I}_H$ (Btu/Day Ft^2)	$\overline{K}_t$	$\overline{R}$	$\overline{I}_T$ (Btu/Day Ft^2)	N Days/Mo	S Btu/Mo. Ft^2
Jan	589.7	0.373	1.48	872.8	31	27,055
Feb	907.0	0.440	1.37	1242.6	28	34,793
Mar	1246.8	0.472	1.16	1446.3	31	44,835
Apr	1662.3	0.514	0.95	1578.2	30	47,376
May	1997.0	0.556	0.82	1637.5	31	50,764
Jun	2149.4	0.573	0.76	1633.5	30	49,006
Jul	2079.7	0.565	0.79	1643.0	31	50,932
Aug	1862.7	0.554	0.89	1657.8	31	51,392
Sep	1600.7	0.556	1.08	1728.8	30	51,863
Oct	1223.6	0.540	1.34	1639.7	31	50,828
Nov	823.2	0.454	1.47	1210.1	30	36,303
Dec	614.4	0.426	1.59	976.9	31	30,284
$\sum_{Jan}^{Dec} S$ = Total Annual Insolation/Ft^2 of Collector =						525,431

manner. Finally to obtain the total average insolation per year, the monthly values of S are added. For the example problem, this value is 525,431 BTU/Ft^2 year. The total insolation per year that is available on the collector array is the insolation value per square foot times the effective collector area.

Annual Solar Incidence = 525,431 BTU/Ft^2 Yr x 203 Ft^2

Annual Solar Incidence = 106.67 MM Btu/Yr.

The ratio, Annual Solar Incidence/Total Annual Heating Load, is therefore 106.7/67.7 = 1.6

Using the curve of Figure 3.2.1-1 gives a 38% Solar contribution.

3.2.2 Collector Array Sizing

The technique described in Section 3.2.1 will now be used to determine the size of the Remote Solar Assemly required for a particular application.

Example 2

Let us assume one desires to determine the required collector array area that is necessary to provide 50% solar contribution to the total annual heating load. The site dwelling has a UA = 556 (given by dwelling architect) and is located in Nashville, Tennessee. The average daily domestic hot water consumption is estimated to be 75 gallons per day and the DHW heater temperature control will be set at 140°F.

To obtain the area of the collector, we solve for A in the equation.

$$A = R \times \frac{\text{Total Annual Load}}{\text{Incidence/Ft}^2}$$

Using the curve of Figure 3.2.1-1 with 50% Solar, we find R to be 2.25.

Since the UA value, site geographical location, DHW consumption and DHW heater set point are all identical to Example 1, the total annual heating load will be the same (67.7 MM BTU/Yr.); and therefore, it will not be recalculated here.

Since the site location, collection tilt (always 45^0 for the Remote Solar Assembly) are identical to Example I, the total annual installation per square foot of collector can be taken from Table 3.2.1-1 (525,431 BTU/Ft^2 Yr. or .525 MM BTU/Ft^2 Yr). The total annual insolation will therefore not be recalculated here.

Solving the equation above gives:

$$A = 2.25 \quad \frac{.67.7}{.525} = 290 \text{ Ft}^2$$

The collector array sizes for the modular designed Remote Solar Assembly are varied in 68 square foot increments (4 collectors) starting with the smallest unit 135 square feet (8 collectors). Possible array sizes are therefore 135, 203, 271 and 339 square feet. Since the closest collector array sizes for the modular designed Remote Solar Assembly are 271 and 339 square feet, one must decide whether a solar fraction slight larger or smaller than the 50% value is acceptable. Using the above equation and solving for the annual solar incidence/total annual load ratios for 271 square foot and 339 square foot collector array gives:

(271 Ft^2 Collector Array) $$\frac{525{,}431\ BTU/Ft^2Yr \times 271\ Ft^2}{67.7\ MM\ BTU/Yr} = 2.1$$

(339 Ft^2 Collector Array) $$\frac{525{,}431\ BTU/Ft^2\ Yr \times 339\ Ft^2}{67.7\ MM\ BTU/Yr} = 2.6$$

Using the curve of Figure 3.2.1-1 to find the % solar for the 271 square feet and 339 square foot collector array gives:

271 Ft^2 collector array - 48%

339 Ft^2 collector array - 56%

3.2.3 Pebble Bed Storage Sizing

The Remote Solar assembly modular design is based on maintaining a storage capacity of slightly higher than 10 BTU/^oF Ft_c^2. Storage size therefore varies with collector array size as follows:

Collector Area	Storage Capacity Volume	Storage Capacity Mass
135	75 Ft^3	3.6 Ton
203	112.5 Ft^3	5.4 Ton
271	150.0	7.2 Ton
339	187.5	9.0 Ton

3.2.4 Blower Sizing

The collector loop and load loop blowers are identical blowers that are capable of delivering varying amounts of air flow. A performance curve for the blower is contained in Figure 3.2.4-1. Amount of air flow can be varied by adjusting the speed of the blower. This is accomplished by adjusting the split sheave on the blower motor to vary the pulley ratio between motor pulley and blower pulley.

The collector loop air flow should be adjusted to maintain a flow equal to 2 cfm per square foot of effective collector area.

The load loop air flow should be adjusted to maintain a flow which produces approximately six (6) air change per hour to the load volume.

The blower is considered adequate for any Remote Solar Assembly size; however, the blower motor and pulleys may have to be changed to obtain the desired blower speed. Blower motor power may exceed the 1/4 and 1/2 horsepower rating of the collector loop and load loop motors. A higher horsepower rating should be selected in the same frame size if a higher horsepower rating is required.

3.2.5 Heat Exchanger Sizing - The heat exchanger described in Section 2.4 is adequate for all Remote Solar Assembly variations.

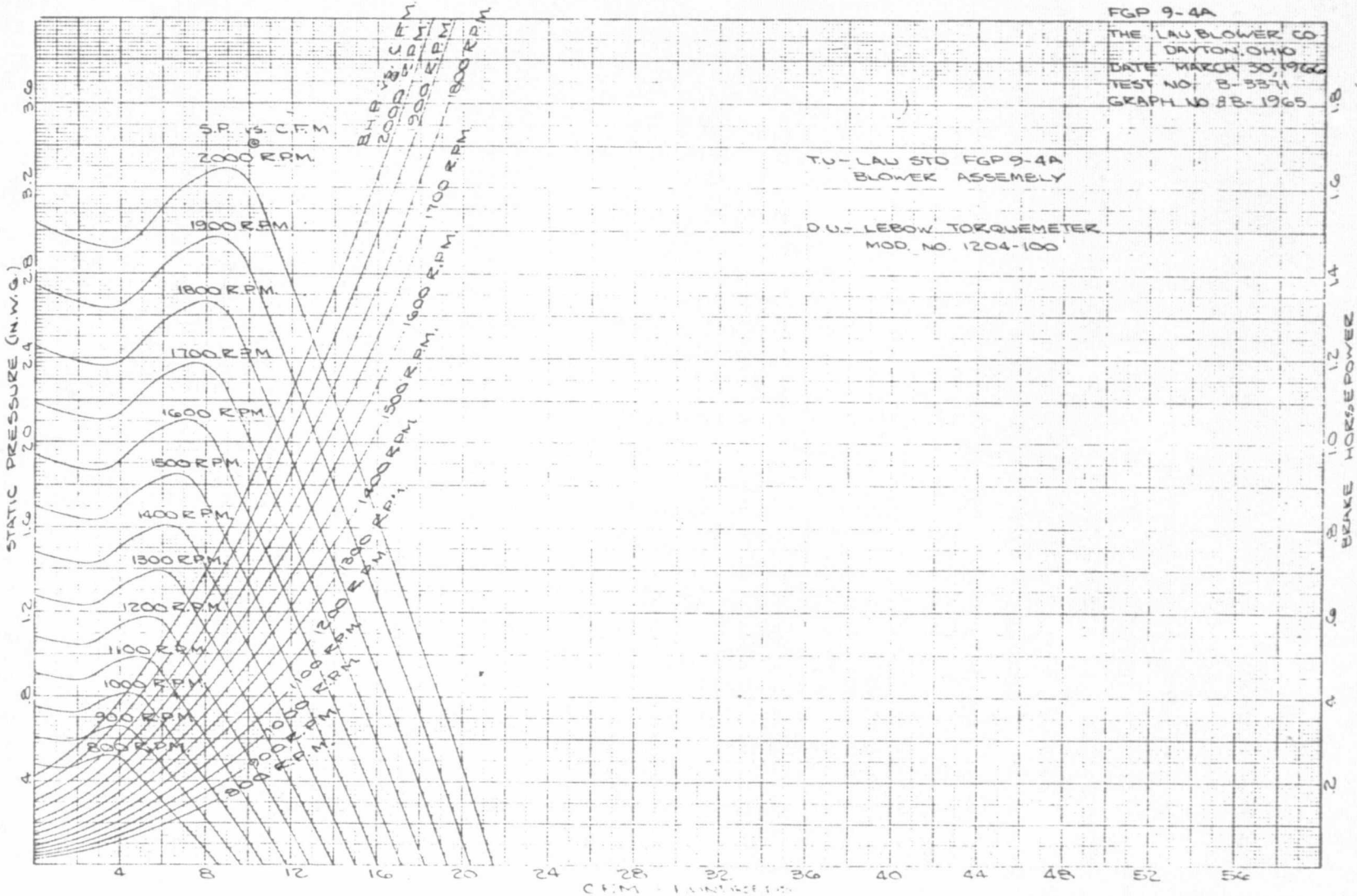

Figure 3.2.4-1, System 4 Collector and Load Loop Blower Performance

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3.3 PERFORMANCE SUMMARY

The system with the Remote Solar Assembly is designed to operate in any region with a latitude less than 45 degrees. In regions with high heating loads, 6500 degree days or higher, the system becomes excessively large. A Remote Solar Assemlby with an effective collector array size of 339 square feet is 30 feet long. Systems larger than this are considered too large to be compatible with the small single family dwelling applicaton.

4.0 SYSTEM OPERATION AND MAINTENANCE

4.1 OPERATING DESCRIPTION

System No. 4 is an air-operated solar space and domestic hot-water heating system. The system operates in any one of three modes of operation as shown in Figure 2.0-2. The operation of the system is described for each of these three modes as follows:

Mode I - Collector to Storage

Normal Mode

The system operates in this mode when solar heat is available in the solar collector, but is not demanded by the heating load. Operation begins when air at the collector air outlet is heated by the Sun's radiation to a temperature which is 40°F or higher than the temperature at the bottom of storage. The relay in Controller No. 1 closes as shown in Figure 2.5-1, completes the collector blower control circuit and therefore picks the blower relay which applies power to the collector blower. Operation is terminated if the air temperature difference between outlet from collector and bottom of storage decreases to 25°F or less. Also, if either rock storage or preheat tank temperatures exceed 200 or 140°F respectively, the collector loop blower circuit will not be completed and the blower and control damper will not operate.

Summer Mode

A summer mode switch as shown in Figure 2.5-1 introduces a second controler, Controller No. 2, into the collector blower control circuit. This controller is identical to Controller No. 1. The relay within this controller is installed electrically in parallel with the relay in Controller No. 1. The relay closes when the air temperature at bottom of storage is 40°F or higher than the water temperature at the bottom of the preheat tank. Operation of the collector blower can be initiated by either controller. Operation is terminated when the control temperature difference for both controllers is 25°F or less. Rock storage or preheat tank temperatures also can terminate collector blower operation in the same manner described for the Normal Mode above.

Operation of the collector loop blower as described for this mode "collector to storage" is independent of any other mode.

Mode II - Collector to Load

The system operates in this mode when solar heat is available at the collectors and heat is demanded by the heating load. Operation in this mode requires that heat be available from the collectors as described for Mode I and also that heat be required by the load. The collector loop blower and control dampers are operated in the same manner as described for Mode I. The load loop blower and control damper must also be initiated in this mode. This is accomplished by the first stage contacts of the site dwelling thermostat which will close when heat is required.

The air flow in the collector and load loops is 400 and 800 cfm respectively. In this mode, since only 400 cfm is available from the collectors, the balance of the air, 400 cfm, is drawn through storage.

Auxiliary heat can be supplied in this mode if either the storage temperature low limit control contact closes or the site dwelling thermostat second stage contacts closes. The latter condition occurs when heat supplied from solar is insufficient to meet the thermal load.

Mode III - Storage to Load

The system operates in this mode when heat is not available at the collectors but heat is demanded by the heating load. It does not matter whether or not heat is available in storage because air to the load always passes through storage. When the storage temperature drops below 90°F, auxiliary heat is called for by the site dwelling thermostat first stage contacts, while air continues to pass through storage allowing storage to be depleted of heat.

4.2 MAINTENANCE

System 4 shall be inspected quarterly and routine maintenance performed at that time. Larger maintenance tasks such as repairing rain water leaks into the collectors, replacing a back draft damper or replacing the thermal bleeder valve, shall be scheduled for the earliest possible completion.

4.2.1 System Control

If the system fails to operate the schematic, Figure 2.5-1, shall be used to troubleshoot the control circuits. Each control element in the collector and load blower control loops can be opened or jumpered as necessary to locate the malfuntion.

Performance of Controllers No. 1 and 2 shall be evaluated with a spare set of temperature sensors. The 40°F "on" and 25°F "off" control temperature differences shall be evaluated with controlled environments. Faulty controllers shall be returned to the manufacturer for repair.

4.2.2 Blowers

Blower "V" belts shall be inspected for proper tension and excessive wear. A belt has proper tension when a force of approximately ten pounds applied to the mid span of the belt in the direction of the apex of the "V" produces a 1/2 inch deflection. Tension adjustments can be made by adjusting motor swivel base to shorten or lengthen the pulley to pulley spacing. Excessive

wear on the belts can be detected by highly glazed surface and deep cracks in the inside of the belt. Tension adjustments and belt replacements shall be made as required. The belts for the collector and load blowers are 4L360 and 4L440 respectively.

Blower motor bearings shall be lubricated with 30 weight non detergent lubricating oil by applying several drops of oil in each of the two oil cups on both of the two blower motors at each inspection.

The blower wheel bearings are sealed ball bearings lubricated for the life of the bearing; therefore, no maintenance is required. The blower is normally extremely quiet. If during servicing a growlling or squealing noise is heard, the insulation and ducting should be removed and the bearings inspected.

Replace both bearing if either is faulty or if in doubt. Use Lau replacement bearings part no. 38-2588-01 (a pair of bearings) or equivalent.

Blower speeds are initially set to obtain 400 cfm in the collector loop and 800 cfm in the load loop. Adjustment in blower speed can be made by adjusting the variable pitch sheaves on the motor shafts. Air flow in the collector loop should be maintained at 400 cfm. Air flow in the load loop may be changed to meet installation requirements. A minimum speed variation is available with the existing split sheave on the motor. Other pulleys can be used to make blower speed adjustments. When adjusting blower speed, the current drawn by the motor should be monitored and the rated current of the motor should not be exceeded. A higher horsepower motor in the same frame size could be used if necessary.

4.2.3 Dampers

The two back pressure dampers and two control dampers contained in the Remote Solar Assembly shall be visually inspected by removing the access plugs in the duct insulation and viewing the dampers by shining light through the transparent lexan port covers.

Back Pressure Dampers

Any deterioration in the back pressure damper fabric blades shall be corrected by replacing the blade or the whole damper assembly. Replace with identical hardware (see design description drawing 7934983).

Control Dampers

Damper blades shall open fully so that the blades are parallel with the air flow. When closed, the damper blade seals shall fit tight. Improper opening and closing of the control dampers shall be corrected by adjusting the linkages between motor crank and damper crank and/or by adjusting spring tension. See illustration showing linkage installation in the appendix.

When blade edge and side seals show sufficient wear to cause leaks, the seals or complete damper shall be replaced. See the sheets in the appendix which describe this item.

4.2.4 Water Leaks

Collector Array

The collector array shall be inspected for water leakage. Leakage may be into the Remote Solar Assembly or into the collectors. Leakage between collectors can be detected by observing the insulation on the back side of the collectors for wet spots and/or water stains. Water leakage into the collectors can be detected by visible water condensation on the inside surface of either the first or second glazing. Either of these two types of leaks shall be repaired by removing cap strips, cleaning hardware and reassembling cap strips per drawing 7934940. Collector glazings, cap strips and rubber seals shall be cleaned with a cloth using detergent and water.

Plumbing

All DHW plumbing shall be inspected for leaks. Leakage can be detected by wet spots or water marks on the floor of the Remote Solar Assembly and/or in the plumbing insulation. The source of any leakage shall be localized and repairs made.

Drain pipes shall be inspected for valve leaks. Washers shall be replaced where necessary in leaky shut-off valves. A leaky thermal bleeder valve should be checked for debris that may prevent valve from seating properly. The valve seat should be cleaned of debris, the valve seat repaired to eliminate erosion grooves or the valve should be replaced.

4.2.5 Maintenance Personnel

Maintenance and repair work shall be performed by qualified personnel. The skills required to service the system are listed below.

Task	Personnel
Repair plumbing leaks	Plumber
Repair or replace dampers	Tin-Smith
Inspect and service blowers	Heating and Ventilating Technician
Troubleshoot system failure	Heating and Ventilating Technician

Most heating and ventilating firms would have the necessary skilled personnel to service the system.

5.0 INSTALLATION

5.1 COLLECTOR SUBSYSTEM INSTALLATION

For optimum results, the collector array should be installed facing south. Variations up to 30° toward east or west, however, would decrease system performance by only 2%. The tilt angle for System 4 is fixed at 45° when the base of the Remote Solar Assembly is leveled. The array must be installed in an area free of shadows from trees or other objects.

Installation of collectors on the System 4 Remote Solar Assembly is similar to the installation shown in Figure 5.1-1 except that the collectors are assembled over 2 inch thick rigid isocyanurate foam insulation, Upjohn CPR9545, and secured to the aluminum rafters as shown in IBM drawing 7934940.

Manifolding of air between collectors is accomplished through gasketed ports between collectors. Unused ports are sealed off by capping plates. The inlet and outlet air openings in the collectors to fastened ducting are sized for the air duct leading to and from the collector array. Attachment of ducting to the collectors is accomplished as shown in Figure 5.1-2.

5.2 STORAGE SUBSYSTEM INSTALLATION

The following hardware is installed in the Remote Solar Assembly in accordance with assembly drawing 7934940 to generate the pebble bed storage subsystem for System 4.

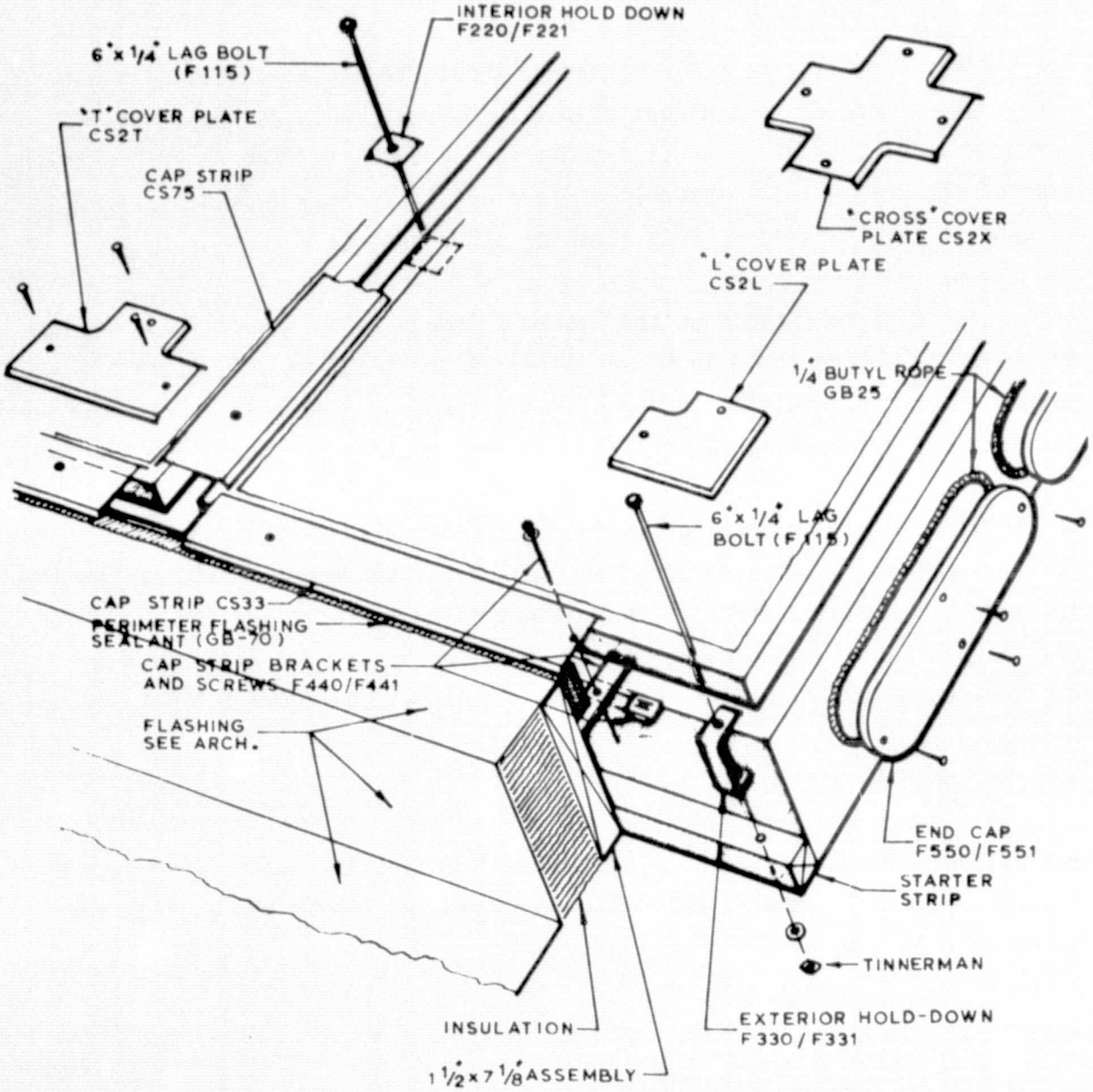

Figure 5.1-1, Collector Installation

NOTE:

TILT PANEL TO ALLOW ACCESS FOR CUTTING HOLE IN BOTTOM (DUCT CONNECTION). DO NOT INVERT PANEL. GLASS IS NOT CLAMPED IN PLACE AND COULD DROP FROM FRAME WITH IMPROPER HANDLING.

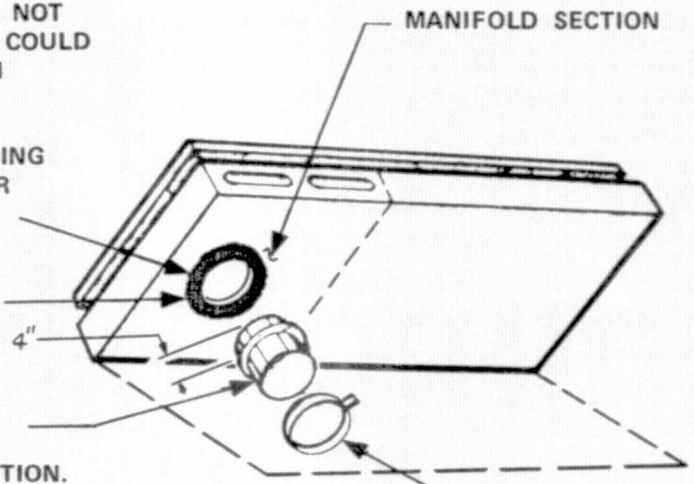

Figure 5.1-2, Duct to Collector Installation

Item	Part Number or Description	Qty.
Side Panel	7934936	6
Top End Panel	7934937	2
Top Center Panel	7934939	1
End Panel	7934938	2
Plate	7934981	8
Angle	7934982	2
Grating Assembly	7934976	3
Base Insulation	7934948	3
Steel Band	.02 "thick x 5/8" wide	AR
Self taping screws	10-24 1/2" long	92
Silicone Rubber Sealant	RTV 77	AR
Silicone Rubber Sealant	RTV 3110	AR
Pebbles	3/4 to 1 1/2 diameter (1)	AR (approx. 5 1/2 ton)
Air Deflector	Perforated sheet (2)	1

Six side panels, 7934936, are first assembled into the Remote Solar Assembly structure using eight plates, 7934981, and screws, to fastened the panels at the top to vertical "I" beams within the structure, 7934975. The panels are fastened at the bottom to structural channels at the base of the RSA structure with screws. End panels, 7934937, are then assembled using plates, 7934981, and screws to fastened the panels at the top to "I" beams within the structure. The panels are fastened at the bottom to an angle, 7934982, which is fastened to the base of the RSA structure.

(1) Rounded pebbles washed clean

(2) Sheet size 24" x 24" x (.03" to .060" thick)
.25 to .38 diameter holes in sheet, 20 to 30% open

After side and end panels are installed, three insulation batts, 793448, are laid over the base plate of the structure in the area enclosed by the panels and three grating assemblies are installed. The mounting feet of the grating assemblies must rest on the base plate of the structure, so the insulation batts must be cut to fit around the mounting feet.

Three steel bands 0.020 "thick by 5/8" wide are installed around the side and end panels and stretched to obtain 600 pounds tension in each band.

The center top panel is next installed using plate, 7934981 to fasten the top panel to the side panels and the "I" beams within the structure, 7934975. Silicone rubber sealant RTV77 is applied to the joint between the top panel and side panel to maintain an air tight seal. The end top panels are next installed using plates 7934981 to fasten the end top panels to the side panels, end panels, center top panel and the vertical "I" beams within the structure. Silicone rubber sealant, RTV 3110, is applied to all sealing edges of the panels to form and air tight seal between panels. The adhesive properties of the RTV 3110 are such that the end panels can be removed for access for filling and removing pebbles. Any RTV 3110 that remains on the surface of the panels can be easily peeled off by hand.

The air deflector plate is placed on the top surface of the pebble bed and centered under the top center air opening before the last top cover is installed.

5.3 ENERGY TRANSPORT SUBSYSTEM INSTALLATION

The energy transport system is installed within the Remote Solar Assembly except for the ducting in the load loop between the RSA inlet and outlet ducts and the site dwelling heating system ducts.

The two blowers are installed by attaching them to the structural "I" beams within the RSA by using 2.0" x 2.0" x .12" aluminum angle and .25" aluminum plate as shown in Remote Solar Assembly drawing 7934940.

Ducting is installed between items such as collectors, storage, blowers and heat exchanger using sheet metal screws. Ducting is supported by overhead structure in the RSA using metal straps or by the flooring in the RSA using structural angle fastened to the ducting to serve as supports. All joints in the ducting are sealed with RTV 140 sealant.

Control dampers are mounted in the 14" square duct using sheet metal screws. RTV 140 sealant is used to seal between the damper frame and duct. The control motor mounts external to the duct on a bracket fastened to the duct. Linkages between the damper and control motor are installed as shown in the appendix.

The back draft dampers are installed in horizontal runs of the 14" square duct using sheet metal screws. RTV 140 sealant is used to seal between the damper frame and duct.

The balancing dampers are installed in the 12" diameter round ducts using sheet metal screws. RTV 140 sealant is used to seal between the damper frame and duct.

5.4 DOMESTIC HOT WATER SUBSYSTEM INSTALLATION

The preheat tank air to water heat exchanger thermal bleeder valve, interconnecting piping, drain piping, and shut-off valves are installed in the Remote Solar Assembly in accordance with assembly drawing 7934940. The domestic hot water heater is considered part of the existing site plumbing. It is connected to the preheat tank with 1/2" CPVC piping so that it draws its supply water from the preheat tank. A bypass valve is installed around the domestic hot water heater so that supply water can be directed to the heater if the preheat tank is disabled. The System 4 domestic hot water system overall plumbing installation configuration is shown in System 4 Design Description drawing 7934983. All piping in the RSA and between the RSA and the site temperature controlled area is insulated with 3 inches of urethane foam to obtain a R-20 or better.

One mounting surface of the air to water heat exchanger is fastened to the center top thermal storage cover panel with self tapping screws. The other mounting surface of the heat exchanger is fastened to a sheet metal duct adapter with sheet metal screws.

The preheat tank is installed on a shelf in the RSA several feet above the heat exchanger. The base of the preheat tank is bolted to the shelf. A 3 1/2 inch thick blanket of fiber glass insulation is wrapped around the preheat tank to add additional insulation.

The thermal bleeder valve is installed in the one inch copper line between the preheat tank and the heat exchanger. Pipe unions are installed in the lines at the heat exchanger and preheat tank to facilitate removal.

5.5 CONTROL SUBSYSTEM INSTALLATION

The control subsystem is installed within the Remote Solar Assembly except for the Site Dwelling Thermostat and the Override Switch. Each of the control subsystem components are physically installed as described below and wired as shown in drawing 7934983.

5.5.1 ΔT Controllers

The two ΔT controllers are mounted on the back side of power control panel which is immediately inside the entry door.

Controller No. 1 - One sensor is mounted on the back side of the air duct in the top collector which is located fourth from the west wall. An opening is provided in the air duct attached to this collector for access to the sensor. Insulation must first be removed from the duct and then a cover panel removed to gain access. The lead wires from this sensor are attached to terminals 4 and 5 on the outside of the controller. The other sensor is inserted into the storage high temperature limit switch probe tube which is located as described below. Lead wires from this sensor are attached to terminals 5 and 6 on the outside of the controller.

Controller No. 2 - One sensor is mounted in the thermosyphoning return line by drilling a 3/16 inch hole in copper tubing inserting a neoprene rubber "O" ring over the forward portion of the sensor, inserting the sensor into the tubing and clamping the sensor to compress the "O" ring with a radiator hose clamp. The lead wires from the sensor are attached to terminals 5 and 6 on the outside of the controller. The other sensor is inserted into the storage high temperature limit switch probe tube in the same location as one of the sensors for Controller No. 1. The lead wires from the sensor are attached to terminals 4 and 5.

5.5.2 Storage Temperature High Limit Switch

The Storage Temperature High Limit Switch is mounted by means of a bracket to a stud within the Remote Solar Assembly near rock storage. The sensing element of the switch is a thermal bulb with 6 feet of capillary tubing between the bulb and body of the switch. The bulb is inserted into rock bed storage at a point which is 4 inches up from the bottom level of pebbles near the center of the bed. A 1/2 inch diameter hard-copper tube with small holes near the end of the tube to facilitate air flow is installed in the rock bed when the bed is being filled with pebbles. This tube facilitates insertion and removal of the sensing bulb into and from the rock bed after the bed has been filled with pebbles. View K-K and detail P of drawing 7934940 show the Storage Temperature High Limit switch installation.

5.5.3 Storage Temperature Low Limit Switch

The Storage Temperature Low Limit Switch installation is identical to the Storage Temperature High Limit Switch above except that the sensing bulb is located at a point 4 inches down from the top level of pebbles.

5.5.4 Preheat Tank Hi Limit Switch

The Preheat Tank High Limit Switch is installed on the Preheat Tank in the location of the upper heating element control thermostat. Both heating elements and the lower control thermostat are removed from the preheat tank which was purchased as a DHW heater.

5.5.5 Blower Relays

The blower relays are mounted on standard electrical outlet boxes. The boxes are mounted to studs in the Remote Solar Assembly in close proximity to the blowers. One hundred fifteen volt (115V) AC service to the outlet box is routed in rigid conduit from the circuit breaker box. Wiring from the relay/ outlet box to the blower is routed in flexible metal conduit.

5.5.6 Transformers

One of the two control voltage transformers is mounted in the Remote Solar Assembly. The other transformer is considered part of the existing site heating control system. It will therefore be located within the site dwelling.

5.5.7 Site Dwelling Thermostat

The Site Dwelling Thermostat is considered part of the existing site heating control system. It will therefore be located within the site dwelling.

5.5.8 Pressure Relief Valve

The Pressure Relief Valve mounts in the upper side of the Preheat tank in the opening provided in the tank for the pressure relief valve if the tank were used as a domestic hot water heater.

5.5.9 Thermal Bleeder Valve

The Thermal Bleeder Valve is installed in the cold water side of the heat exchanger. The valve is installed with a Tee in the one-inch diameter copper tube line. A 3/4 inch diameter PVC tubing is attached to the drain port of the valve to carry away drain water.

5.5.10 Summer Mode Switch

The Summer Mode switch is physically installed on Controller No. 2 which is located on the back side of the power control panel immediately inside the entry door.

5.6 AUXILIARY HEATING SUBSYSTEM

The auxiliary heating subsystem shall be installed in the site dwelling in accordance with local codes. Figure 2.0-1 shows the preferred location of the auxiliary heating subsystems. In this configuration, the auxiliary heat subsystem is installed in series with the solar subsystem. It is expected that the solar load blower is adequate to provide the air flow desired in the load loop. The blower in the auxiliary heating system shall therefore be removed. If however the pressure drops through the load is excessive, the auxiliary heating system blower shall be operated in series with the solar load loop blower. In the later case, an additional relay shall be added in the load loop control circuit. The coil of this relay shall be wired in parallel with the existing load loop blower relay. The operating temperature capability of the auxiliary heating system blower shall be compatible with the solar heated air environment or be replaced with one that is.

If the system were used with a heat pump or if the heating ducts are also to be used for air conditioning, the heat pump or air conditioning, the heat pump or air conditioner would have to be added in parallel with the solar heating system as shown in Figure 2.6-1. A control damper and back draft damper identical to those described in section 2.2 are required to separate the solar system from the auxiliary heating system. The control damper and auxiliary heat would be controlled by the site thermostat second stage contacts and by the air conditioner contacts.

5.7 REMOTE SOLAR ASSEMBLY INSTALLATION

5.7.1 RSA Module

The Remote Solar Assembly module shall be installed on the concrete pad described in Design Description Drawing 7934983. The requirements for transporting and lowering the RSA to the pad are also described in 7934983.

The RSA shall be anchored at gusset plates located inside at the four corners of the base frame. One half inch diameter machine bolt anchors shall be centered on the holes in the gusset plates and installed 2 inches deep in the concrete pad. Large washers shall be used when installing the bolts to compensate for the oversized clearance holes in the gusset plates.

5.7.2 Rock Storage Filling

The top west-side storage panel, 7934937, shall be removed. Washed pebbles 0.75 to 1.5 inch diameter shall be installed over the top of the grating to a level 6 inches from the top inside surface of the storage bin. The site instrumentation temperature measurement tubes for T200, T201 and T202 and the storage high and low temperature limit switch probe tubes shall be inserted as shown in drawing 7934940 while storage is filled. The air baffle plate, described in drawing 7934940 shall be placed over the top layer of stones and the top panel shall be reinstalled. RTV 3110 shall be applied to mating surfaces of the cover to obtain an air tight seal. Machine screws, 10-24 x 1/2 long round head, shall be used to hold the cover in place.

5.7.3 RSA Electrical Ground

The Remote Solar Assembly main structure shall be grounded to earth with an 8 foot long by 0.50 inch diameter grounding rod with a number 2 AWG bare copper wire installed from rod to structure. Use Graybar GR128 rod, with ABS 12 safety rod clamp or equivalent.

5.7.4 RSA to Site Dwelling Interconnections

5.7.4.1 Water Connections

Cold water supply, hot water return and pressure drain lines shall be installed between the RSA and attach points within the site dwelling as follows:

Cold water supply - 3/4 inch PVC tubing

Preheat hot water return - 1/2 inch CPVC tubing

Pressure drain - 3/4 PVC tubing

All lines shall be insulated R-20 or better. Insulation shall be covered with a weatherproof cover. Lines shall be physically supported to insure excessive stresses are not developed. Drain valves shall be installed at low points in the lines to facilitate draining.

5.7.4.2 Air Ducts

Supply air and return air ducts shall be 14 x 14 inches or have equivalent flow characteristics. Ducts shall be insulated R-20 or better. The insulation shall be covered with a weatherproof cover. Duct joints shall be sealed to eliminate all potential leakage. Ducts shall be physically supported to insure that excessive stresses are not developed.

5.7.4.3 Air Filters

One inch thick dust - stop replaceable filters shall be installed in the replaceable filters shall be installed in the return air registers.

5.7.4.3 Electrical Power Service

A 100 amp electrical service line shall be installed to the RSA. The service line shall be connected to the master control switch on the power control panel. The electrical service installation shall meet local codes and UL requirements.

6.0 REMOTE SOLAR ASSEMBLY TRANSPORTABILITY REQUIREMENTS

The following transportability requirements apply to the Remote Solar Assembly, 7934940, hereafter referred to as the RSA.

6.1 PREPARATION FOR SHIPMENT

Before lifting the Remote Solar Assembly for trailer loading operations, the following shall be performed:

1) Remove the west cover panel from the pebble storage enclosure, remove pebbles and reinstall cover panel. The sealant should not be applied to the panel when reinstalled.

2) Drain the preheat tank.

3) If the Remote Solar Assembly is to be shipped during freezing weather, blow all water from preheat tank, heat exchanger, valves and pipes.

4) Secure the preheat tank for shipment.

5) Remote SDAS and ship separately.

6.2 LIFTING AND LOWERING REQUIREMENTS

When lifting or lowering the RSA from or to its mounting pad, the following requirements apply:

1) The RSA shall be lifted by applying forces to the base frame at six points.

2) The lifting points shall be the two outside and middle lifting sockets at the north and south side of the RSA as shown in Figure 6.2-1.

3) When lifting or lowering the RSA, all lifting points shall be moved together such that all points remain in a plane within 1/4 inch.

4) Outrigger bars may be inserted into the lifting sockets to obtain jack clearance as necessary to facilitate lifting. The lift points on the outriggers shall be as close to the RSA frame as possible to minimize torsional loading on the base.

5) The RSA shall be lowered either to beams on the transporter as described below or a concrete slab as described in Design Description Drawing 7934983.

6.3 TRANSPORTER REQUIREMENTS

When moving the RSA by transporter, the following requirements apply:

1) A low-boy semi-trailer shall be used to minimize overhead clearance problems.

2) The base of the RSA shall be supported by four (4) 6" X 6" wood beams running crosswise on the trailer. The mounting surfaces of all the beams shall be in a plane within 1/4 of an inch.

3) The RSA shall be securely tied to the trailer frame at each of the 6 lift sockets described above.

4) The transporter maximum speed shall be limited to 40 mph to minimize emergency stop inertia loads on the RSA.

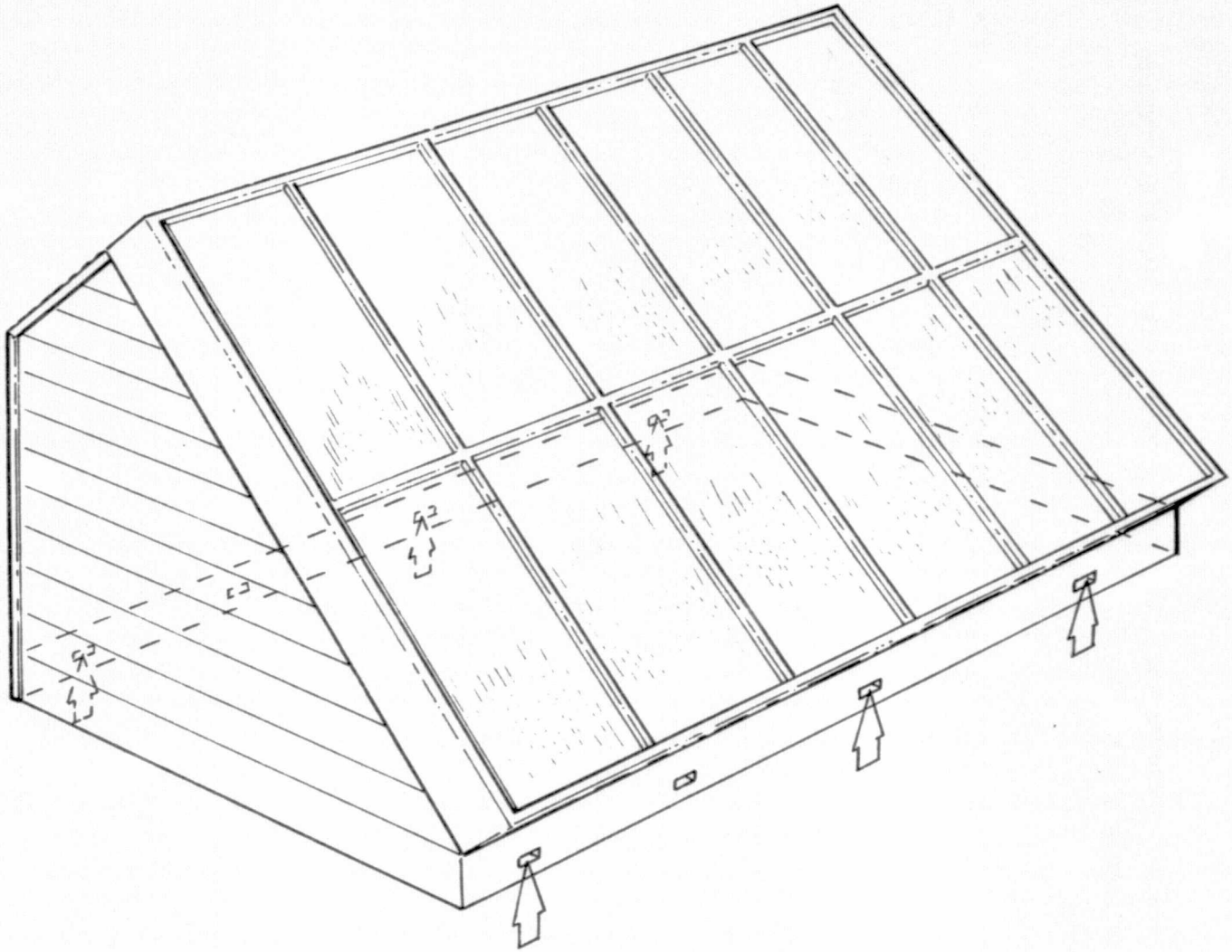

Figure 6.2-1, RSA Lifting Provisions

5) Bumpy roads shall be avoided. When crossing bumps (existing at railroad crossings, etc.), the speed shall be reduced to 5 mph or less as deemed necessary.

6) Tire air pressure shall be lowered to the minimum safe pressure to obtain a soft ride.

REFERENCES

1. American Society of Heating Refrigeration and Air Conditioning Engineers, Inc. Handbook 1976 Systems; Guide and Data Book Fundamentals.

2. "Intermediate Minimum Property Standards for Solar Heating and Domestic Hot Water Systems," Volume 5, U. S. Department of Housing and Urban Development, Washington, D.C., 1977.

3. Local Climatological Data, Annual Summary with Comparative Data, 1974, National Ocenic and Atmospheric Administration, National Climatic Center, Asheville, N.C.

4. Beckman, W. A., Klein, S. A., and Duffie, J. A., "Solar Heating Design by the FCHART Method," John Wiley and Sons, New York, 1977.

APPENDIX

Major Component Vendor Data

SOLARON COLLECTOR PANEL DETAILS

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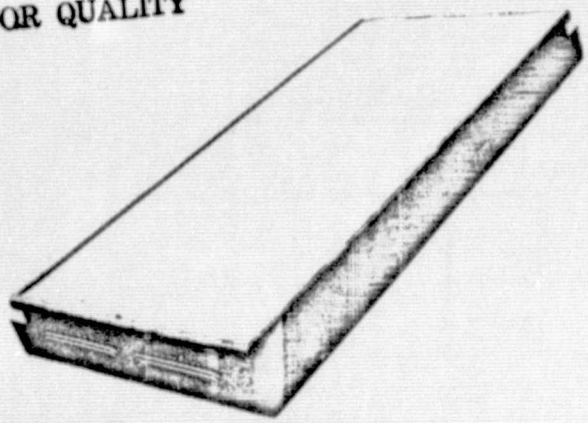

COLLECTOR PANEL

FIGURE 2 COLLECTOR

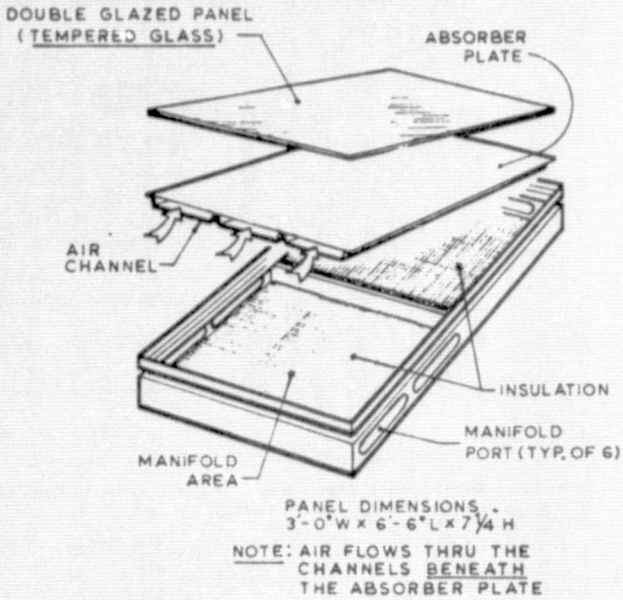

FIGURE 3 COLLECTOR MANIFOLD

C. Components (Fig. 2, 3 & 4)

1. Solar Collector (PATENTS APPLIED FOR)

The Solaron solar collector is an advanced type of an air heating, flat plate collector. Our exclusive internal manifolding allows the Solaron collector to be completely modular. Factory pre-assembled collector panels are plugged into each other with a minimum of installation time. Air inlets and outlets are field cut into each collector array as required. The Solaron solar collector is designed for installation on any structurally sound surface, such as a roof, wall or specially made supports.

The Solaron solar collector has the following general construction characteristics:

Absorber: 28 gauge steel with porcelain enamel coating.

Glazing: Two 1/8" sealed special low iron tempered glass panels with a long life EPDM perimeter gasket. Glass plate can be easily removed for service or replacement.

Pan: 20 gauge steel, fully insulated with 3 3/4" fiberglass batt. Painted external surfaces.

Connection Ports: Unique flange configuration permits tight air seal automatically as modules are installed.

Cap Strip: Painted steel designed to provide weather seal between panels.

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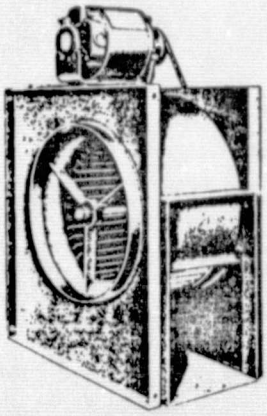
SINGLE-INLET, 4-WAY DISCHARGE BLOWERS



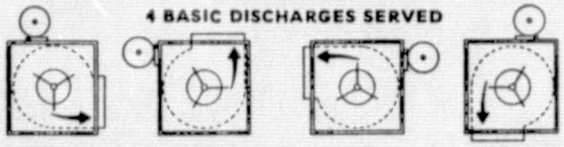
Adaptable to 4 Discharge Positions on the Job
9½ to 18⅛" Dia. Single-Width Wheels

Dayton

$50.72
No. 2C986

Designed and built for general duct ventilation, exhausting, air conditioning, and industrial air-moving applications. Single-inlet type for quiet, efficient performance. Adaptable to any of 4 standard discharges on the job by merely re-locating adj. motor mount and motor on frame—see diagrams. Belt length remains same for each discharge position. Precision, balanced, single-width wheels on ball bearings. Heavy gauge, die-stamped steel housings. Gray finish. Resilient-mounted, automatic-reset thermally protected Dayton motor and drive packed separately when blower is ordered complete. Request Bulletin 706.

4 BASIC DISCHARGES SERVED



BOTTOM HORIZONTAL — UP BLAST — TOP HORIZONTAL — DOWN BLAST

Wheel Dia.	Wheel Width	Shaft Dia.	Inlet Dia.	Outlet H	Outlet W	Overall Size H	Overall Size W	Overall Size D	BLOWER ONLY Less Motor & Drive Stock No.	Retail	Each	Shpg. Wt. Less Mtr. & Drive
9½"	4½"	¾"	10"	10¼"	6½"	16⅛"	10¾"	14⅝"	2C986	884.70	$50.72	22
10⅝	6	¾	11	11⅝	8¼	18	12½	16⅜	2C987	97.21	58.21	29
12⅝	6	¾	13¼	13⅞	8¼	21⅛	12½	19¼	2C988	153.32	91.81	36
15"	6	1	15⅞	15⅞	8¼	25	12½	22½	2C989	155.84	145.81	47
18⅛	9	1	19 15/16	18⅞	12¼	30	17⅞	26⅞	4C218	193.10	180.67	82

SINGLE-INLET BLOWERS WITH MOTOR & DRIVE

Wheel Dia.	CFM AIR DELIVERY AT RPM SHOWN: Free Air	1/8" SP	1/4" SP	3/8" SP	1/2" SP	5/8" SP	Blower RPM	BLOWER WITH 1725 RPM MOTOR & DRIVE — MOTOR DATA: HP	Volts 60 Hz	Type	All With Automatic Thermal Protection: Stock No.	Each
9½"	1090	940	810	695	590	450	926	1/4	115	Split	7C808	$80.43
	1210	1075	945	865	745	645	1030	1/3	115	Split	7C810	85.76
	1330	1205	1085	980	885	800	1100	1/2	115	Split	7C812	100.19
10⅝"	1360	1205	1030	840	600	—	705	1/4	115	Split	7C814	92.47
	1485	1360	1220	1065	885	625	765	1/3	115	Split	7C816	93.91
	1680	1575	1445	1310	1175	1010	850	1/2	115	Split	7C818	108.75
	1935	1850	1740	1610	1485	1350	1030	3/4	115/230	Cap.	7C820	121.14
12⅝"	1820	1610	1310	1030	645	—	580	1/3	115	Split	7C822	128.25
	2050	1885	1690	1390	1165	880	652	1/2	115	Split	7C824	142.01
	2345	2190	2020	1815	1505	1285	750	3/4	115/230	Cap.	7C826	153.33
	(f)	(f)	(f)	(f)	1820	1565	816	3/4	115/230	Cap.	7C828	151.52
15"	2100	1775	1450	1000	—	—	480	1/3	115	Split	7C830	183.84
	2400	2150	1860	1550	1070	—	500	1/2	115	Split	7C832	195.06
	2670	2580	2375	2100	1750	1360	605	3/4	115/230	Cap.	7C834	210.97
	3010	2830	2640	2430	2165	1830	652	1	115/230	Cap.	7C836	227.68
	3010	2830	2640	2430	2165	1830	652	1	230/460	3-Ph.	7C837(*)	219.47
18⅛"	4390	3980	3510	2980	2320	—	467	1	230/460	3-Ph.	7C337(*)	296.03
	4950	4570	4180	3750	3250	2660	525	1½	230/460	3-Ph.	7C338(*)	299.08
	5480	5190	4860	4490	4020	3480	583	2	230/460	3-Ph.	7C339(*)	306.37
	6120	5900	5630	5320	4940	4530	653	3	230/460	3-Ph.	7C340(*)	342.49

(*) 3-phase rigid mounted motors—Not thermally protected.
(f) **Motor Overloaded**—Not recommended for operation at this static pressure, with this HP.

Dayton Full-Fact Carton Label Makes Motor Stocking and Selection Easier

Over 975 Dayton motor types have Full-Fact carton labels. The helpful Dayton label illustrates and identifies specific motor, and lists all its important electrical and mechanical features clearly, for easy reference by dealer and user. Providing complete information on the label simplifies motor selection, helps assure customer satisfaction.

SEE WARRANTY INFORMATION ON PAGE BEFORE INDEX

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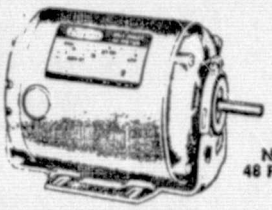
FURNACE BLOWER and FAN-DUTY MOTORS



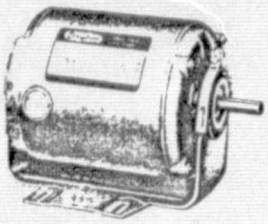
NEMA 48 FRAME

1/6 to 3/4 HP, 1725 or 1725/1140 RPM
Split Phase. Thermal Protection
40° & 50°C Rise, Continuous Duty
Low Noise, Reduced Starting Torque

$26.83
1/6 HP

Dayton

NEMA 56 FRAME

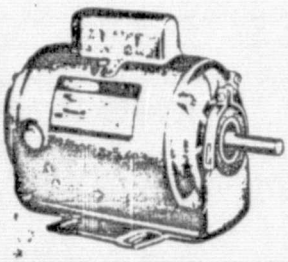


For furnace blowers, air coolers, belt-driven fans and similar applications that require reduced starting torque, low starting amps and low noise level. Split phase, 115, 208-230 & 115/230V, 60 Hz. Resilient mounted. Sleeve bearings. 40°C ambient, Class A insulation, continuous duty. Rotation easily reversed. Open, dripproof. Automatic reset thermal protection. Recognized by UL for construction under the Motor Component Recognition Program. CSA approved. Gray.

HP	RPM	Volts 60 Hz	NEMA Frame	Shaft Dia.	Shaft Long	Type Shaft	Full-Load Amps†	°C Rise	Service Factor	Stock No.	Retail	Each	Shpg. Wt.
1/6	1725	115	48	1/2"	1 1/2"	Flat	3.3	40	1.35	5K906	$40.98	$26.83	13
1/4	1725	115	48	1/2	1 1/2	Flat	5.3	50	1.0	5K908	42.39	27.76	13
	1725	115	48	1/2	1 1/2	Flat	4.4	40	1.35	5K907	44.13	28.90	15
	1725	115	48/56*	1/2*	1 1/2	Flat*	3.4	40	1.35	5K977*	44.13	28.90	16
	1725	115	56	5/8	1 7/8	Key	4.4	40	1.35	5K260	44.13	28.90	16
1/3	1725	115	48	1/2	1 1/2	Flat	6.3	50	1.0	5K909	46.49	30.44	14
	1725	115	48	1/2	1 1/2	Flat	5.8	40	1.35	5K682	51.22	33.54	17
	1725	208-230	48	1/2	1 1/2	Flat	2.8	40	1.0	6K717	54.37	35.60	17
	1725	115	48/56*	1/2*	1 1/2	Flat*	5.8	40	1.35	6K030*	51.22	33.54	17
	1725	115	56	5/8	1 7/8	Key	5.4	40	1.35	5K261	51.22	33.54	19
	1725/1140‡	115	56	5/8	1 7/8	Key	6.0	40	1.35	5K654	79.59	52.12	21
1/2	1725	115	48	1/2	1 1/2	Flat	7.0	40	1.25	5K910	71.71	46.96	19
	1725	115	48/56*	1/2*	1 1/2	Flat*	7.0	40	1.25	5K258*	71.71	46.96	18
	1725	115	56	5/8	1 7/8	Key	7.6	50	1.0	6K399	58.00	37.98	18
	1725	208-230	56	5/8	1 7/8	Key	3.9	40	1.25	6K729	74.86	49.02	21
	1725	115	56	5/8	1 7/8	Key	7.4	40	1.25	5K416	71.71	46.96	20
	1725/1140§	115	56	5/8	1 7/8	Key	9.2	50	1.0	5K620	79.59	52.12	23
	1725/1140§	115	56	5/8	1 7/8	Key	8.5	40	1.25	6K394	101.65	66.56	24
3/4	1725	115/230	56	5/8	1 13/16	Key	12.0	40	1.25	6K624	96.92	63.47	24

(*) Nos. 5K977, 5K258 and 6K030 have NEMA 48 frame body mounted on NEMA 56 frame cradle base and supplied with 5/8" split steel bushing. (†) At 1725 RPM. (‡) 1/6 HP at 1140 RPM. (§) 1/4 HP at 1140 RPM.

1/2 to 2 HP CAPACITOR-START BLOWER MOTORS

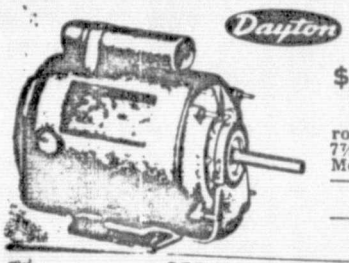


Dayton

$39.22
1/2 HP

For belt-driven furnace fans and blowers that require reduced starting torque, lower starting amps and noise level. Capacitor-start, induction-run type. 40°C ambient, 1.25 service factor, Class A insulation (40°C rise), continuous duty. Automatic reset thermal protection. Open, dripproof. Sleeve bearings, except No. 6K805 has ball bearings. Resilient mount. NEMA 48 and 56 frames. Reversible rotation. Recognized by UL for construction under the Motor Component Recognition Program. CSA approved. Gray. Dayton brand.

HP	RPM	Volts 60 Hz	NEMA Frame (See p. 16)	Full-Load Amps @115V	Stock No.	Retail	Each	Shpg. Wt.
1/2	3450	115/208-230	48	8.6	6K804	$59.89	$39.22	16
3/4	3450	115/208-230	56	9.2	5K900	71.71	46.96	21
1	1725	115/208-230	56	12.8	6K157	122.93	80.50	30
1	3450	115/208-230	56	11.6	5K901	90.62	59.34	23
2	3450	115/208-230	56	20.4	6K805	145.78	95.46	37



Dayton

1/4 HP, 1 & 2-SPEED FAN DUTY

Permanent Split Capacitor Type. TENV, Air-Over

$38.72
1100 RPM

For direct driven exhaust and circulator fans. 115V, 60 Hz. Resilient mounted. Sleeve bearings. 40°C ambient, 55°C rise, continuous duty. Totally enclosed. Automatic reset thermal protection. CW rotation, easily reversed. NEMA 48 frame. Overall length 10 3/8"; 7 7/8" less shaft. Recognized by UL for construction under the Motor Component Recognition Program. CSA approved. Gray.

HP	RPM	Full-Load Amps @1100 RPM	Stock No.	Retail	Each	Shpg. Wt.
1/4	1100	3.6	3M339	$58.39	$38.72	16
1/4	1100/2-Spd.	3.1	3M340	60.19	39.44	18

R8225A,B,C,D FAN RELAY

FOR [illegible] CONTROL [illegible] VOLT [illegible] AND [illegible] CIRCUITS.

Used in heating, cooling, or heating-cooling systems. Integral 1/2 inch conduit spud allows relay to be mounted on a standard junction box. Contacts: Silver cadmium oxide. Max. Operating Ambient: 115 F. Mounting Means: Threaded 1/2 inch NPT conduit spud. Dimensions (inches): 2-11/16 high, 2-1/2 wide, 3-7/16 deep. Listed by Underwriters Laboratories Inc.

RESISTIVE RATINGS: For N.O. contacts—16 amp at 120V, 8 amp at 240V; auxiliary contacts—3 amp at 120V, 2 amp at 240V ac.

TRADELINE MODELS:

Order Number	Contact Ratings (amperes)			
	120V ac		240V ac	
	N.O. (1 hp)	N.C. (3/4 hp)	N.O. (1 hp)	N.C. (3/4 hp)
R8225A1017[a]	16.0 FL 96.0 LR	13.8 FL 82.8 LR	8.0 FL 48.0 LR	6.9 FL 41.4 LR

Additional Models:

Order Number	Contact Ratings (amperes)			
	120V ac		240V ac	
	N.O. (3/4 hp)	N.C. (3/4 hp)	N.O. (1 hp)	N.C. (3/4 hp)
R8225A1041	13.8 FL 82.8 LR	13.8 FL 82.8 LR	8.0 FL 48.0 LR	6.9 FL 41.4 LR
R8225B1007	13.8 FL 82.8 LR	–	8.0 FL 48.0 LR	–
R8225C1005	13.8 FL 82.8 LR	13.8 FL 82.8 LR	8.0 FL 48.0 LR	6.9 FL 41.4 LR
R8225D1003 (main)	13.8 FL 82.8 LR	–	8.0 FL 48.0 LR	–
(aux.)	3.0 FL 18.0 LR	–	1.9 FL 11.4 LR	–

[a]134259 Flush Mounting Bracket included.

SWITCHING AND COIL RATINGS:

Models	Switching	Configuration and Color-coding	Operating Coil Pull-in		
			Inrush	Sealed	Voltage
R8225A	spdt	BLACK — RED; BROWN	11 VA maximum	6 VA maximum	18V maximum at 75 percent of rated voltage.
R8225B	1 spst N.O.	BLACK — BLACK			
R8225C	1 spst N.O. 1 spst N.C.	BLACK — BLACK; RED — RED			
R8225D	dpst 1 main N.O. 1 aux. N.O.	LOAD CONTACTS: BLACK — BLACK; AUXILIARY CONTACTS: YELLOW — YELLOW			

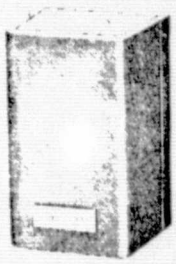
R8146A ADD-ON HEATING RELAY

PROVIDES SWITCHING FOR A SELF-GENERATING (POWERPILE) HEATING SYSTEM WHEN COOLING IS ADDED TO EXISTING INSTALLATION.

Used with R856B, R8226, R8227, or R8239 Fan Centers and T87F Room Thermostat. R8146A isolates millivolt heating system power from 24 volt cooling system control circuit. Electrical Rating: Contacts—0.25 amp at 0.25 to 12V dc or 1.5 amp at 24V ac. Relay Coil—0.4 amp at 24V ac. Ambient Temp. Range: 0 to 100 F. Mounting Dimensions (inches): 5-1/4 high, 4-1/4 wide, 3 deep. Listed by Underwriters Laboratories Inc.

Order Number	Switching	Coil Voltage
R8146A1005	spst	24V ac

R8093A THERMAL TIME DELAY RELAY



IMPROVES INTERMITTENT COMPRESSOR OPERATION BY DELAYING START OF COMPRESSOR ON DEMAND FROM THERMOSTAT.

Prevents compressor damage as a result of rapid cycling. Prevents excessive inrush current on simultaneous start of 2 compressors. Switch Action: Spst normally open contacts. Contact Rating: 1.5 amp at 24V ac, 50/60 Hz. Heater Voltage: 24V ac; heater current 0.08 amp. Timing: Make—35 seconds (nominal); Break—35 seconds maximum (minimum on time is 3 seconds). Ambient Temperature: 40 to 140 F at 85 to 110 percent rated voltage. Unit will operate at 0 F at rated voltage. Quick-connect terminals. Case Dimensions (inches): 3-3/4 high, 2-5/16 wide, 2-1/8 deep.

Order Number	Case and Cover
R8093A1008	Yes
R8093A1024[a]	No

[a]Includes mounting bracket.

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2 circuits 590 BTU/hr/°F

PRICE BULLETIN WS– 12

DATE SEPTEMBER 1, 1976

SUPERSEDES WS– 11

Halstead & Mitchell
A DIVISION OF HALSTEAD INDUSTRIES INC.

SEE PRICE LIST FSP–11 FOR DE, CW & LARGER SIZE COILS

Hot Water and Standard Steam Coils *

4gpm $\Delta P_w = 2.4$ ft
6gpm $\Delta P_w = 4.2$ ft

WITH PLATE FINNED SURFACE. 5/8" O.D. STAGGERED TUBE DESIGN

MOST COIL SIZES SHIPPED FROM STOCK

1 ROW COILS				2 ROW COILS			
	MBH @60° EAT 800 FPM				MBH @60° EAT 800 FPM		
COIL MODEL	200° - 180° Hot Water	5 PSI STEAM	LIST PRICE	COIL MODEL	200° - 180° Hot Water	5 PSI STEAM	LIST PRICE
SW1-6-12-8	13	15	131.00	SW2-6-12-8	20	26	166.00
SW1-6-15-8*	16	19	136.00	SW2-6-15-8*	26	33	170.00
SW1-6-18-8	18	23	138.00	SW2-6-18-8*	31	40	173.00
SW1-9-9-8*	14	17	136.00	SW2-9-9-8*	23	30	168.00
SW1-9-12-8	18	23	140.00	SW2-9-12-8	30	39	173.00
SW1-9-15-8*	23	28	145.00	SW2-9-15-8	38	49	180.00
SW1-9-18-8	28	34	150.00	SW2-9-18-8	46	60	186.00
SW1-12-12-8	25	30	150.00	SW2-12-12-8	41	53	186.00
SW1-12-15-8*	31	37	160.00	SW2-12-15-8	51	66	196.00
SW1-12-18-8	37	46	170.00	SW2-12-18-8	61	79	202.00
SW1-12-24-8	49	61	180.00	SW2-12-24-8	81	106	232.00
SW1-12-30-8	63	75	198.00	SW2-12-30-8	102	133	254.00
SW1-12-36-8*	75	90	220.00	SW2-12-36-8	122	158	281.00
SW1-15-18-8	46	57	180.00	SW2-15-18-8	76	99	215.00
SW1-15-24-8	61	76	195.00	SW2-15-24-8	102	132	251.00
SW1-15-30-8	78	94	225.00	SW2-15-30-8	126	164	292.00 *
SW1-15-36-8*	94	113	256.00	SW2-15-36-8	152	198	328.00
SW1-18-18-8*	56	68	200.00	SW2-18-18-8	92	119	235.00
SW1-18-24-8	75	90	232.00	SW2-18-24-8	122	158	297.00
SW1-18-30-8*	94	113	260.00	SW2-18-30-8	152	198	333.00
SW1-18-36-8	113	135	280.00	SW2-18-36-8	183	238	359.00
SW1-18-48-8*	150	180	328.00	SW2-18-48-8	244	316	420.00
SW1-21-30-8*	110	131	288.00	SW2-21-30-8	178	231	369.00
SW1-21-36-8*	131	158	314.00	SW2-21-36-8	213	277	402.00
SW1-21-48-8*	175	210	368.00	SW2-21-48-8	287	371	472.00
SW1-24-24-8	100	120	281.00	SW2-24-24-8	164	212	360.00
SW1-24-30-8*	125	150	319.00	SW2-24-30-8	205	265	409.00
SW1-24-36-8	150	180	345.00	SW2-24-36-8	244	316	442.00
SW1-24-48-8	200	240	398.00	SW2-24-48-8	325	421	510.00
SW1-27-54-8*	253	304	459.00	SW2-27-54-8	415	537	589.00
SW1-30-48-8*	250	300	470.00	SW2-30-48-8	410	530	602.00

MODEL NUMBER EXPLANATION:
Coil Type, Rows Deep, Fin Height, Fin Length, Fins Per Inch
Example:
SW—1—6—18—8 Steam or Water, 1 Row Deep 6" Finned Height 18" Finned Length, 8 Fins Per Inch.

NOTES:

1. All prices are subject to change without notice.
2. F.O.B.—Scottsboro, Alabama; Terms-Net 30
3. Prices include casing.
4. Aluminum fins and copper tubing are standard.
5. For copper fins, contact factory for quotation.
6. For red brass tubing, contact factory for quotation.
7. Cleanable tube water coils are available. Contact factory for quotation.

*NORMALLY NOT STOCK ITEM

SEE REVERSE SIDE FOR FURTHER DETAILS

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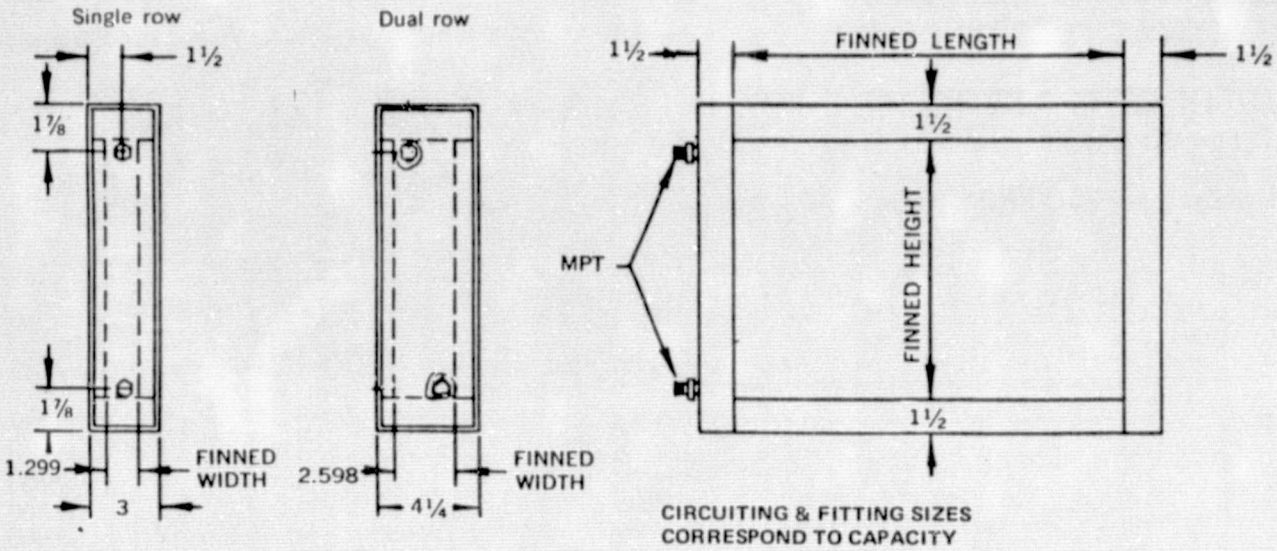
3

HALSTEAD & MITCHELL BOOSTER COILS

DIMENSIONS



CAPACITY CORRECTION FACTORS

FACE VELOCITY		
FPM Face Vel.	Water Coil.	Steam Coil
400		
500	.83	.77
600	.87	.85
700	.94	.94
800	1.00	1.00
900	1.05	1.085
1000	1.09	1.125

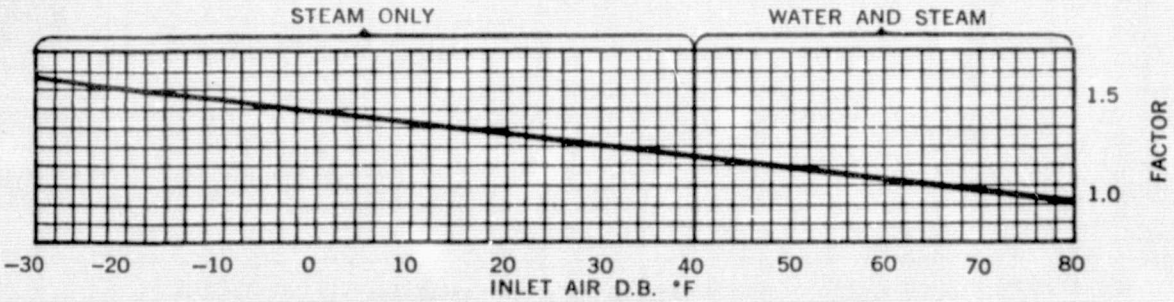
STEAM TEMP.	
PSI	Corr.* Factor
2	.95
5	1.00
10	1.07
15	1.13
20	1.18
25	1.22

AVER. WATER TEMP.	
Degree	Corr. Factor
140	.63
150	.71
160	.79
170	.86
180	.93
190	1.00
200	1.07

FINS/INCH	
FPI	Corr. Factor
6	.85
8	1.00
10	1.13
12	1.22
14	1.31

* @ 60° EAT

Inlet Air Dry Bulb Temp.



AIR SIDE FRICTION LOSS

FACE VELOCITY FPM (STD. AIR)	PRESSURE DROP (Inches W.G.)	
	1 Row	2 Row
400	.04	.09
500	.07	.14
600	.09	.19
700	.12	.24
800	.15	.30
1000	.22	.45
1200	.30	.63
1400	.39	.80

CORRECTION FACTORS AIR SIDE FRICTION LOSS

FINS/INCH	Corr. Factor
6	.84
8	1.00
10	1.16
12	1.33
14	1.52

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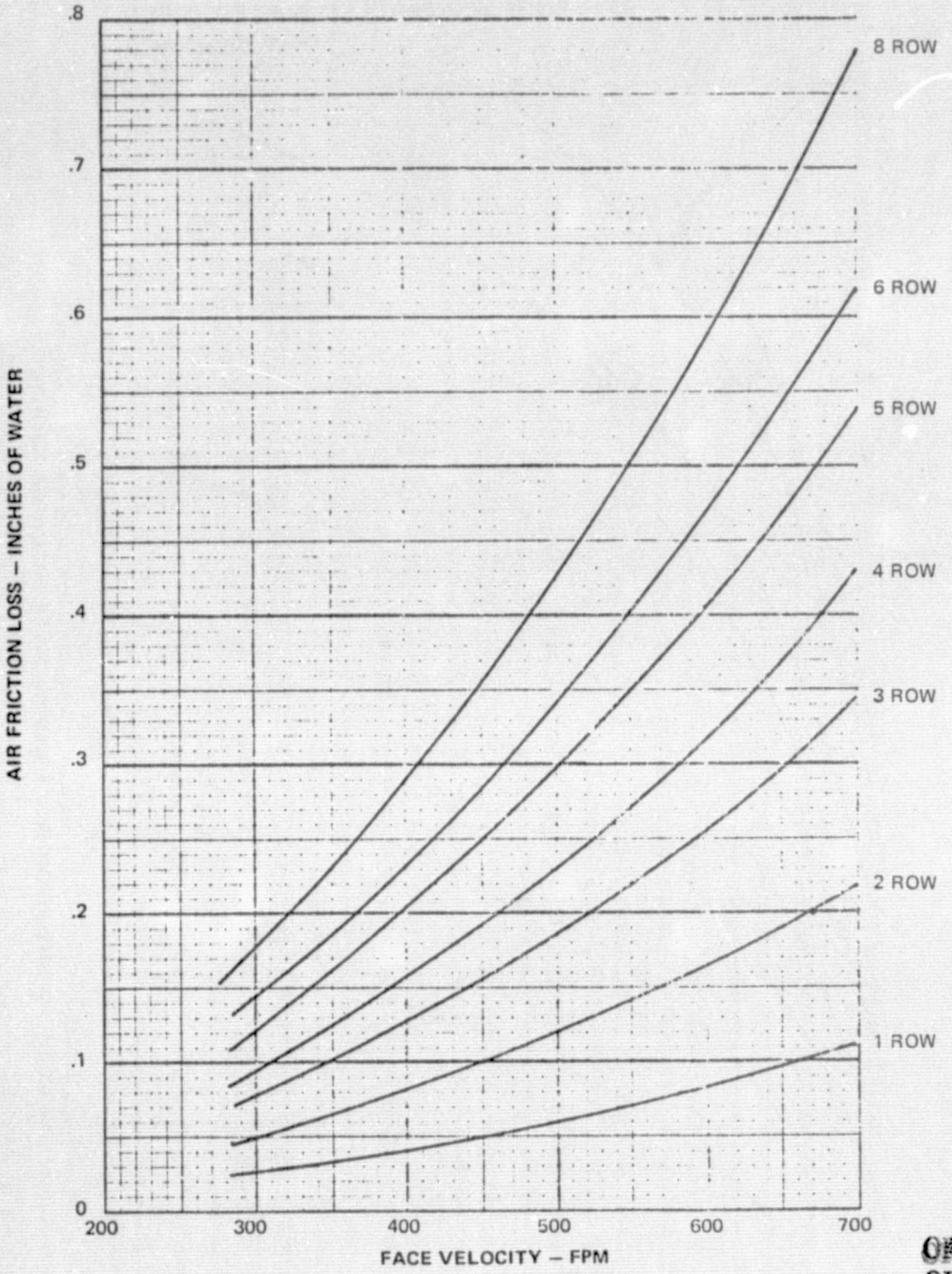
AIR FRICTION LOSS FOR DRY SURFACE



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WETTED SURFACE CORRECTION FACTORS

Entering Dew Point Minus Refrig. or Water Temp	Factor
0	1.00
10	1.11
20	1.20
30	1.27
40	1.35

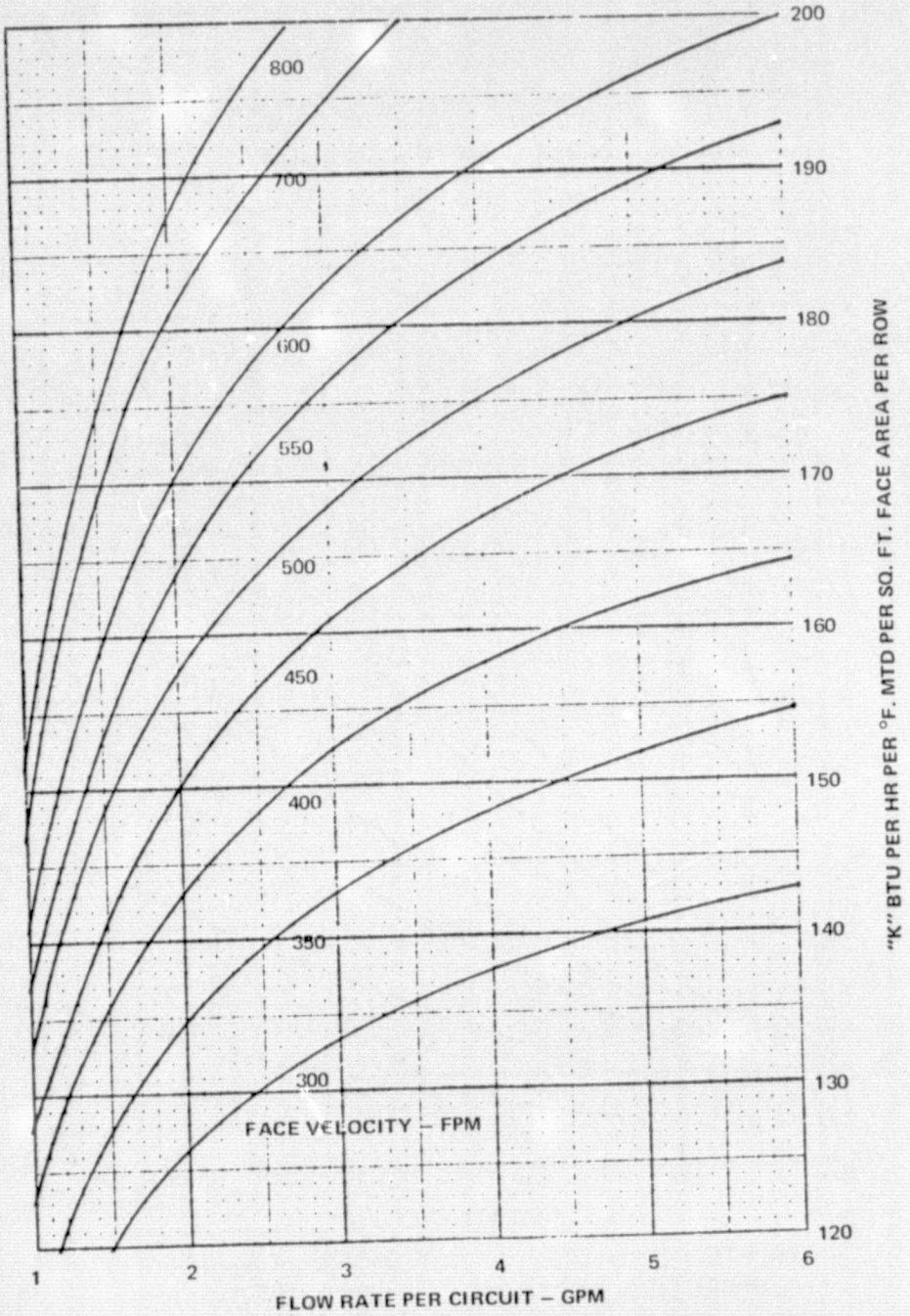
FINS PER INCH CORRECTION FACTORS

FPI	Factor
6	.84
8	1.00
10	1.16
12	1.33
14	1.51

Halstead & Mitchell
Zellenople, Pennsylvania • Wynne, Arkansas

HEAT TRANSFER COEFFICIENTS

6210 SURFACE CHILLED WATER COILS
DRY SURFACE



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Halstead & Mitchell
Zelienople, Pennsylvania • Wynne, Arkansas
Telephone: 412-452-9400

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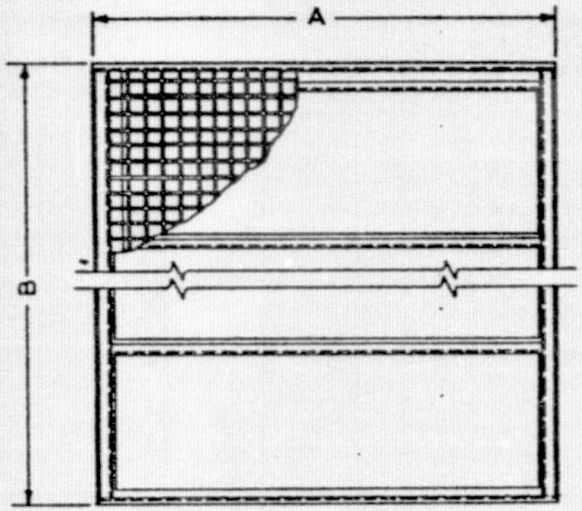

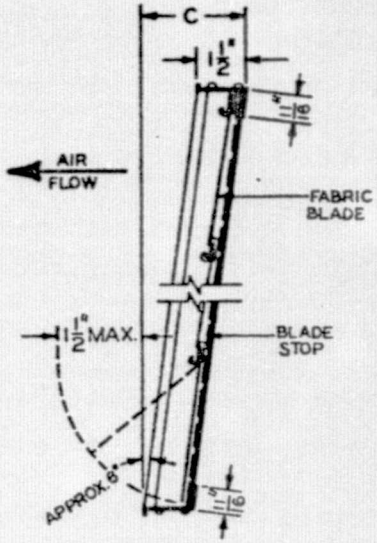

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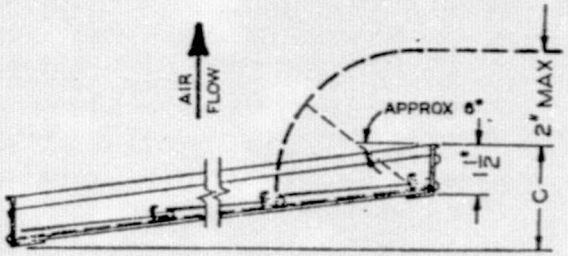
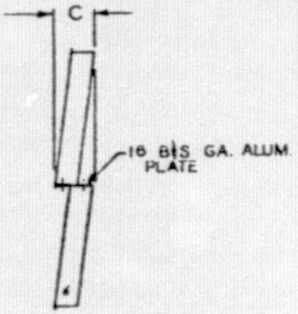
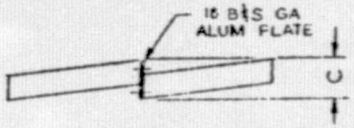


HORIZONTALLY MOUNTED



MULLION FOR VERTICALLY MOUNTED UNITS



MULLION FOR HORIZONTALLY MOUNTED UNITS

SPECIFICATIONS:

THE FOLLOWING SPECIFICATIONS INDICATE NORMAL CONSTRUCTION OF THE FABRIC BLADE BACK PRESSURE DAMPERS.

FRAME - .050" EXTRUDED ALUMINUM, 6063-15 ALLOY.
BLADES - FOR DUCT VELOCITY THRU 900 F.P.M. A COATED FABRIC MATERIAL 4" WIDE WILL BE USED. WHERE VELOCITY IS UNDER 300 F.P.M. #1010 CONRLASTIC IS RECOMMENDED, AVAILABLE AT EXTRA COST. ADVISE VELOCITY AND BLADE MATERIAL.
BLADE STOPS - COATED 1/2" .063 GALVANIZED STEEL SCREEN
FINISH - MILL
MAXIMUM 'C' DIMENSION - 0" TO 12" HIGH - 2-3/4"
13" TO 19" HIGH - 3-1/2"
23" TO 24" HIGH - 4"

BLADE ANGLE WILL BE CONSTANT, APPROXIMATELY 6 DEGREES, THEREFORE, DEPTH WILL VARY DEPENDING ON HEIGHT, BUT WILL NEVER EXCEED ABOVE 'C' DIMENSIONS.
MAXIMUM PANEL SIZE - 36" WIDE X 24" HIGH. WHEN LARGER UNIT IS REQUIRED DAMPER WILL BE FABRICATED IN MULTIPLE SECTIONS FOR FIELD ASSEMBLY.
MAXIMUM TEMPERATURE ALLOWANCE 250 DEGREES F. FOR SPECIAL HIGH TEMPERATURE APPLICATION, INFORMATION ON REQUEST.

A&B ARE DUCT SIZES. BACK PRESSURE DAMPERS ARE FABRICATED 1/8" UNDERSIZE.

UNITS ARE FABRICATED FOR EITHER HORIZONTAL OR VERTICAL MOUNTING, PLEASE SPECIFY.

OTHER GAUGES AND MATERIAL FOR FRAME, BLADE STOP AND BLADES ARE AVAILABLE ON REQUEST.

FASTENERS, THEIR TYPE AND LOCATION AND METHOD OF FASTENING ARE SUBJECT TO OUR SELECTION TO MAINTAIN BEST CONSTRUCTION PRACTICES. SPECIFICATIONS ARE SUBJECT TO NORMAL TOLERANCES, DIMENSIONAL AND VISUAL.

DRAWINGS ARE SUBJECT TO CHANGE WITHOUT NOTICE.

NO. REQ'D	A	B	BLADE MAT'L	VELOCITY	NO PANELS	GA. FRAME	TYPE MOUNTING

DATE _____
CUSTOMER _____
CUSTOMER ORDER NO. _____
AGENTS ORDER NO. _____
JOB _____

H	LOGO CHG'D	12-6-71	JH
G	REDRAWN, FRAME CHG'D	12-26-68	DVL
F	FRAME MATERIAL CHG'D	5-14-65	N.C.
E	REDRAWN, GEN. REV	1-5-65	GH
	REVISION	DATE	BY

american warming and ventilating inc
1012 SUMMIT ST TOLEDO OHIO

FABRIC BLADE BACK PRESSURE DAMPER
SHB-P-1217 21236-3

CKD BY | APPD BY
DRN. BY DVL | DWG NO SHB-D-1217 | REV H
DATE 12-27-68

CATALOG SECTION 2
DAMPERS - BACK PRESSURE

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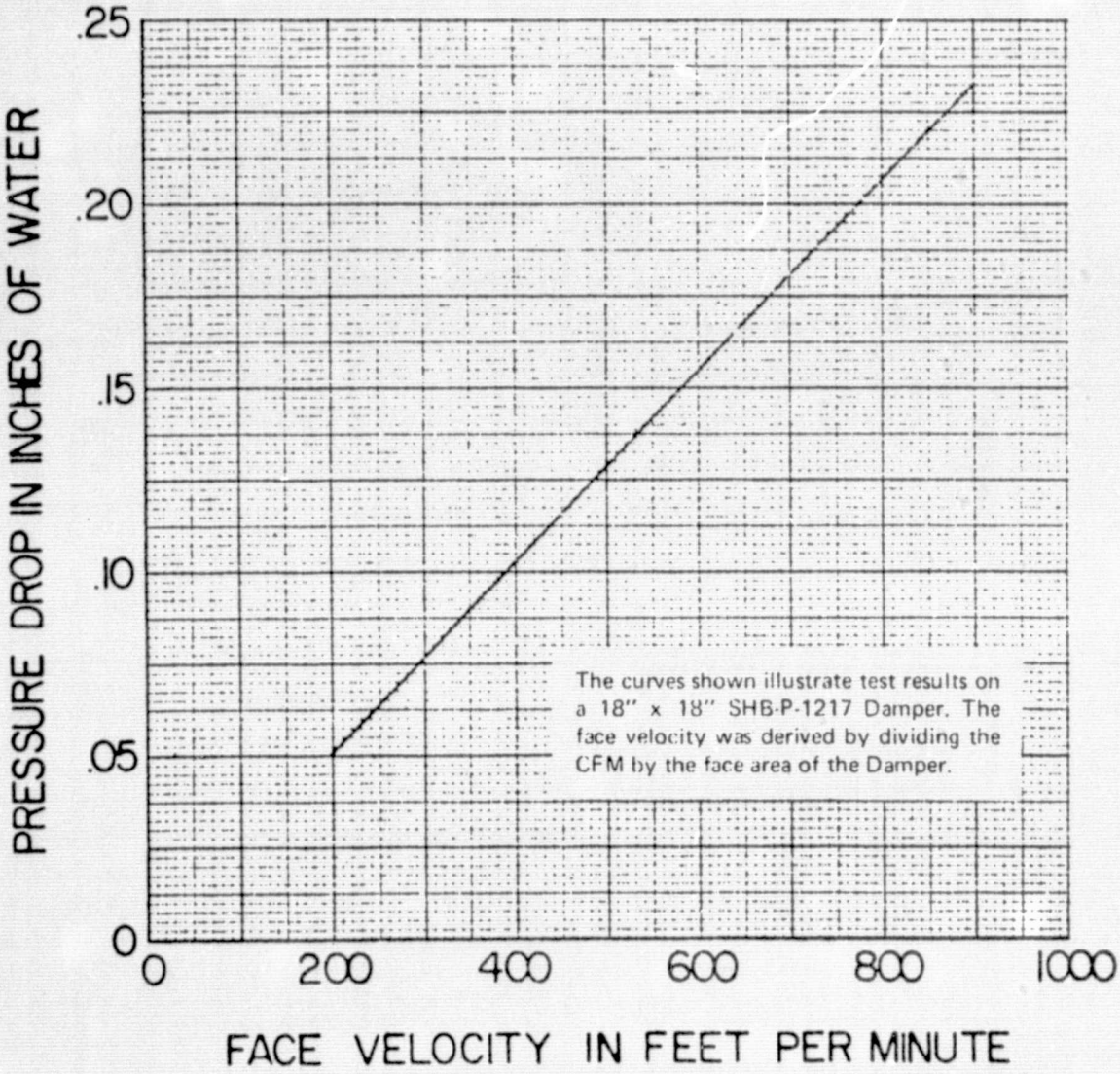
american warming
and ventilating inc

SERIES SHB-P-1217 DAMPER
FACE VELOCITY VS. STATIC PRESSURE



P.O. BOX 1717CS
1017 SUMMIT ST.
TOLEDO, OHIO 43603
(419) 243-7151

AMCA MEMBER

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Thermal Bleeder Valves

Automatically drains water lines and water cooled equipment for positive protection against freeze-ups . . . eliminates freeze damage repairs, down-time, and wasted water. Opens only when danger of freezing is imminent and closes as soon as temperature rises to a safe level. Self-actuating and self-operating . . . does not depend on any power source. **Maximum working pressure 100 PSI.** Has ¾" IPS inlet and outlet. Constructed of heavy brass body, stainless steel spring, and Buna S poppet . . . **will not rust or corrode.** Sensor is sealed, never needs to be replaced under normal operating conditions . . . requires no service.

Nos. 4858N12 & N14—is full open or closed for use where temp. drops rapidly; **N16**—trickle starts at 38°F.

No.	Actuated By Temp.	Full Open	Full Closed	NET EACH
4858N12	Ambient Air	34°F.	40°F.	$105.98
4858N14	Ambient Air	29°F.	35°F.	105.98
4858N16	Surround. Water	34°F.	40°F.	105.98

By-Pass Relief Valves

This valve has bronze body and stainless steel trim. It is popular for use with hydraulic pumping units, where a predetermined pump discharge pressure must be maintained on such equipment as a machine tool hydraulic mechanism, ram, press, lift, or any system requiring regulation of the pump discharge pressure. Suitable in systems where the valve must discharge into high or variable pressures in the bypass return lines. Suitable for water, other liquids and fuel oils of all types. Not recommended for steam. **Maximum Temperature, 450°F.**

No.	Size In.	Spring Adjustment Range Lbs.	NET EACH
4662K12	½	5-75	$36.68
4662K13	½	50-150	36.68
4662K14	½	100-300	36.68
4662K15	½	200-600	36.68
4662K16	¾	5-75	36.68
4662N17	¾	50-150	36.68
4662K18	¾	100-300	36.68
4662K19	¾	200-600	36.68
4662N21	1	5-75	76.37
4662N22	1	50-150	76.37
4662N23	1	100-300	76.37
4662K24	1	200-600	76.37
4662K25	1¼	5-75	76.37
4662N26	1¼	50-150	76.37
4662N27	1¼	100-300	76.37
4662N28	1¼	200-600	76.37

Pressure-Temperature Relief Valves

Construction features include: Brass on lower end of valve, bronze on upper part, stainless steel spring and all working parts brass.

Combines the outstanding qualities of a pressure relief and a temperature relief valve into one unit. Valve reseats automatically.

All connections ¾" female thread. Meets ASME requirements. Rated and certified by the National Board. Temperature relief capacities established by AGA at 205,000 BTU/hr. (steam). Thermostatic element starts to open at 200°F, opens fully at 210°F.

No.	9761N11	9761N12	9761N13	9761N14
Opening Pressure, PSI	75	100	125	150
Pressure Relief, BTU/Hr. Steam Disch. ASME	1,229,000	1,576,000	1,924,000	2,271,000
NET EACH	$14.45	$14.45	$14.45	$14.45

Forged Steel Relief Valves

Standard construction provides for carbon steel springs for relieving pressure to 600 PSI at temperatures to 450°.

Valves are available for greater relieving pressure (to 900 PSI) and higher temperatures. Prices On Request.

A maximum working pressure of 2000 PSI at 100°F. or 700 PSI at 850°F is permissable. Meets ASME code for unfired pressure vessels.

Relieves pressure in pump lines, drums, heat exchangers, unfired pressure vessels handling water, steam, oil, or vapor. May be used to relieve into the atmosphere or into another part of the piping system. Forged steel body, stainless steel ball and seat. Angle pattern, screwed connections.

No. 4709N

Size, In.	¼	⅜	½	¾	1
NET EACH	$57.00	$57.00	$78.53	$93.32	$112.71

NOTE: When ordering specify: Set Pressure, Service Temperature, Size and Number.

Guided Piston Relief Valves

ALUMINUM • BRASS • STAINLESS STEEL

These relief valves are available with Aluminum, Brass or Stainless Steel bodies. Spring and piston are all stainless steel.

Furnished with a soft seat for gas and liquid service. Seat Material: 5-125 PSI Synthetic rubber; 125-3100 PSI Teflon. **For Service from −65 to 225°F.**

Also available with metal to metal seat, designed for general industrial liquid application such as oil and water and Silicone seat designed for fuel, chemical and other services . . . **Prices on request.**

Furnished standard with female inlet and outlet. Male inlet and female outlet available . . . **Prices on request.**

Available with factory-set pressure as indicated.

Direct acting relief valve with excellent characteristics of quick, smooth unloading and accurate operation within the pressure range.

NOTE: When ordering specify No. 4706K, Size, Factory Pressure Setting, Type of Service and whether aluminum, brass or stainless steel is desired.

No. 4706K

	NET EACH ⅛" Size	¼" Size	⅜" Size	½" Size	¾" Size
Aluminum	$ 32.38	$ 33.17	$ 34.44	$ 38.63	$ 40.38
Brass	32.38	33.17	34.44	38.63	40.38
Stainless Steel	91.44	93.02	94.21	109.25	111.63

Pressure Range Settings Available: Range	Factory Set
5-15 PSI	10 PSI
10-50 PSI	35 PSI
40-125 PSI	90 PSI

	NET EACH ⅛" Size	¼" Size	⅜" Size	½" Size	¾" Size
Aluminum	$ 32.38	$ 33.17	$ 34.44	$ 38.63	$ 40.38
Brass	32.38	33.17	34.44	38.63	40.38
Stainless Steel	91.44	93.02	94.21	109.25	111.63

Pressure Range Settings Available: Range	Factory Set
115-250 PSI	200 PSI
235-450 PSI	360 PSI
430-650 PSI	550 PSI
630-850 PSI	750 PSI
630-1020 PSI	850 PSI

	NET EACH ⅛" Size	¼" Size	⅜" Size	½" Size	¾" Size
Aluminum	$ 42.28	$ 43.15	$ 44.18	$ 48.61	$ 50.51
Brass	42.28	43.15	44.18	48.61	50.51
Stainless Steel	104.50	106.08	107.27	122.71	124.93

Pressure Range Settings Available: Range	Factory Set
800-1500 PSI	1000 PSI
1400-2100 PSI	1750 PSI
1500-2750 PSI	2200 PSI
2000-3100 PSI	2600 PSI

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ASCO's TRI POINT™

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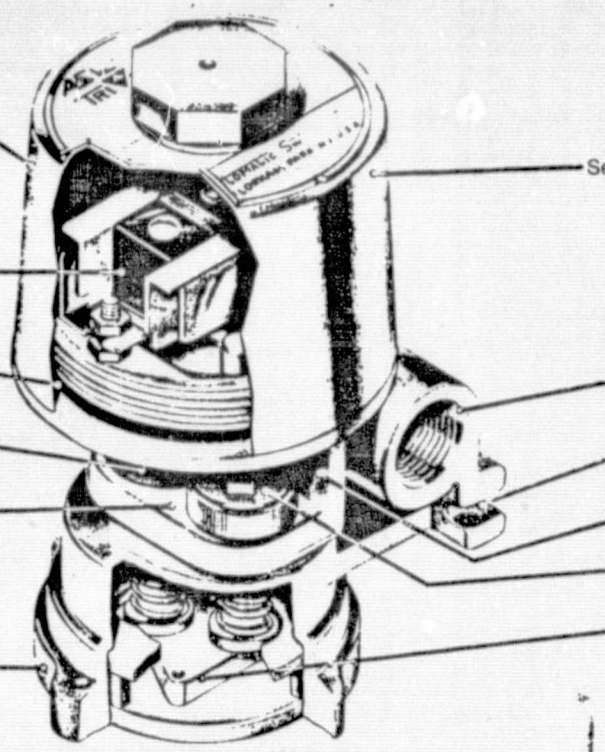
TEMPERATURE SWITCH

incorporates the features most wanted!



Fifteen Different Standard Switch Units Available

Available in General Purpose, Watertight, and Explosion-Proof Construction (Explosion-Proof Construction Shown)

Separate Electrical Chamber

Fixed Factory Mounted Snap Action Switch

Watertight Gasket

Two ¾" Through Wiring Conduit Hubs

Adjustable Reactuation (Reset) Point Over Full Scale

External Mounting Lugs

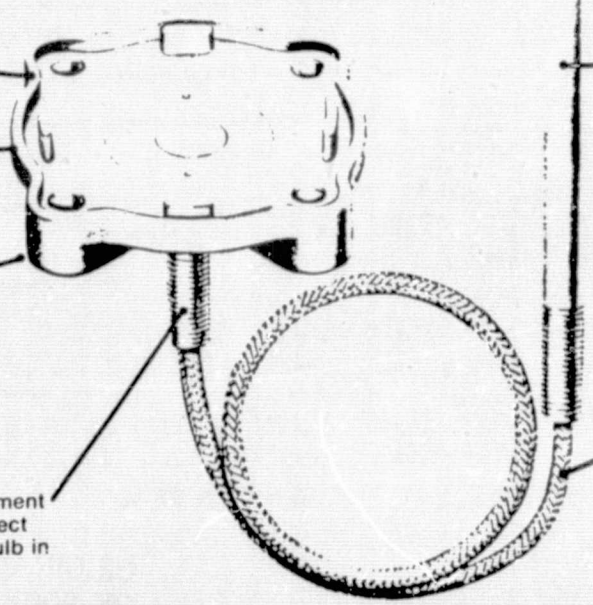
Cover and Gasket for Adjusting Nuts Furnished on Watertight and Explosion-Proof Models

Externally Visible Temperature Scale in °F and °C

Adjustable Actuation (Set) Point Over Full Scale

Unique TRI-POINT Alternating Fulcrum Balance Plate

Copper-Free* Aluminum Die-Cast Body



Separate Temperature Transducer for Field or Distributor Assembly to Switch Unit

⅜" Diameter Bulb (or Probe) may be Mounted Horizontally or Vertically Without Affecting Operation

Thirty-six Different Standard Temperature Transducers Available in 9 Different Standard Temperature Ranges

Vapor Pressure Operation—Limited Fill of Volatile Liquid Assures High Over Temperature Protection and Minimizes Ambient Temperature Effects

Capillary Standard with Double Braided Copper or Plain Stainless Steel. Also Available with Galvanized Steel or Stainless Steel Spiral Interlocked Armor

Temperature Sensing Element Available Standard as Direct Probe or Capillary and Bulb in Copper or Stainless Steel

*0.6% copper content or less.

ASCO TRI-POINT

SERIES: SA10 • SA11 • SA12

Temperature Switches

ADJUSTABLE DEADBAND TYPE

Independently Adjustable Set and Reset Points Over Entire Range

GENERAL DESCRIPTION: This series of ASCO TRI-POINT Temperature Switches is the adjustable deadband type. They consist of two separate sub units, a factory adjusted switch assembly unit and a temperature transducer unit. The temperature transducer utilizes a vapor fill to actuate the switch assembly unit in response to temperature changes. These temperature switches may be purchased as an assembled unit, or they may be purchased as two separate units for field assembly. *In all cases, when ordering, the third digit of the switch assembly unit must be identical to the third digit of the temperature transducer unit.*

Example: SA10A Assembled to **QA10A1**

Must Be Identical

OPERATION: The temperature transducer uses the vapor pressure principle in which the vapor pressure of the liquid in the sensing bulb is related to the temperature being sensed. This pressure is converted into a force and transmitted to the balance plate. Two independently adjustable springs apply a counter force to the balance plate. Movement of the balance plate in two steps is transmitted to the snap action electrical switch by an operating rod. The actuation (set) point and the reactuation (reset) point are both independently adjustable over the full temperature range of the switch. The temperature difference between the set and reset points is the deadband and is adjustable from the minimum as listed below to the maximum of the full range.

OPTIONAL FEATURES: Several options are available; for details and availability, consult pages 9, 10 and 11.

ELECTRICAL INFORMATION: Consult page 9 for electrical ratings and schematics for standard and optional snap action switches.

SPECIFICATIONS

HOW TO SELECT AND ORDER

1. Determine the temperature range needed. Preferably the actuation point should be in the middle two-thirds of the span. Check that the maximum temperature rating is sufficient.
2. Read across and select one switch assembly unit with the proper enclosure.
3. Continue across the same line and select one transducer according to the construction desired.
4. **Field Assembly:** Order the switch assembly unit and the transducer unit by their respective catalog numbers if you desire to field assemble the temperature switch. The third digit in each catalog number must be identical.
5. **Factory Assembly:** Add the two catalog numbers together separated by a slash ( ), if you desire a completely assembled temperature switch.

Example: For a temperature switch required to actuate at 50°F, select a 0-90°F switch. Such a temperature switch with a general purpose enclosure and copper capillary and bulb would be catalog number SA10A QD11A1.

SWITCH ASSEMBLY UNITS

(Two ¾" NPT Conduit Hubs Standard)

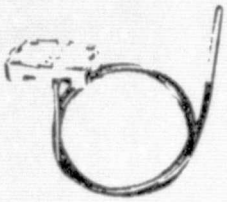
General Purpose Type

Explosion-Proof Type

TEMPERATURE TRANSDUCER UNITS

Direct Probe

Capillary and Bulb



Armored Copper Capillary or Plain Stainless Steel Capillary

	ADJUSTABLE OPERATING RANGE (In Degrees)	MAX. TEMP. (In Degrees)	DEADBAND AT MID RANGE* (In Degrees)	GENERAL PURPOSE ENCLOSURE CATALOG NO.	WATERTIGHT ENCLOSURE CATALOG NO.	EXPLOSION-PROOF ENCLOSURE CATALOG NO.	DIRECT PROBE COPPER CATALOG NO.	DIRECT PROBE 316 S.S. CATALOG NO.	6' CAPILLARY AND BULB COPPER (Armored Capillary) CATALOG NO.	6' CAPILLARY AND BULB 316 S.S. (Plain Capillary) CATALOG NO.
°F	−60 - 20	200	6	SA10A	SA11A	SA12A	QA10A1	QA10A4	QA11A1	QA11A4
°C	−51 - −7	93	3.3							
°F	−30 - 60	250	6	SA10A	SA11A	SA12A	QB10A1	QB10A4	QB11A1	QB11A4
°C	−34 - 16	121	3.3							
°F	0 - 90	300	8	SA10A	SA11A	SA12A	QD10A1	QD10A4	QD11A1	QD11A4
°C	−18 - 32	149	4.4							
°F	50 - 160	350	7	SA10A	SA11A	SA12A	QF10A1	QF10A4	QF11A1	QF11A4
°C	10 - 71	177	3.8							
°F	100 - 220	450	8	SA10A	SA11A	SA12A	QJ10A1	QJ10A4	QJ11A1	QJ11A4
°C	38 - 104	232	4.4							
°F	160 - 260	500	9	SA10A	SA11A	SA12A	QL10A1	QL10A4	QL11A1	QL11A4
°C	71 - 127	260	5.0							
°F	225 - 340	600	12	SA10A	SA11A	SA12A	QN10A1	QN10A4	QN11A1	QN11A4
°C	107 - 171	316	6.7							
°F	300 - 450	700	12	SA10A	SA11A	SA12A	QT10A1	QT10A4	QT11A1	QT11A4
°C	149 - 232	371	6.7							
°F	350 - 510	800	18	SA10A	SA11A	SA12A	QU10A1	QU10A4	QU11A1	QU11A4
°C	177 - 266	427	10							

*At Extreme Ends of Range, Values May Vary up to 50% of Listed Deadband.

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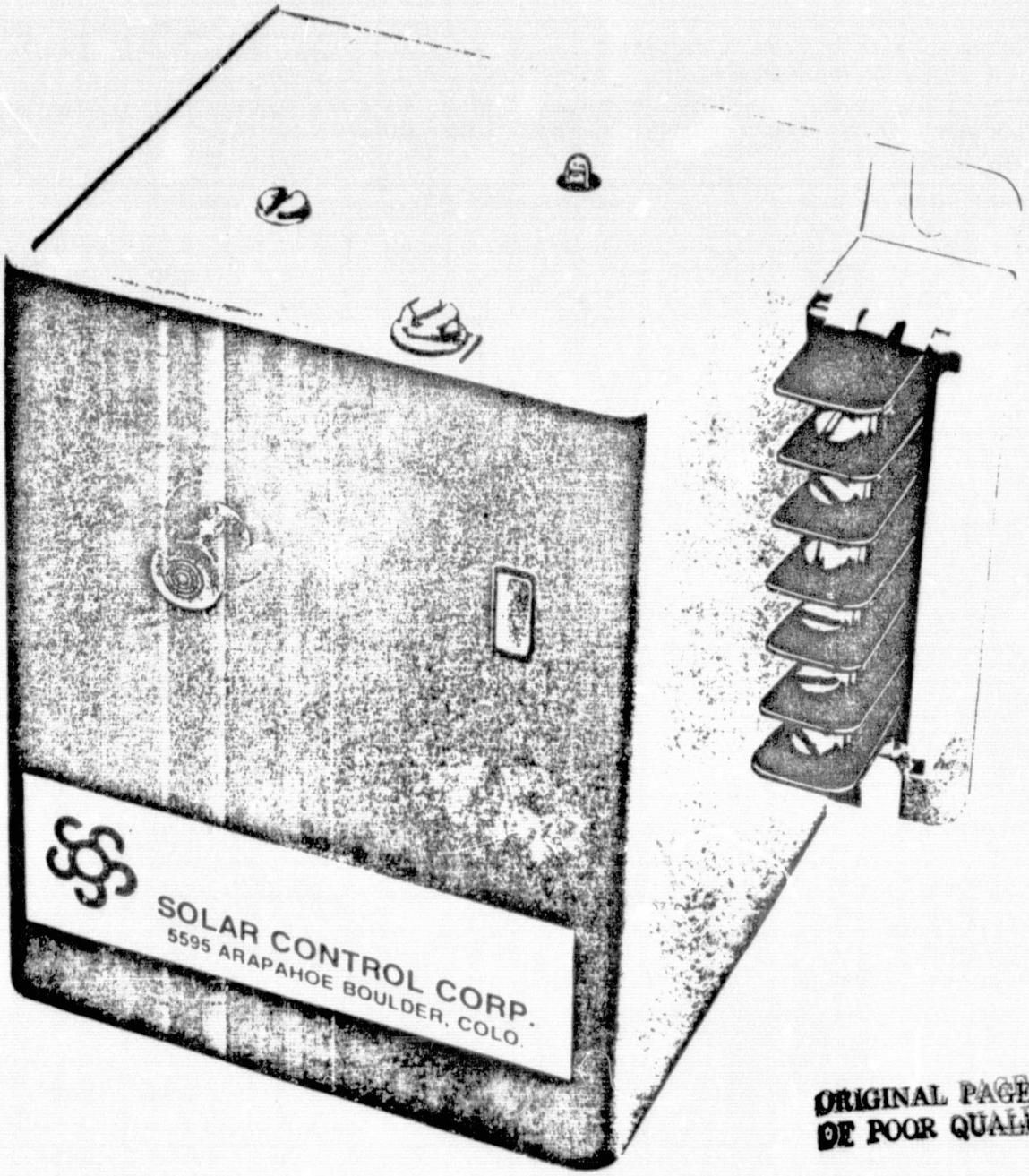
SOLAR CONTROL CORP.

SOLID STATE SOLAR HOT WATER CONTROLLER



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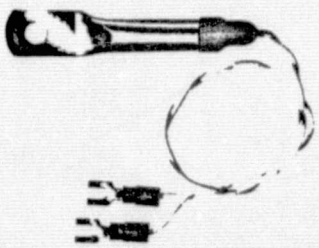
Model 77-171
Solid-State Solar Hot Water Controller

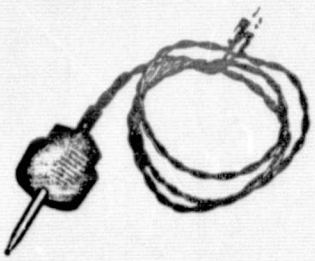
Description

The model 77-171 is a solid-state differential thermostat capable of fully controlling a solar hot water heating system. The unit is designed for a lifetime of maintenance free service, and incorporates freeze and boil protect circuitry.

Air and Water Probes



Air probes are available for clamp or screw mounting.



Water probes have ½" NPC thread, in lengths from 2¾" to 28".

Specifications

Input Voltage	Either 120 VAC ±10V or 24 VAC ±4V.
Input Power	3 watts, no load.
Control Relay	SPDT, 10A. (resistive) at 28 VDC or 120 VAC. Higher ratings available.
Output Voltage	Either 120 VAC or 24 VAC.
Sensors	Matched thermistors, (±1°C over range from 0°C to +100°C) in a metal housing, with high temperature teflon leads.
Differential Turn-off Offset	Typically 4°F ±2° @100°F, (can be adjusted by a resistor change).
Differential Turn-on Offset	Typically 20°F ±2° @ 100°F, (can be adjusted by a resistor change).
Temperature Range	Controller chassis: −40°F to 140°F Sensors: −40°F to +300°F
Tracking Accuracy	± 5°F over entire operating range.
Isolation Protection	1500 V
Size	4" × 4" × 3½"
Weight	2 lbs.
Mounting	Mounts on 4" × 4" "J" box.

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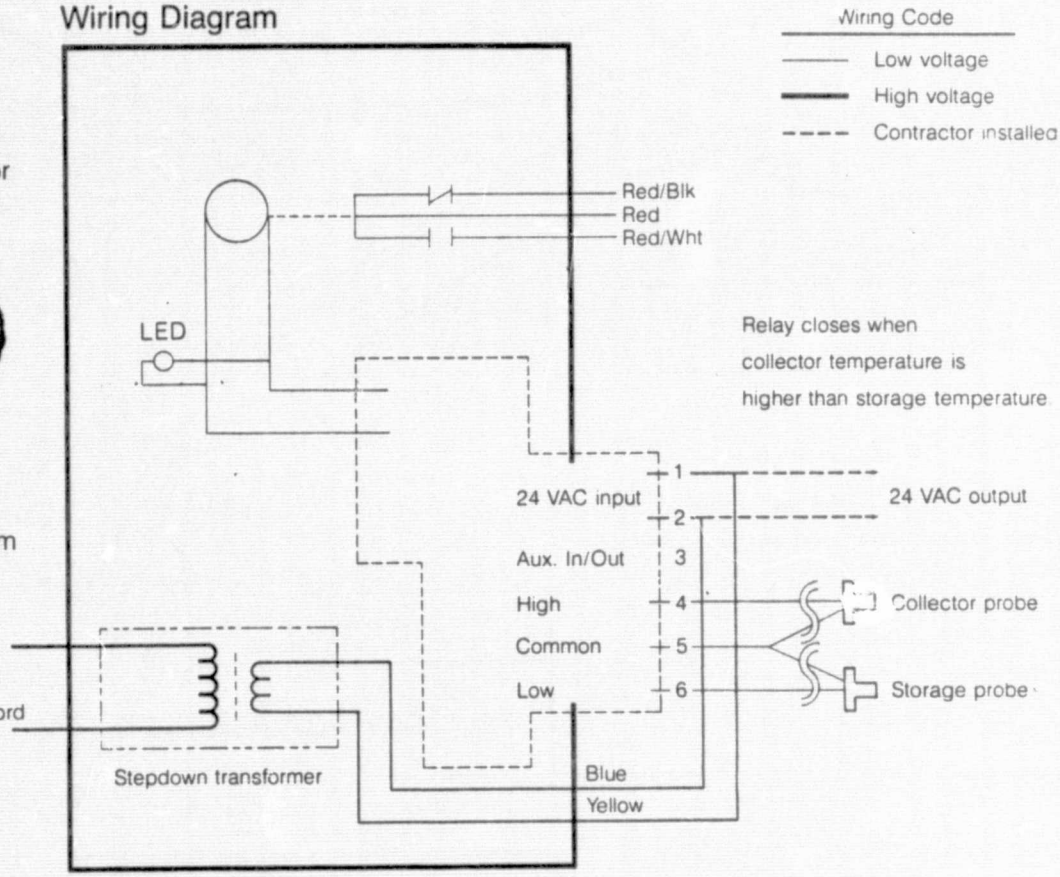
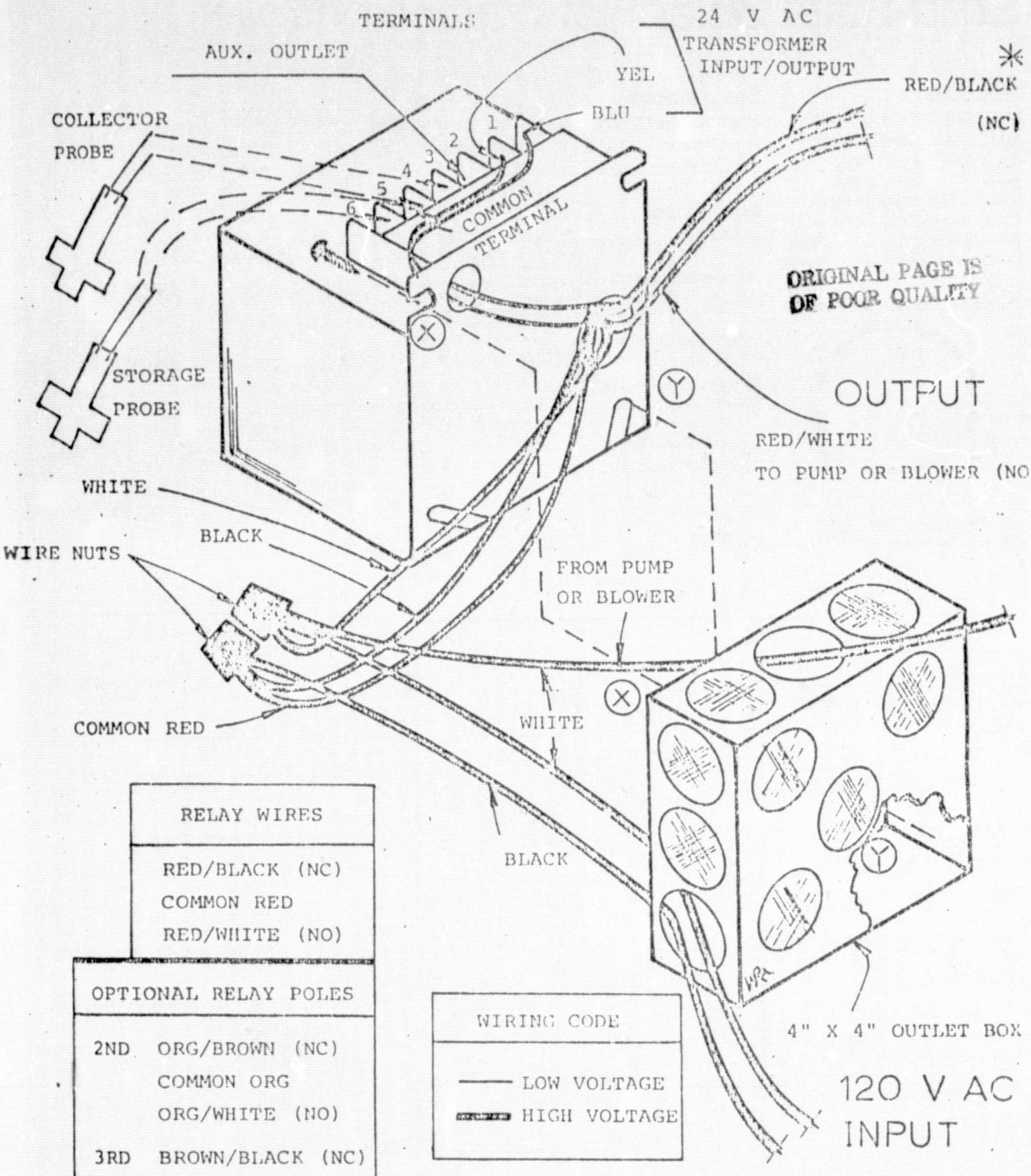
Wiring Diagram



SOLAR CONTROL CORP. 5595 Arapahoe Road, Boulder, Colorado 80302 303/449-9180

FIELD INSTALLATION DIAGRAM



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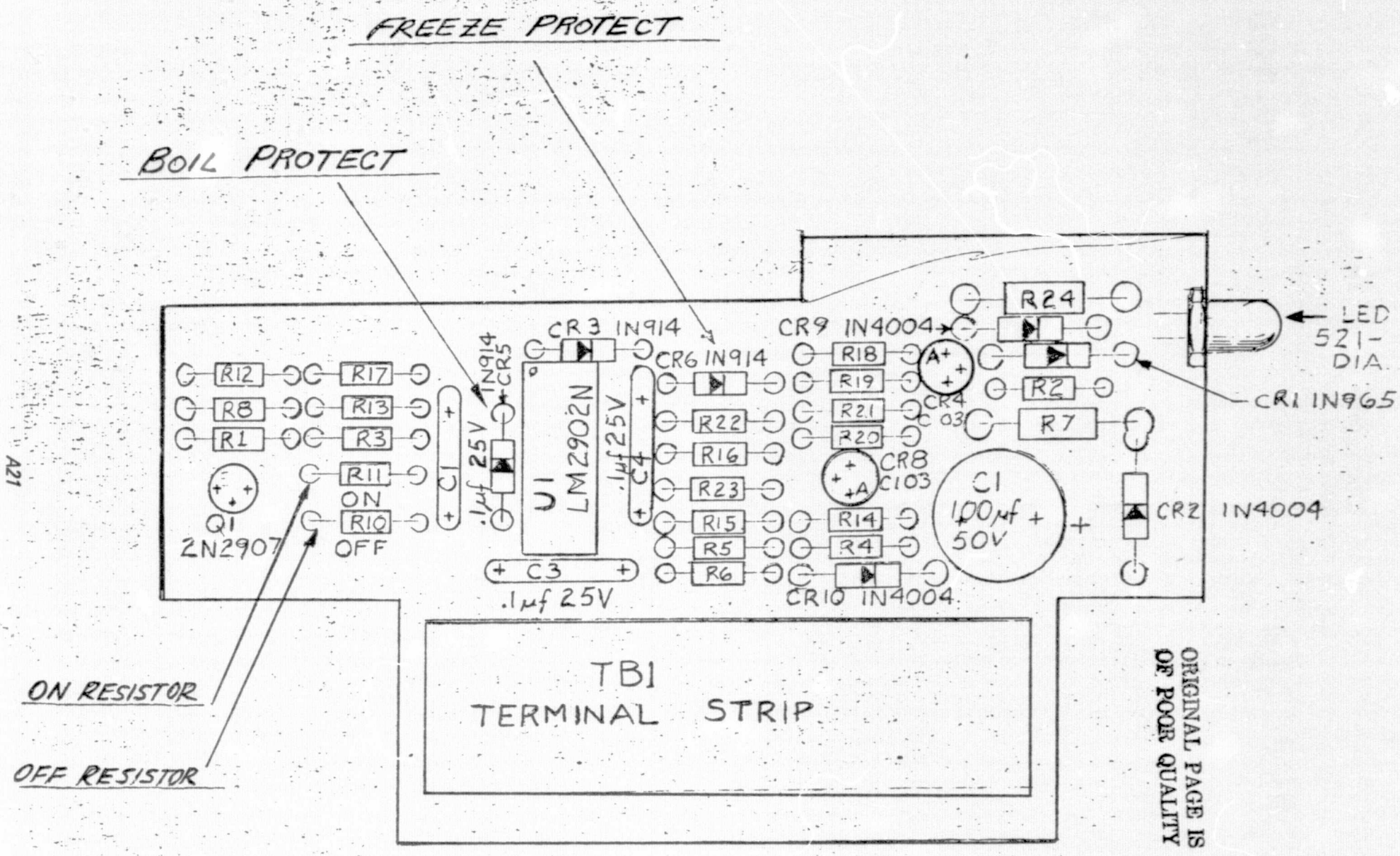
RELAY WIRES
RED/BLACK (NC)
COMMON RED
RED/WHITE (NO)

OPTIONAL RELAY POLES	
2ND	ORG/BROWN (NC)
	COMMON ORG
	ORG/WHITE (NO)
3RD	BROWN/BLACK (NC)
	COMMON BROWN
	BROWN/WHITE (NO)

WIRING CODE
—— LOW VOLTAGE
▬▬ HIGH VOLTAGE

✳ CAP IF NOT USED.



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MINCO

RESISTANCE TEMPERATURE TABLE
U.S. INDUSTRIAL SPEC. $R_{212F}/R_{32F} = 1.3911$
PLATINUM RESISTANCE THERMOMETER
100 OHMS AT 32°F.

TABLE 12-100

7500 Commerce Lane, Minneapolis, Minnesota 55432 USA Telephone: (612) 786-3121

T(F)	R(OHMS)	T(F)	R(OHMS)	T(F)	R(OHMS)	T(F)	R(OHMS)
-328.0	17.26	-283.0	28.12	-238.0	38.79	-193.0	49.28
-327.0	17.50	-282.0	28.36	-237.0	39.02	-192.0	49.52
-326.0	17.75	-281.0	28.60	-236.0	39.26	-191.0	49.75
-325.0	17.99	-280.0	28.84	-235.0	39.49	-190.0	49.98
-324.0	18.23	-279.0	29.08	-234.0	39.73	-189.0	50.21
-323.0	18.48	-278.0	29.32	-233.0	39.96	-188.0	50.44
-322.0	18.72	-277.0	29.56	-232.0	40.20	-187.0	50.67
-321.0	18.96	-276.0	29.79	-231.0	40.43	-186.0	50.90
-320.0	19.21	-275.0	30.03	-230.0	40.67	-185.0	51.14
-319.0	19.45	-274.0	30.27	-229.0	40.90	-184.0	51.37
-318.0	19.69	-273.0	30.51	-228.0	41.13	-183.0	51.60
-317.0	19.94	-272.0	30.75	-227.0	41.37	-182.0	51.83
-316.0	20.18	-271.0	30.99	-226.0	41.60	-181.0	52.06
-315.0	20.42	-270.0	31.22	-225.0	41.84	-180.0	52.29
-314.0	20.66	-269.0	31.46	-224.0	42.07	-179.0	52.52
-313.0	20.91	-268.0	31.70	-223.0	42.30	-178.0	52.75
-312.0	21.15	-267.0	31.94	-222.0	42.54	-177.0	52.98
-311.0	21.39	-266.0	32.17	-221.0	42.77	-176.0	53.21
-310.0	21.63	-265.0	32.41	-220.0	43.01	-175.0	53.44
-309.0	21.87	-264.0	32.65	-219.0	43.24	-174.0	53.67
-308.0	22.11	-263.0	32.89	-218.0	43.47	-173.0	53.90
-307.0	22.36	-262.0	33.12	-217.0	43.71	-172.0	54.13
-306.0	22.60	-261.0	33.36	-216.0	43.94	-171.0	54.36
-305.0	22.84	-260.0	33.60	-215.0	44.17	-170.0	54.59
-304.0	23.08	-259.0	33.83	-214.0	44.41	-169.0	54.82
-303.0	23.32	-258.0	34.07	-213.0	44.64	-168.0	55.05
-302.0	23.56	-257.0	34.31	-212.0	44.87	-167.0	55.28
-301.0	23.80	-256.0	34.54	-211.0	45.10	-166.0	55.51
-300.0	24.04	-255.0	34.78	-210.0	45.34	-165.0	55.74
-299.0	24.29	-254.0	35.02	-209.0	45.57	-164.0	55.97
-298.0	24.53	-253.0	35.25	-208.0	45.80	-163.0	56.20
-297.0	24.77	-252.0	35.49	-207.0	46.04	-162.0	56.43
-296.0	25.01	-251.0	35.73	-206.0	46.27	-161.0	56.66
-295.0	25.25	-250.0	35.96	-205.0	46.50	-160.0	56.89
-294.0	25.49	-249.0	36.20	-204.0	46.73	-159.0	57.12
-293.0	25.73	-248.0	36.43	-203.0	46.97	-158.0	57.35
-292.0	25.97	-247.0	36.67	-202.0	47.20	-157.0	57.58
-291.0	26.21	-246.0	36.91	-201.0	47.43	-156.0	57.81
-290.0	26.45	-245.0	37.14	-200.0	47.66	-155.0	58.04
-289.0	26.69	-244.0	37.38	-199.0	47.89	-154.0	58.27
-288.0	26.93	-243.0	37.61	-198.0	48.13	-153.0	58.49
-287.0	27.17	-242.0	37.85	-197.0	48.36	-152.0	58.72
-286.0	27.41	-241.0	38.08	-196.0	48.59	-151.0	58.95
-285.0	27.65	-240.0	38.32	-195.0	48.82	-150.0	59.18
-284.0	27.88	-239.0	38.55	-194.0	49.05	-149.0	59.41

T(F)	R(OHMS)	T(F)	R(OHMS)	T(F)	R(OHMS)	T(F)	R(OHMS)
-148.0	59.64	-103.0	69.87	-58.0	80.00	-13.0	90.04
-147.0	59.87	-102.0	70.10	-57.0	80.22	-12.0	90.24
-146.0	60.10	-101.0	70.32	-56.0	80.45	-11.0	90.45
-145.0	60.32	-100.0	70.55	-55.0	80.67	-10.0	90.71
-144.0	60.55	-99.0	70.77	-54.0	80.90	-9.0	90.93
-143.0	60.78	-98.0	71.00	-53.0	81.12	-8.0	91.15
-142.0	61.01	-97.0	71.23	-52.0	81.34	-7.0	91.37
-141.0	61.24	-96.0	71.45	-51.0	81.57	-6.0	91.59
-140.0	61.47	-95.0	71.68	-50.0	81.79	-5.0	91.82
-139.0	61.69	-94.0	71.90	-49.0	82.01	-4.0	92.04
-138.0	61.92	-93.0	72.13	-48.0	82.24	-3.0	92.26
-137.0	62.15	-92.0	72.36	-47.0	82.46	-2.0	92.48
-136.0	62.38	-91.0	72.58	-46.0	82.69	-1.0	92.70
-135.0	62.61	-90.0	72.81	-45.0	82.91	0.0	92.93
-134.0	62.83	-89.0	73.03	-44.0	83.13	1.0	93.15
-133.0	63.06	-88.0	73.26	-43.0	83.36	2.0	93.37
-132.0	63.29	-87.0	73.48	-42.0	83.58	3.0	93.59
-131.0	63.52	-86.0	73.71	-41.0	83.80	4.0	93.81
-130.0	63.74	-85.0	73.93	-40.0	84.03	5.0	94.03
-129.0	63.97	-84.0	74.16	-39.0	84.25	6.0	94.25
-128.0	64.20	-83.0	74.38	-38.0	84.47	7.0	94.48
-127.0	64.43	-82.0	74.61	-37.0	84.70	8.0	94.70
-126.0	64.65	-81.0	74.83	-36.0	84.92	9.0	94.92
-125.0	64.88	-80.0	75.06	-35.0	85.14	10.0	95.14
-124.0	65.11	-79.0	75.28	-34.0	85.35	11.0	95.36
-123.0	65.34	-78.0	75.51	-33.0	85.57	12.0	95.58
-122.0	65.56	-77.0	75.73	-32.0	85.81	13.0	95.80
-121.0	65.79	-76.0	75.96	-31.0	86.03	14.0	96.02
-120.0	66.02	-75.0	76.18	-30.0	86.26	15.0	96.25
-119.0	66.25	-74.0	76.41	-29.0	86.48	16.0	96.47
-118.0	66.47	-73.0	76.63	-28.0	86.70	17.0	96.69
-117.0	66.70	-72.0	76.86	-27.0	86.92	18.0	96.91
-116.0	66.93	-71.0	77.08	-26.0	87.13	19.0	97.13
-115.0	67.15	-70.0	77.31	-25.0	87.37	20.0	97.35
-114.0	67.38	-69.0	77.53	-24.0	87.59	21.0	97.57
-113.0	67.61	-68.0	77.76	-23.0	87.82	22.0	97.79
-112.0	67.83	-67.0	77.98	-22.0	88.04	23.0	98.01
-111.0	68.06	-66.0	78.21	-21.0	88.26	24.0	98.23
-110.0	68.29	-65.0	78.43	-20.0	88.48	25.0	98.46
-109.0	68.51	-64.0	78.65	-19.0	88.71	26.0	98.68
-108.0	68.74	-63.0	78.88	-18.0	88.93	27.0	98.90
-107.0	68.97	-62.0	79.10	-17.0	89.15	28.0	99.12
-106.0	69.19	-61.0	79.33	-16.0	89.37	29.0	99.34
-105.0	69.42	-60.0	79.55	-15.0	89.60	30.0	99.56
-104.0	69.64	-59.0	79.78	-14.0	89.82	31.0	99.78

T(F)	R(OHMS)	T(F)	R(OHMS)	T(F)	R(OHMS)	T(F)	R(OHMS)
32.0	100.00	77.0	109.89	122.0	119.70	167.0	129.44
33.0	100.22	78.0	110.11	123.0	119.92	168.0	129.66
34.0	100.44	79.0	110.32	124.0	120.13	169.0	129.87
35.0	100.66	80.0	110.54	125.0	120.35	170.0	130.09
36.0	100.88	81.0	110.76	126.0	120.57	171.0	130.30
37.0	101.10	82.0	110.98	127.0	120.79	172.0	130.52
38.0	101.32	83.0	111.20	128.0	121.00	173.0	130.73
39.0	101.54	84.0	111.42	129.0	121.22	174.0	130.95
40.0	101.76	85.0	111.64	130.0	121.44	175.0	131.16
41.0	101.98	86.0	111.86	131.0	121.65	176.0	131.38
42.0	102.20	87.0	112.07	132.0	121.87	177.0	131.59
43.0	102.42	88.0	112.29	133.0	122.09	178.0	131.81
44.0	102.64	89.0	112.51	134.0	122.30	179.0	132.03
45.0	102.86	90.0	112.73	135.0	122.52	180.0	132.24
46.0	103.08	91.0	112.95	136.0	122.74	181.0	132.46
47.0	103.30	92.0	113.17	137.0	122.95	182.0	132.67
48.0	103.52	93.0	113.38	138.0	123.17	183.0	132.89
49.0	103.74	94.0	113.60	139.0	123.39	184.0	133.10
50.0	103.96	95.0	113.82	140.0	123.60	185.0	133.32
51.0	104.18	96.0	114.04	141.0	123.82	186.0	133.53
52.0	104.40	97.0	114.26	142.0	124.04	187.0	133.75
53.0	104.62	98.0	114.48	143.0	124.25	188.0	133.96
54.0	104.84	99.0	114.69	144.0	124.47	189.0	134.18
55.0	105.05	100.0	114.91	145.0	124.69	190.0	134.39
56.0	105.28	101.0	115.13	146.0	124.90	191.0	134.60
57.0	105.50	102.0	115.35	147.0	125.12	192.0	134.82
58.0	105.72	103.0	115.57	148.0	125.34	193.0	135.03
59.0	105.94	104.0	115.78	149.0	125.55	194.0	135.25
60.0	106.16	105.0	116.00	150.0	125.77	195.0	135.46
61.0	106.38	106.0	116.22	151.0	125.99	196.0	135.68
62.0	106.60	107.0	116.44	152.0	126.20	197.0	135.89
63.0	106.82	108.0	116.65	153.0	126.42	198.0	136.11
64.0	107.04	109.0	116.87	154.0	126.63	199.0	136.32
65.0	107.26	110.0	117.09	155.0	126.85	200.0	136.54
66.0	107.48	111.0	117.31	156.0	127.07	201.0	136.75
67.0	107.70	112.0	117.53	157.0	127.28	202.0	136.97
68.0	107.92	113.0	117.74	158.0	127.50	203.0	137.18
69.0	108.13	114.0	117.96	159.0	127.71	204.0	137.39
70.0	108.35	115.0	118.18	160.0	127.93	205.0	137.61
71.0	108.57	116.0	118.40	161.0	128.15	206.0	137.82
72.0	108.79	117.0	118.61	162.0	128.36	207.0	138.04
73.0	109.01	118.0	118.83	163.0	128.58	208.0	138.25
74.0	109.23	119.0	119.05	164.0	128.79	209.0	138.47
75.0	109.45	120.0	119.27	165.0	129.01	210.0	138.68
76.0	109.67	121.0	119.48	166.0	129.22	211.0	138.89

T(F)	R(OHMS)	T(F)	R(OHMS)	T(F)	R(OHMS)	T(F)	R(OHMS)
212.0	139.11	257.0	148.70	302.0	158.22	347.0	167.67
213.0	139.32	258.0	148.91	303.0	158.43	348.0	167.88
214.0	139.54	259.0	149.13	304.0	158.64	349.0	168.09
215.0	139.75	260.0	149.34	305.0	158.85	350.0	168.30
216.0	139.96	261.0	149.55	306.0	159.06	351.0	168.51
217.0	140.18	262.0	149.76	307.0	159.26	352.0	168.72
218.0	140.39	263.0	149.97	308.0	159.47	353.0	168.92
219.0	140.60	264.0	150.18	309.0	159.68	354.0	169.13
220.0	140.82	265.0	150.39	310.0	159.89	355.0	169.34
221.0	141.03	266.0	150.61	311.0	160.12	356.0	169.55
222.0	141.25	267.0	150.82	312.0	160.33	357.0	169.76
223.0	141.46	268.0	151.04	313.0	160.54	358.0	169.97
224.0	141.67	269.0	151.25	314.0	160.75	359.0	170.18
225.0	141.89	270.0	151.46	315.0	160.96	360.0	170.39
226.0	142.10	271.0	151.67	316.0	161.17	361.0	170.59
227.0	142.31	272.0	151.88	317.0	161.38	362.0	170.80
228.0	142.53	273.0	152.09	318.0	161.59	363.0	171.01
229.0	142.74	274.0	152.31	319.0	161.80	364.0	171.22
230.0	142.95	275.0	152.52	320.0	162.01	365.0	171.43
231.0	143.17	276.0	152.73	321.0	162.22	366.0	171.64
232.0	143.38	277.0	152.94	322.0	162.43	367.0	171.85
233.0	143.59	278.0	153.15	323.0	162.64	368.0	172.05
234.0	143.81	279.0	153.37	324.0	162.85	369.0	172.26
235.0	144.02	280.0	153.58	325.0	163.06	370.0	172.47
236.0	144.23	281.0	153.79	326.0	163.27	371.0	172.68
237.0	144.45	282.0	154.00	327.0	163.48	372.0	172.89
238.0	144.66	283.0	154.21	328.0	163.69	373.0	173.10
239.0	144.87	284.0	154.42	329.0	163.90	374.0	173.30
240.0	145.09	285.0	154.63	330.0	164.11	375.0	173.51
241.0	145.30	286.0	154.85	331.0	164.32	376.0	173.72
242.0	145.51	287.0	155.06	332.0	164.53	377.0	173.93
243.0	145.72	288.0	155.27	333.0	164.74	378.0	174.14
244.0	145.94	289.0	155.48	334.0	164.95	379.0	174.34
245.0	146.15	290.0	155.69	335.0	165.16	380.0	174.55
246.0	146.36	291.0	155.90	336.0	165.37	381.0	174.76
247.0	146.58	292.0	156.11	337.0	165.58	382.0	174.97
248.0	146.79	293.0	156.32	338.0	165.79	383.0	175.18
249.0	147.00	294.0	156.53	339.0	166.00	384.0	175.38
250.0	147.21	295.0	156.75	340.0	166.21	385.0	175.59
251.0	147.43	296.0	156.96	341.0	166.41	386.0	175.80
252.0	147.64	297.0	157.17	342.0	166.62	387.0	176.01
253.0	147.85	298.0	157.38	343.0	166.83	388.0	176.21
254.0	148.06	299.0	157.59	344.0	167.04	389.0	176.42
255.0	148.28	300.0	157.80	345.0	167.25	390.0	176.63
256.0	148.49	301.0	158.01	346.0	167.46	391.0	176.84

PENN BASO

PENN CONTROLS

DIVISION OF JOHNSON SERVICE COMPANY

Y

Y61, Y62, Y63

3741-C

3741-B

series Y61, Y62, Y63

BASO™ TRANSFORMERS

For Use With PENN-BASO Gas Controls and Ignition Systems

ORIGINAL PAGE IS OF POOR QUALITY

APPLICATION

These transformers are designed to match the 25 volt power requirements of Penn-Baso gas controls and ignition systems.

Transformers for use with Penn motor actuators, Actrol™ staging and other low voltage control circuits are described in Bulletin 3742. Bulletin 3740 describes the Penn-Baso igniter transformers.

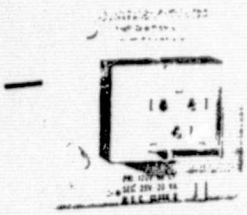

Fig. 1 — Y61AA-3 plate mounted 20 VA. transformer is illustrated above. Note the three secondary terminals.

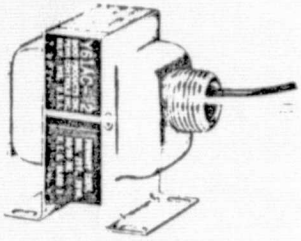

Fig. 2 — The foot mounted Y61AC-2 is illustrated. Note addition of the conduit hub.

FEATURES

- Transformers deliver 25 volts minimum at their VA. ratings at 100% power factor.
- Choice of primary voltages to meet power requirements.
- Plate, foot or conduit hub mounting models available.
- Choice of terminal board or lead wire connections.
- Two or three terminal secondary as selected.
- Color coded lead wires for simplicity and standardization.

GENERAL DESCRIPTION

Baso transformers are high quality devices that provide rated secondary output under rated load.

Secondary voltage of 25 volts. Transformers may be used on 50 or 60 Hz. power supply.

Series Y61 and Y62 are NEC Class 2 energy limiting.

Series Y63 is NEC Class 2 internally fuse protected.

MISCELLANEOUS SPECIFICATIONS

Open Circuit Voltage (No Load): Y61, 27.5; Y62, 29.5; Y63, 27.5.

Finish: Cold drawn steel end bells, frame, feet and plate, zinc plated with dichromate dip.

Laminations: Soft Silicon iron with edges painted black.

Identification: Stamped on laminations, foot or hub mounted models. Stamped on plate of plate mounted models.

Minimum Ambient Temperature: –40° F (–40° C).

Packaging: Bulk pack supplied to OEM's. Individual reshippable package supplied at extra cost.

Series Number	Bulk Pack Qty.	Approx. Wt.-Lbs. (kg)
Y61 Plate	36	60.5 (27.2)
Y61 Foot	45	54 (24.3)
Y62 Plate	36	76 (34.2)
Y62 Foot	30	49 (22)
Y63 Plate	12	30 (13.5)
Y63 Hub	32	66 (29.7)

PRODUCT NUMBER SELECTION CHART

Product Number	Primary		Secondary		Mounting	Dimensions (See Figure)
	Voltage	Electrical Connection	Voltage	Electrical Connection		
20 VA. CAPACITY TRANSFORMERS						
Y61AA-3	120	8" B & W Lead Wires	25	3 Terminals	4" x 4" Plate	3
Y61AB-3	120	8" B & W Lead Wires	25	2 Terminals	2" x 4" Plate	4
Y61AC-2	120	8" B & W Lead Wires	25	2 Terminals	Foot, ½"-14 NPS Male Hub	5
Y61AE-2	120	10" B & W Lead Wires	25	3 Terminals	Foot	6
Y61AF-2	120	8" B & W Lead Wires	25	2 Terminals	½"-14 NPS Male Hub	7
Y61BF-2	240	8" B & Y Lead Wires	25	2 Terminals	½"-14 NPS Male Hub	7

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