DOE/NASA CONTRACTOR REPORT

DOE/NASA CR-150743

INSTALLATION PACKAGE FOR 77-180 SOLARSTAT AND 77-171 CONTROLLER

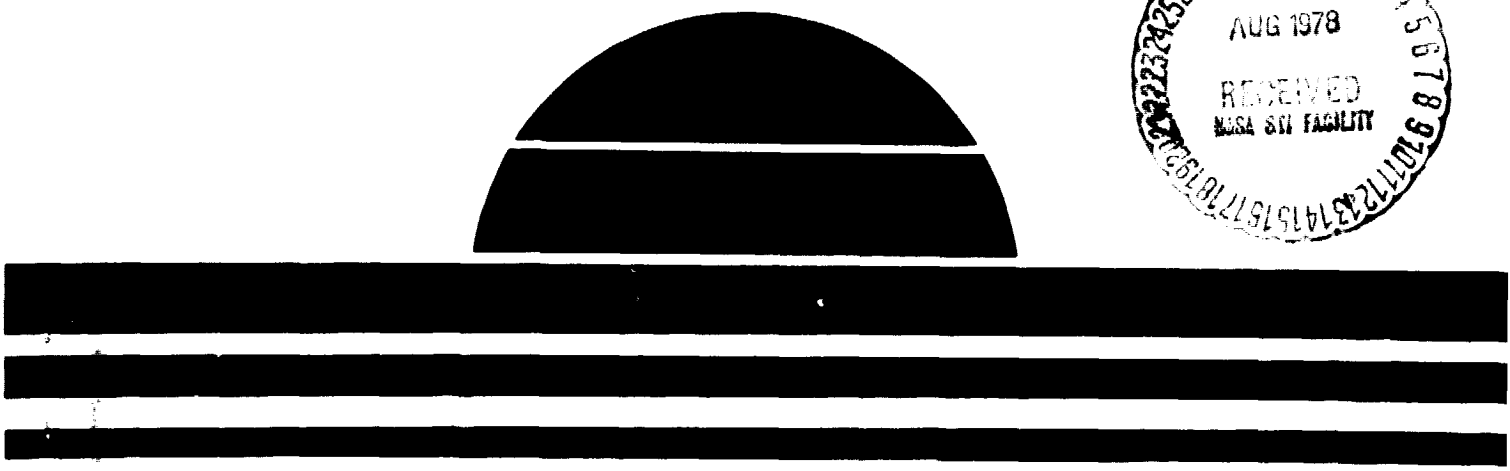
Prepared from documents provided by

Solar Control Corporation (ZIA)
5595 Arapahoe Road
Boulder, Colorado 80303

Under Contract NAS8-32258 with

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

For the U. S. Department of Energy



U.S. Department of Energy

Solar Energy

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SECTION A

INSTALLATION, OPERATION, AND MAINTENANCE MANUAL

77-180 SOLARSTAT

SOLARSTAT

The SCC 77-180 Solarstat gives the home owner accurate real-time readings and operating mode indication. Outdoor temperature is continuously displayed on the three digit LED readout. Either collection or storage temperature is obtained by the touch of a button.

Three light emitting diodes (LED) give a bright red indication of the solar heating system's present operating mode, i.e. solar collecting, solar distribution, or back-up heating. The thermostat gives room temperature as well as providing the two stage (2^{o}-4^{o} offset) signals to the home's solar and back-up heating system.

Solid state components are used throughout the circuitry. The Solarstat uses less than 10 watts of 24 VAC power and is compatible with all of the conventional HVAC equipment.

General Specifications and Features

1. Input voltage	24 VAC
2. Input power	10 watts maximum
3. Temperature sensors	Inexpensive silicon diodes, linear in excess of -300°F to +300°F with high temperature teflon wire;
4. Display	3 digit LED readout with "-" sign; digit height 0.3"
5. Range	± 199°F
6. Accuracy	0.5% + one count on least significant digit
7. Measurement points	Three switch selectable measurement points
8. Solarstat ambient temperature	32°F to 120°F
9. Size and weight	8" x 7⅛" x 2 1/8"; weight less than two pounds

SOLARSTAT INSTALLATION AND OPERATION

Application: The SCC 77-180 Solarstat is a panel which provides instant display of collector, storage and another temperature. It is provided with its own set of thermal sensors (probes) to be mounted in the appropriate locations. It is equipped with a two stage thermostat.

Installation:

I. Solarstat package contains:

- 1 Solarstat panel
- 1 thermostat
- 1 thermostat sub-base
- 1 template for wall opening
- 3 probes: one for storage, one for the collector and one for the normally displayed temperature. (Outside suggested)

II. Install probes in appropriate sensing locations.

CAUTION: The circuits are specifically calibrated at the factory to match each probe. It is crucial that the storage probe be used only for the storage and the collector probe only for the collector. The third probe is to be placed at the location whose temperature is to be displayed normally. If the probes are mixed, recalibration will be necessary.

III. Route probe wires to Solarstat location, taking care to maintain polarity. Use different colored wires if possible. Bell wire (18 to 24 ga) is adequate.

IV. Install Solarstat.

1. Cut hole in wall, using template as a guide. Drill two holes for No. 6 screws in positions indicated on template.

2. Connect probe leads to Solarstat as indicated in Fig. 1.

   Connect 24V input and signal inputs as indicated in Fig. 1.

3. Mount Solarstat panel using screw anchors in holes drilled in step 1.

4. Attach thermostat sub-base to Solarstat panel.

5. Connect thermostat to heating system per Honeywell instructions.

6. Mount thermostat on sub-base.

V. Check system:

1. Blinking display usually indicates polarity reversal or possibly short or open probe leads.

2. Normal display: This should indicate temperature at the location of the third probe.

3. Collector display: Push "Collector" button. this should indicate temperature of the collector.

4. Storage display: Push "Storage" button. This should indicate temperature of the storage.

Operation:

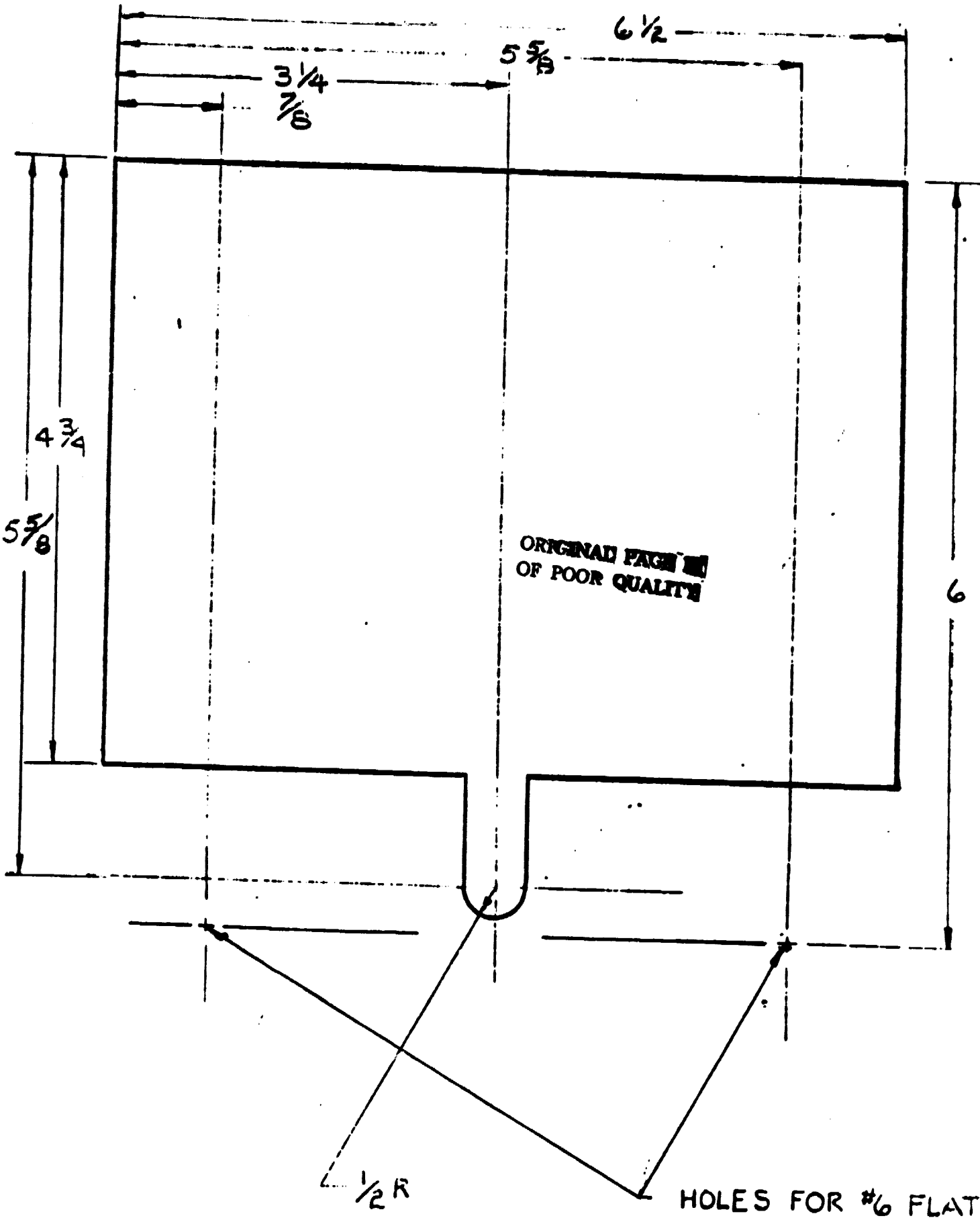
"Status" lights provide an indication of which function is operating at any time. The LED readout normally shows the outdoor temperature. Use of the pushbuttons on either side of the LED permits momentary display of collector and storage temperatures.

Connections for probes to SAM controller should be done as indicated on face of controller.

Status Panel connections to controller are also indicated on face of controller. BE SURE to observe polarity.

Connections from thermostat and from auxiliary furnace and auxiliary blower are indicated on controller face.

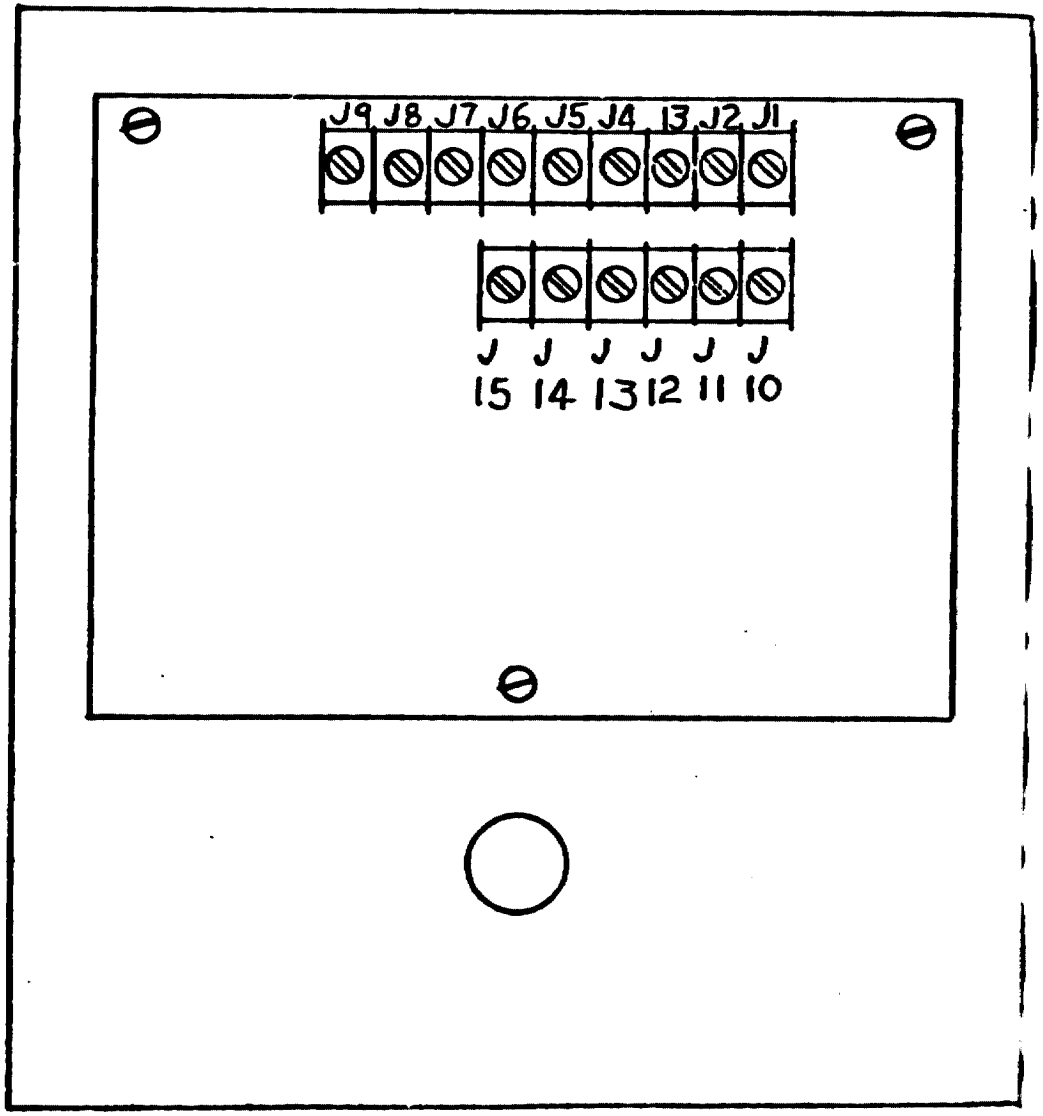
NOTE: The Solarstat requires a 24V power supply.
Suggested: Use a 115V-24V stepdown transformer.
Solarstat requires maximum 10 watts input power.



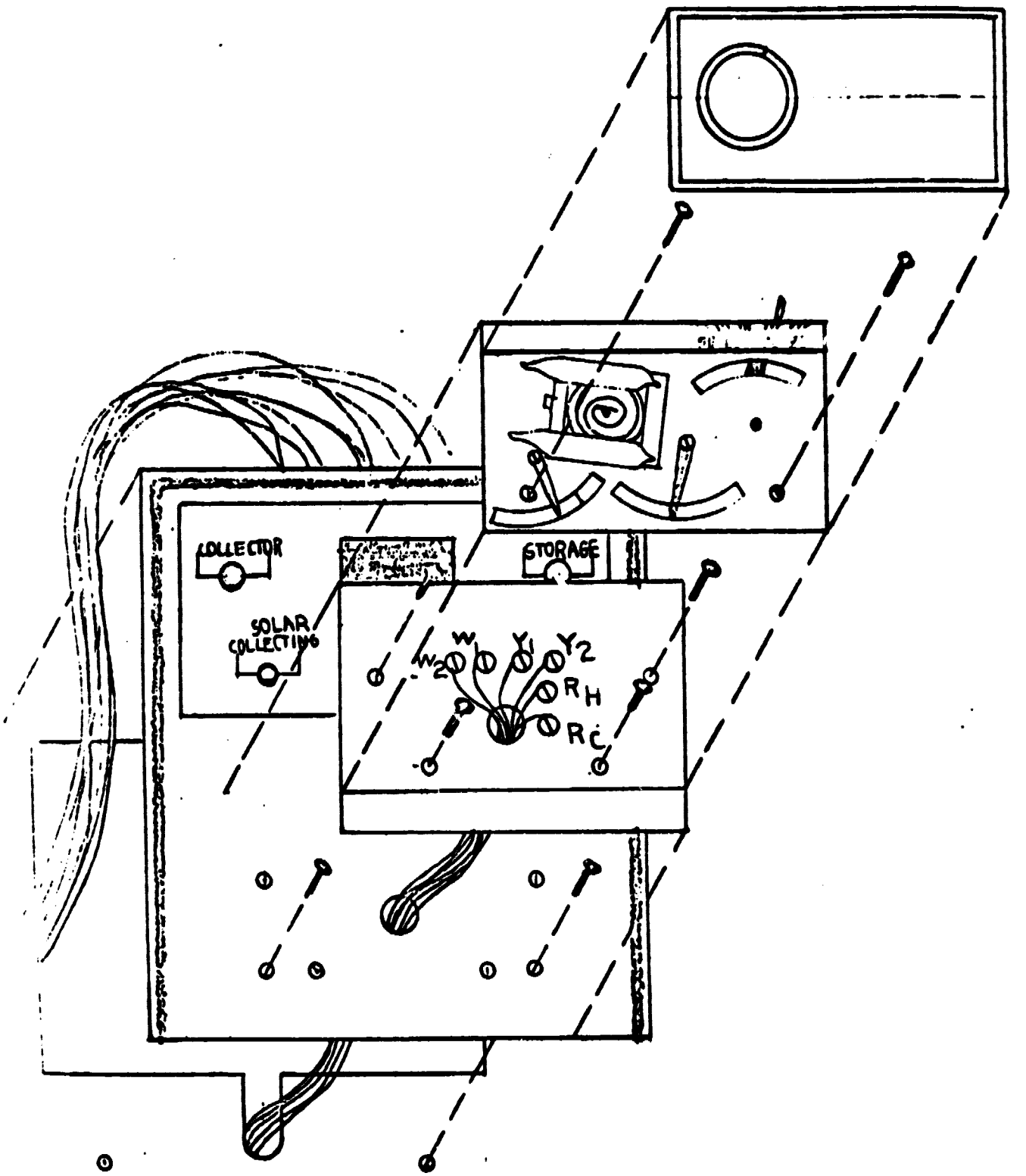
WALL MOUNTING HOLE

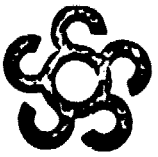
SOLARSTAT
REAR TERMINATIONS

"J" CONNECTOR	INTERFACE
J1	24 V AC
J2	24 V AC
J3	GROUND
J4	STORAGE PROBE
J5	STORAGE PROBE NEG.
J6	COLLECTOR PROBE
J7	COLLECTOR PROBE NEG.
J8	NORMAL PROBE
J9	NORMAL PROBE NEG.
J10	SOLAR COLLECTING RELAY- 24 V AC OR POS DC
J11	SOLAR COLLECTING RELAY- 24 V AC OR NEG. DC
J12	SOLAR HEATING RELAY 24 VAC OR POS. DC
J13	SOLAR HEATING RELAY 24 VAC OR NEG DC.
J14	CONVENTIONAL HEATING RELAY-24VAC OR POS. DC
J15	CONVENTIONAL HEATING RELAY-24VAC OR NEG. DC



SOLARSTAT
FIELD INSTALLATION DIAGRAM





LIMITED WARRANTY

Solar Control Corporation warrants the equipment of its manufacture to be free from defects in material and/or workmanship under normal use and service. This obligation under this warranty is limited to making good any part or parts thereof, which 1) upon examinations at SCC shall be disclosed to be defective, and which 2) shall be returned to SCC, transportation charges prepaid, within one year after delivery to the original purchaser. This warranty shall not apply to any equipment which shall have been repaired or altered outside of Solar Control Corporation in any way so as to affect its use, function, or reliability, or which shall have been subject to misuse, alteration, improper installation, negligence or accident. In no event shall SCC be liable for damage of any kind connected with the use of the equipment of its failure to function properly.

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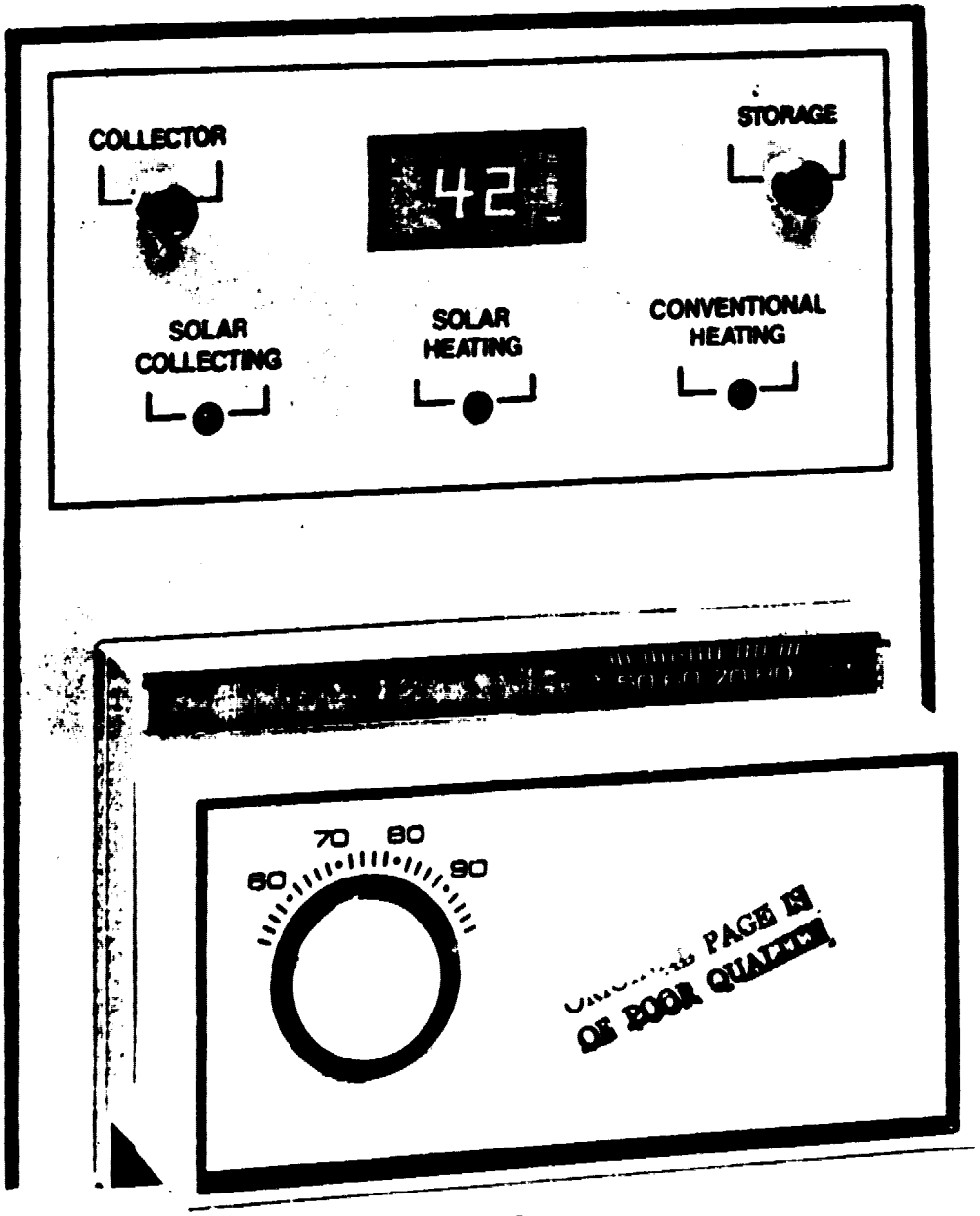
Boulder, Colorado 80302
303/449-9180

SOLAR CONTROL CORP.

SOLARSTAT SOLID STATE SOLAR SYSTEM MONITOR



Model 77-180
Solid State Solar System Monitor

Description

The model 77-180 is a solid state temperature and system function monitor that provides the homeowner with accurate outdoor, indoor, collector and storage temperature readings.

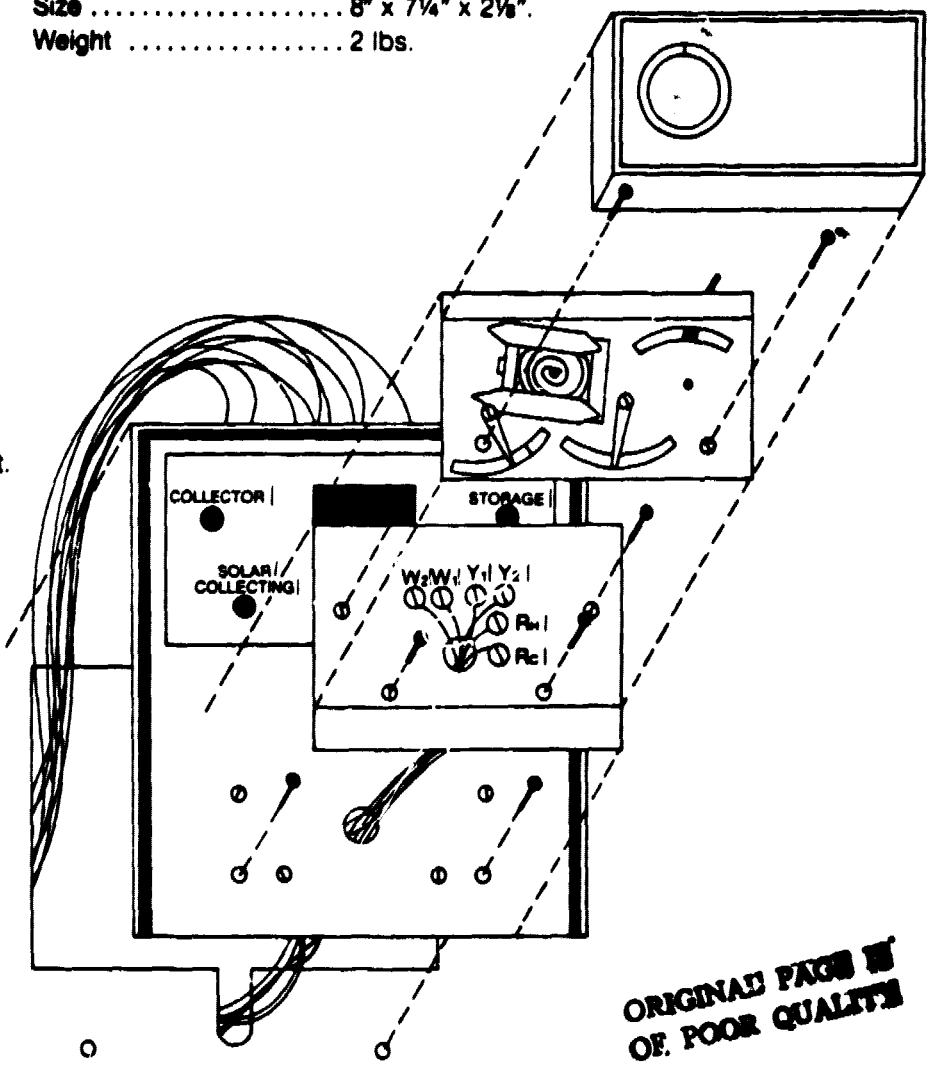
The outdoor temperature is continuously indicated by a 0.3 inch liquid crystal display. Collector and storage temperatures may be selected by depressing the appropriate button. The control thermostat provides room temperature as well as two stage signals to the home's solar and back-up heating system.

The solar heating system's current mode of operation is indicated by three light emitting diodes which give a bright red indication of solar collecting, solar distribution, or back-up heating function.

The Solarstat uses less than 10 watts at 24 VAC and is compatible with all conventional HVAC equipment.

Specifications

Input voltage ..... 24 VAC ±20%.
Input power ..... 10 watts maximum.
Temperature sensors ..... Diodes, linear from −40° to +199°F.
Displays ..... Temperature—0.3 inch liquid crystal, 3 digits plus (−) sign. Mode of operation—3 light emitting diodes.
Display range ..... Temperature—−40° to +199°F.
Accuracy ..... ±0.5% one count on least significant digit.
Measurement points ..... Outdoor, collector, storage and room.
Thermostat ..... Two stage heating. Optional: two stage heating, one stage cooling and fan on/off.
Solarstat operating temperature ..... 32° to 120°F.
Size ..... 8" x 7¼" x 2⅛".
Weight ..... 2 lbs.



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

SECTION B

INSTALLATION, OPERATION, AND MAINTENANCE MANUAL

77-171 CONTROLLER

77-171 BASIC MODULE CONTROLLER

A solar heating or cooling system is only as good as the control system operating it. Solar Control Corporation is offering a top quality control system whose reliability and versatility put it at the top of the market. The 77-171 BASIC MODULE CONTROLLER offers not only reliable operation, but a long life of maintenance-free operation. It can be used singly, or in multiple configurations. Optional multiple outputs provide a variety of control functions, from the simplest (such as pre-heat for domestic hot water), to complex operations (such as differential heat switching to multiple storage systems). Solid state provides reliability. Essentially, the system is a differential thermostat comparing temperatures at two locations, and providing control according to the customer's specifications.

IMPORTANT NOTE: If this controller is to be used for starting motors greater than 1/4 horsepower, an auxiliary relay MUST be used between the controller and the motor.

APPLICATION

The 77-171 Basic Module Controller is essentially a differential thermostat which is capable of controlling the operation of a solar heating and/or cooling system. The Basic Module may be used individually or may be combined with other Basic Modules to perform a variety of control functions as required for individual systems, such as pre-heat for domestic hot water, operation of air-flow to equalize temperatures, and many others.

INSTALLATION

CAUTION: 1. Disconnect power to system before installing controller.

2. Check all connections before restoring power.

3. Make certain no high voltage leads are connected to low voltage points.

4. Make certain no low voltage leads are connected to high voltage points.

MOUNTING: The controller may be mounted in any position which is accessible for operation. The 77-171 Basic Module Controller is designed to be mounted on a standard 4" x 4" junction box. The mounting plate of the controller replaces the box cover.

TO INSTALL:

1. Install junction box at chosen location. (Junction box is not furnished with the controller.)

2. Bring into the box all wires which will be connected to the controller.

3. Make wiring connections inside the box, according to the following:

Wiring Description (See Fig. 1, Installation Drawing.):

a. Connect 115 V input: high side to black, ground side to white wires.

b. Bring blue and yellow wires from beneath controller through small hole below terminal #6, and connect to terminals #1 & #2. (On some controllers this wiring may already be completed.) This provides 24V input to the controller.

c. Connect probe #1 (typically collector probe) to terminals #4 & #5.

d. Connect probe #2 (typically storage probe) to terminals #5 & #6.

Connection of Relay Leads

The SPDT relay of the Basic Module is connected in the following manner (See Fig. 1):

Function	Connection
Pump, fan or other device "ON" when probe #1 is hotter by 20°F than #2.	Connect the red/white lead and the red lead to the device to be turned on.
Pump, fan or other device "OFF" when probe #1 is hotter by 20°F than #2.	Connect the red/black lead and the red lead to the device to be turned off.

Check-Out: After the Basic Module has been connected to the system, it may be checked in the following manner for correct operation:

1. Depress and hold down the button on the front of the box. Check to see whether the functions controlled by the N-O (normally open) contacts are turned on. If so, the controller is operating properly.

2. Now release the button. Functions controlled by the N-O contacts will turn off, and those controlled by the N-C (normally closed) contacts will turn on.

OPERATION

The relay in the controller will pull in when probe #1 is hotter than probe #2. N-C contacts will open and N-O contacts will close. The functions controlled by the N-O contacts will be "ON". The functions controlled by the N-C contacts will be "OFF". When the temperature of the low temperature probe becomes $4^{\circ}F \pm 2^{\circ}F$ colder than the high temperature probe, the relay will open; then the functions controlled by the N-O contacts will turn off; those controlled by the N-C contacts will turn on.

Freeze Protect: The 77-171 Controller is factory equipped with a freeze protect feature that will close the N-O contacts when probe #1 (typically collector probe) shows a temperature of $40^{\circ}F \pm 5^{\circ}F$.

Boil Protect: The 77-171 Controller is factory equipped with a boil protect feature that will turn the controller off (i.e., N-O contacts will return to N-O and N-C contacts will return to N-C) when a temperature of $180^{\circ}F$ is reached at the collector.

Use of "Out" Terminal (#3): This terminal goes along with special options that are available on the controller.

PROBE INSTALLATION

Collector, Air Transport System: Probe may be mounted on the back of collector or inserted directly into the air flow path, e.g. as air leaves the collector. Usually it is sufficient to attach the probe to the back of the collector.

Collector, Water Transport System: Probe may be mounted on the back of collector, in contact with collector plate; alternatively, it may be attached to fluid transport tubes, e.g. at outlet from collector to storage.

Storage, Air Transport System: Probe is to be located in the cooler part of storage. (For control systems having three probes, a second probe is to be placed in the warmer part of the storage.)

Storage, Water Transport System: Place "O" ring on end of probe, seat ring against flange of probe. Insert probe into 3/16 inch hole drilled into pipe at outlet from storage. Use clamp to hold probe in place.

STANDARD FEATURES

- 110 VAC output
- 100% solid state circuits
- Multi-output relays
- Manual "ON" button permits quick check of controller operation
- Active filtering to reject noise
- Optimum hysteresis to eliminate switching chatter
- High impedance temperature sensors for accurate temperature sensing
- High and low temperature control (can be overridden)
- Can be mounted on a standard junction box
- Non-shorting terminal hookups
- Screw-type terminals
- Flying power leads for junction box terminals
- Rugged, electrically insulated unit
- Designed to UL specifications and the National Electric Code
- Differential temperature tracking accuracy: controller maintains temperature differential within $\pm$ 5°F over entire range of operation
- Ease of installation: can be installed by electricians or heating contractors using ordinary tools

- Control relay rated 1/4 hp, 120 VAC, 10 amp at 28 VDC or 120 VAC 80% power factor

- Can be mounted in any position which is accessible for operation. Small size (4" x 4" x 3-1/2") makes it ideal for mounting directly on a pump.

- Controller operating temperature range of 40°F to 130°F provides for flexibility in location of controller

- Sensors have operating temperature range of -40°F to 300°F -- ample for use with flat plate collecting systems and air or water storage systems

INSTALLATION DRAWING

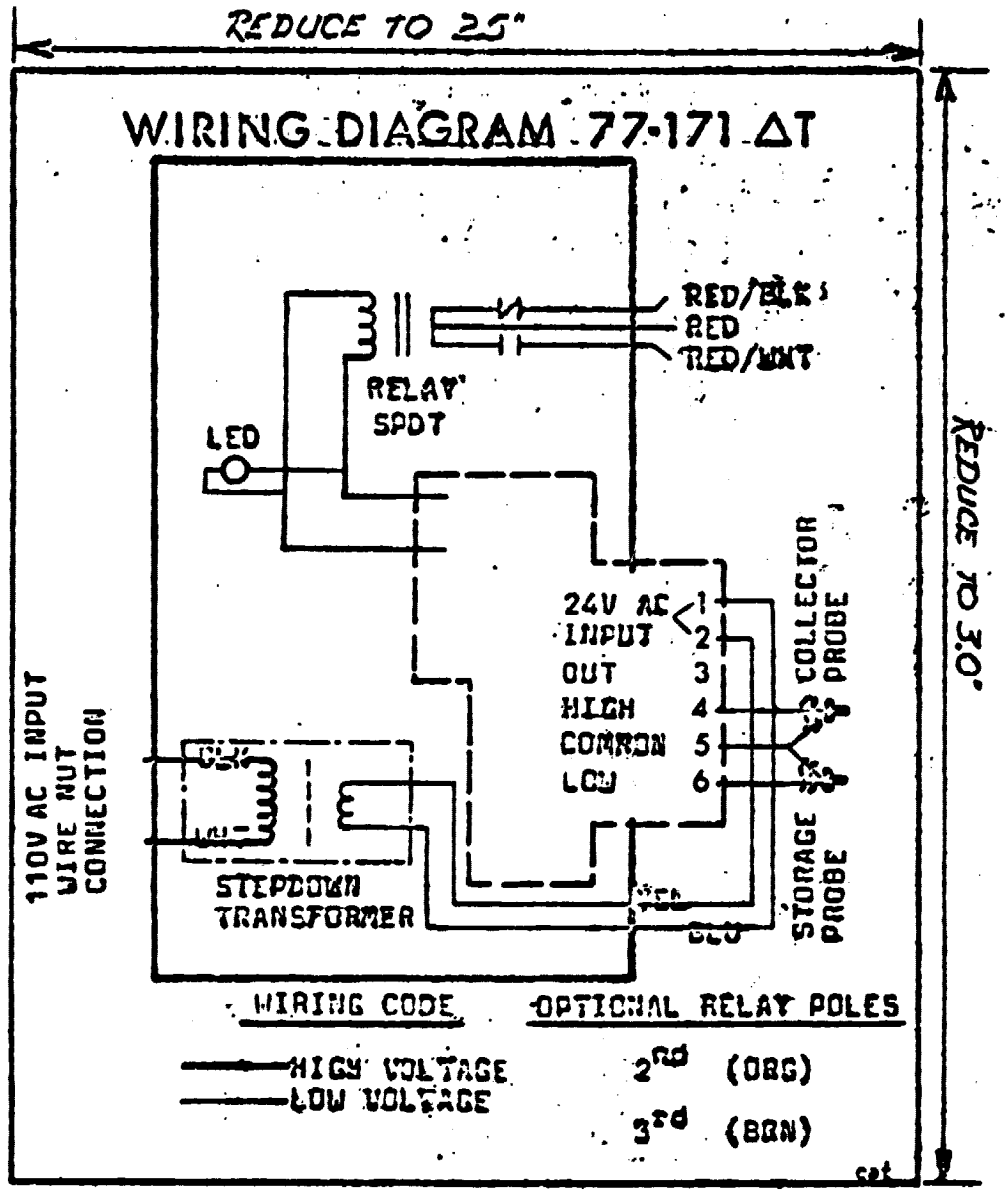


Figure 1

RATINGS 77-171 CONTROLLER:

Input Voltage	120 VAC, 60 Hz
Input Power	3 Watts, no load
Control Relay	10 A (resistive) at 28 VDC 1/4 HP at 120 VAC
Output Voltage	Between terminals 1&2 - 24 VAC
Output Rating	Between terminals 2&3 - 24V, halfwave AC 1/2 amp RMS
Maximum Ambient Temperature	130°F.

RATINGS 77-171 CONTROLLER (WITHOUT TRANSFORMER)

Input Voltage	24 VAC at terminals 1&2
Input Power	3 Watts, no load
Control Relay	10 A (resistive) at 28 VDC 1/4 HP at 120 VAC
Output Voltage	Between terminals 1&2 - 24 VAC
Output Rating	Between terminals 2&3 - 24V, halfwave AC 1/2 amp RMS
Maximum Ambient Temperature	130°F.

	Resistance	°F Temp.	Resistance	°F Temp.	Resistance	°F Temp.	Resistance
20	152,029	70	36,055	120	10,546	170	3,657
21	147,337	71	35,111	121	10,310	171	3,583
22	142,871	72	34,201	122	10,077	172	3,515
23	138,470	73	33,311	123	9,854	173	3,447
24	134,317	74	32,451	124	9,633	174	3,380
25	130,222	75	31,607	125	9,421	175	3,315
26	126,324	76	30,800	126	9,211	176	3,251
27	122,523	77	30,000	127	9,008	177	3,189
28	118,847	78	29,241	128	8,810	178	3,128
29	115,309	79	28,490	129	8,616	179	3,069
30	111,850	80	27,770	130	8,428	180	3,011
31	108,563	81	27,065	131	8,243	181	2,953
32	105,310	82	26,380	132	8,065	182	2,897
33	102,244	83	25,717	133	7,889	183	2,842
34	99,215	84	25,067	134	7,719	184	2,789
35	96,326	85	24,444	135	7,552	185	2,736
36	93,509	86	23,827	136	7,390	186	2,685
37	90,785	87	23,240	137	7,231	187	2,635
38	88,160	88	22,666	138	7,076	188	2,586
39	85,593	89	22,102	139	6,926	189	2,538
40	83,146	90	21,580	140	6,777	190	2,491
41	80,725	91	21,026	141	6,635	191	2,445
42	78,440	92	20,510	142	6,494	192	2,400
43	76,186	93	20,008	143	6,357	193	2,356
44	74,029	94	19,530	144	6,223	194	2,312
45	71,925	95	19,044	145	6,090	195	2,270
46	69,890	96	18,580	146	5,966	196	2,229
47	67,926	97	18,136	147	5,841	197	2,188
48	66,004	98	17,700	148	5,720	198	2,148
49	64,170	99	17,276	149	5,600	199	2,110
50	62,354	100	16,860	150	5,500	200	2,072
51	60,368	101	16,461	151	5,372	201	2,034
52	58,944	102	16,070	152	5,262	202	1,998
53	57,323	103	15,689	153	5,154	203	1,962
54	55,740	104	15,314	154	5,049	204	1,927
55	54,206	105	14,957	155	4,946	205	1,893
56	52,726	106	14,600	156	4,845	206	1,859
57	51,275	107	14,263	157	4,747	207	1,826
58	49,891	108	13,930	158	4,651	208	1,794
59	48,519	109	13,605	159	4,553	209	1,762
60	47,221	110	13,290	160	4,466	210	1,731
61	45,937	111	12,981	161	4,376	211	1,701
62	44,710	112	12,690	162	4,289	212	1,671
63	43,510	113	12,388	163	4,203	213	1,642
64	42,346	114	12,100	164	4,120	214	1,613
65	41,222	115	11,827	165	4,038	215	1,585
66	40,120	116	11,559	166	3,958	216	1,558
67	39,066	117	11,296	167	3,880	217	1,531
68	38,022	118	11,039	168	3,804	218	1,404
69	37,032	119	10,790	169	3,729	219	1,478

FENWAL THERMISTOR
#UUT - 43J1
°F vs. Resistance

UNDERWRITERS LABORATORIES

CERTIFICATION

77-171 CONTROLLER

December 9, 1977

Paul Duks
Underwriters Laboratories
333 Pfingsten Road
Northbrook,IL 60062

Ref: File No. MH 10810
Project No. 77 NK5784

Dear Mr. Duks:

Thank you for your telegram confirming that our Type 75-171 controllers comply with your requirements. This letter confirms the revisions we discussed by phone November 18, 1977.

1. The wiring diagram will show the 2-pole relay option, and will be on an adhesive label inside the cover of the controller.

2. Ratings (see attached list) will also be on an adhesive label, on one side of the controller.

3. This label will also include the following:
   NOTE: ALL circuits must be wired NEC Class 1.

4. This legend will be stamped in permanent ink on the outside on the box (letters 1/8" high).
   "CAUTION: Risk of electric shock - More than one disconnect switch may be required to de-energize the device for servicing." (per paragraph 45-1, 2, UL-873.)

5. A bushing of thermoplastic material or nylon will be placed in the opening in the bottom of the controller through which the wires emerge.

6. A grounding screw will be attached to the body of the controller.

7. Units without transformers will have a snap-in plug to cover the opening in the bottom through which the wires emerge.

An additional note: The model number for the controller is

actually 77-171. (Although the original design was begun in 1975, the controller development was completed in 1977, hence the "77".) This is the model which you evaluated.

It has been a pleasure working with you and I look forward to the next time we may call upon you. Thank you again for your services.

Sincerely,

SOLAR CONTROL CORPORATION

Martha J. McGavin
Manager of Operations

MJM:em

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