(NASA-CR-150615) PRELIMINARY DESIGN PACKAGE FOR PROTOTYPE SOLAR HEATING SYSTEM (Contemporary Systems, Inc.) 54 p HC A04/MF A01 CSCL 10A
N78-24610
Unclas
G3/44 16737

DOE/NASA CONTRACTOR REPORT

DOE/NASA CR-150615

PRELIMINARY DESIGN PACKAGE FOR PROTOTYPE SOLAR HEATING SYSTEM

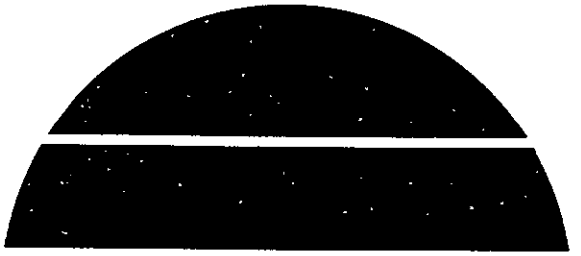
Prepared by

Contemporary Systems, Inc.
68 Charlonne Street
Jaffrey, New Hampshire

Under Contract NAS8-32243 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

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO.	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
DOE/NASA CR-150615		

4. TITLE AND SUBTITLE	5. REPORT DATE
Preliminary Design Package for Prototype Solar Heating System	November 23, 1976
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9. PERFORMING ORGANIZATION NAME AND ADDRESS Contemporary Systems, Inc. 68 Charlonne Street Jaffrey, New Hampshire	10. WORK UNIT, NO.
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	13. TYPE OF REPORT & PERIOD COVERED Contractor Report
12 SPONSORING AGENCY NAME AND ADDRESS National Aeronautics and Space Administration Washington, D. C. 20546	14 SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

This work was done under the technical management of Mr. Valmore Fogle, George C. Marshall Space Flight Center, Alabama.

16. ABSTRACT

This report is a collation of documents that were submitted by Contemporary Systems, Inc., for the preliminary design review on the development of a prototype solar heating system for single-family dwellings. Included are the Proposed Instrumentation Plan, Deviation Requirement, System Changes and Rationale, Preliminary Design Drawings, and other information pertaining to the progress and design of the system.

This space heating system consists of the following subsystems: collector, storage, transport, control, and Government-furnished site data acquisition. The two prototype systems will be installed at York, Pennsylvania, and Manchester, New Hampshire.

A small amount of typing and reformatting has been done for clarity.

17. KEY WORDS	18. DISTRIBUTION STATEMENT Unclassified-Unlimited William A. Brooksbank Jr. WILLIAM A. BROOKSBANK, JR. Manager, Solar Heating and Cooling Proj Ofc

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)		22. PRICE
Unclassified	Unclassified		NTIS

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NAS8-32243

Systems Inc

Proposed Instrumentation Plan

Jaffrey, NH

11/23/76

1.0 Site and System Description

1.1 Site Contractor - Contemporary Systems Incorporated; contractor; 68 Charlonne St, Jaffrey N.H. 03452; 603-532-7972

1.2 Site address - a. (proposed) Grodin house, Prescott Hill Rd., Jaffrey N.H.
b. unspecified at this time

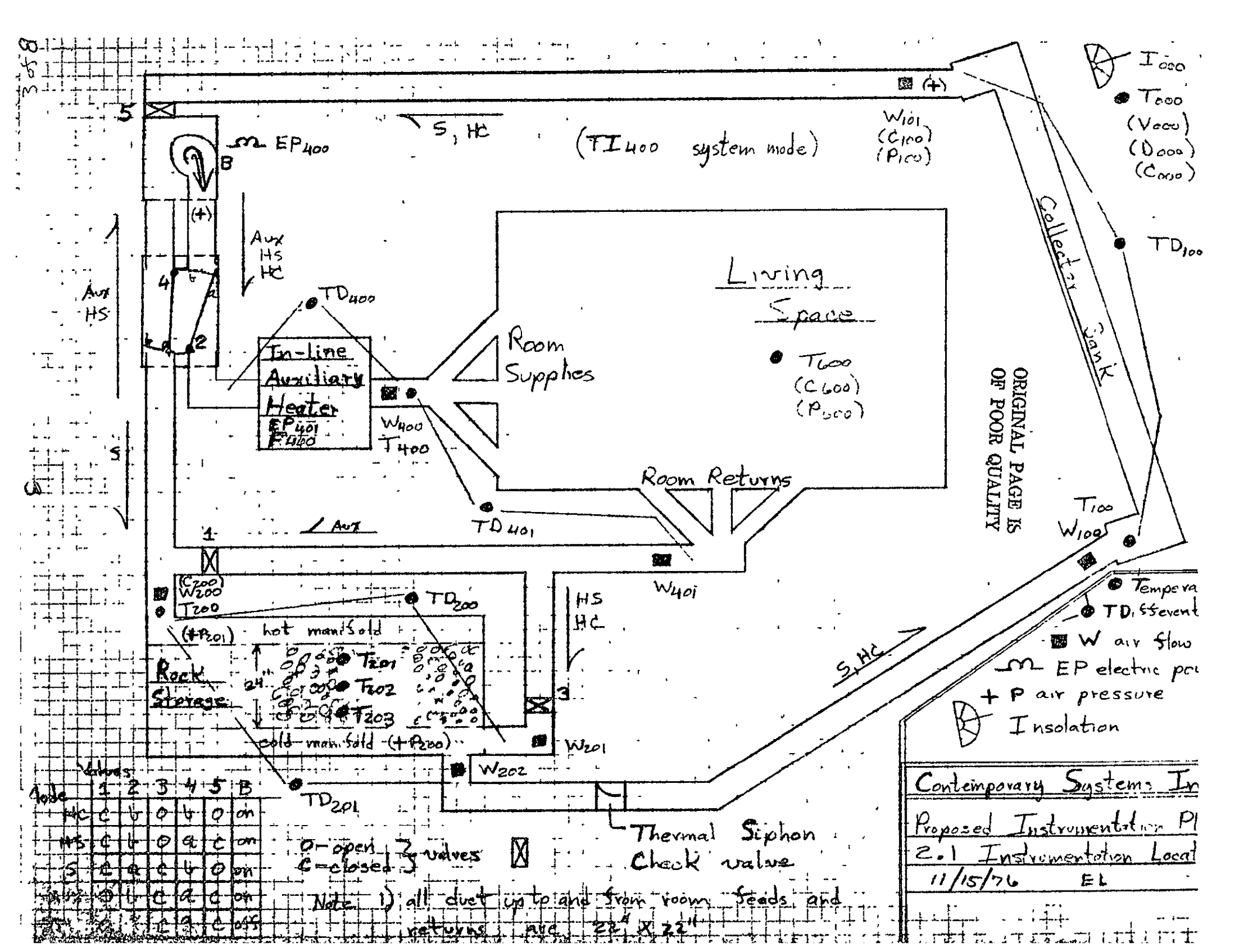
1.3 Purpose of site = a residence
b. unspecified

1.4 Building Description - a & b will be supplied when the two sites are finalized.

1.5 System Descriptive Summary (a & b)

1) type - air circulating space heating system
2) collector area - 850 ft^2
3) collector description - CSI Series IV air circulating solar collectors
4) storage - rock sensible heat storage system, size is sub dependant, to be specified later.
5) space heating method - forced air
6) hot water subsystem - unspecified, conventional
7) energy transport
fans - 3400 CFM, low static pressure, high efficiency blowers, single phase 115 VAC
ducts - tentatively 22" square sheet metal duct, insulated (loss ≤ 12 BTU/ft^2 at 110 °F)
fluid - air

8) space cooling method - none specified
9) auxiliary energy source - oil fired hot air furnace
10) operational control sequence - The logic control unit (LCU-100) generates one of five system state: HC heating from collectors, HS heating from storage, S storing collected heat, AUX. heating from auxiliary source, and IDLE. Priority for heat source is given to collectors, then storage, then auxiliary system. When the system is manually shutdown thermostat control is returned to the auxiliary system.
11) energy conversion equipment efficiency - calculated COP: 42:1 heating from collectors, 26:1 heating from storage



Mode	Valves 1	2	3	4	5	B	
HC	C	O	C	O	C	O	on
HS	C	O	C	C	C	O	on
S	C	C	C	O	C	O	on
Aux HS	C	O	C	C	C	O	on
Aux S	C	C	C	O	C	O	off

O-open
C-closed
3 valves

Note 1) all duct up to and from room feeds and returns are 22" X 22"

Contemporary Systems In
Proposed Instrumentation Pl
2.1 Instrumentation Locat
11/15/76 EL

Proposed Instrumentation Plan
2.2 Instrumentation Parts Schedule

Senson	Measurement		
I_{000}	Total normal solar insolation to collector	0-350 $\frac{BTU}{hr.\ ft^2}$	PSP
T_{000}	Outdoor ambient temp	-40 to +110 °F	553-P___
T_{100}	Collector input manifold entrance temp.	-20 to +200 °F	553-P85
T_{200}	Storage hot manifold entrance temp.	+60 to +~~200~~ 150 °F	553-P85
T_{201}	Storage temp at 20"	+60 to +150 °F	553-P40
T_{202}	Storage temp at 12"	+60 to +150 °F	553-P40
T_{203}	Storage temp at 4"	+60 to +150 °F	553-P40
T_{400}	Room supply feed temp	+60 to +140 °F	553-P85
T_{600}	Room temp. at thermostat	+40 to +100 °F	553-P___
TD_{100}	Collector in/out manifold differential temp	0 to +100 °F	557-P85
TD_{200}	Storage in/out manifold diff. temp. (HS mode)	0 to +100 °F	557-P85
TD_{201}	Storage in/out manifold diff temp (S mode)	0 to +100 °F	557-P85
TD_{400}	Auxiliary heater diff temp.	0 to +100 °F	557-P85
TD_{401}	Room feed/return diff temp	0 to +100 °F	557-P85
W_{100}	Collector input air flow rate	0 to 4000 CFM	74/157A
W_{101}	Collector output air flow rate	0 to 4000 CFM	74/157A
W_{200}	Storage hot air flow rate	0 to 4000 CFM	74/157A
W_{201}	Storage cold air flow rate (HS mode)	0 to 4000 CFM	74/157A
W_{202}	Storage cold air flow rate (S, HC mode)	0 to 4000 CFM	74/157A
W_{400}	Room supply air flow rate	0 to 4000 CFM	74/157A
W_{401}	Room return air flow rate	0 to 4000 CFM	74/157A
EP_{400}	Electric power to run solar system		PCS-
EP_{401}	Electric power to run auxiliary system		PCS-
F_{400}	Fuel flow rate to auxiliary system		MR-V

PIP 2.3) Operating Modes

The LCU-100 control unit monitors four inputs; the house thermostat, collector and storage sensible heat thermostats (with setable hysteresis) and collector - storage differential temperature (setable with hysteresis). The LCU determines system state and sets the triac switched outputs:

Inputs	System state: HC	HS	S	Aux	Idle
H - house thermostat demand	1	1	0	1	0
T_{SH} - storage above sensible heat level	X	1	X	0	X
T_{CH} - collectors above sensible heat level	1	0	X	0	X
D - positive collector/storage diff.	X	X	1	X	0

state	priority
HC - heating from collectors	1
HS - heating from storage	2
Aux - heating from auxiliary system	3
S - storing collected heat	4
Idle - idle, stand-by	5

Control of the air transport system's dampers and blower and the flow paths for the different modes are given in the system schematic of PIP 2.1) Instrumentation Locations

The LCU-100 has a three position function switch:

OFF/AUX - In this position the system is set up in the AUX mode with control of the auxiliary heater and the blower returned to the house thermostat

ON/AUTO - The solar and auxiliary system are under the automatic control of the LCU-100

DEICE - For thawing ice from the collectors, in this position the system circulates stored heat through the collectors. When the house thermostat demands heat the system goes into the AUX mode. This function is a short time period, manual option.

PIP 2.4) Architectural Rendering

CSI is unable to submitt an architectural rendering for either site at this time. It will be submitted after the two sites have been chosen.

PIP 3.0) Installation Cost Proposal

CSI is unable to submitt this cost proposal until the two sites have been chosen and signing of the solar systems is complete.

4.0) Instrumentation Installation Completion Schedule

	week
Instrumentation receipt	0 (8/22/77)
Instr. installation period	0 & 1
completion point	end 1
Instr check out	6 - 8
Complete system start-up	7
stabelization point	8
AIP implementation complete	end 8

note: Instrumentation schedule week 0 corresponds with week 44 from Authority - to - proceed.

1.1 3.1 — Deviation Requirement

Date: 11/23/16

Site number: 1 and 2

Site location: unspecified

Site contractor: Contemporary Systems Inc; 603-532-7972, 68 Charlonne St, Jaffrey NH 03452

Deviation Requirement Summary:

A) CSI requests the addition of a wind speed and direction probe and a relative humidity probe to the SDAS for both sites.

B) CSI requests the addition of three relative humidity probes and four low air pressure probes to the SDAS for both sites.

C) CSI requests the time recording of system mode be added to the SDAS for both sites.

D) CSI requests additional storage stratification temperature probes for both site SDAS.

Date Desired for Implementation of Requirement:

Implementation to coincide with AIP.

Purpose of Deviation Requirement:

A) The addition of wind speed and direction and relative humidity data will allow more complete evaluation of thermal losses from the collector assembly and the building.

B) The addition of circulating air pressure and moisture content data will improve the accuracy of system evaluation by allowing

... Deviation Requirement

Date : 11/-3/76

Site number: 1 and 2

Site location: unspecified

Site contractor: Contemporary Systems Inc, 603-532-7972, 68 Charlonne St, Jaffrey NH

accurate determination of the specific heat of the heat transport medium, air.

c) The addition of system mode vs. time data will allow evaluation of the Logic Control Unit with respect to system cycling times and system absolute and differential set temperatures. CSI will provide a standard logic output from the Logic Control Unit describing system mode for interface with the SDAS as required by [redacted]/NASA

D) Because our solar system's rock storage is unconventional (large surface area and short path length), more temperature probes are needed to accurately determine its effectiveness.

Deviation Requirement Details:

The additional probes requested are listed below according to section A) - D). Then locations in the system are given in parentheses in the included PIP section 2.2

Date: 11/13/76

Site number: 1 and 2

Site location: unspecified

Site contractor: Contemporary Systems Inc., 603-532-7972, 68 Charlonne St, Jaffrey NH

Deviation Request Probes

Sensor	Measurement	Range	Model
	(section A)		
V000	wind velocity	0-60 mph	W101-P-
D000	wind direction	360°	DC/540
C000	relative humidity, ambient	0-100 %	HM111-P
	(section B)		
C100	collector output air relative humidity	0-100 %	HM111-P
C200	storage output air relative humidity	0-100 %	HM111-P
C600	room relative humidity	0-100 %	HM111-P
P100	collector output air pressure	ambient ± 2 in H_2O	157A
P200	storage cold manifold air pressure	ambient ± 2 in H_2O	157A
P201	storage hot manifold air pressure	ambient ± 2 in H_2O	157A
P600	room (ambient) air pressure	ambient ± 2 in H_2O	157A
	(section C)		
I400	SDAS interface to standard logic output provided by CSI and specified by [redacted]/NASA		
	(section D)		
T204	storage stratification temps	+60 to +150 °F	553-P40
T205	storage stratification temps	+60 to +150 °F	553-P40
T206	storage stratification temps	+60 to +150 °F	553-P40
T207	storage stratification temps	+60 to +150 °F	553-P40
T208	storage stratification temps	+60 to +150 °F	553 P40

CONTEMPORARY SYSTEMS, INC.

68 CHARLONNE STREET JAFFREY, N. H. 03452 603-532-7972

January 11, 1977

SYSTEM CHANGES AND RATIONALE TD 2

The original baseline air transport system, as per drawing #500-002, operated with a slight positive pressure in the collectors, and the auxiliary heating system was connected in 'parallel' to the solar system. With the current system changes, drawing # 500-006, both of these design elements have been changed. By repositioning the blower from the cold side to the hot side of the system there is now a slight negative pressure in the collectors (with respect to outside atmospheric pressure). This change is advantageous because of the glazing system in use on the collectors. The position of the auxiliary heating system has also been changed and the two-part USS I #200-003 A & B, #200-004, #250-001, is now replaced by the USU "Universal Switching Unit" #200-008, #200-009. These changes greatly simplify the design of the air transport system, reducing the costs, making it easier to service, and allowing more useful heat to be extracted from the collectors.

#200-010,

The baseline collector chassis utilized formed galvanized sheet metal side components and one piece end caps, and a separate inner glazing of PVF, as per drawings #110-002, #110-003, #130-006. The side components have been redesigned and are made of aluminum extrusion, drawings #110-001, #130-002, providing greater precision, improved structural integrity, and a reduction in costs. The end caps of the chassis have been revised to a two-part system of ~~galvanized~~ aluminum cap plus extruded aluminum cap retainer, drawing #130-007. This gives better allowance for longitudinal expansion of the glazing system, and provides a better air seal. The placement of the inner PVF glazing has been altered, drawing # 110-001. The primary reason for this was to facilitate maintenance and replacement of the glazing, if ever necessary, but it has also reduced the stress on this inner glazing, provided more uniform spacing, less heat loss, and a cost reduction.

CONTEMPORARY SYSTEMS, INC.
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January 11, 1977

MATERIALS IN CONTACT WITH TRANSFER MEDIUM (AIR)

COLLECTOR

Kalwall	.040" Sun-Lite Premium fiberglass
Tedlar	Dulont Tedlar PVF film
Nextel paint	3M Nextel Velvet coating #101-C10
Tempered hardboard	
Silicon sealant	
Aluminum extrusion	
Closed-cell vinyl foam tape	

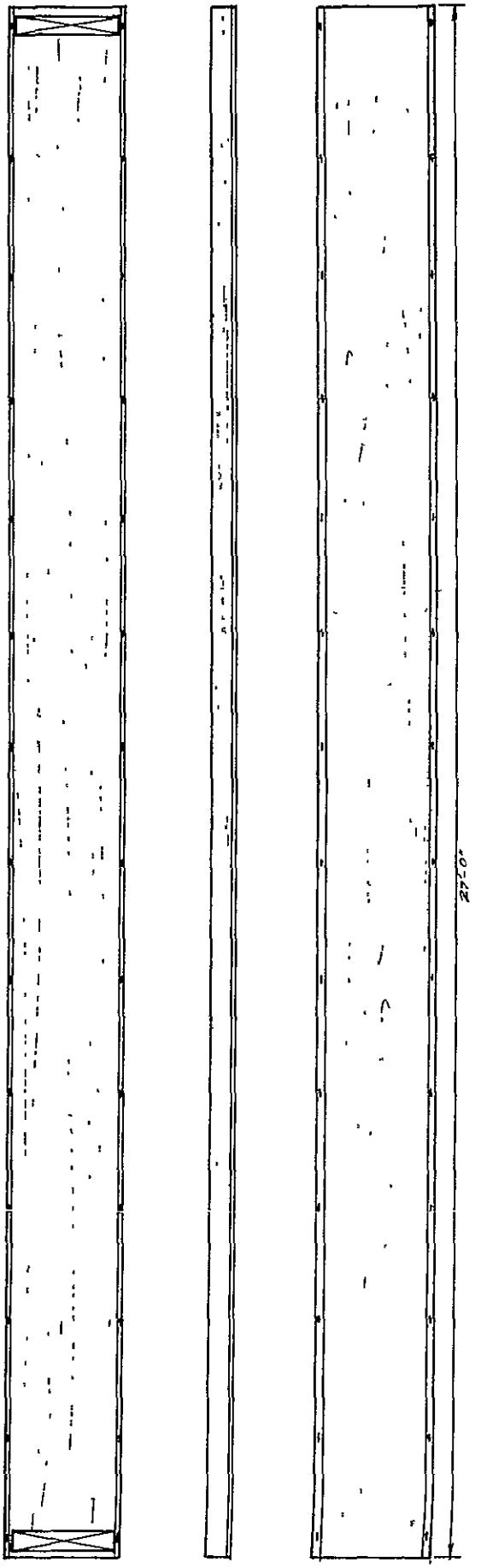
AIR TRANSFER SYSTEM

Galvanized steel ductwork		
Louvers:	aluminum	Honeywell type
	galvanized steel	
	neoprene	
Construction adhesive		(to be specified at later date)

THERMAL STORAGE

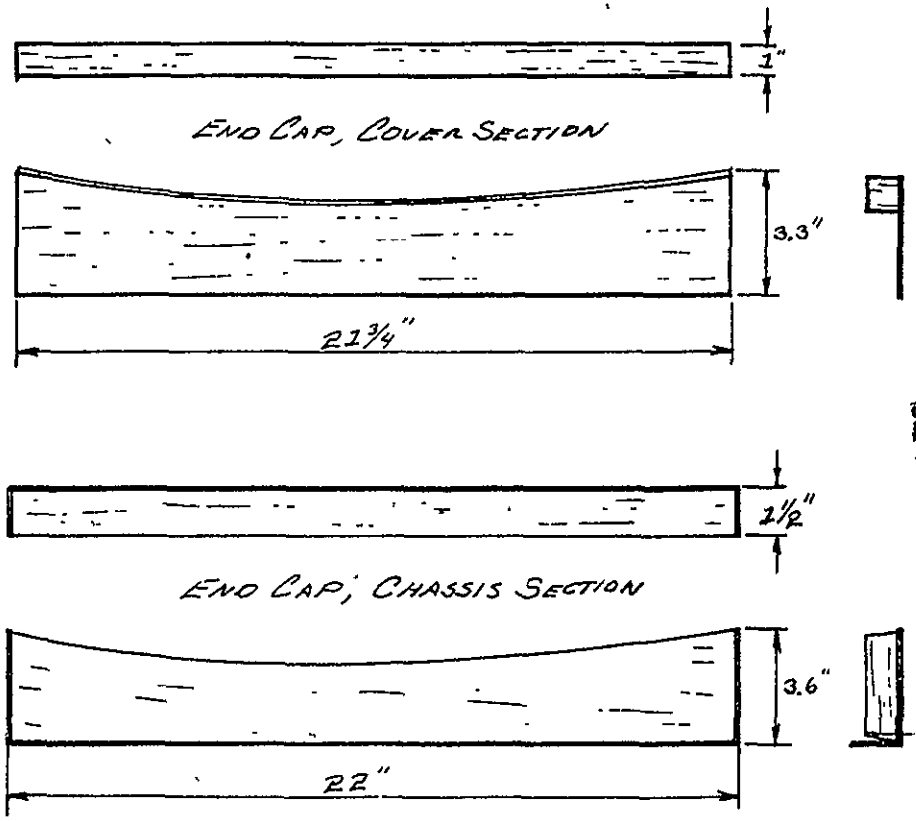
Washed pea stone
Concrete
Urethane slab insulation
PVC pipe
Exterior grade plywood

A. SERIES IV COLLECT. SCALE 1½" = 1'



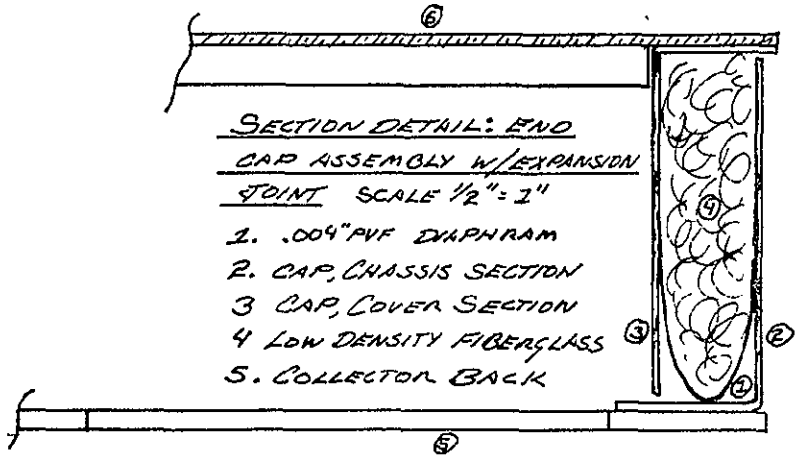
CSI
110-001 A

B. END CAP DETAIL 2" = 1' SCALE



END CAP, COVER SECTION

END CAP, CHASSIS SECTION

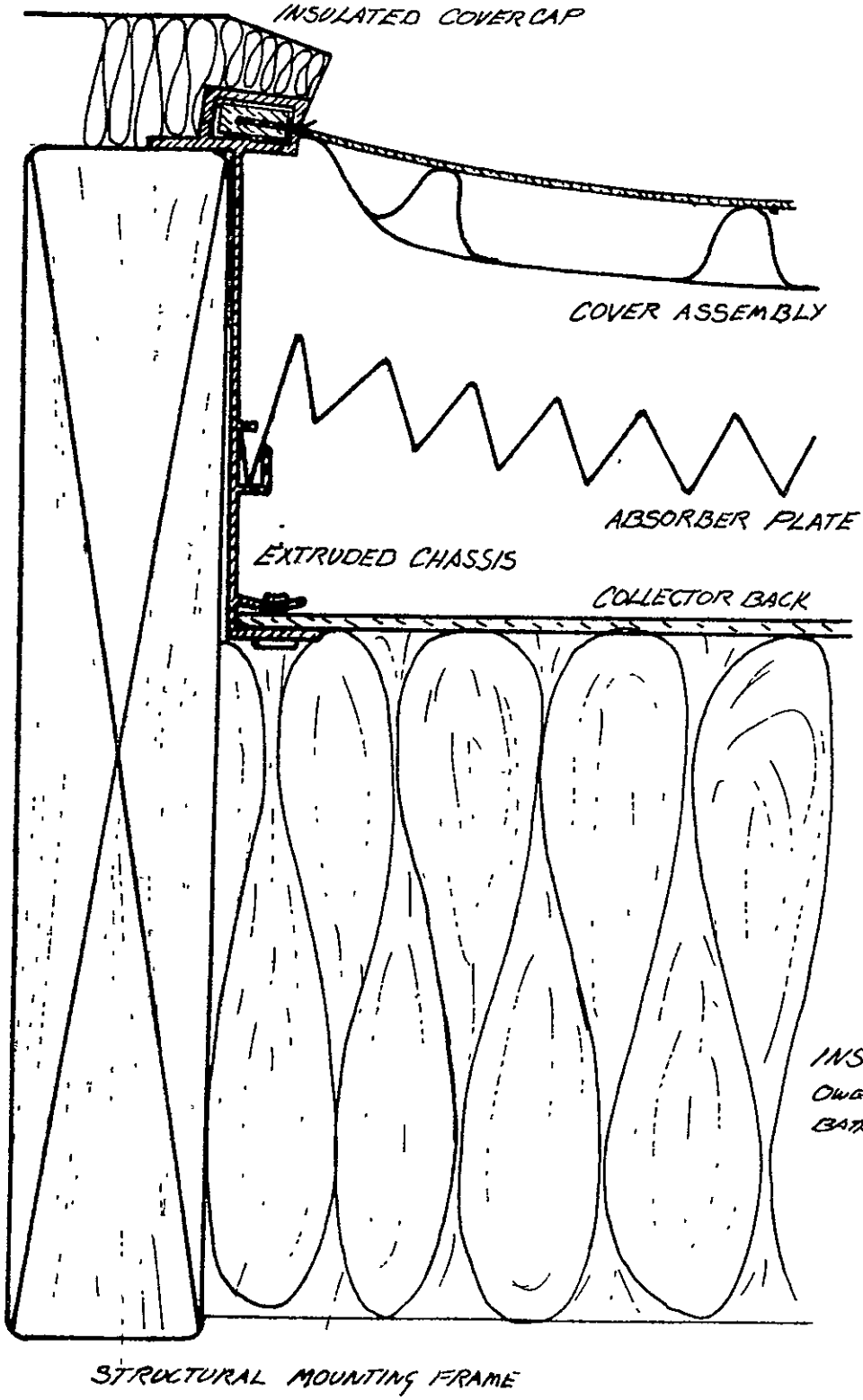


SECTION DETAIL: END CAP ASSEMBLY W/EXPANSION JOINT SCALE 1/2" = 1"

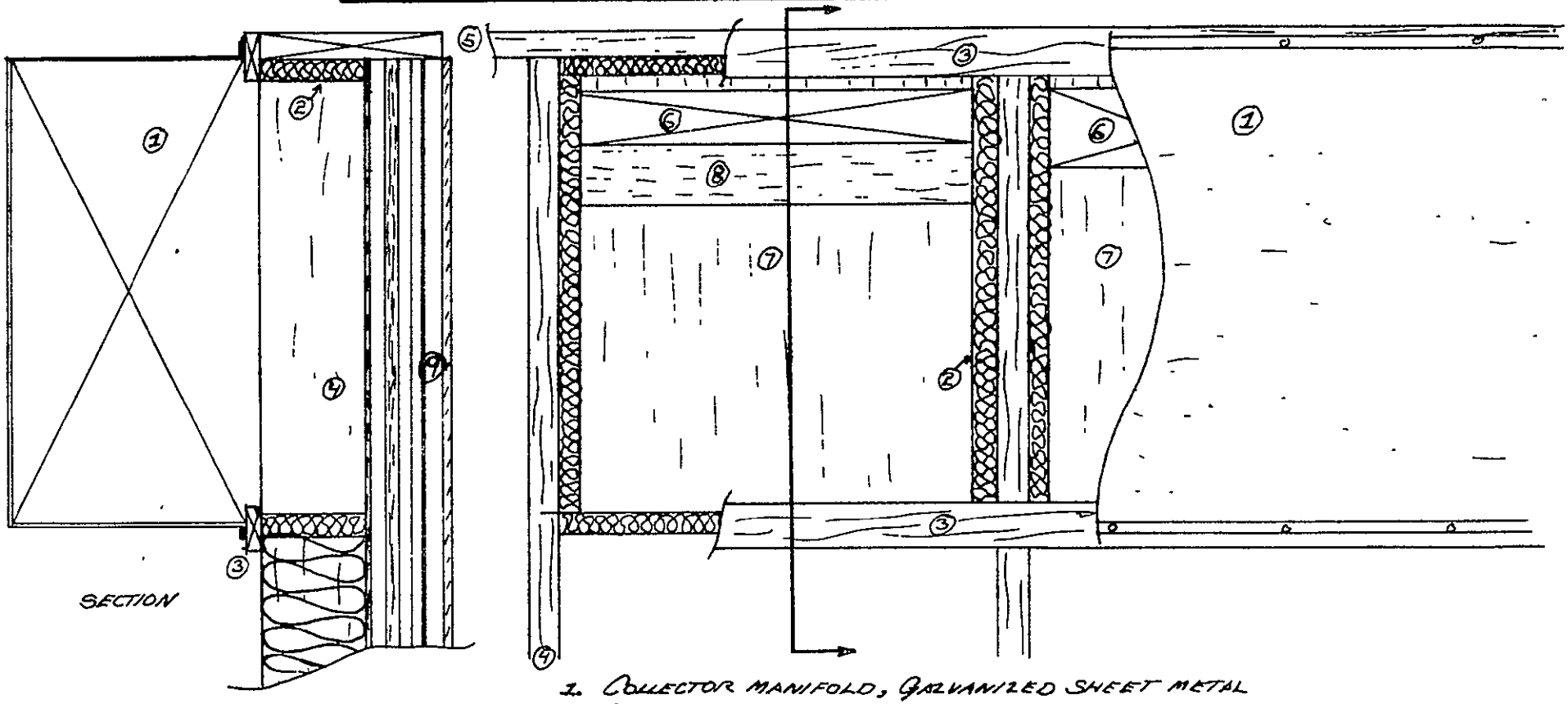
1. .004" PVF DIAPHRAM
2. CAP, CHASSIS SECTION
3 CAP, COVER SECTION
4 LOW DENSITY FIBERGLASS
5. COLLECTOR BACK

6. COVER ASSEMBLY

C. INSTALLATION & ASSEMBLY DETAILS SCALE 3/4" = 1"

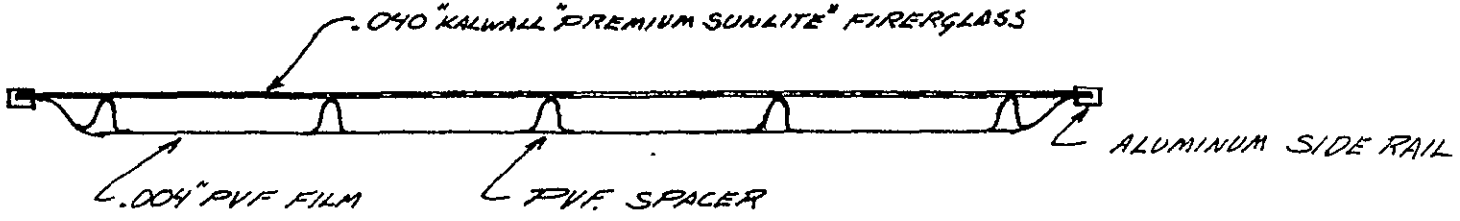


a. Collector Manifolding Detail 1½" = 1' scale



1. Collector manifold, galvanized sheet metal
2. Collector to manifold interconnect box, 1" rigid fiberglass board
3. 1x3 strapping for manifold mounting (seal to box #2 with caulking)
4. 2x10 Collector mounting frame
5. 2x10 Header
6. Collector input-output port.
7. Collector back
8. Balancing baffle
9. Sectional view of collector

E. Cover Assembly Details Scale 3" = 1'



CONTEMPORARY SYSTEMS, INC.
JAFFREY, N.H. 03452 PHONE (603) 532-7972

PROJECT: SERIES IV COLLECTOR ASSEMBLY

General Details

A. Collector Series IV
B. End Cap Details
C. Assembly Details
D. Manifolding Details
E. Cover Assembly

NOTE: DETAILS DEPICTED ON THIS PAGE ARE PATENTED OR IN A PATENT PENDING STATE.

CSI 110-001

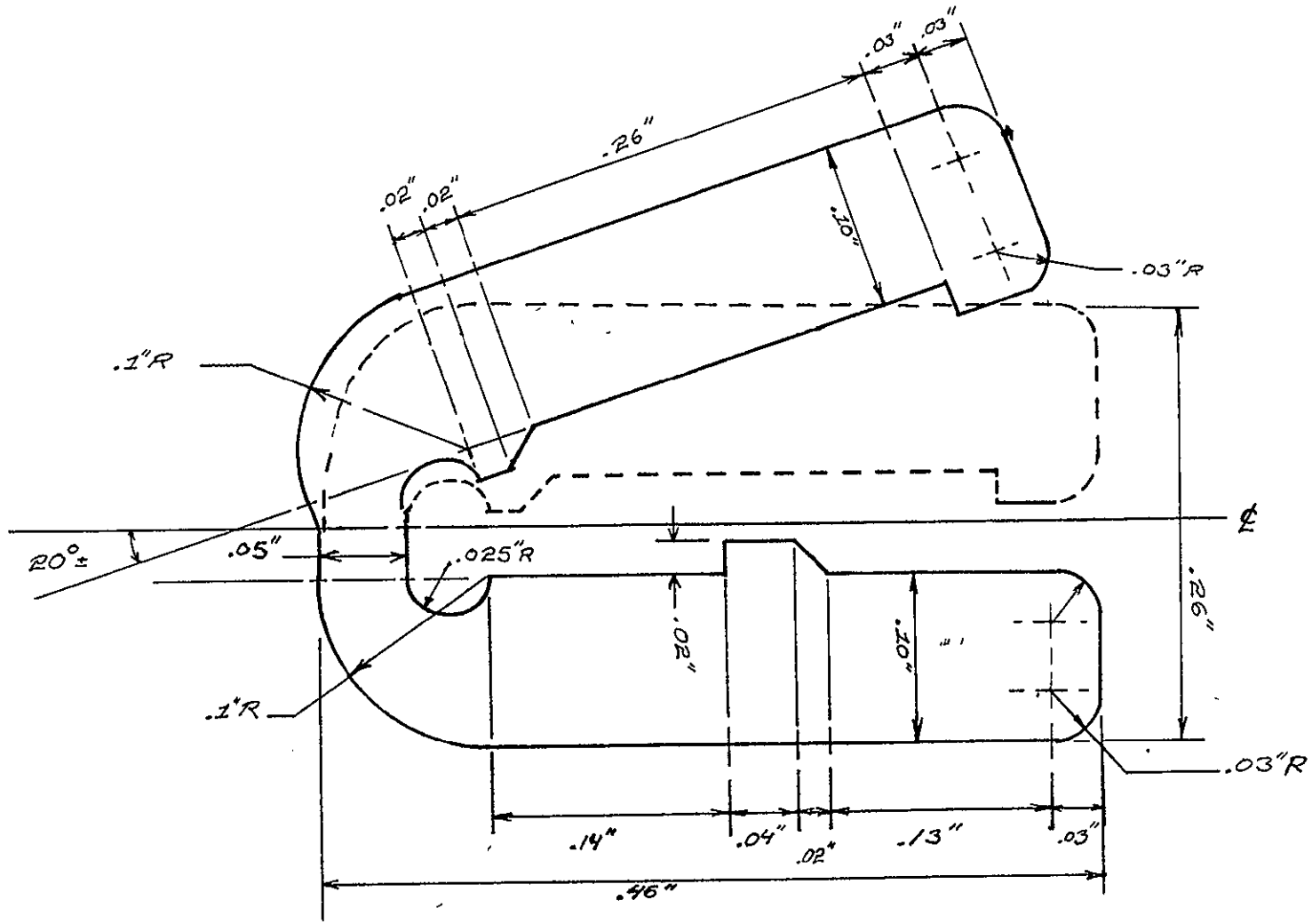
CONTEMPORARY SYSTEMS, INC.
68 CHARLONNE ST
JAFFREY, NH 03452 PHONE 603-532-7972

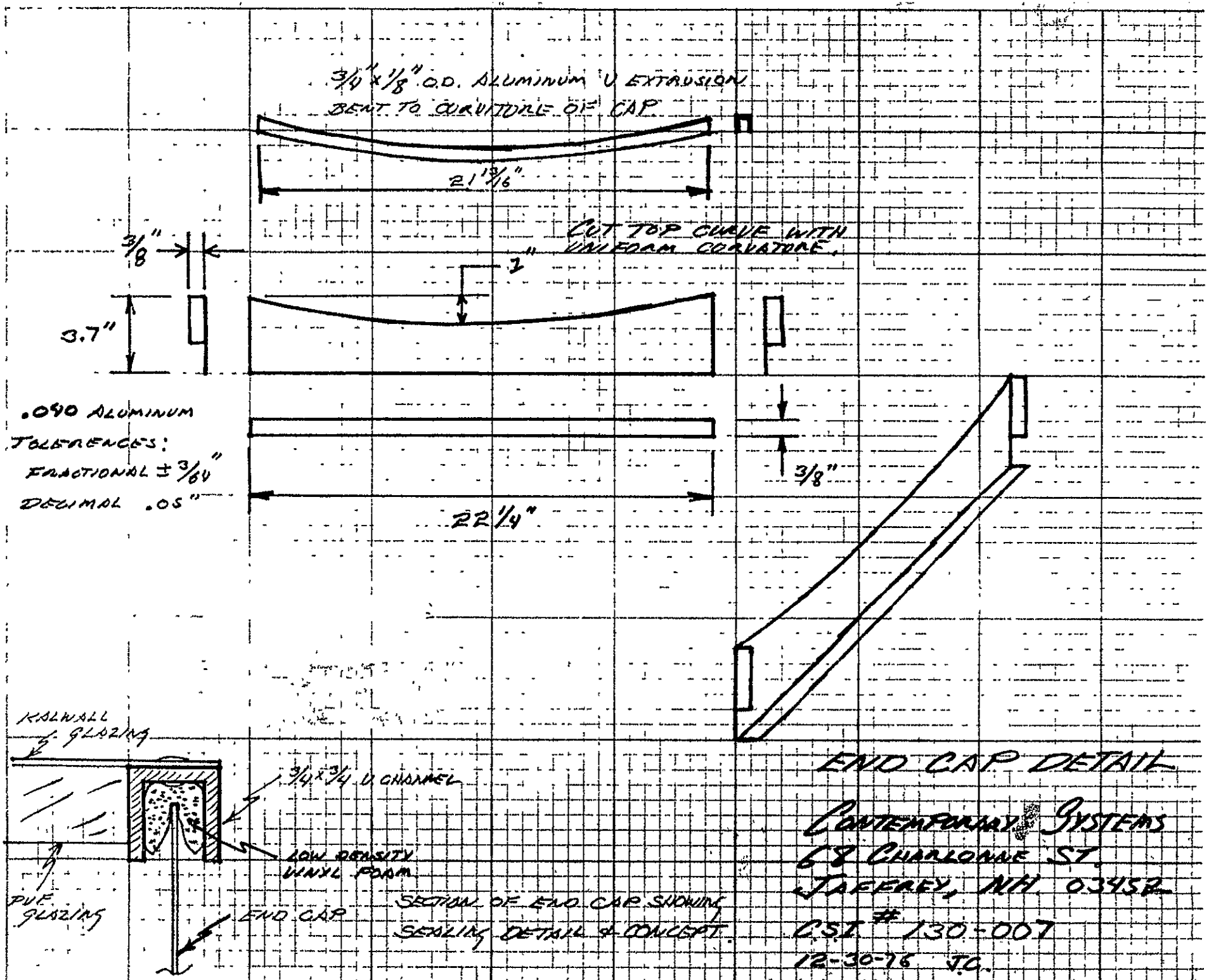
TITLE: GLAZING PANEL SIDE CLIP
SERIES II COLLECTOR

BY: J. CHRISTOPHER
11-29-76

DRW. NO. 120-004 11-29-76 JC

SCALE 1" = .1"





END CAP DETAIL

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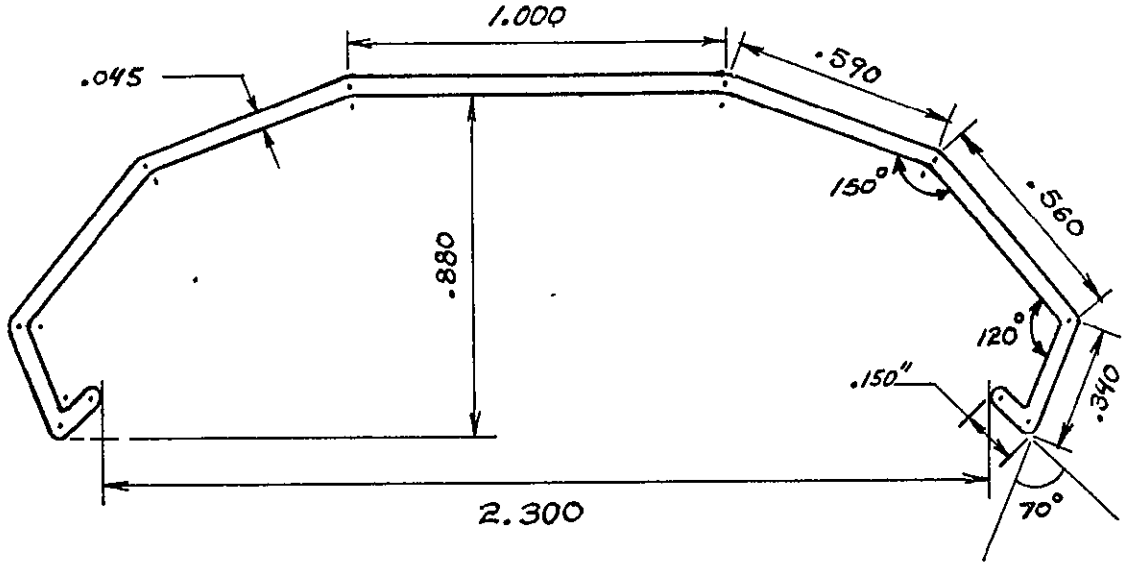
CSI # 130-007
12-30-76 T.C.

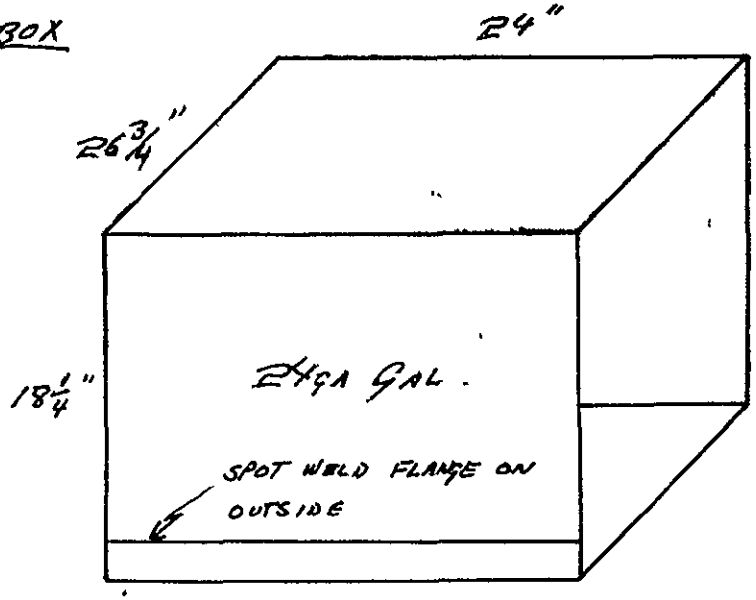


18

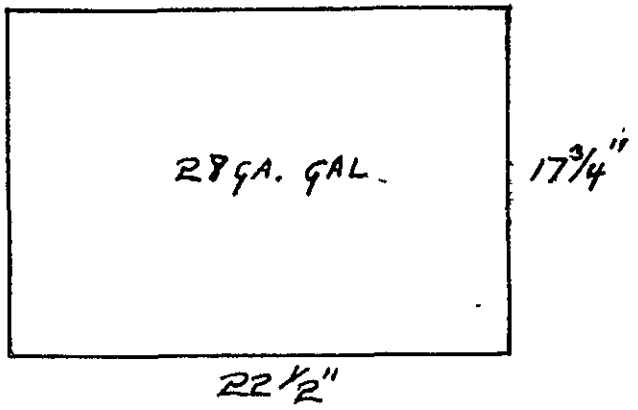
CONTEMPORARY SYSTEMS
68 CHARLONNE ST.
JAFFREY, NH 03452

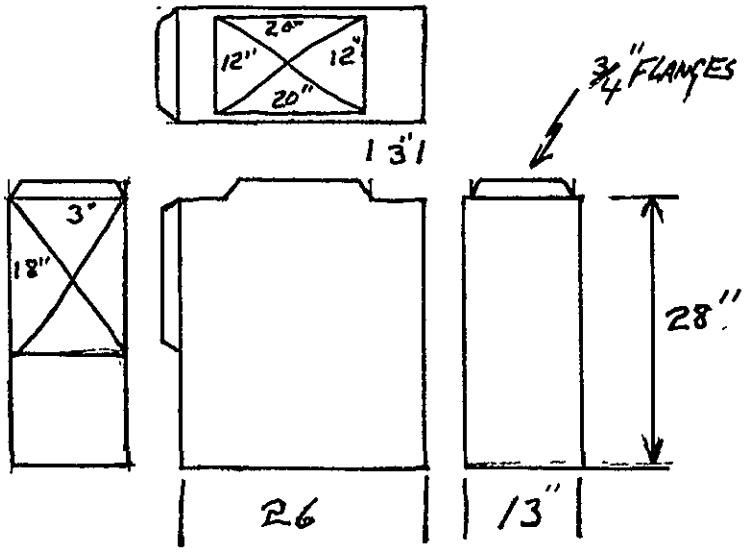
TITLE: BATTEN CAP
SCALE 2":1" 12-9-76 J.C
4.28"x.045 = .19 IN²/IN = .02 LBS/IN = .23 LBS/
ALLOY: 6063-T5
#150-004

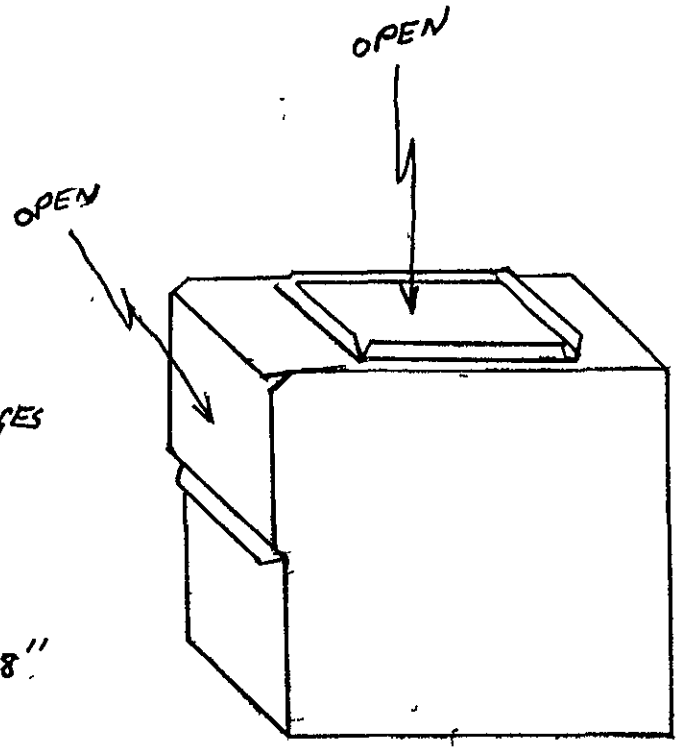
VALVE BOX



DAMPER BLADES







CHASSIS

CONTEMPORARY SYSTEMS
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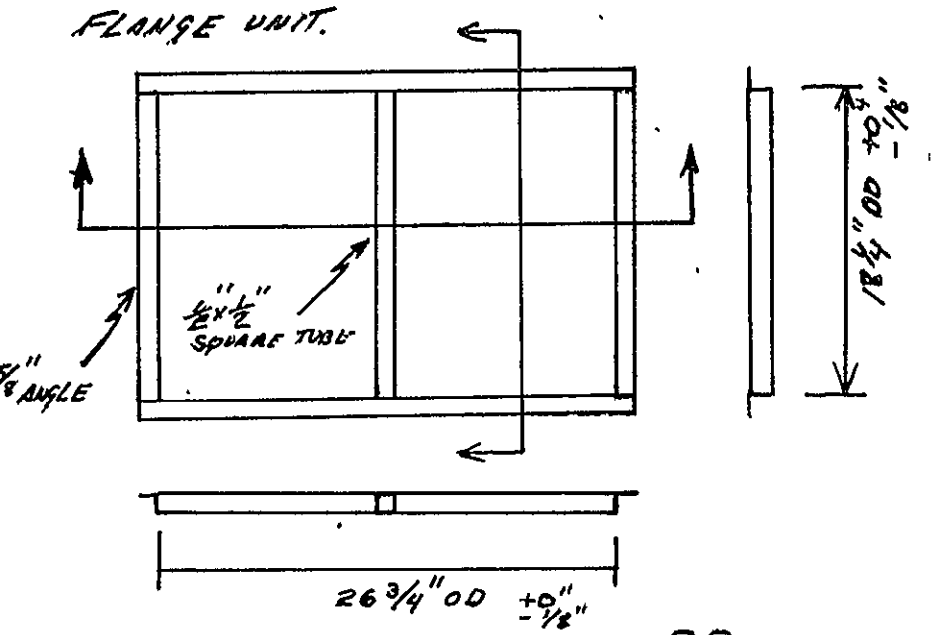
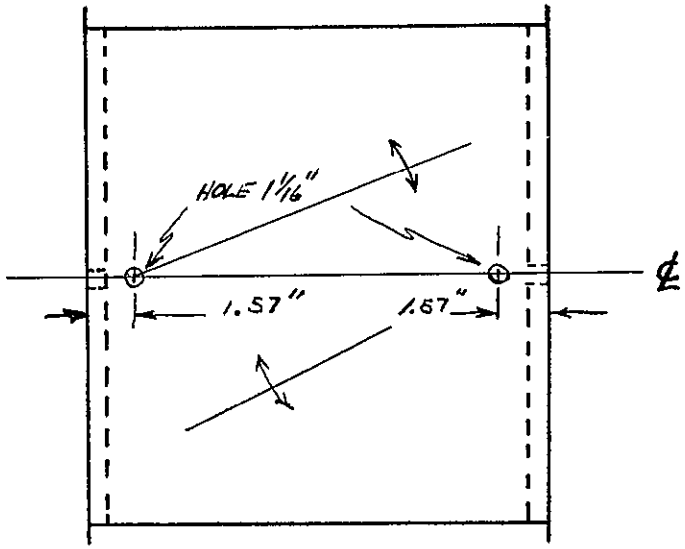
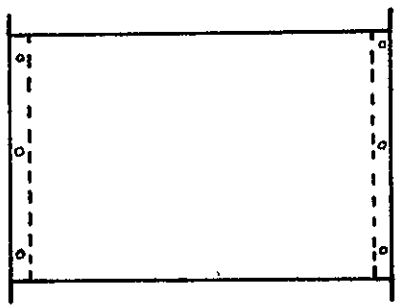
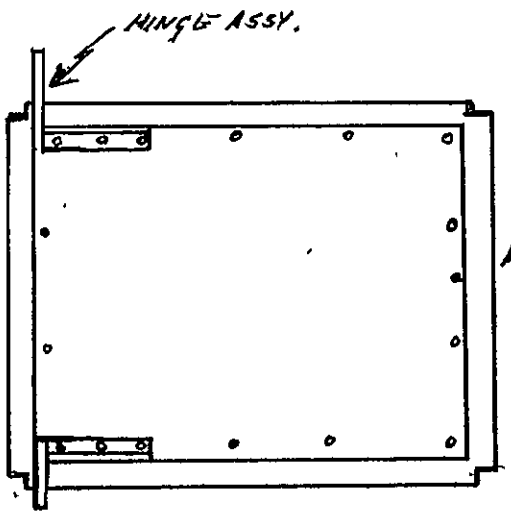
(603) 532-7972
SHEET METAL DRAWINGS U.S.U.
CSI # 200-008
JC 1-10-77





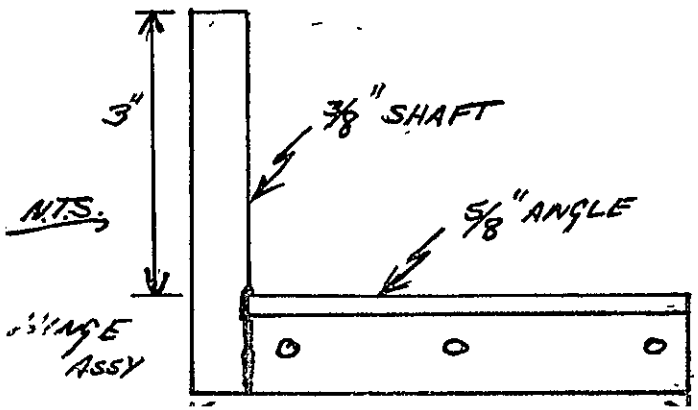


VALVE BOX W/ FLANGE UNITS RIVETED IN ENDS.



NOTE: PREDRILL HOLES USED TO RIVET HINGE ASSY TO DAMPER TO ASSURE ACCURATE POSITION.

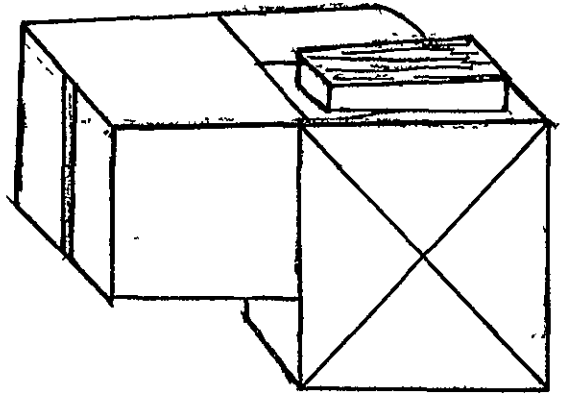
DAMPER ASSY.
GALVANIZED PCS. LAMINATED OVER 2 LAYERS .004" PVF FILM ALLOW 1" PVF FLAP ON ALL EDGES.

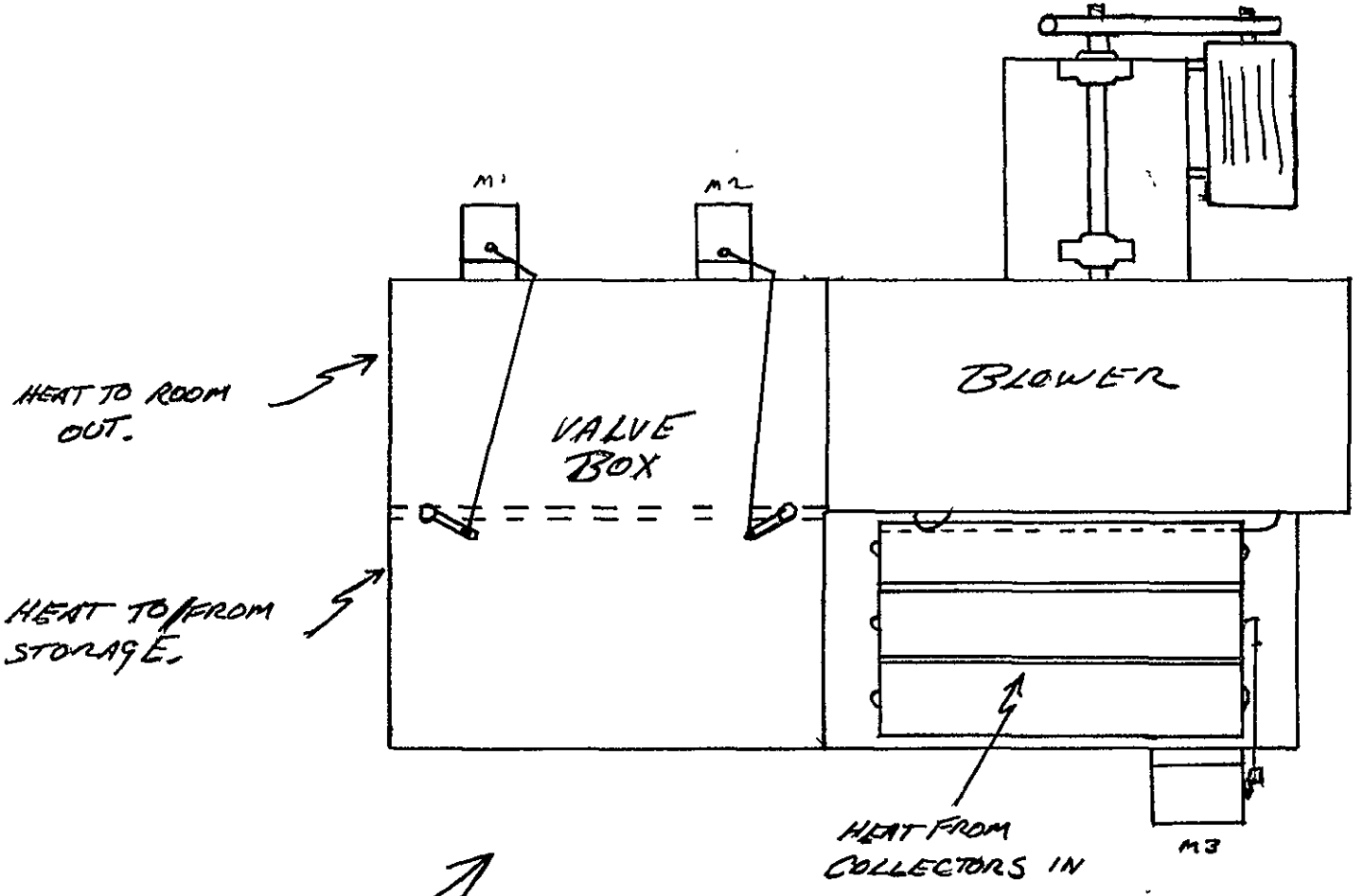


U.S.U.A. ASSY. DRAWING

CONTEMPORARY SYSTEMS
JAFFREY, N.H. 03452
(603) 532-7972

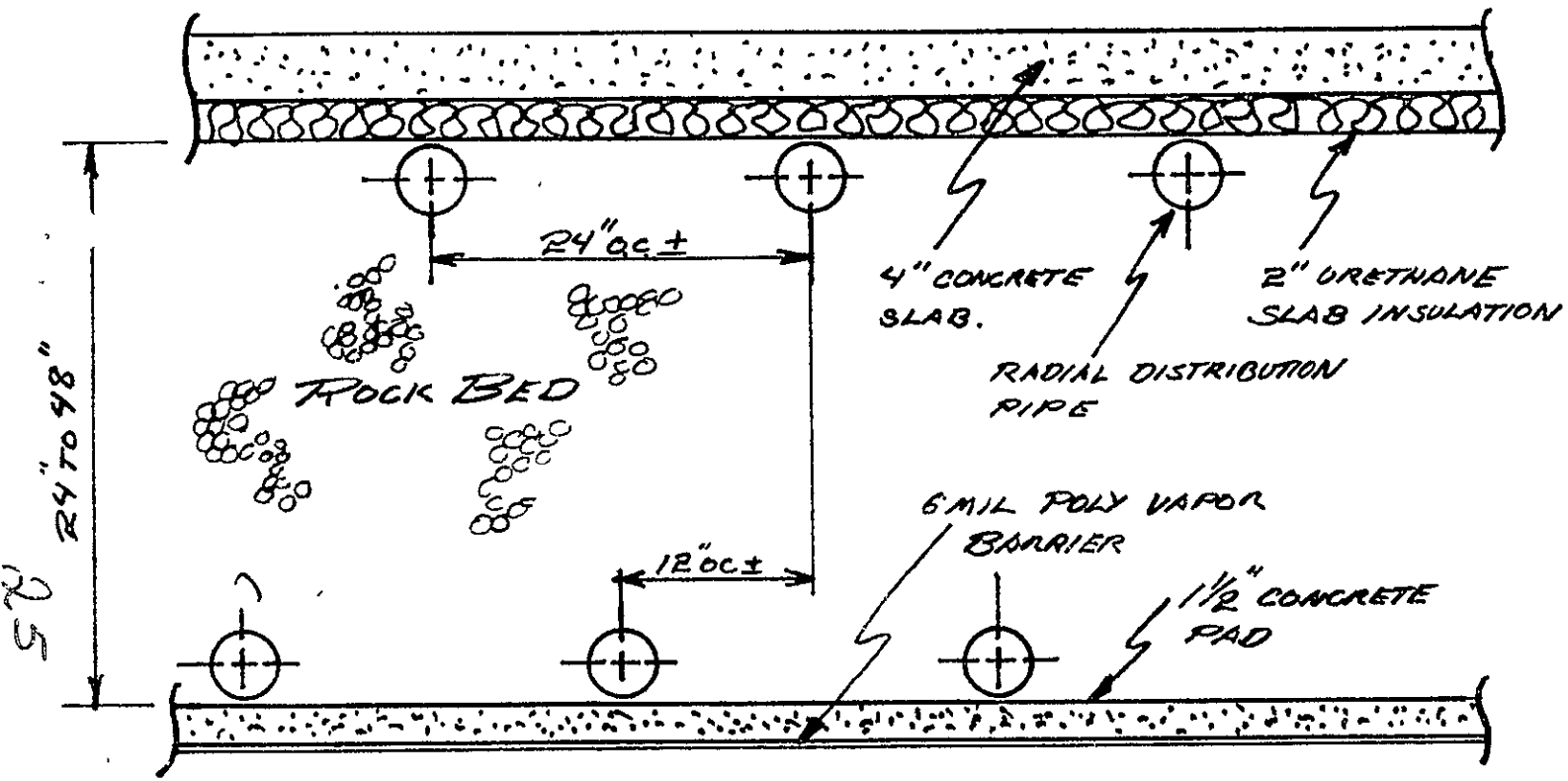
QSI # 200-009
1-11-77 JC



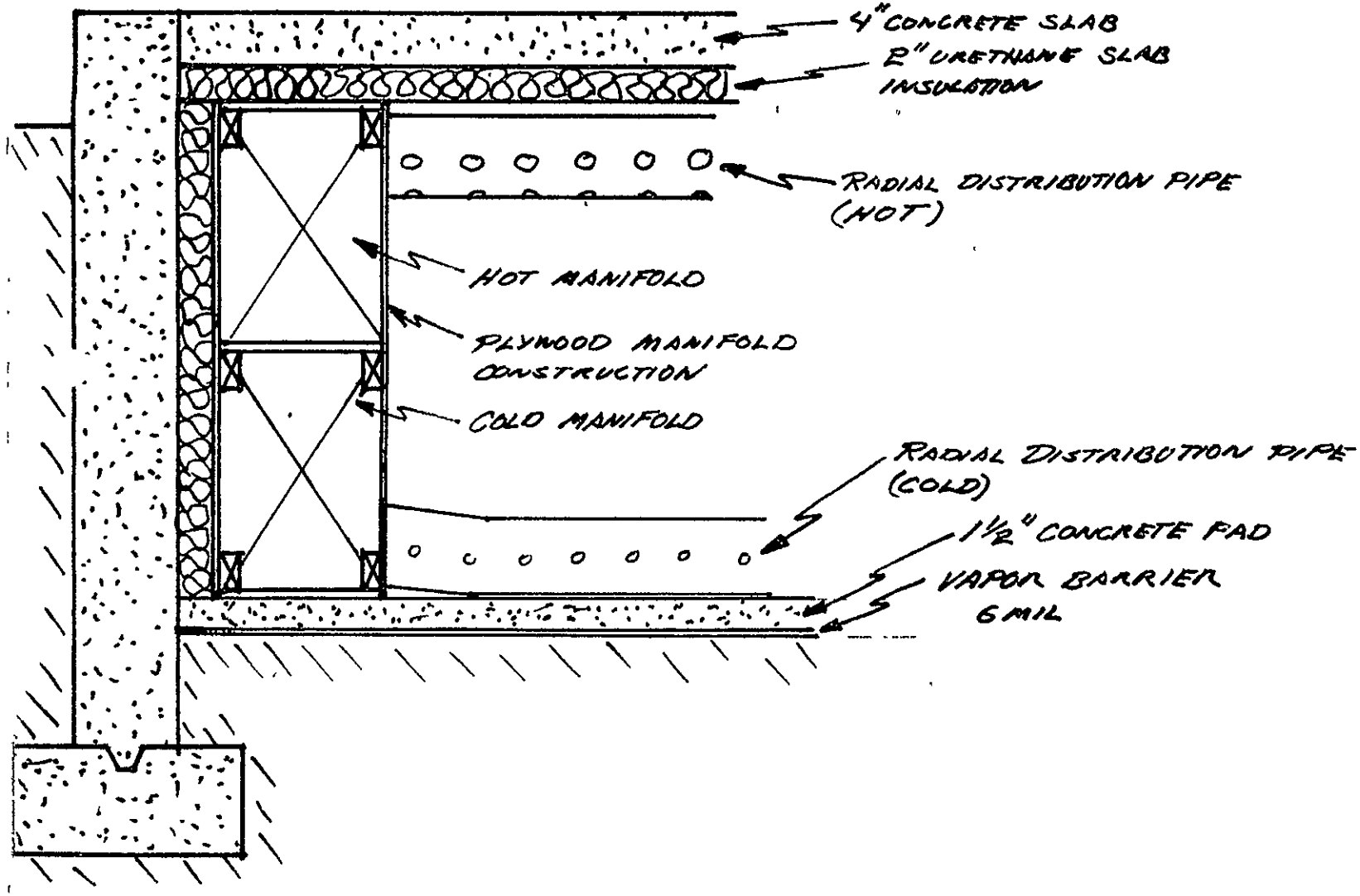


TOP VIEW USU-A

Contemporary Systems
USU-A
1/77 J.C.
200-010

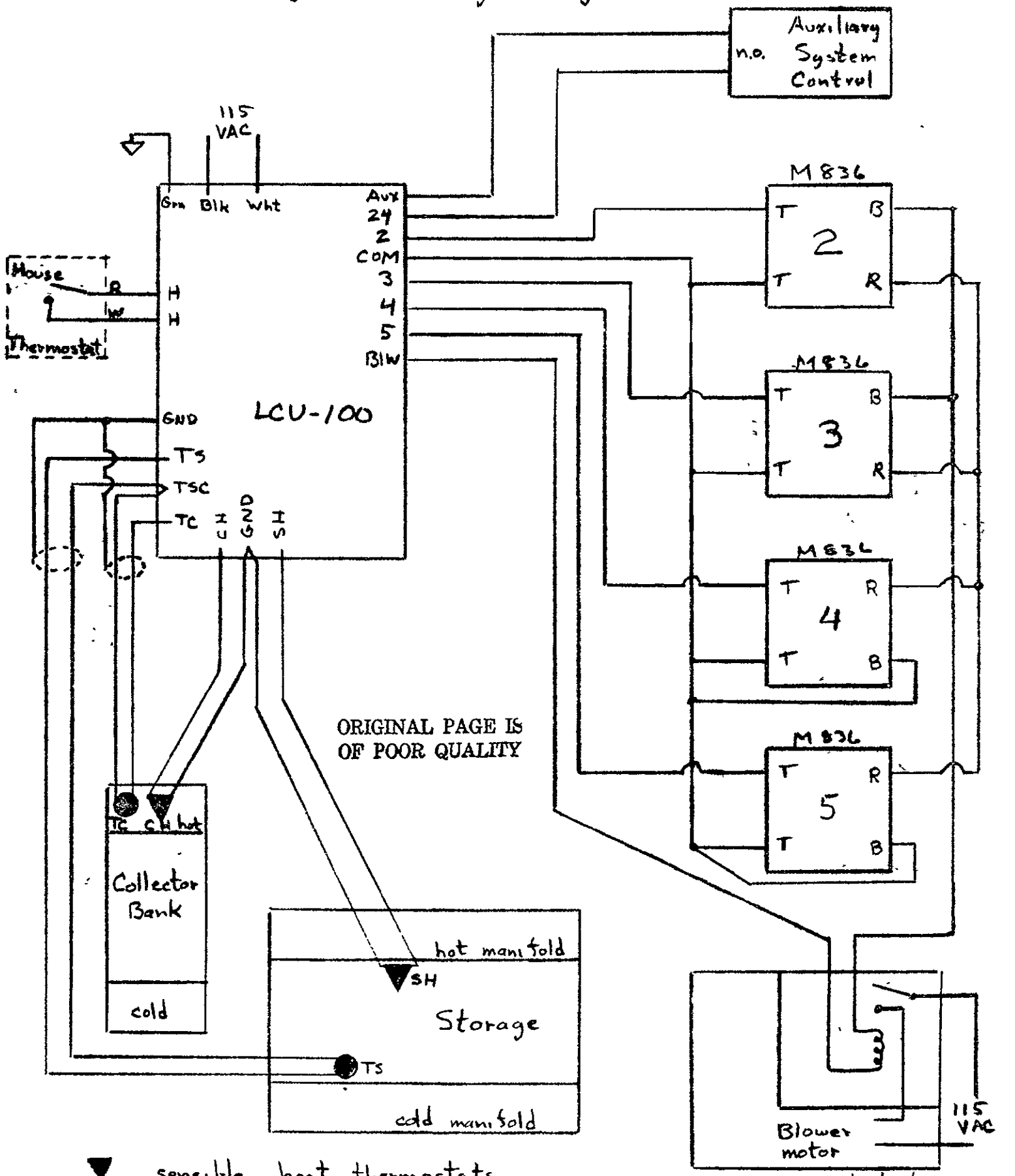


CONTEMPORARY SYSTEMS, INC
68 CHARLONNE ST. JAFFREY, N.H.
THERMAL STORAGE
SECTIONAL VIEW ROCK BED
12-22-76 J.C.
DRAWING # 310-004



CONTEMPORARY SYSTEMS, INC
JAFFREY, NEW HAMPSHIRE
THERMAL STORAGE
SECTIONAL VIEW & MANIFOLDING
12-22-76 JC
DRAWING # 310-005

Series IV System Wiring Diagram



Revised 11/24/76 EL

Contemporary Systems Inc.		
11/1/76	EL	400-012

CONTEMPORARY SYSTEMS, INC.
68 CHARLONNE STREET JAFFREY, N. H. 03452 603-532-7972

Logic Control Unit

The LCU-100 logic control unit, utilizing low-power CMOS integrated circuits optically isolated from the outputs, monitors various system parameters and determines the correct operating mode. It is preprogrammed for each installation to control dampers and blowers for each flow path in the five operating modes. There is a three position manual function switch.

The LCU-100 monitors the house thermostat demand, storage temperature, collector temperature, and collector/storage differential and determines the operating mode according to the following priority:

	Priority
HC - heating from collectors	1
HS - heating from storage	2
AUX - heating from auxiliary system	3
S - storing collected heat	4
STBY - standby	5

INPUTS	OPERATING MODE				
	HC	HS	AUX	S	STBY
H - house thermostat demand	1	1	1	0	0
T_{sh} - storage temperature above sensible heat level	X	1	0	X	X
T_{ch} - collector temperature above sensible heat level	1	0	0	X	X
D - positive collector/storage differential	X	X	X	1	0

The correct damper and blower combinations for each operating mode flow path are determined by the preprogrammed diode matrix. A blower interlock circuit keeps air from circulating during damper changes (refer to system wiring diagram).

The LCU-100 has a three position function switch:

OFF/AUX — the system is set up in AUX mode with control of the auxiliary heater and blower through the house thermostat

ON/AUTO — the solar and auxiliary systems are under the automatic control of the LCU-100

DE-ICE — a short time period, manual option to circulate stored heat through the collectors for the rare occasions when a severe ice storm glazes the collectors

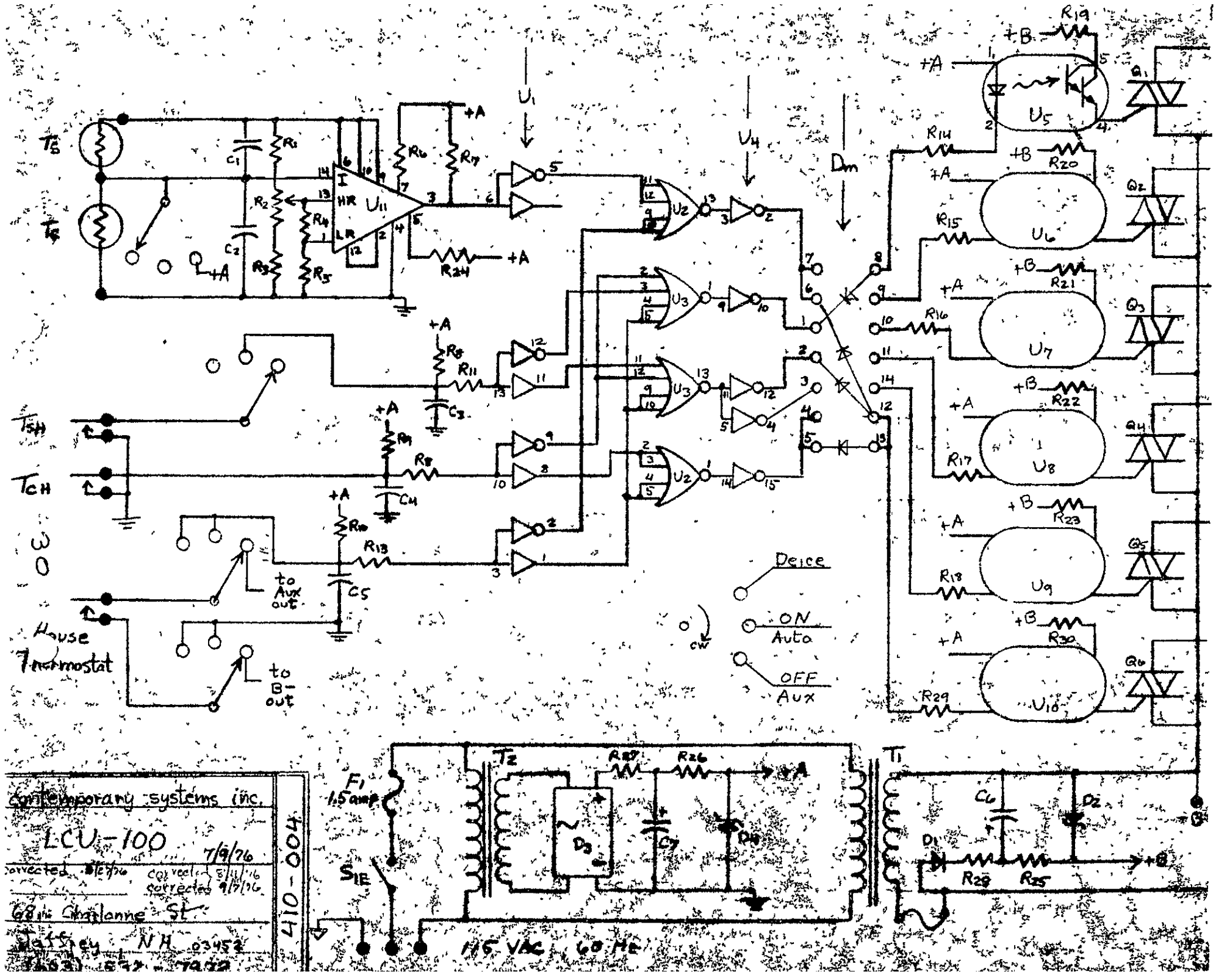
LCU-100 : Input/Output : Specifications

Collector/Storage Differential Inputs (T_s, T_c)
- use only CSI probes and shielded 2-conductor cable ($0 \leq T_{in} \leq +7$), ($7K \leq R_{thermistor} \leq 10K$)

Thermostat Inputs (SH, CH, H)
- use conventional thermostats and wiring; contacts closing on temperature rise; electrically isolated from ducting, line voltage, etc. ($0 \leq V_H \leq +10$) (input time constant, RC = 2.2 msec)

Triac Outputs (Aux, 2, 3, 4, 5, Blw)
- max current 2.5 A per output with total for the six outputs ≤ 4 A fused

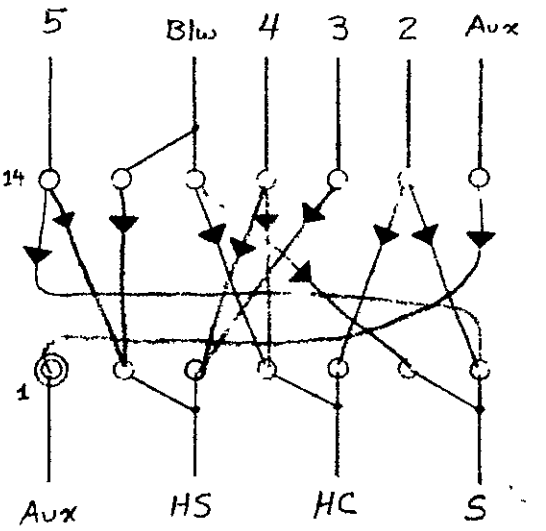
Power - 115 VAC ±10%, 60 Hz, 1.5 A fused



contemporary systems inc.	
LCU-100	7/9/76
corrected 8/6/76	corrected 8/11/76 corrected 9/17/76
68 Clotilde St	
Nashua NH 03062	
(603) 882-7972	

410-004

Diode Matrix, USSI



Triac gate 'ckts'

System modes

Contemporary Systems Inc
Diode matrix - USSI
8/25/76 Redrawn 12/76 EL
410 - 005

Parts List 7/76 CSI 420-0011

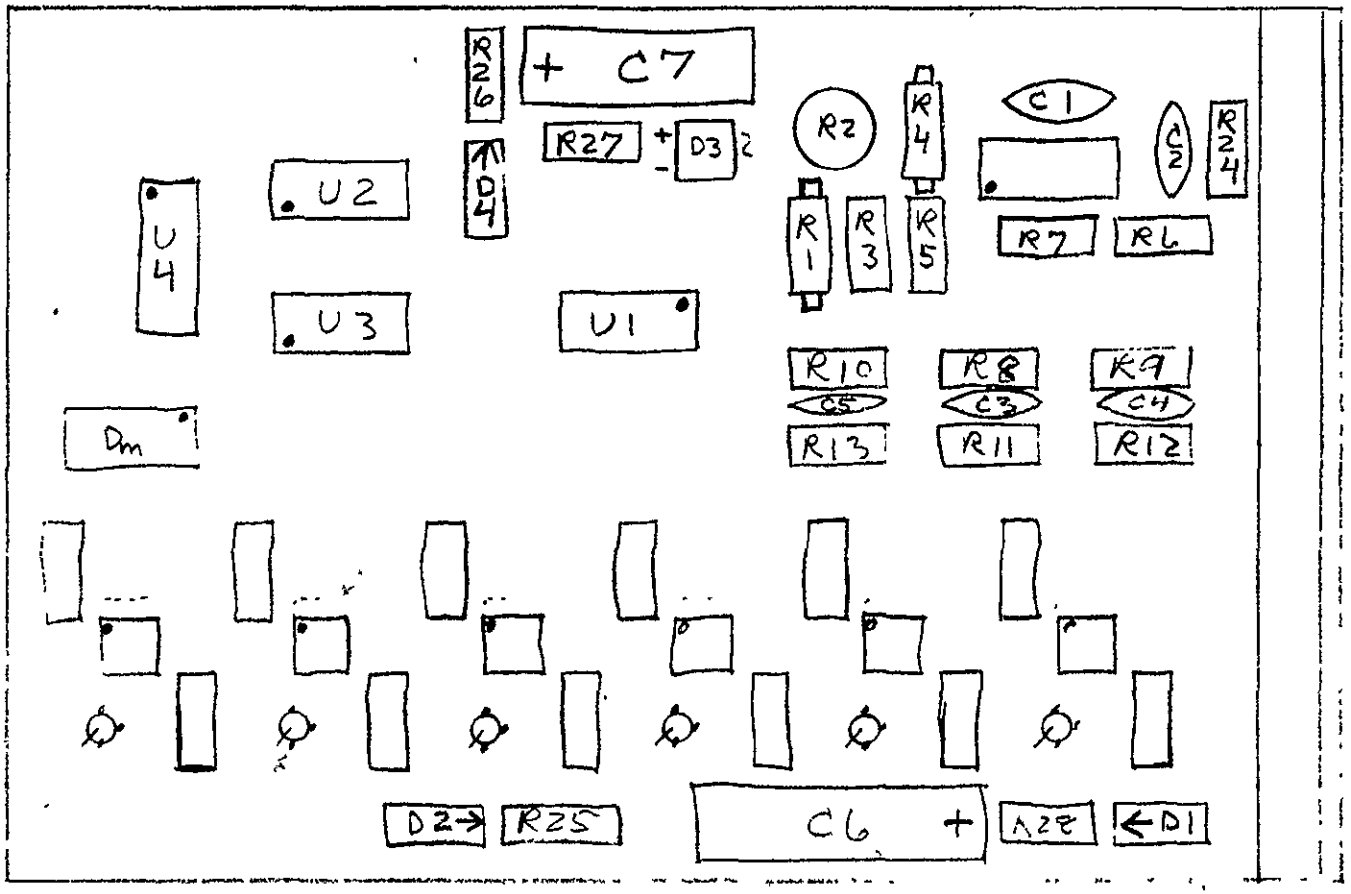
part	qty.	description	such as
R_1	1	~~10K~~ ~~10%~~ 1/4 W	RCR07G 103 KS (Allen Bradley)
R_2	1	1K potentiometer	TRW 550 -1K
$R_{3,7}$	2	10K 10% 1/4 W	RCR07G 103 KS (AB)
$R_{4,24}$	2	1K 10% 1/4 W	RCR07G 102 KS
R_5	1	18K 10% 1/4 W	RCR07G 183 KS
R_6	1	100K 10% 1/4 W	RCR07G 104 KS
$R_{8,9,10}$	3	220K 10% 1/4 W	RCR07G 224 KS
$R_{11,12,13}$	3	8.2K 10% 1/4 W	RCR07G 822 KS
$R_{14-18+1}$	5/6	3.3K 10% 1/4 W	RCR07G 332 KS
$R_{19-23+1}$	5/6	2.2K 10% 1/4 W	RCR07G 222 KS
R_{25}	1	600Ω 10% 3W	Axiohm 3X 600Ω
R_{26}	1	150Ω 10% 1/2W	RCR20G 151 KS
$R_{27,28}$	2	10Ω 10% 1/2W	RCR20G 100 KS
C_{1-5}	5	.01 μF ceramic	ARCO CC0-103
C_6	1	100 μF 50V	Sprague TVA-1310
C_7	1	100 μF 25V	TVA-1207
D_m	8/9	(matrix diodes) IN4154	GE
D_1	1	IN5391 (rect)	M
D_2	1	IN4739 10% (9.1 V Zener)	M
D_3	1	1 amp 50 volt FW bridge	MDA 920A-2
D_4	1	IN4742 10% (12 V Zener)	M

CSI 420-001

part	qty	description	such as
Q_{1-5+1}	5/6	50 V 2.5 amp 3mA Triac	RCA T 2300 A
U_1	1	CD 4041 AE CD 4002 AE	RCA
$U_{2,3}$	2	~~CD 4012 AE~~ CD 4049 AE	RCA
U_4	1	~~CD 4050 AE~~	RCA
~~U_{5-9+1}~~	~~5/6~~	~~25 V, 15 mA, 100% opto-isolator~~	~~MOC 1200~~
U_{5-9+1}	5/6	30 V, 100%	4N 37
U_{11}	1	CA 3099 E	RCA
~~T_1~~	~~1~~	24 V 96 VA	Stancor P-8663
~~T_2~~	~~1~~	12 V	Triad F-113X
~~F_1~~	~~1~~	~~1 amp~~	~~Littlefuse 312001~~
~~F_2~~	~~1~~	~~4 amp~~	312004
~~S_1~~	~~1~~	~~DPDT on-none-on~~	C&K 7201 ~~Raytheon 20SN~~
	5	14 DIP socket	Augat 314-AG37D
	1	16 DIP socket	Augat 316-AG37D
	5/6	6 DIP socket	Augat 308-AG37D
	1	14 DIP component carrier	Cambion 702-3725-01-03-00
	1	22 pin edge connector	Amphenol 143-022-03
	2	pc 10-term block	Cinch 10-176-2
	1	main pc. board	CSI LCU-100
	1	term pc board	CSI LCU-100

CSI 420-001

part	qty	description	such as
	1	chassis 5"x16x9"	Bud CU-1099 HG BR
T_1	1	24V 96 VA	Stancor P-8663
T_2	1	12V	Triad F-13X
F1	1	1½ amp	Little fuse 312 01.5
	1	fuse holder panel	" 347014A
F2	1	4 amp	" 312004
	2	fuse holder (clip)	" 357001
S1	1	3PDT on-none-on	CTR 7301
			Raytheon 705A1
	3	card guides	Cinch 50-GP-1
	1	3 term block	Cinch 3-140
	3	cable clamps	
S01	1	1 sty 4 pole nonshort rotary	CTS T208
S2	1	Ac SPST for above	CTS GC-21
	1	Knob	Alco PK-70B
	6	Aluminum Hex threaded spacers 6-32	HH Smith 4007 Waldom
	12	Screws 3/16 x 6-32	HH Smith 1375C
	1	chassis 8"x10"x4"	Lee 8104
			Vero T-7084



W
4

$R_{14-18-2}$

U_{5-9+10}

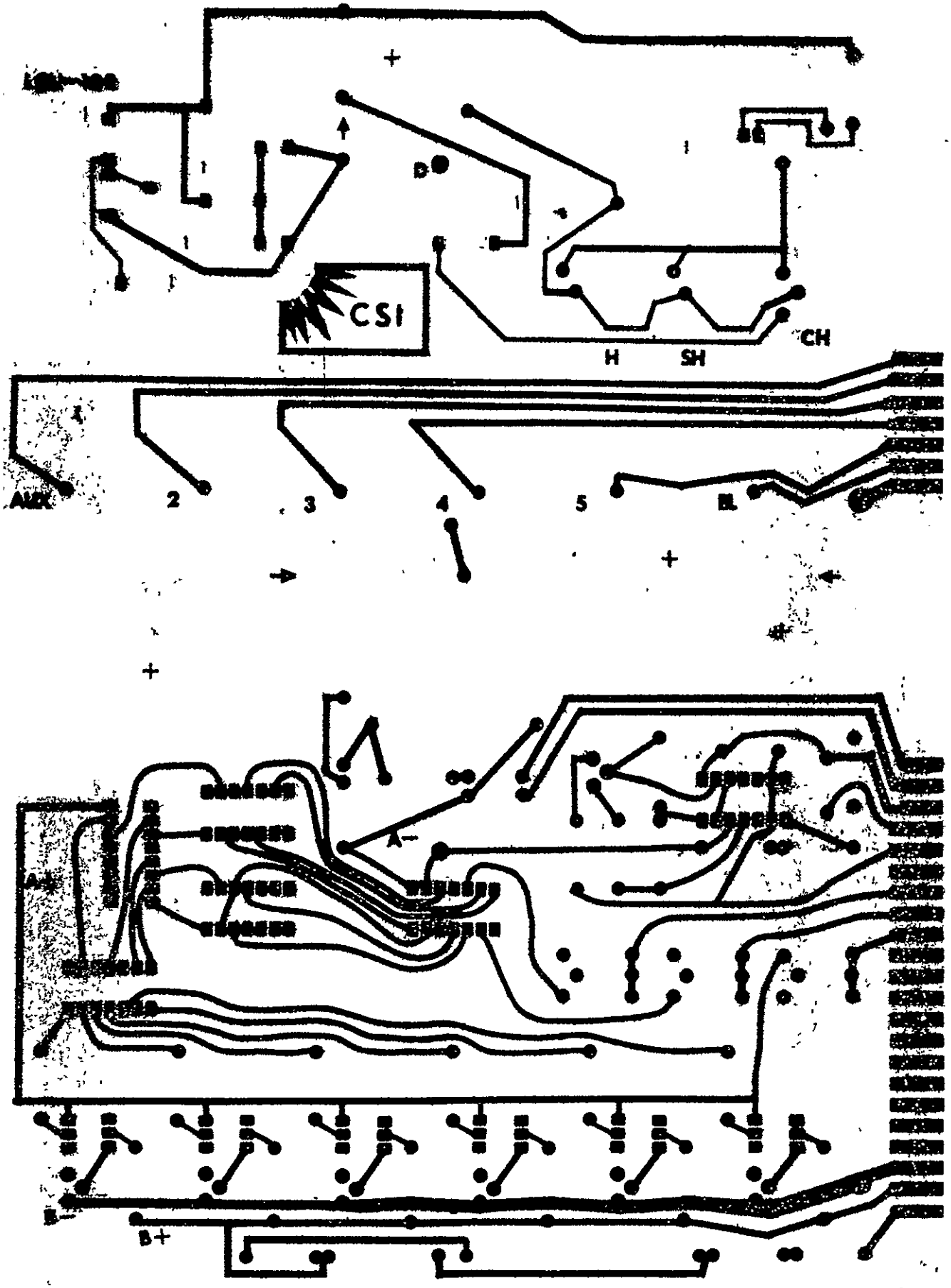
$K_{14-23+20}$

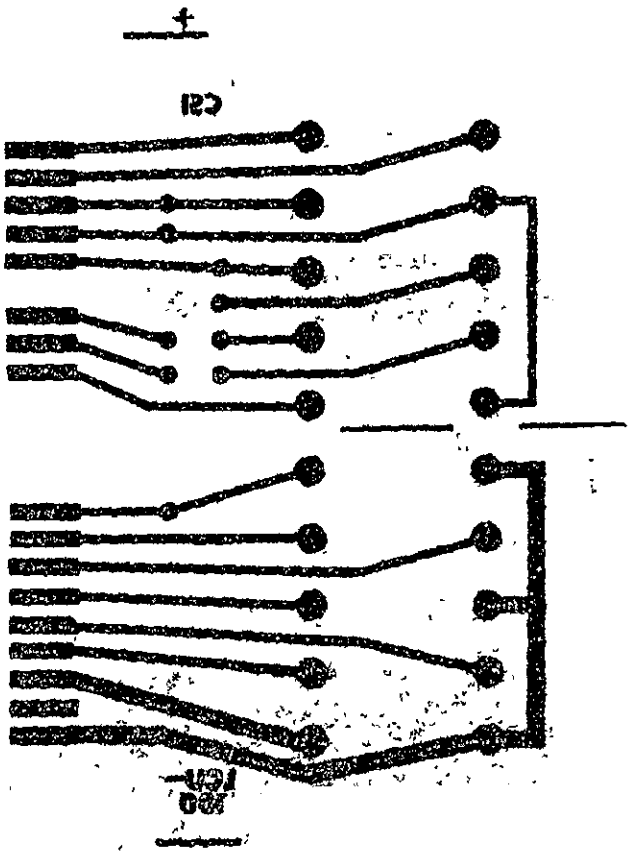
6 5+6

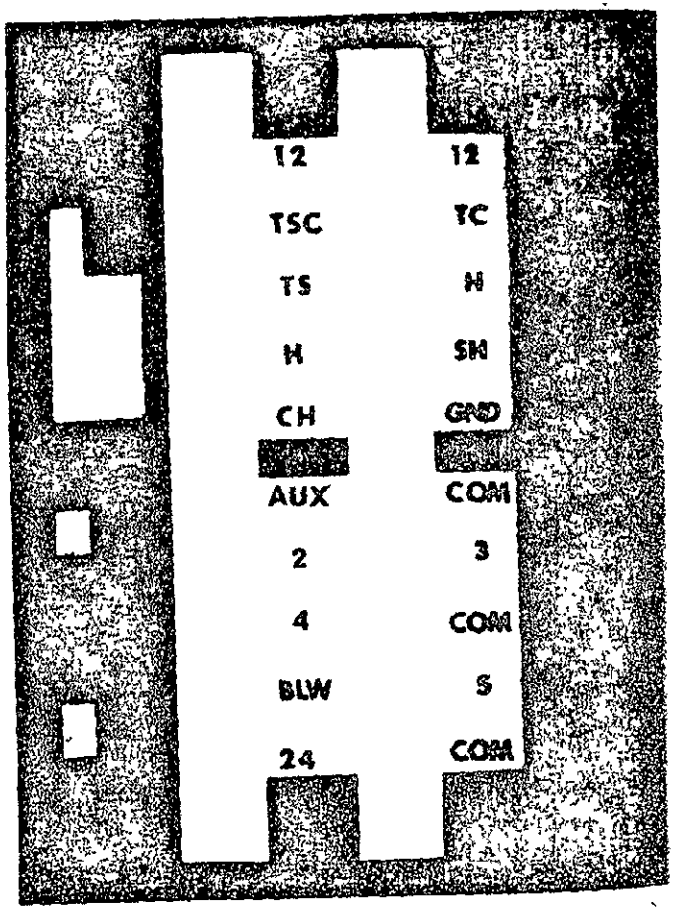
LCU-100

P.C. board layout

5:1 430-001

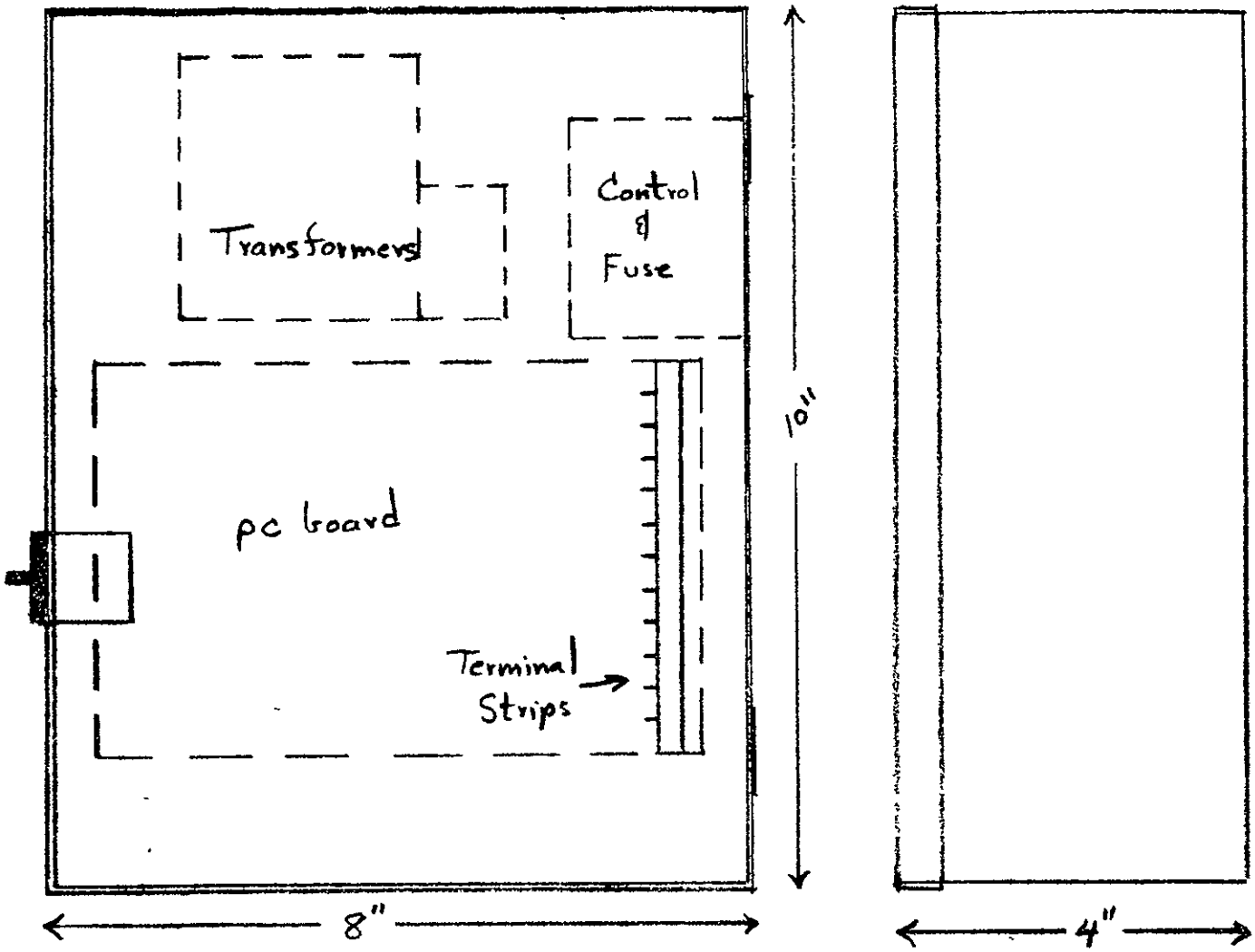


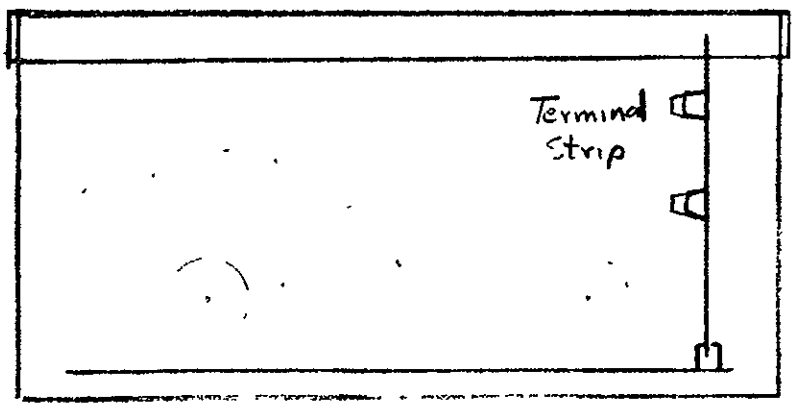




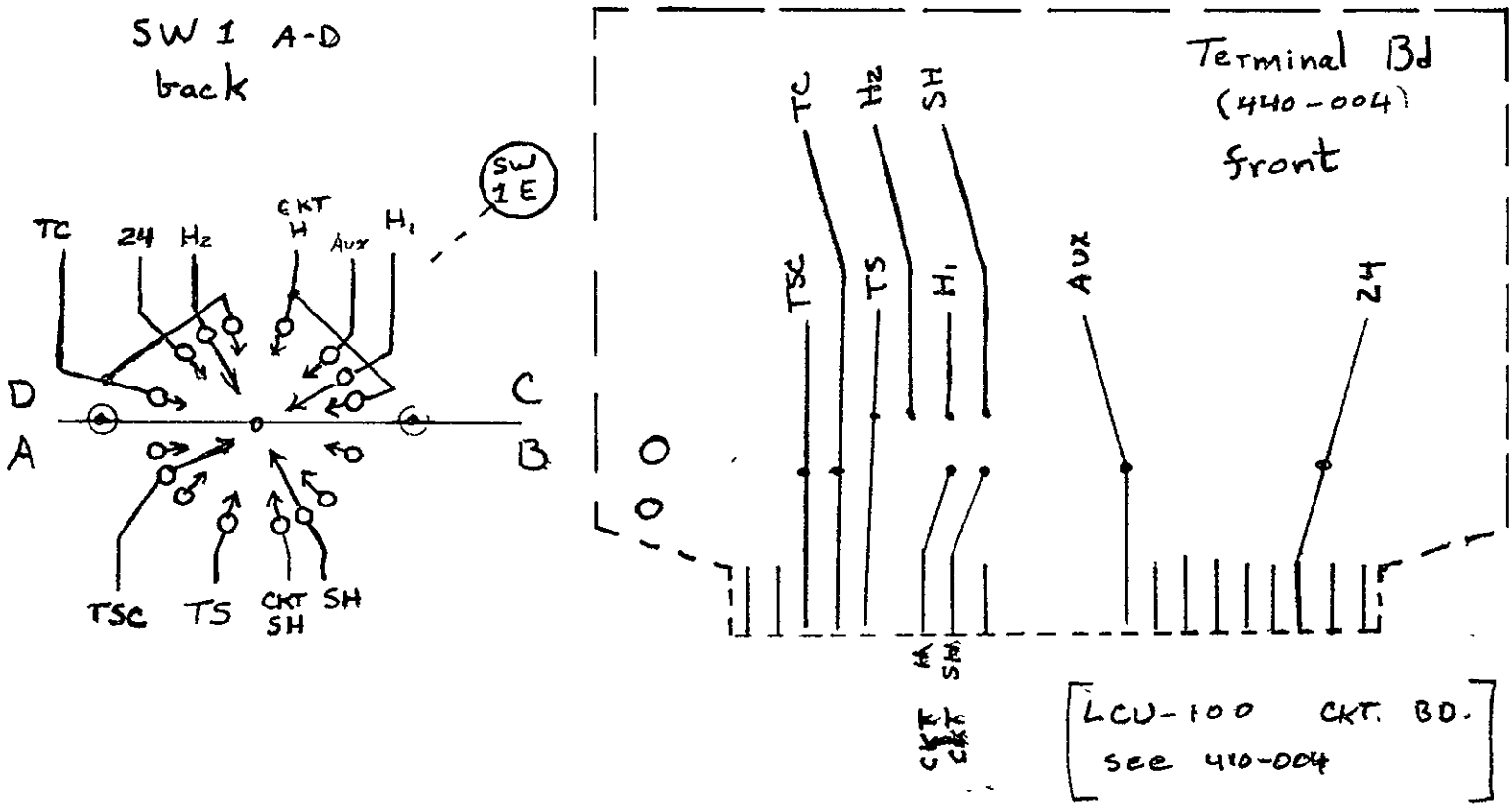
37

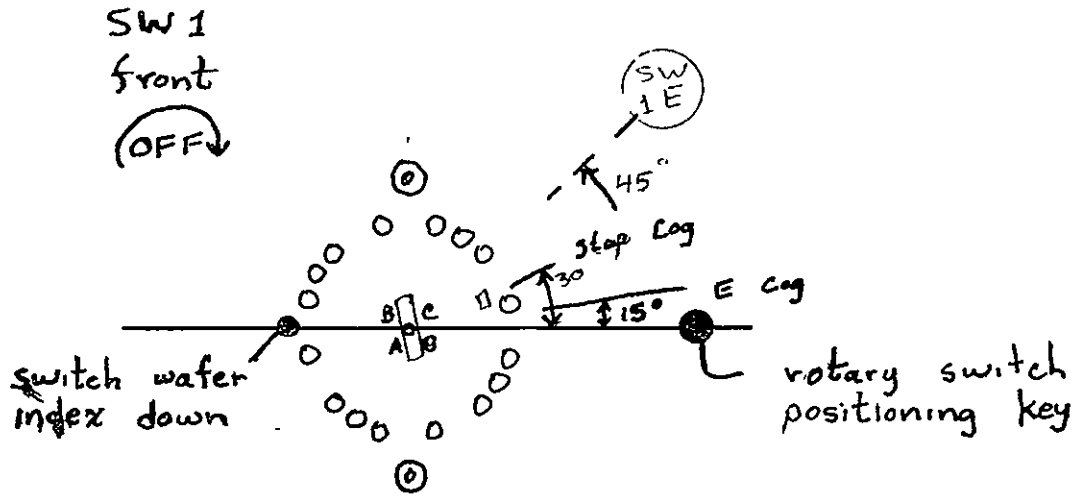
440-004

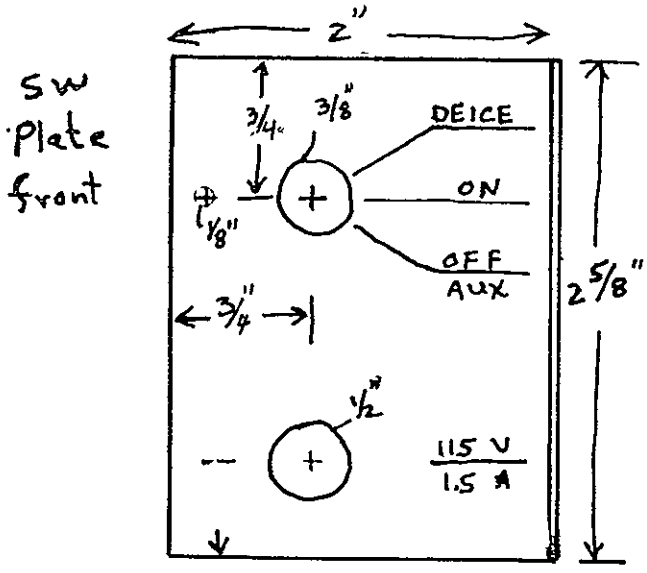




Contemporary Systems Inc.	
LCU-100	
1/2 scale	450-201
11/5/76	EL

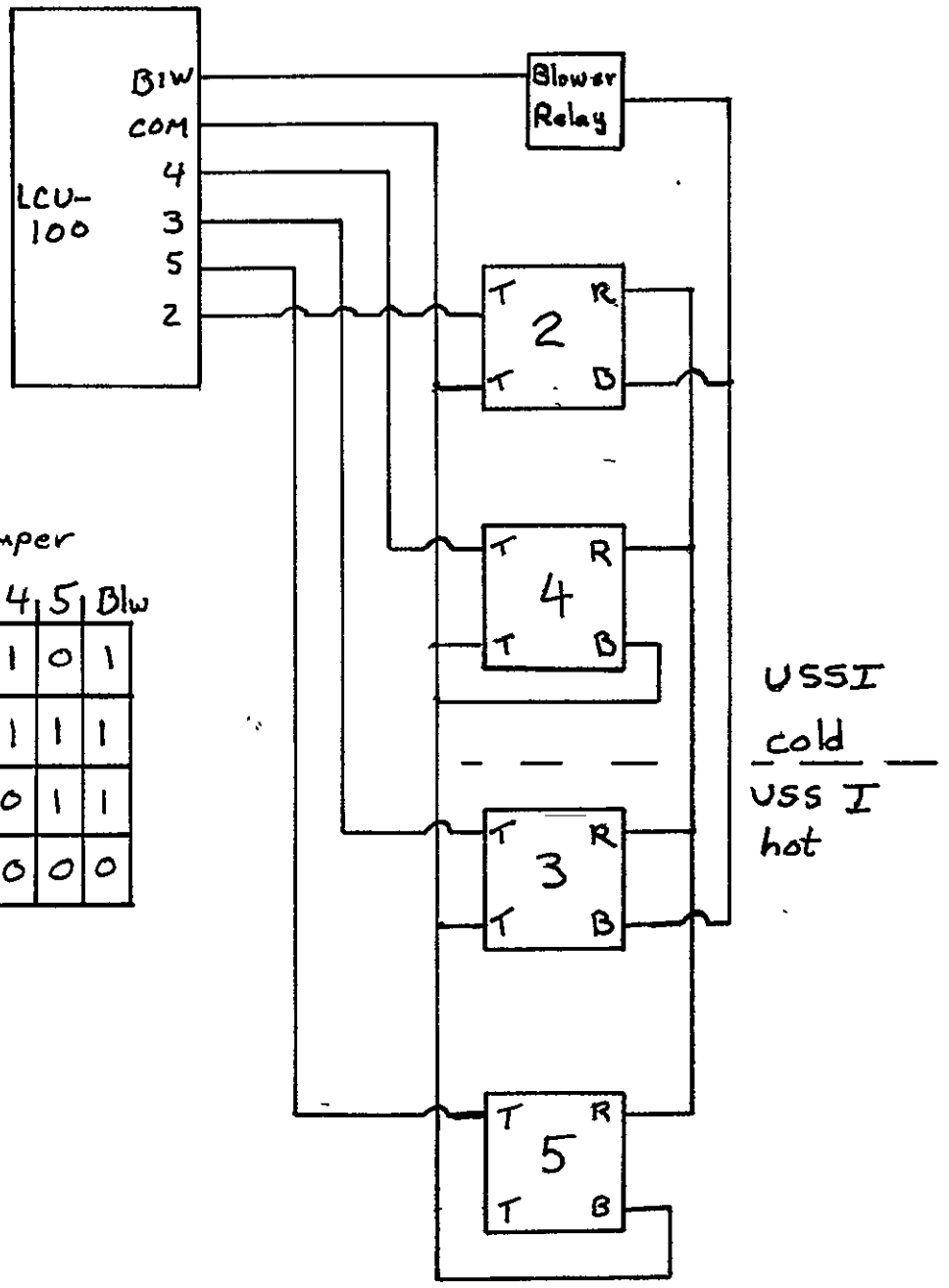






Contemporary Systems Inc	
Function switch - terminal board wiring - LCU-100	
11/23/76 EL	450-002
Rev 12/16/76 EL	

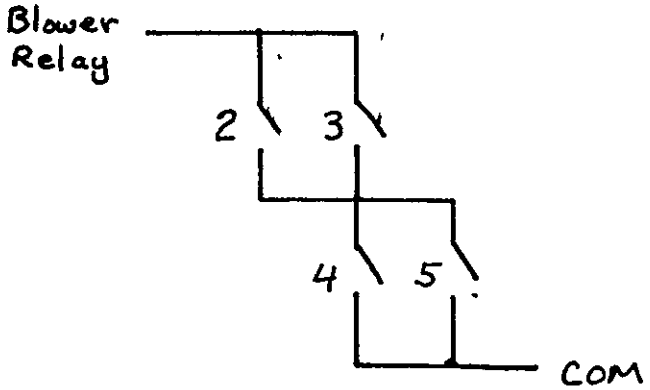
Blower Relay Interlock Wiring



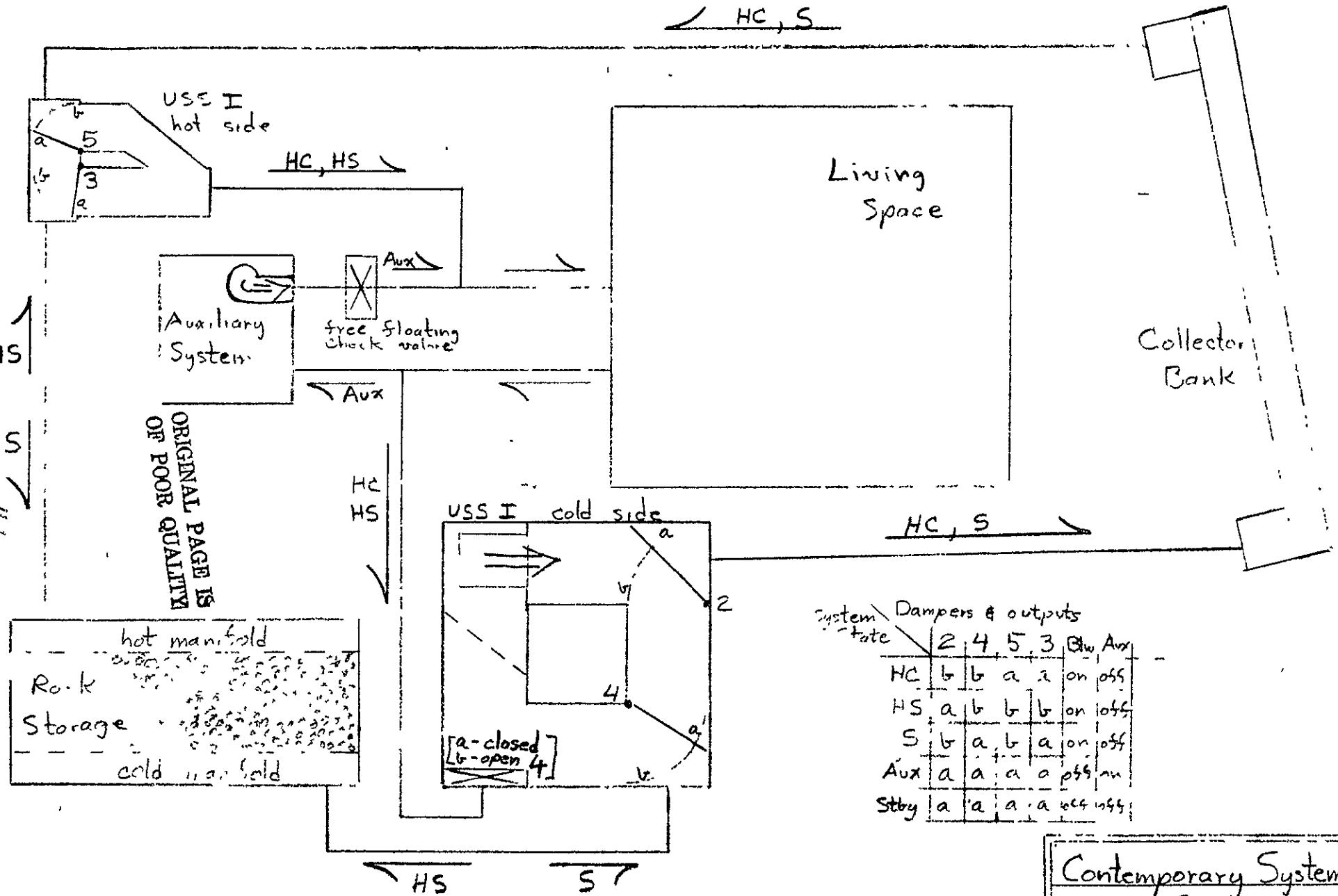
Truth Table

State	Interlock 2·4	2·5	3·4	3·5	Damper 2	3	4	5	Blw
HC	1	0	0	0	1	0	1	0	1
HS	0	0	1	1	0	1	1	1	1
S	0	1	0	0	1	0	0	1	1
Stby	0	0	0	0	0	0	0	0	0

Schematic

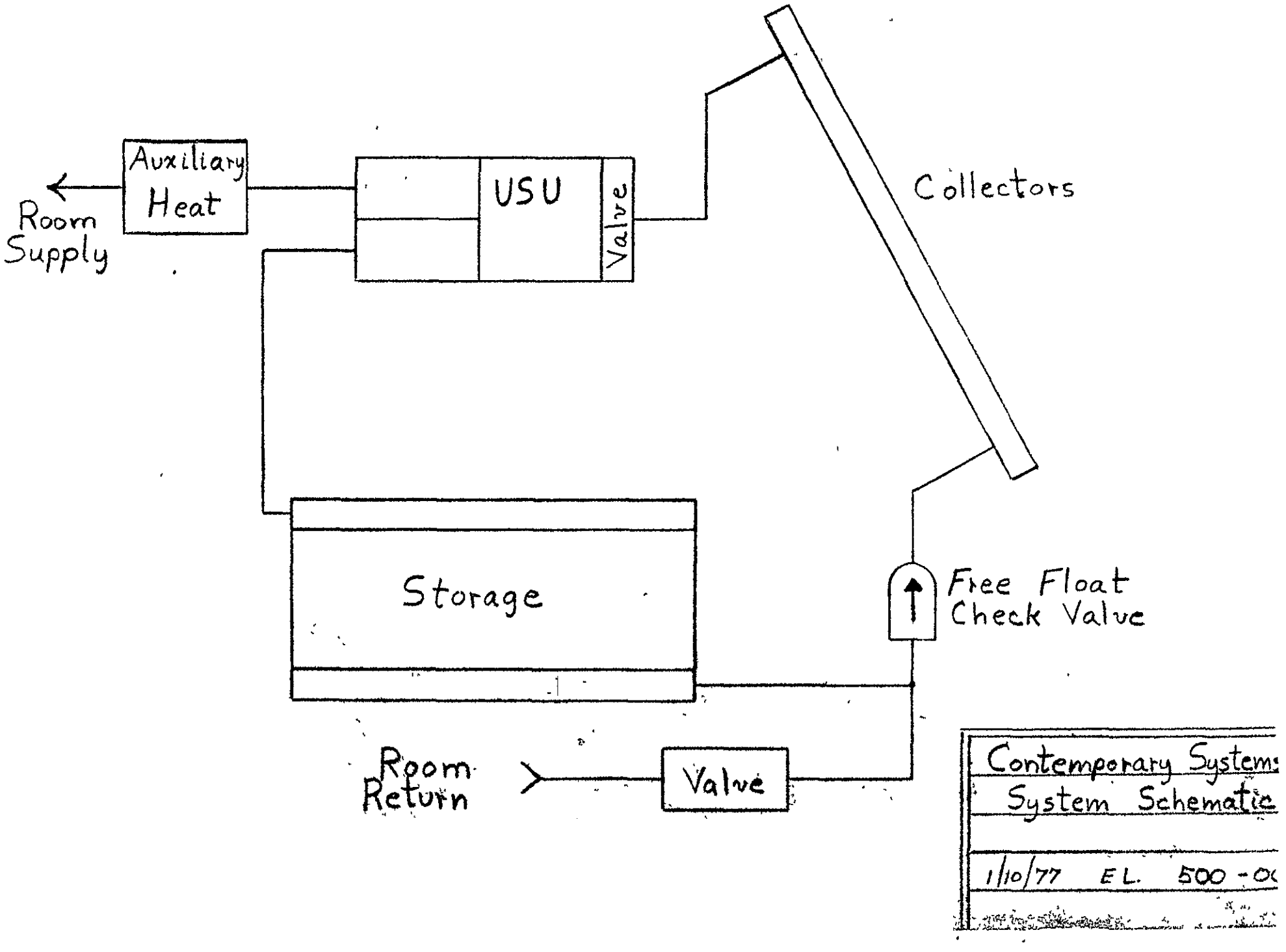


Contemporary Systems Inc.	
Blower Relay Interlock	
	460-002



System state \ Dampers & outputs	2	4	5	3	Blw	Aux
HC	b	b	a	a	on	off
HS	a	b	b	b	on	off
S	b	a	b	a	on	off
Aux	a	a	a	a	off	on
Stby	a	a	a	a	off	off

Contemporary Systems Inc	
USSI System Schematic	
11/76 EL	500-002


Auxiliary Heat
Room Supply
USU
Valve
Collectors
Storage
Free Float Check Valve
Room Return
Valve
Contemporary System:
System Schematic
1/10/77 EL. 500 -0

APPENDIX A

COLLECTOR MATERIAL BROCHURES

KALWALL CORPORATION

1111 CANDIA ROAD
P. O. BOX 237
MANCHESTER, N. H. 03105
TELEPHONE: A/C 603 627-3861

SUN-LITE SOLAR COLLECTOR COVER MATERIAL PROPERTIES

FEATURES:

**Solar Properties as Good as or Better Than Glass
**Superior Impact and Shatter Resistance
**Easy Maintenance and Repair
**Economical (Low Initial and Life Cycle Costs)
**Thermal Expansion Matches Aluminum
**UV and Weather Resistant
**Inert to Chemical Atmosphere
**Large Sheet Size Eliminate Joint
**Easily Cut with Hand Tools
**Light Weight, Yet Rigid

AVERAGE PHYSICAL PROPERTIES	METHOD	UNITS	SUN-LITE REGULAR	SUN-LITE PREMIUM
Solar Energy Transmittance	E 424 Method B	%	85%-90%	85%-90%
Estimated Solar Lifetime(1)		Years	7	20
Thermal Senstitivity (2)	@	200°F	Excellent	Excellent
	@	300°F	Poor	Good
Heat Transmittance	5-20 Microns	%	10%	10%
Index of Refraction	D 542	Ratio	1.54	1.54
Tensile Strength	D 638	PSI	16,000	16,000
Flexural Strength	D 790	PSI	24,500	24,500
Flexural Modulus	D 790	PSI x 10^6	1.0	1.0
Shear Strength	D 732	PSI	14,000	14,000
Izod Impact	D 256	Ft.lb./In.	18	18
Water Absorption	D 570	%	0.20-0.33	0.20-0.33
Thermal Expansion	D 696	(In./In./°F) x 10^{-5}	1.4	1.4
Thermal Conductivity	C 177	BTU-In./Hr./$Ft.^2$/°F	.87	.87
Specific Heat	D 2766	BTU/lb./°F	.35	.35
Specific Gravity	D 792	Ratio	1.4	1.4
Weight	NBS PS53	Oz./$Ft.^2$	2.8-4.7	2.8-4.7
Thickness	NBS PS53	Inches	.025 or .040	.025 or .040
Sheet Size	NBS PS53	Feet	4' or 5' wide, up to 1,200 l	

NOTE:

1. Tests indicate that Regular Sun-lite will lose about 10% solar transmission in 7 years while Sun-lite Premium should have no appreciable loss for 20 years (estimat
2. Sun-lite products are generally not affected by higher temperatures. The resins will not melt or cold flow since they are thermosetting and reinforced with glass fibers. The ignition temperature exceeds 900°F. However, continuous exposure at temperatures exceeding 200°F will cause a slight amber color to appear which will have only a modest effect (5%) on Sun-lite's properties. Continuous exposure at 300°F, causes about a 10% decline in solar transmittance in Sun-lite Premium and a more severe decline in Sun-lite Regular.
3. Special Sun-lites are now under development to meet additional fire code requirem and for moist heat applications. Sun-lite Regular and Premium are not recommende for moist heat applications.
4. The above information is presented in good faith, but no warranty is expressed or implied.

Form: SP-33
5/20/75

TECHNICAL INFORMATION

DU PONT TEDLAR® PVF FILM

BULLETIN TD-1A
Revised 8/74

GENERAL

SUMMARY OF PROPERTIES

GENERAL

The unique properties of "Tedlar"* PVF film include excellent resistance to weathering, outstanding mechanical properties and inertness towards a wide variety of chemicals, solvents and staining agents. General properties are summarized in the table on the reverse side.

"Tedlar" is available in clear or pigmented forms in type 30, and in clear types 20 and 40. These range from a high tensile strength, high flex variety (type 20) to a high elongation, high tear modification (type 40). A special type 15 film is also available which has controlled shrinkage for surfacing fiberglass reinforced polyester panels. "Tedlar" contains no plasticizers, hence it is a film with good aging properties which remains tough and flexible over a broad temperature range.

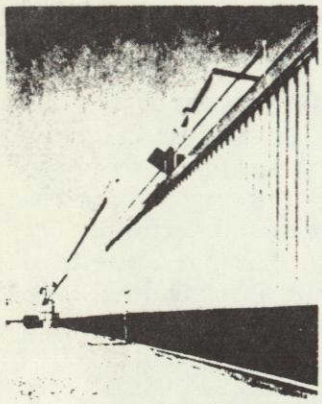
"Tedlar" is supplied with different surface characteristics. The "A" and "B" surfaces are used with adhesives for bonding to a wide variety of substrates. These surfaces have excellent compatibility with many classes of adhesives, including acrylics, polyesters, epoxies, rubbers and pressure sensitive masses.

The "S" surface has excellent anti-stick properties for use as a mold release agent for epoxies, phenolics, rubbers and other plastic resins. It is especially suited as a release for printed circuit board lamination.

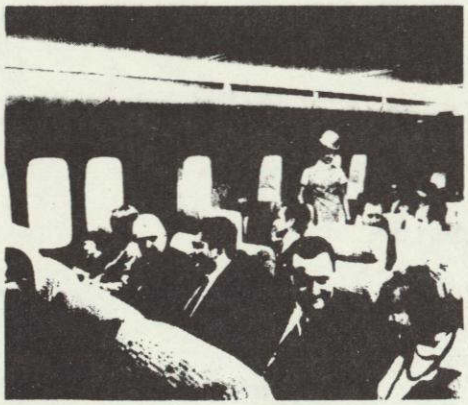
Outdoor weathering tests on "Tedlar" have been conducted for over thirty-one years. The weather resistance, inertness and toughness characteristics suggest broad use as a finish for metals, hardboards, felts, or plastics in architectural, decorative, or industrial uses.

Properties of interest to the electrical industry include hydrolytic stability and high dielectric strength and dielectric constant.

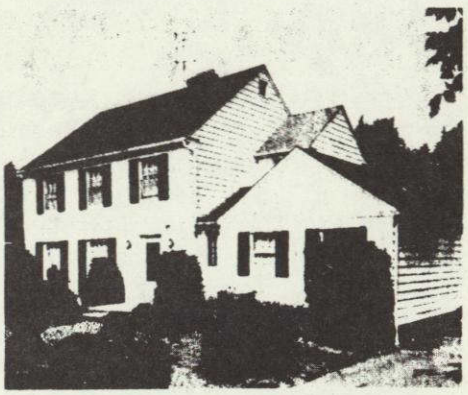
"Tedlar" PVF film is currently available in thicknesses from 0.5 to 4.0 mils.



INDUSTRIAL BUILDINGS
Architectural panels surfaced with "TEDLAR"



BOEING 747 INTERIOR PANEL



RESIDENTAL SIDING

*Reg. U.S. Pat. Off.

	PROPERTY	TYPICAL VALUE	TEST METHOD	TEST CONDITION
Physical	Bursting Strength	19-70 psi.	Mullen, ASTM D-774	23°C. (72°F.)
	Coefficient of Friction (Film/Metal)	0.15-0.30	Instron	23°C. (72°F.)
	Density	1.38-1.57 g./cc.	Weighed samples	23°C. (72°F.)
	Impact Strength	2.7-5.6 Kg.-cm./mil	Du Pont Pneumatic Tester	23°C. (72°F.)
	Moisture Absorption	< 0.5% for all types	Water immersion	23°C. (72°F.)
	Moisture Vapor Transmission	157-205 g./(100m²) (hr.) (mil) (53mm Hg.)		39.5°C. (103°F.)
		1.5 perms/mil	ASTM E-96-58T	39.5°C. 80% RH
	Refractive Index	1.46 n_D	ASTM D-542 Abbé Refractometer	30°C. (86°F.)
	Tear Strength			
	Propagated	12-100 g./mil	Elmendorf	23°C. (72°F.)
	Initial (Graves)	450-620 g./mil	ASTM 1004	23°C. (72°F.)
	Initial (Graves)	997-1398 lbs./in.	ASTM 1004	23°C. (72°F.)
	Tensile Modulus	250-375 x 10^3 psi.	ASTM D-882, Method A 100% elong./min.—Instron	23°C. (72°F.)
	Ultimate Tensile Strength	7.0-18.0 x 10^3 psi.	ASTM D-882, Method A 100% elong./min.—Instron	23°C. (72°F.)
	Ultimate Elongation	115-250%	ASTM D-882, Method A 100% elong./min.—Instron	23°C. (72°F.)
	Ultimate Yield	6000-4900 psi.	ASTM D-882, Method A 100% elong./min.—Instron	23°C. (72°F.)
Chemical	Chemical Resistance	No visible effect	1 year immersion in	
			Acids	25°C. (77°F.)
			Bases	25°C. (77°F.)
			Solvents	25°C. (77°F.)
	Chemical Resistance	No visible effect	2 hours immersion in	
			Acids	Boiling
			Bases	Boiling
			Solvents	Boiling
	Chemical Resistance	Strength and Appearance not affected	Soil Burial—5 years	—
	Gas Permeability Carbon Dioxide	11.1 cc./(100 sq. in.) (24 hrs.) (atm) (mil)	ASTM D-1434	23.5°C. (75°F.)
	Helium	150 cc./(100 sq. in.) (24 hrs.) (atm) (mil)	ASTM D-1434	23.5°C. (75°F.)
	Hydrogen	58.1 cc./(100 sq. in.) (24 hrs.) (atm) (mil)	ASTM D-1434	23.5°C. (75°F.)
	Nitrogen	0.25 cc./(100 sq. in.) (24 hrs.) (atm) (mil)	ASTM D-1434	23.5°C. (75°F.)
	Oxygen	3.2 cc./(100 sq. in.) (24 hrs.) (atm) (mil)	ASTM D-1434	23.5°C. (75°F.)
	Vapor Permeability (at part. press. of vapor at given temp.)			
	Acetic Acid	45 gms./(100m²) (hr.) (mil)	ASTM E-96, modified	23.5°C. (75°F.)
	Acetone	10,000 gms./(100m²) (hr.) (mil)	ASTM E-96, modified	23.5°C. (75°F.)
	Benzene	90 gms./(100m²) (hr.) (mil)	ASTM E-96, modified	23.5°C. (75°F.)
	Carbon Tetrachloride	50 gms./(100m²) (hr.) (mil)	ASTM E-96, modified	23.5°C. (75°F.)
	Ethyl Acetate	1000 gms./(100m²) (hr.) (mil)	ASTM E-96, modified	23.5°C. (75°F.)
	Ethyl Alcohol	35 gms./(100m²) (hr.) (mil)	ASTM E-96, modified	23.5°C. (75°F.)
	Hexane	55 gms./(100m²) (hr.) (mil)	ASTM E-96, modified	23.5°C. (75°F.)
	Water	180 gms./(100m²) (hr.) (mil) (53mm Hg.)	Du Pont Permeability Method	39.5°C. (103°F.)
	Weatherability	Excellent	Florida exposure	Facing South at 45° to horizontal
Thermal	Aging	3000 hours	Circulating Air Oven	150°C. (302°F.)
	Heat Sealability	Some varieties—see Bulletin TD-14		
	Linear Coefficient of Expansion	2.8 x 10^{-5} ins./in./°F.		
	Shrinkage (Type 20) MD & TD	4% at 110°C. (266°F.)	Air Oven, 30 minutes	
	(Type 30) TD only	4% at 170°C. (338°F.)	Air Oven, 30 minutes	
	(Type 40) TD only	2.5% at 170°C. (338°F.)	Air Oven, 30 minutes	
	Temperature Range			
	Continuous Use	-72°C. to 107°C. (—100°F. to 225°F.)		
	Short Cycles or Release (1-2 Hrs.)	up to 175°C. (350°F.)		
	Zero Strength	260°C. to 300°C. (570°F.)	Hot Bar	
Electrical		200 SG40TR / 200 BS30WH		
	Corona Endurance (Hours)	2.5 / 6.2	ASTM Suggested T Method	60 cps., 1000 V./mil
	Dielectric Constant	8.5 / 9.9	ASTM D-150	1 Kc. at 23°C. (72°F.)
	Dielectric Strength (KV/mil)	3.4 / 3.5	ASTM D-150	60 cps., Kilovolts/mil
	Dissipation Factor (%)			
		1.6 / 1.4	ASTM D-150	1000 cps., 23°C.
		2.7 / 1.7	ASTM D-150	1000 cps., 70°C.
		4.2 / 3.4	ASTM D-150	10 Kc., 23°C.
		2.1 / 1.6	ASTM D-150	10 Kc., 70°C.
	Volume Resistivity (ohm-cm.)			
		4×10^{13} / 7×10^{14}	ASTM D-257	23°C.
		2×10^{10} / 1.5×10^{11}	ASTM D-257	100°C.

*N.A. = not available

Product Bulletin

DECORATIVE PRODUCTS DIVISION

201

3M

DATE: NOVEMBER 1973

"NEXTEL" BRAND VELVET COATING
SERIES 101

I. DESCRIPTION

"NEXTEL" Brand Velvet Coating Series 101 is an air dry enamel designed for spray application to properly primed surfaces. This coating uniformly scatters light regardless of incidence angle and provides a velvet-like appearance without the glare of ordinary flat and textured finishes. The resulting surface has a soft, velvety appearance and provides extremely uniform light diffusion over a wide range of viewing angles. Dirt and light abrasion are easily removed from the smooth surface without changing its original appearance.

Black 101-C10 is the recommended Velvet Coating Optical Black and is designed for application to interior surfaces or cameras, optical equipment and darkrooms where control of stray light reflection is required.

White 101-A10 is suitable for most optical white uses; however, White 202-A10 provides slightly more total reflectance.

Note: Not intended for interior architectural applications.

Typical uses include:

1. Optical and electro-optical equipment, instrument interiors, and darkrooms – To minimize stray light reflections.
2. Instrument dials – For consistent contrast thru a broad range of viewing angles.
3. As a contrast with bright chrome and stainless steel – For unique accents, such as on exterior automotive trim.
4. Aircraft glare shield nose exteriors – To reduce glare.
5. Infrared absorbing coating – For thermal control.

Colors	
White	101-A10
Black	101-C10

Primers
Series 901
DuPont 65 Line
Rinshed – Mason
U51C008 Clear Primer
(for chrome and stainless steel)

This bulletin does not contain application procedures for the subject products. The appropriate Instruction Bulletin(s) may be obtained by contacting your Decorative Products sales representative.

II DURABILITY

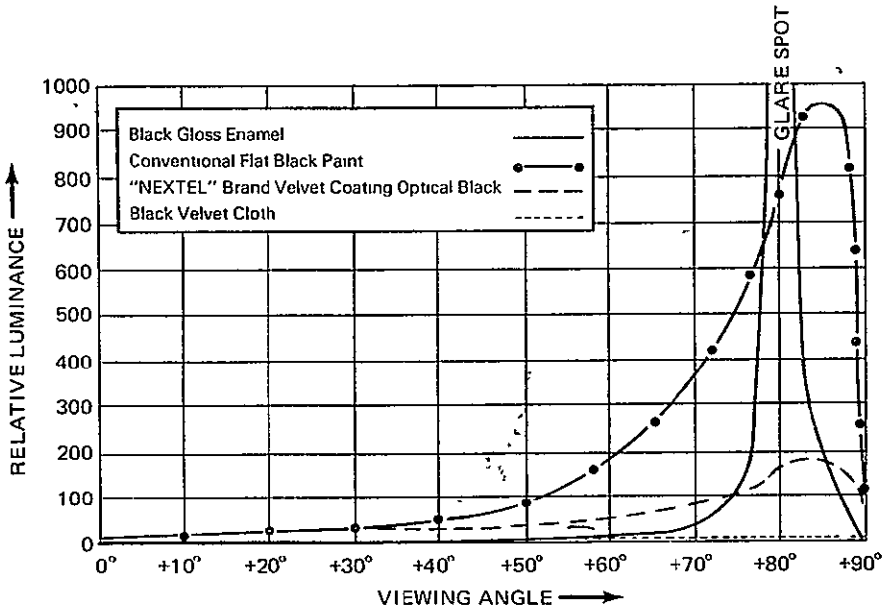
When applied in accordance with procedures recommended by 3M, the following exterior performance may be expected Durability statements are based upon representative experience obtained from testing throughout the United States, however, actual durability will be determined by substrate selection and preparation, exposure conditions and maintenance of the coating

White 101-A10	3 Years
Black 101-C10	3 Years

III PROPERTIES

Values given are typical and not for use in specifications

A. Optical



The graph shows the relative luminance of "NEXTEL" Velvet Coating Optical Black, conventional flat black paint, black gloss enamel, and black velvet cloth at various viewing angles when illuminated from -80° At viewing angles to +40°, all materials appear much the same Beyond 40°, the conventional flat black appears lighter because of glare For gloss black, this glare component is present over a much narrower range, but is many times more intense "NEXTEL" Velvet Coating minimizes this glare and is effective as a light trap even when viewed directly opposite the source (+80°)

Initially, the 85° gloss of "NEXTEL" Velvet Coating is less than half that of conventional flat finishes When rubbed, the advantage increases considerably, since ordinary flat finishes burnish to much higher gloss when rubbed or cleaned. Listed below are 85° Glossmeter readings of "NEXTEL" Velvet Coating and conventional flat finishes after various amounts of abrasion from a Gardner Laboratory Scrubbing Machine (Fed Test Method Std No 141a, Method 6143)

85° GLOSSMETER READINGS				
	New	25 Scrubs	125 Scrubs	250 Scrubs
Commercial Flat Finish	5	10	12	14
"Nextel" Velvet Coating	2	2	2	2

PROPERTY	TEST METHOD	RESULTS
Gloss	ASTM D523-53T	
101-C10	60°	0
	85°	2
Total Reflectance	ASTM E97-55	
101-C10		< 2 1/2%
101-A10		> 85%
Solar Absorption		
101-C10		0 98
101-A10		0.21
Infrared Emittance	At 25°C	
101-C10		0 89
101-A10		0 88
Infrared Reflectance	Fed Test Method Std. No 141a Method 6241 at 5% Incidence	
	Millimicrons	101-C10
	700-1400	1/2%
	1400-2500	2%
		101-A10
	600	90%
	800	88%
	1000	82%
	1500	70%
	2000	65%
	2600	50%

B PHYSICAL

PROPERTY	TEST METHOD	RESULTS
Outgassing Weight Loss	10^{-5} to 10^{-6} torr. 84°F (29°C), 20 hours	1.3×10^{-4} gm/cm^2
Thermal Conductivity		0 17 BTU/hr /ft^2 / ft/°F (101 C10 only)

PROPERTY	TEST METHODS	English Units	Metric Units
Reverse Impact		60 in lb	6 8 x 10^7 dyne-cm.
Abrasion Resistance	Weight loss, 750 Taber Abraser cycles, CS 0 wheels, 1000 gm load (Fed Test Method Std 141a Method 6192)	–	01 gram
Coverage (Approximately)	On 2' x 3' (61 cm x 91 cm) Flat Panel	200 sq ft / Gal	5 sq meters/ liter
Temperature (Maximum recommended continuous service)	500 hours exposure		
	101-C10	300°F.	149°C
	101-A10	150°F	65°C

IV SAFETY

WARNING FLAMMABLE Contains petroleum distillates Keep from heat, sparks, and open flames Use only in well ventilated areas Avoid prolonged breathing of vapors and repeated contact with skin Keep closed when not in use KEEP OUT OF REACH OF CHILDREN

Decorative Products Division 3M COMPANY

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