UNCLASSIFIED

AD NUMBER
AD477479
NEW LIMITATION CHANGE
TO Approved for public release, distribution unlimited
FROM Distribution authorized to U.S. Gov't. agencies only; Administrative/Operational Use; 27 Sep 1965. Other requests shall be referred to Army Research and Development Procurement Office, For Belvoir, VA.
AUTHORITY
USAERDL ltr, 21 Jul 1966

THIS PAGE IS UNCLASSIFIED

Engineering Design Report

THERMOELECTRIC ENVIRONMENTAL CONTROL UNIT

For

RESEARCH AND DEVELOPMENT PROCUREMENT OFFICE

U.S. ARMY ENGINEER RESEARCH AND DEVELOPMENT LABORATORIES

FORT BELVOIR VIRGINIA

CONTRACT DA-44-009-AMC-1135(T)

TASK NO. 1D 643303 D54503

Carrier Air Conditioning Company
MILITARY EQUIPMENT DEPARTMENT

Each transmittal of this document outside the agencies of the U. S. Government must have prior approval of Commanding Officer, Army Engineer Research & Development Labs, Fort Belvoir, Va. 22060 Cu

ACCESSION for

CFSTI WHITE SECTION

DDC BUFF SECTION

UNANNOUNCED

JUSTIFICATION

per statement on doc

DISTRIBUTION/AVAILABILITY

DIST.	AVAIL. and/or SPECIAL	
3		

THE VIEWS CONTAINED HEREIN REPRESENT ONLY THE VIEWS OF THE PREPARING AGENCY AND HAVE NOT BEEN APPROVED BY THE DEPARTMENT OF THE ARMY.

(9) Final Engineering Design Report,

for

(6) THERMOELECTRIC ENVIRONMENTAL CONTROL UNIT,

(10) G. D. Fudelson, [illegible] A. A. [illegible]

(11) 27 Sep 65, (12) 100p.

Prepared for

RESEARCH AND DEVELOPMENT PROCUREMENT OFFICE

U.S. ARMY ENGINEER RESEARCH AND DEVELOPMENT LABORATORIES

FORT BELVOIR, VIRGINIA

(15)

[redacted] DA-44-009-AMC-1135 (T)

[redacted] 1D-643303 D54503

(17)

Submitted by

Military Equipment Department, Carrier Air Conditioning Company

Syracuse, New York

27 September 1965

TABLE OF CONTENTS

TABLE OF CONTENTS
(continued)

1.0 INTRODUCTION

1.1 General

This report is submitted in fulfillment of contract DA-44-009-AMC-1135(T) dated June 2, 1965. In accordance with the requirements of the contract, a detailed engineering design is provided for a 24,000 Btu/hr thermoelectric environmental control unit. The design has been formulated to meet the system requirements described in Exhibit "A", Purchase Description of Request for Quotation No. 65-1816-B dated January 5, 1965 and Amendment No. 1 dated April 26, 1965.

The design presented in this report is a practical one for the application. The analytical and design optimization techniques which are employed have been qualified by previous experience in designing and building thermoelectric systems. Useful experience which was utilized in this study includes the design and development of a thermoelectric air conditioning system for submarines, performed under contracts NObs 77112 and 84598 for the Bureau of Ships, U.S. Navy Department. More recently the first thermoelectric air conditioning and control systems to be sold for a commercial application were developed by Carrier for installation in the headquarters office building of S.C. Johnson and Son, Inc., Racine, Wisconsin. Twenty-eight complete systems have been in operation for approximately one year. The advantages and proven methods which were utilized in these systems have been incorporated into the environmental control unit design provided herein. The experience gained in these and other similar developments provides assurance that an actual system of the design shown can be built successfully and will perform in accordance with the operational characteristics described.

1.2 System Requirements

The Purchase Description calls for a complete engineering design of a thermoelectric environmental control unit to be optimized for minimum size and weight as well as for maximum efficiency. The design conditions for this system are detailed in the Purchase Description. A brief summary of the design conditions is listed in Table I:

TABLE I.

Cooling capacity	24,000 Btu/hr
Ambient air temperature	120°F
Supply air temperature	92°F
Coefficient of performance	Minimum of 1.0
Heating capacity	Unspecified, consistent with full reversal of design operating voltage
Maximum dimensions	40 in. wide x 18 in. deep x 66 in. high
Maximum volume	15 cubic feet
Supply air flow	840 to 1,000
Supply air pressure	0.25 in. of water
Control	Provisions for both automatic and manual operation
Power conversion	Solid state without voltage transformation
Main power supply	208 volt, 3 phase, adaptable to both 60 and 400 cps.
Reliability	Capable of continuous operating for 10,000 hours
Maximum noise level	ASHRAE NC-60

1.3 Proposed Work

On February 5, 1965 Carrier Proposal No. MD8512-2 was submitted to USAERDL in reply to the subject Proposal Request. This proposal detailed the work required to meet the specifications of the Purchase Description. No exceptions were taken to these specifications. The proposed work included a complete system analysis in order to provide an optimum design for the subject unit. This work has subsequently been completed as proposed; the exact procedure followed and the results obtained are described in the following sections of this report.

1.4 Summary of Work Completed

In order to formulate the system design, an extensive optimization analysis was carried out. In this analysis, twelve design parameters were optimized for minimum weight and maximum efficiency, four of which describe the TE panel configuration and eight which describe the heat exchanger characteristics.

Next, a study was made of the various system arrangements that could incorporate the optimized TE coil into a practical design which would meet the requirements of the purchase description. Consideration was also given to the type of fans which could be utilized with these various system arrangements. Similarly, various methods for controlling the system were studied. From the results of these studies, a final system design was developed as shown in Section 3.0 of this report. Further calculations were then made to determine the performance characteristics of this unit over a complete range of operating conditions. Performance information is contained in Section 4.3.

The system described in Section 3.0 is 28 inches wide by 18 inches deep by 63 inches high, weighs approximately 380 pounds, operates at an overall coefficient of performance (COP) of 1.12, and has a net cooling capacity of 24,000 Btu/hr at design operating conditions. The dual frequency vaneaxial fans selected for the design are well suited to meet the reliability and noise requirements. The power rectifier will furnish 3 phase, full wave d-c power without voltage transformation. The control system will furnish modulated capacity control from full cooling to full heating as required by the system load.

2.0 SYSTEM ANALYSIS

2.1 General

In order to make a complete system analysis, the environmental control unit was divided into three subsystems which, for convenience purposes, can be considered separately. These subsystems consist of the thermoelectric coil, the air handling system, and the control and power conversion system. The thermoelectric coil and the air handling system are very closely related physically. However, for purposes of design, the control and power conversion system may be considered to be independent of the other subsystems so far as physical interrelations are concerned. Some reasons for this include the small size, light weight, and high efficiency of this subsystem. Also, because this portion of the system is physically connected to the other parts by light flexible wire, it is not restricted in its physical location or orientation to the others.

2.2 Thermoelectric Coil

There are 14 major physical and operating parameters that affect the size, weight, and performance of an air-to-air thermoelectric unit. These are:

1. Element length
2. Element diameter
3. Element packing density (ratio of element area to panel area)
4. Conductor strap thickness
5. Operating current
6. Internal fin spacing
7. External fin spacing
8. Internal fin thickness
9. External fin thickness
10. Internal fin height
11. External fin height
12. Fin material
13. Internal air velocity
14. External air velocity

Because the thermoelectric coil is the heaviest part of the system, it is of considerable importance that this coil be optimized for minimum weight. The system fans also represent a substantial portion of the overall weight, the size and power requirements of which must also be included in this study in order to yield an optimum system. Fortunately, some of the system parameters do not require optimization. For example, the fin material must be aluminum, since it has the highest ratio of thermal conductivity to weight. Also, from past experience, it is known that the optimum strap thickness is considerably less than the minimum thickness that can be physically handled efficiently. The minimum conductor strap thickness is considered to be 0.020 inches for this system.

2.2.1 System Optimization Procedure. In order to optimize the remaining 12 parameters, equations were written which describe the system in terms of these parameters. These equations were then programmed into an analog computer and solved while each parameter was varied through a complete range of values. The results were then plotted to show variation in system coefficient of performance over a range of operating current density and for various values of the parameter being varied. An example of this plot is shown in Figure 1. This curve illustrates the significance of parameter variation since it shows the large change in performance that can be expected as a result of changes in internal air velocity. Not all of the parameters have this much effect on system performance or weight.

Fortunately, the optimum value of each parameter is somewhat independent of the others and; therefore, this procedure converges on an optimum design quite rapidly. To initiate this procedure, it was necessary to first assume a value for each parameter. Next, for each parameter, calculations were made over the complete range and the optimum parameter value was then used while the next parameter was varied. This procedure continued until all parameters were optimized the first time, then the entire procedure was repeated a second time to insure that all values represented the true optimum. Table II shows these parameters in the order they were optimized, the initial assumed parameter value, the parameter value after the first optimization, and the final value after the second optimization.

TABLE II

PARAMETER	ASSUMED INITIAL VALUE	VALUE AFTER FIRST OPTIMIZATION	VALUE AFTER SECOND OPTIMIZATION
Packing density (%)	--	50	50
Internal air velocity (ft/min.)	600	300	300
External air velocity (ft/min.)	1000	800	700
Internal fin spacing (fin/in.)	24	28	30
External fin spacing (fin/in.)	24	28	30
Internal fin thickness (in.)	0.010	0.007	0.006
External fin thickness (in.)	0.010	0.007	0.006
Internal fin height (in.)	1.00	0.80	0.80
External fin height (in.)	1.00	1.00	1.00

Some of the thermoelectric panel parameters are not shown in Table II. The element length is not included because this value was set up as a variable on the computer program and was varied to give the maximum coefficient of performance for each calculation (the element length was optimized for each solution). The other parameters not shown are element diameter and operating current. Indirectly, these values are combined into the current density and show up as one of the variables on the optimization curve, Figure 1. The element diameter is not actually optimized until the system design is finalized. Figure 2 shows the final results of this optimization procedure. This curve shows the optimum relation between system weight and system performance over the practical range of operating current density.

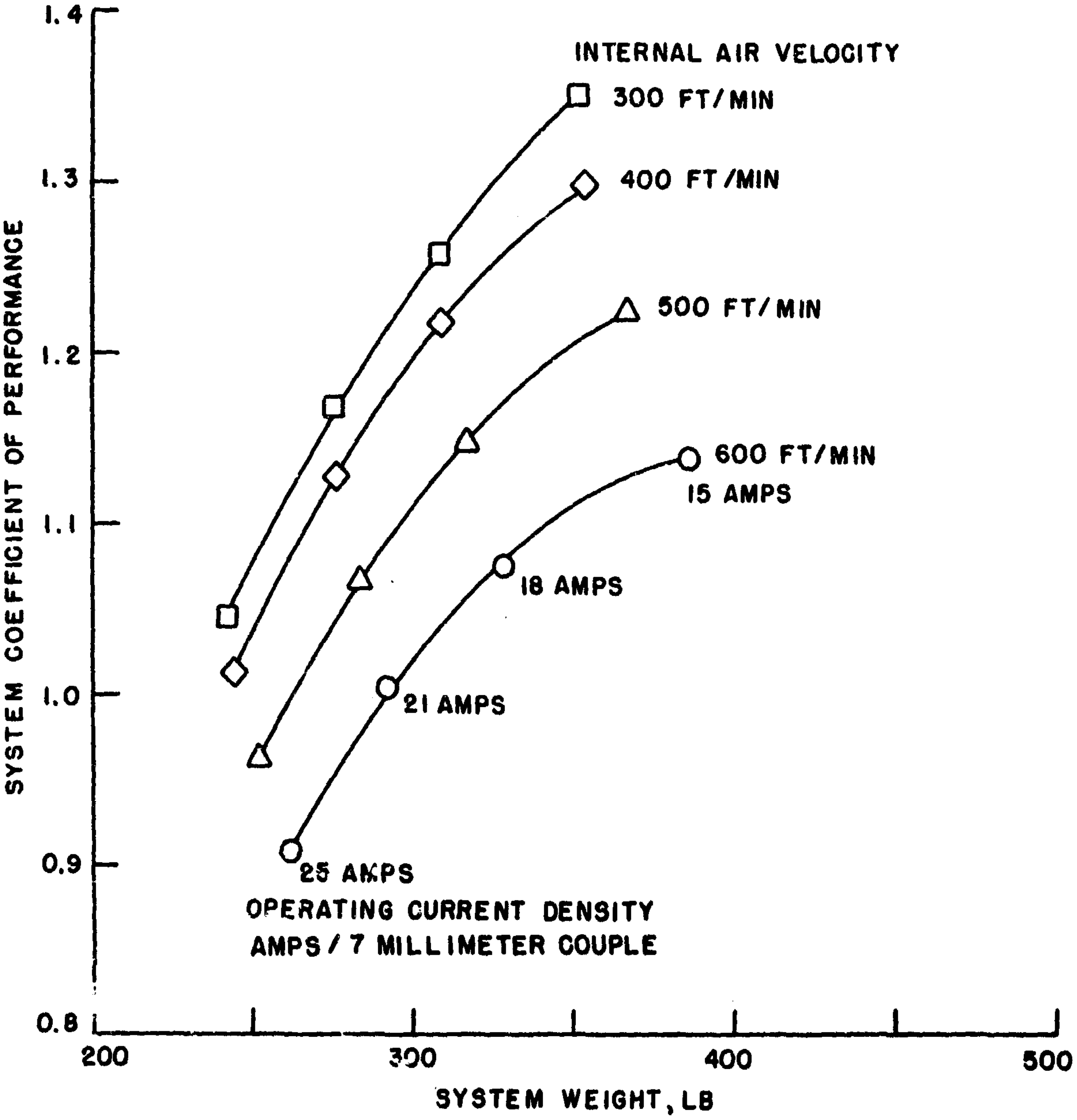


Figure 1. Optimization Curve Showing Weight and Performance over a Range of Internal Air Velocity

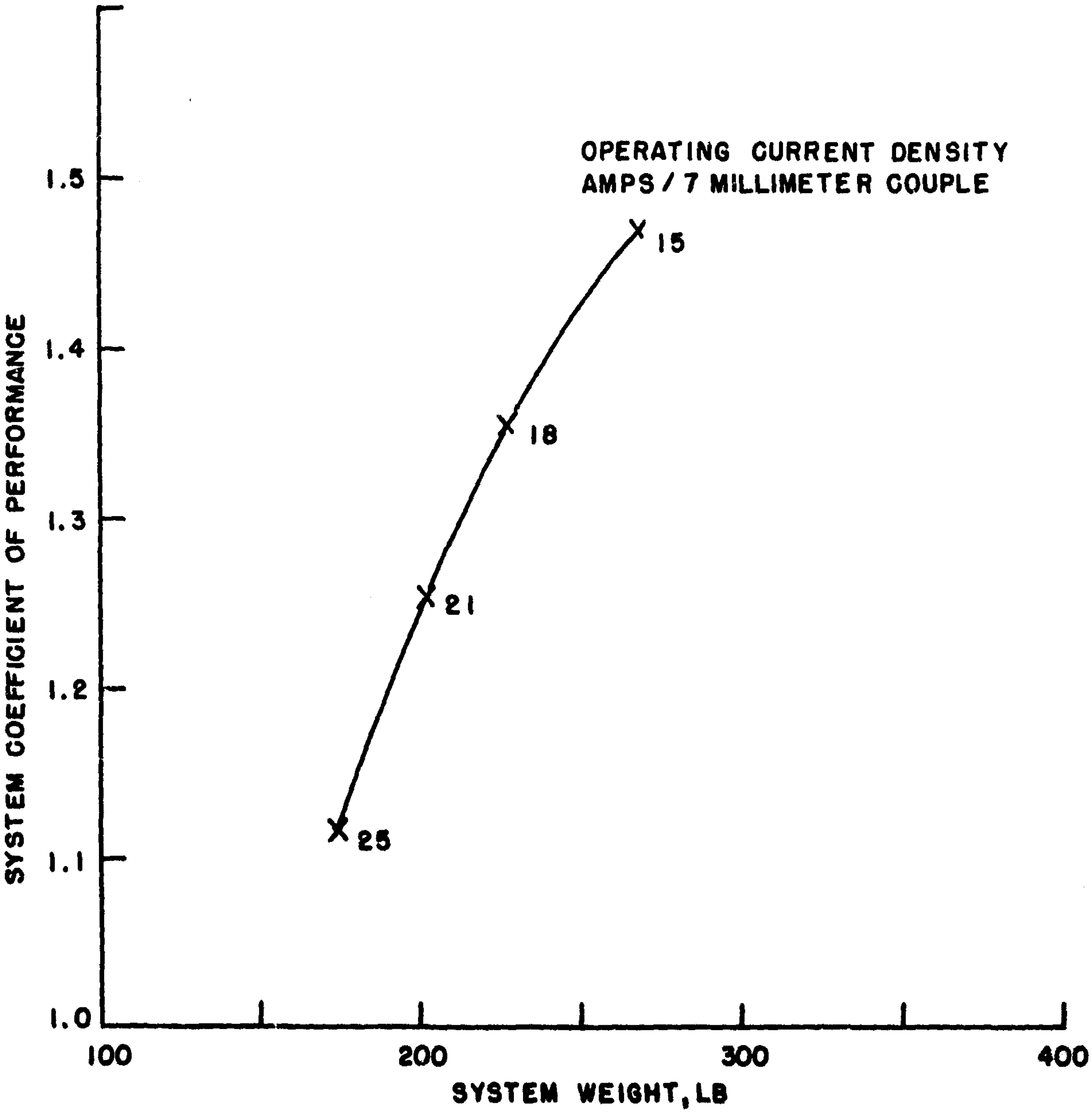


Figure 2. Final Optimization Curve showing System Weight and Performance as a Function of Current Density

It should be pointed out that in this study, reference is always made to overall system weight and system performance, not thermoelectric coil weight or performance. System weight includes the weight of the thermoelectric coil, the weight of the fans (which is calculated as a function of the fan power requirement) and the weight of the unit frame and manifolds which are assumed to equal 50 per cent of the fan and coil weight. System coefficient of performance is defined as the system cooling capacity divided by system power required. System power required includes fan power as well as the power required by the thermoelectric coil. Fan power is calculated from fin pressure drop and air velocity based on an overall fan-motor efficiency of 40 per cent. System cooling capacity is always equal to 24,000 Btu/hr, but is calculated by subtracting the internal fan power from the thermoelectric coil cooling capacity.

2.2.2. Analog Procedure. The optimization equations and the analog procedure used to solve these equations are essentially the same as those described in detail in Carrier's Proposal No. MD-8512-2. The exact equations and calculations are presented in the original design calculations attached to Copy No. 1 of this report.

2.2.3 Material Parameters. Thermoelectric material parameters used in this study are also the same as described in the reference proposal. These parameters represent average values obtained from actual measurement during fabrication of more than 600 thermoelectric panels built by Carrier, and are based on currently available commercial thermoelectric material. Table III shows the variation in material parameters with temperature.

TABLE III

PARAMETER	SYMBOL	UNITS	NUMERICAL VALUE AT 81°F	NUMERICAL VALUE AT 152°F
Seebeck coefficient	α	Volts/couple -°F	1.98×10^{-4}	2.18×10^{-4}
Electrical resistivity	$\rho_n + \rho_p$	Ohm-in. /couple	7.84×10^{-4}	9.37×10^{-4}
Thermal conductivity	k	Btu-in. /hr-ft^2-°F	7.72	7.84
Figure of merit	Z	°C	2.86×10^{-3}	2.86×10^{-3}
Electrical resistance of TE junctions	r	Ohm-cm^2	1×10^{-8}	1×10^{-8}
Thermal conductivity of foam insulation	k_{ins}	Btu-in. /hr-ft^2 -°F	0.20	0.20

Although these parameter values do vary with temperature, they were considered constant at the 152°F value for the optimization calculations. This is justified because the figure of merit is directly related to efficiency and this parameter does not vary with temperature over this range. It is important to note, however, that these variations are taken into account in the final design and the performance calculations described in Section 3.0 and Section 4.3.

The heat exchanger surfaces utilized in this analysis are a straight fin laminar flow type. The performance characteristics of these surfaces may be found in the original design calculations section.

2.3 Air Handling System

Optimization of the air handling system was accomplished to the greatest extent possible as described in paragraph 2.2.1. Other aspects of this subsystem which were further analyzed include fan efficiency, fan type, system noise level, and air manifold arrangement.

Fan efficiency has a definite relationship to fan type. If dual fans (two fans operating in parallel flow) are used for both the internal and external air streams, these fans would operate at specific speeds of 82,500 and 88,000 respectively:

$$[\text{specific speed} = (\text{rpm})\ (\text{cfm})^{1/2} \ / \ (\text{inch water pressure})^{3/4}]$$

These specific speed ranges represent an efficient operating condition for vaneaxial type fans. If it were desirable to use forward-curved, squirrel-cage type blowers; two double-inlet scrolls or four single-inlet units should be used. It was estimated that the overall fan-motor efficiency of the vaneaxial units would be twice that of the squirrel-cage units. Other type blowers available were not considered to be feasible for this system.

In order to meet the dual frequency requirement, it is necessary that fan motors operate at both 60 and 400 cps. Dual frequency motors are available with separate windings within the same motor frame. Also, statically commutated motors have recently been developed which will operate on either frequency; however, information obtained from the manufacturers indicate that these motors are not sufficiently developed to be considered at this time. Thus, it appears that the dual frequency motors are best suited for this application. With these motors, it will be necessary to connect the power to the proper winding terminals depending on the power supply frequency.

With respect to system noise level, it appears that the NC-60 requirement could be met using either type of blower considered. Typically a squirrel-cage blower will generate the greatest noise in the low octave bands where the human ear is less sensitive. Although the vaneaxial fan generates the highest noise levels in the center octave bands, this noise is more readily attenuated with acoustical insulation. In this system, one inch thick fiberglass insulation will be used wherever it will effectively absorb sound or decrease thermal conduction losses.

Probably the most important consideration related to the air handling system is the manifold arrangement. This, in conjunction with the type and number of fans used, largely dictates the size and shape of the overall unit. The possibility exists that the manifolds could be eliminated by going to a cross-flow coil design; however, this presents other problems. In a crossflow design, the coil must be shallow in two directions in order to keep the fan pressure requirements at a reasonable level. Making the coil shallow in two directions on a system of this size results in a long thin coil which is difficult to design into a system. A counterflow coil, being shallow in only one direction, does not have this limitation.

In order to obtain a good manifold arrangement, five possible systems were sketched out and the advantages and disadvantages of each were considered. Systems 1, 2, and 3 were relatively short and wide. A combination of squirrel-cage and vaneaxial fans were used in System 1. System 2 was similar except that it used only vaneaxial fans. System 3 used vaneaxial fans in a somewhat different arrangement than System 2. The major disadvantages of all three systems was large size and poor fan and manifold air entrance arrangements. System 4 was a relatively high and narrow arrangement using all vaneaxial fans. This system was smaller and had considerably better air flow arrangements than the other three systems. From this arrangement it became obvious that System 4 could be made shorter by increasing the coil depth slightly. System 5 includes this change which saved 12 per cent in system volume and 20 per cent in manifold length. The penalty for this saving was a 20 per cent increase in fan power resulting in a three and one-half per cent decrease in system coefficient of performance.

System 5 was then selected as the best fan and manifold arrangement to be incorporated into the final design. The advantages of this system arrangement are pointed out in Section 3.0 of this report.

2.4 Control and Power Conversion System

The object of the control and power conversion system is to regulate d-c power to the thermoelectric coil in response to a signal obtained from the temperature sensor. In order to provide this power regulation, two step-control methods and five proportional-control methods were considered. The criteria used to evaluate these methods were size, efficiency, reliability, degree of modulation, and cost.

The first method considered was a switching scheme whereby the total current through the thermoelectric coil could be increased in discrete steps by automatically reconnecting the thermoelectric modules from a series to a parallel circuit. The main objection to this method is the increased cost of the coil, since a proportionately larger number of smaller couples would be required if the unit were to operate at full capacity with the modules connected in parallel. Transforming the power to a lower voltage would solve the problem mentioned above, but this could be accomplished only at the expense of transformer weight and power loss. In addition, the specifications stated that power conversion should be accomplished without voltage transformation.

A simple two-step control was considered whereby the voltage to the coil would be increased by switching from half-wave to full-wave rectification. The limited degree of modulation attainable, which in turn affects the system efficiency, is the main disadvantage of this method. Also, a special power generator would be necessary in order to operate on half-wave power.

The five types of proportional control systems that were considered include: (1) motor-generator set; (2) magnetic amplifier and rectifier; (3) servo-driven variable transformer; (4) thyratron bridge; (5) silicon controlled rectifier bridge. SCR's and thyratrons can be used in circuits other than the bridge circuits to accomplish proportional power conversion; however, the bridge circuit is more efficient and requires fewer power components.

The SCR bridge control method is easily the best of those considered above. The reasons for this largely involve the small size, high efficiency, and low cost of this system. Reliability information on SCR systems is incomplete at this time, but experience to date indicates this method is at least as reliable as any of the other methods considered. On this basis, the SCR full-wave bridge method was used in the final system design.

3.0 SYSTEM DESIGN

3.1 Thermoelectric Coil

The final design of the thermoelectric environmental control unit was largely dictated by the results obtained from the system analysis. However, in order to make this design realistic, experience and engineering knowledge require that numerical values obtained from the computer study be somewhat compromised.

It has been well substantiated that there are cooling capacity losses in this type system that are very difficult to calculate. This includes such losses as air leakage, joule heating in electrical wires and connectors, structural heat conduction, ductwork and manifold conduction, thermoelectric material parameter variation, and non-uniform air flow distribution. Added together, these losses equal nearly ten per cent of the system cooling capacity. Consequently, for a net capacity of 24,000 Btu/hr, the system should actually be designed for a capacity of 26,400 Btu/hr. Figure 3 shows the relationship between system weight and system performance when this ten per cent loss factor is included.

As mentioned in paragraph 2.2.1, the relationship between operating current and element diameter must be such that the system will operate at 278 volts. A graphical method shown in Figure 4 was used to determine this relationship. As shown on this graph, a single line represents the relationship between operating current, d-c power and voltage (design voltage = 278 volts d-c). The diagonal lines which cross the voltage line represent the relationship between current and power for systems made up of various diameter elements. The vertical lines show the approximate relationship between system coefficient of performance and d-c power draw. Thus, a system COP of 1.20 may be obtained by using 7.3 millimeter diameter elements and the system should operate at 18.0 amperes.

More exact calculations of the system performance later determined that the element diameter should be 6.9 mm. and the system should operate at 17.5 amperes. Reasons for this deviation from the optimum result include:

(1) Thermoelectric material parameters were considered to be independent of temperature for the optimization calculations.

(2) Changes in coil depth and air flow velocities were made in order to compact the system as described in paragraph 2.2.

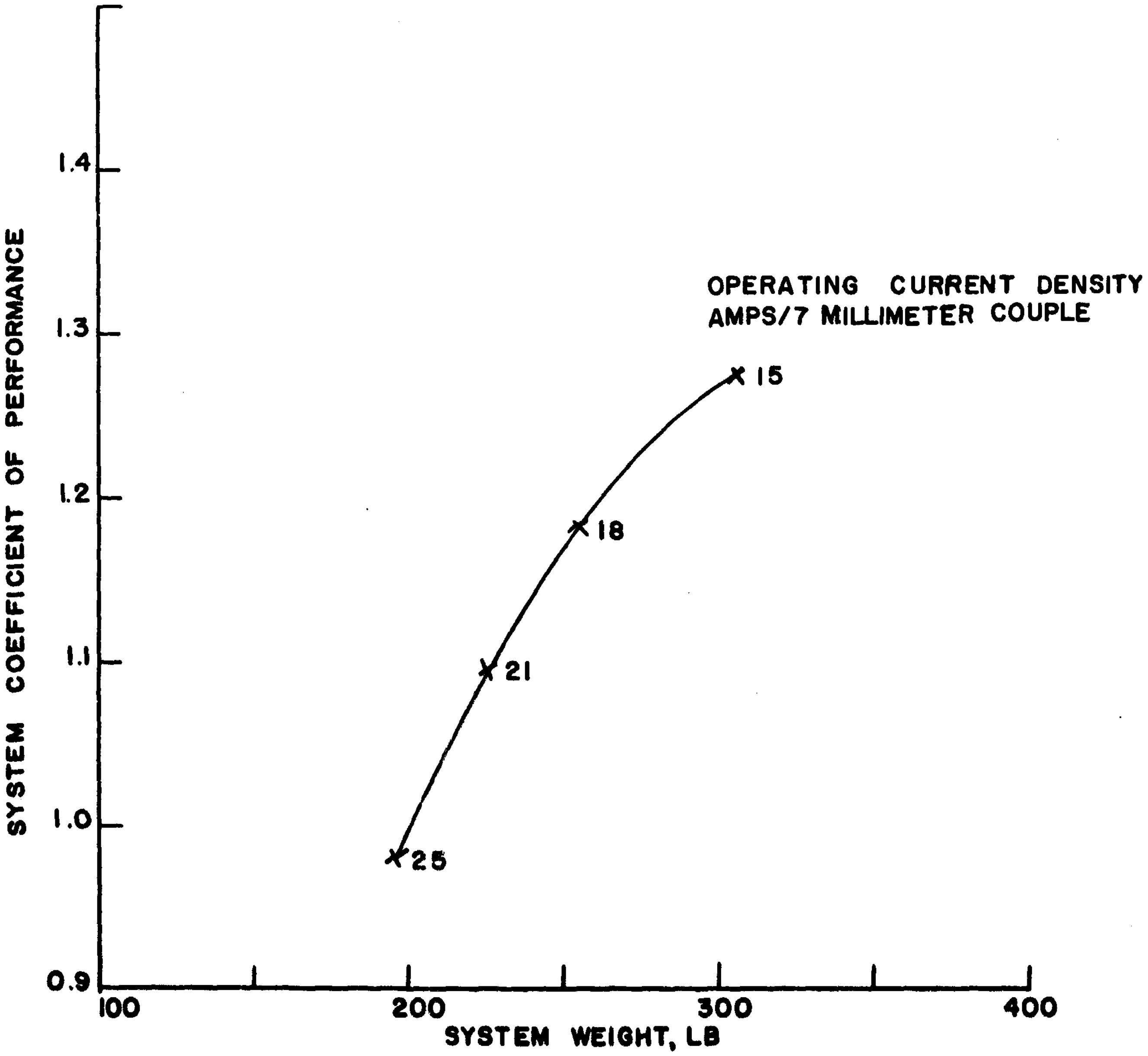


Figure 3. Design Curve Showing System Weight and Performance when 10 Per Cent Capacity Losses are Included

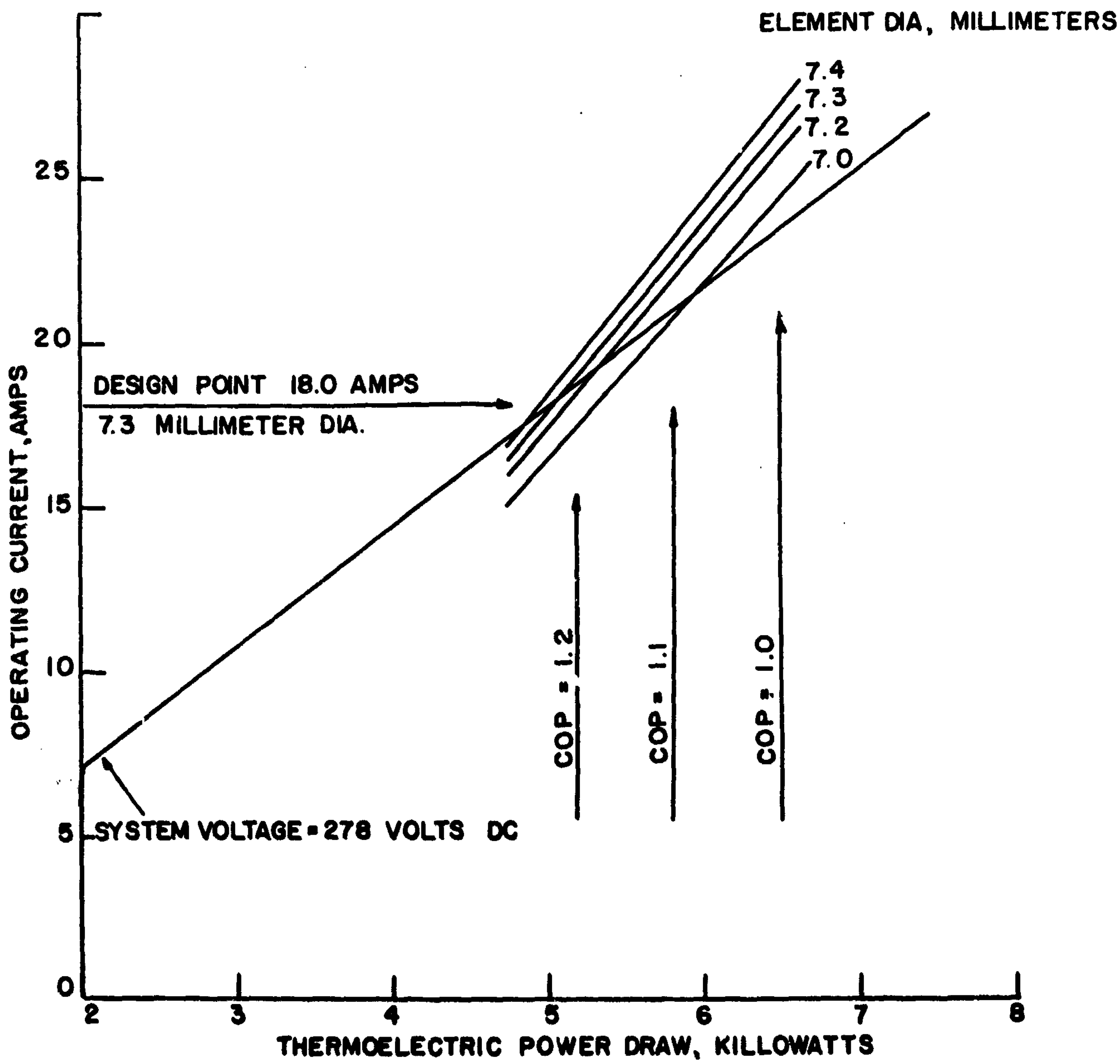


Figure 4. Graphical Determination of Thermoelectric Element Diameter

3.2 Control and Power Conversion

Although the system analysis determined that an SCR full-wave bridge would provide the best means of supplying power to the thermoelectric coil, a number of considerations must be taken into account before the exact control and power conversions circuit is finalized. The power conversion is accomplished with a 3-phase bridge capable of supplying approximately six kilowatts of d-c power when operated from a 208 volt, 60 or 400 cycle supply. After full-wave rectification and allowing for a 2.5 volt drop across the SCR's, the 208 volt a-c supply converts to 278 volts d-c. The magnitude of the d-c voltage can be controlled by controlling the conduction time of the SCR's. Thus, the main problem was to design the necessary circuitry to control the SCR conduction time in proportion to the deviation from the system set point temperature. Also, the polarity of the output voltage must be reversed as the heat pumping requirement changes from heating to cooling and vice versa. Additional circuitry must be designed for manual operation as well as for over-temperature protection.

Automatic reversing could be accomplished statically by using 12 SCR's in the bridge, or by using a double pole, double throw relay in conjunction with a bridge containing three SCR's and three diodes. The relay method was used because of its simplicity.

The control circuitry includes a firing circuit, a signal shaping network, an amplifier, a temperature sensor and a Schmitt trigger. The Schmitt trigger is used to convert the analog signal from the temperature sensor to a digital signal for operating the reversing relay.

The temperature sensor consists of a thermistor connected in a d-c bridge. The voltage signal from the bridge is proportional to the resistance of the thermistor. The amplifier is required to increase this signal to a workable level.

The signal shaping network is required to provide a dead zone about the set point temperature and also to provide a 180 degree phase shift in the amplifier voltage signal when cooling is required.

The firing circuit controls the conduction time of the SCR's. The SCR's are nonconducting until voltage pulses from the firing circuit are supplied to the SCR gates, at which time conduction begins and continues until the end of a cycle.

Transistors and other semiconductor devices used in this circuit have characteristics which vary with temperature. Therefore, the circuit is temperature compensated so that temperature change of the control components will not affect the operation of the unit.

A diode bypass of the SCR's is used for manual operation. A relay connects three diodes into the bridge in place of the three SCR's. All of the automatic circuitry is bypassed and maximum power will be supplied to the heat pump.

A thermistor over-temperature protection network was designed to protect the thermoelectric modules from excessively high temperatures that might result from a fan failure. If a thermistor detects a high temperature condition, power to the thermoelectric modules is removed.

A radio frequency filter was designed and is used in the system for suppression of interference which will be introduced by the switching of the SCR's.

The use of a filter for reducing the ripple at low output voltage was studied. The results of the study indicated that the filter was not worth the extra weight it would add to the system.

3.3 Design Details

The physical system configuration and the design system performance are outlined below:

3.3.1 Physical Configuration

a. Thermoelectric Panels

Element length, 0.087 inch
Element diameter, 6.9 mm.
Element packing density, 0.45
Conductor strap thickness, 0.020 inch
Number of couples, 34 per panel
Panel size, 3.625 x 2.540 x 0.177 inches

b. Heat Exchangers

Parameter	Internal HX	External HX
Fin spacing, fin/inch	30	30
Fin material	Aluminum	Aluminum
Fin thickness, inch	0.006	0.006
Fin height, inch	0.80	1.00
Size, inches	5.25 x 7.37 x 0.34	5.25 x 7.37 x 1.04

c. Thermoelectric Modules

Number of TE panels per module	4
Number of TE couples per module	136
Number of heat exchanges per module	1 internal, 1 external
Size	5.25 x 7.37 x 2.06 inches
Weight	2.67 lb

d. Fans

Parameter	Internal	External
Manufacturer	General Dynamics	General Dynamics
Type	Vaneaxial	Vaneaxial
Identification	Proposal No. RA-5519	Proposal No. RA-5520
Model No.	9071-A	9092-A
Length, inches	7-1/4	10-1/8
Diameter, inches	8-3/4	11
Weight, lb	13-1/2	28

e. Control and Monitor Panel

Size	14 x 13 x 4 inches
Weight	5 lb

f. Control and Power Conversion Package

Size	20 x 8 x 4 inches
Weight	16 lb

g. Complete Thermoelectric System (24,000 Btu/hr)

Number of TE modules	60
Number of TE panels	240
Number of TE couples	8160
Number of internal fans	2
Number of external fans	2
Overall size	18 in. deep x 28 in. wide x 63 in. high
Overall volume	18.4 cubic feet
Overall weight	380 lb

3.3.2 System Performance (Design Point Operation)

a. Thermoelectric Coil

	Main Power Supply Frequency	
	60 cps	400 cps
Current, amperes d-c	17.5	17.7
Voltage, volts d-c	278	278
Power draw, kilowatts	4.86	4.92
Cooling capacity, Btu/hr	28,050	28,230
Coefficient of performance	1.69	1.68
Internal air velocity, ft/min	359	402
External air velocity, ft/min	838	945

b. Internal Fan, Each Unit

	60 cps	400 cps
Voltage, volts a-c	208	208
Phase	3	3
Current, amperes a-c	0.6	1.5
Power factor	0.85	0.51
Motor efficiency	0.65	0.57
Brake horsepower, hp	0.16	0.21
Power draw, watts	184	275
Sound pressure level, C-scale	70	70
Guaranteed life, hr	3,000	3,000
Expected life, hr	20,000	20,000
Air flow, cfm	510	560
Air pressure, in. of water	1.26	1.43

c. External Fans, Each Unit

	Main Power Supply Frequency 60 cps	400 cps
Voltage, volts a-c	208	208
Phase	3	3
Current, amperes a-c	2.4	5.3
Power factor	0.90	0.57
Motor efficiency	0.70	0.63
Brake horsepower, hp	0.73	0.92
Power draw, watts	780	1090
Sound pressure level, C-scale	80	80
Guaranteed life, hr	3,000	3,000
Expected life, hr	20,000	20,000
Air flow, cfm	1260	1380
Air pressure, in. of water	1.75	2.00

d. Complete System

	60 cps	400 cps
Voltage, volts a-c	208	208
Current, amperes a-c	19.7	24.4
Power factor	0.99	0.89
Phase	3	3
Power draw, kilowatts	6.84	7.70
Cooling capacity, Btu/hr	26,230	25,800
Overall coefficient of performance	1.12	0.98

Performance curves for the internal and external fans are shown in Figures 5 and 6, respectively. These graphs also show the system characteristic curves.

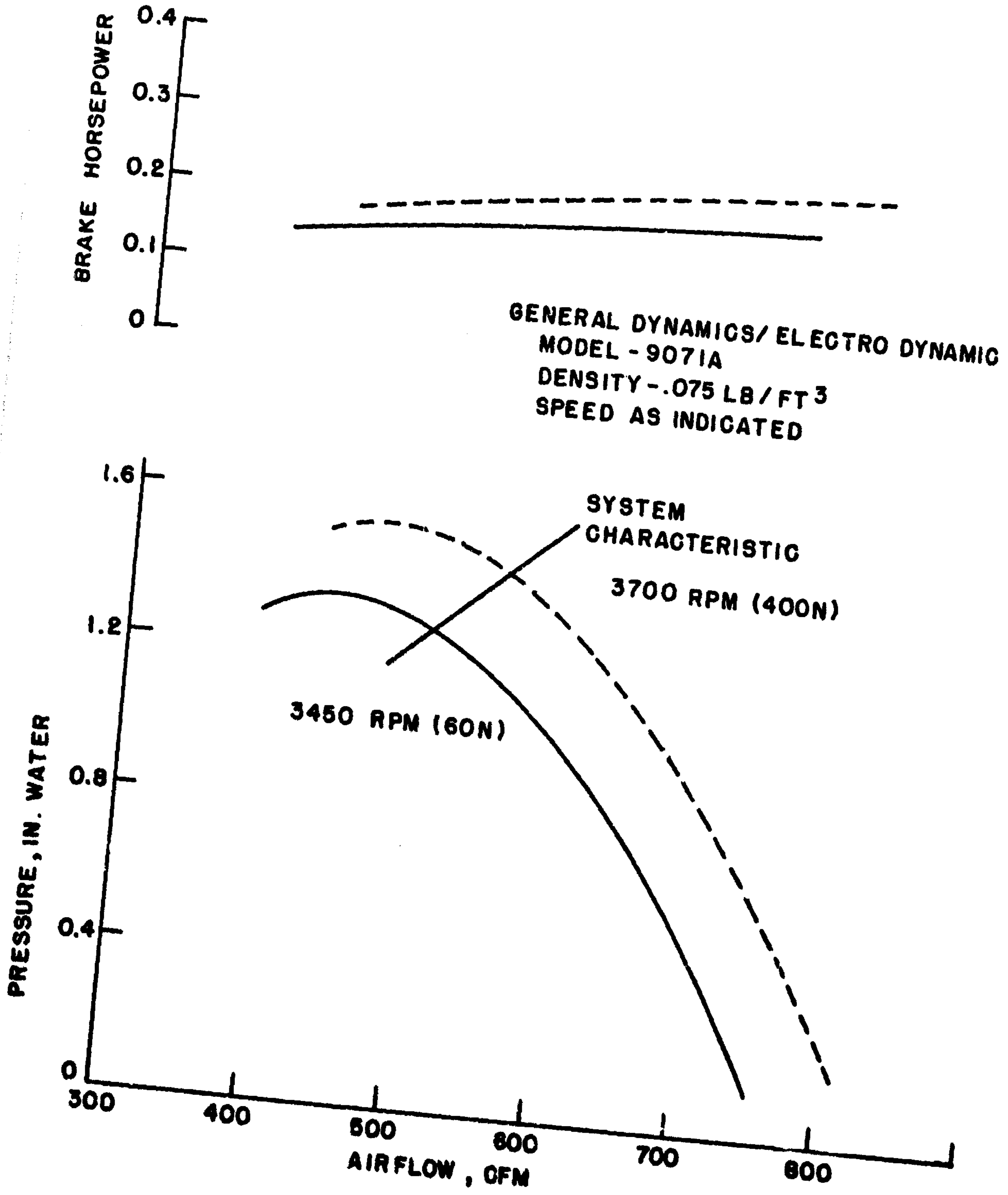


Figure 5. Internal Fan Performance

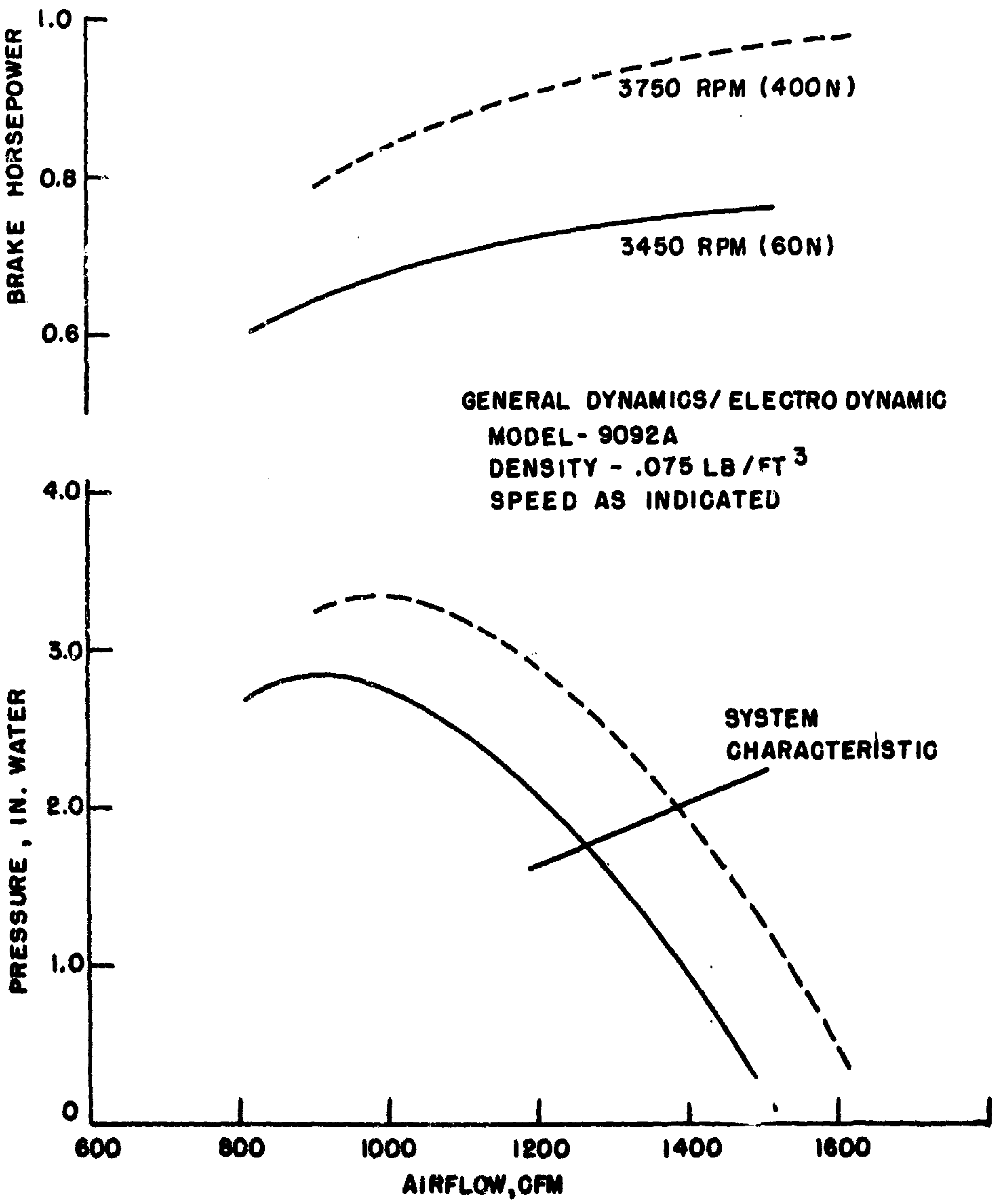


Figure 6. External Fan Performance

3.4 Design Drawings

Detailed engineering drawings are included in Appendix A. Most of these are assembly drawings, and the appropriate bill of material for each assembly is shown on the drawing. Exact design details for all special components which are pertinent to the operation of the system are also shown on these drawings.

Drawing number R-1058-3429 shows a thermoelectric panel assembly. In operation, the electrical current will feed into the panel through one of the insulated lead straps then alternately through the n-type and p-type bismuth telluride elements and out the insulated lead strap at the opposite end of the panel. The 34 pairs of elements in each panel are connected in series by means of the 67 insulated conductor straps. The insulated conductor straps are made of a metalized ceramic wafer soldered between a copper conductor strap, and a copper spacer. This sandwich assembly has a dielectric breakdown strength in excess of 4000 volts d-c, and an electrical resistivity in excess of 10^{12} ohms.

Drawing number R-1058-4430 shows how four of the thermoelectric panels are soldered in place between the aluminum internal and external air heat exchangers to form a module assembly. This module assembly is the basic building block of the thermoelectric coil. In the complete system, 60 of these modules are stacked in 12 side-by-side banks, each bank five modules high. The current flows through two panels on one side of each module in series, then on through the two panels on the same side of the next module located directly above the first, and so on through the five modules in one bank to the top of the bank. At the top, current flows through a jumper strap to the panel located on the opposite side of the top module and then back down through the same five modules. At the bottom of each bank the current will flow to the next bank of modules and so on in series through all 12 banks.

Drawing R-1058-9434 shows the unit framework assembly. The frame is constructed from 1-1/2 x 1-1/2 x 3/16 inch aluminum angle and 1-1/2 x 1-1/2 x 1/8 inch square aluminum tubing welded together. Calculations determined that this size angle would keep the natural frequency of the long structural members well above the rotational frequency of the system fans. Item 26 of this drawing is the internal air supply manifold. These manifolds, as well as the return manifolds, are formed from aluminum sheets insulated with a 3/16 inch layer of free foamed epoxy prior to cutting and forming.

Drawing R-1058-9431 shows the system control and monitor panel. This panel mounts into a sealed, recessed compartment on the inside face of the unit such that it may, if desired, be remotely located without resealing the opening from which it was removed. Electrically, this panel is connected to the unit by a single feed-through connector mounted near the bottom of the recessed compartment wall. The system temperature sensor mounted on the face of this panel is detailed on drawing R-1058-3432.

Drawing R-1058-9433 shows the power conversion and control package. This package is made up of a two-compartment box designed to confine radio frequency noise generated by the silicon control rectifiers. The free convection fins mounted to the outside of this box are designed to conduct heat away from the power rectifier which is mounted directly adjacent to the fins on the inside of the box. The rectifier mounting blocks are in good thermal contact with the aluminum box, but are electrically insulated from the box by 18 electrically insulated ceramic conductor straps.

Drawing R-1058-4435 shows the access cover assembly. This removable cover mounts on the outside face of the unit and is easily removed to allow access to the thermoelectric modules, the internal and external fans and the power rectifier and control package. A fine mesh wire screen prevents dust and dirt from entering the external air inlet, and the outer grill protects the unit from damage. The internal air return manifolds are mounted to the cover such that when the cover is tightened down, it will hold the thermoelectric modules firmly in position.

Drawing R-1058-9436 shows six views of the complete environmental control unit along with a sectional side elevation. This drawing shows the mounted location of all the system components described above. The buss-bar which carries the electrical current from one bank of modules to the next is detailed in drawing R-1058-3437.

Drawing R-1058-9439 shows a pictorial side elevation of the unit indicating the flow paths of the internal and external air streams.

3.5 Electrical Circuit Diagram

Drawing R-1058-4428 shows the schematic wiring diagram for the system. As shown, the 3-phase, 208 volt, 60 or 400 cycle power feeds into the unit through the main power circuit breaker switch (CB1), through the power rectifier, through the reversing relay (RR), and to the thermoelectric heat pump. Lead wires connect the module selector switch to each of the 12 banks of thermoelectric modules so that the voltage drop across each individual module bank, or across the total coil, may be monitored on the voltmeter (VM).

The same input power feeds through the fan power circuit breaker (CB2) to the internal and external fans, as well as to the control system voltage transformer (TRANS. 1). The automatic control network is made up of a temperature sensor circuit, amplifier, Schmitt trigger, signal shaping circuit, and firing circuit. This network picks up a signal from the temperature sensor thermistor (TH1) and feeds a control signal through the pulse transformers (PT1, PT2, PT3) to the gates of the silicon control rectifiers (SCR1, SCR2, SCR3). At the same time, the Schmitt trigger controls the operation of the control relay (CR1) which in turn operates the reversing relay (RR). The system selector switch (SW1) bypasses the automatic control network when it is in the manual heat or manual cool position. In the manual position, the reversing relay and the power rectifier circuit are controlled such that the unit may operate at either full cooling or full heating. During manual operation, the power to the thermoelectric coil bypasses the SCR's and is supplied through the power diodes (D4, D5, D6). The over-temperature protection circuit monitors the signal from the over-temperature thermistors (TH2, TH3, TH4, TH5), and will cut off the power to the rectifiers by operating the control relay (CR2) which in turn will open the main contactor (MC). The over-temperature thermistors are mounted to the thermoelectric coil frame so that they are in good thermal contact with the internal and external air fins.

3.6 Design Requirements

The design requirements for this system are specified in Section 2 of the Purchase Description as amended by Amendment No. 1. The system design described in Sections 3.2, 3.3, and 3.4 above meets or exceeds all of the specified requirements with the exception of unit volume. The 18.4 cubic foot volume of this design exceeds the 15 cubic foot requirement described in Section 2.2.3 of the Purchase Description.

With regard to certain requirements describing the method of control, variations are made in the exact method specified. However, the same end result is accomplished by means that are considered better than those described. These variations are described below; the section numbers listed refer to those used in the Purchase Description.

Section 2.4.2.2 - Automatic Capacity Control:

With this system design, automatic capacity control is accomplished by modulating the voltage applied to the thermoelectric coil. This modulation is continually proportional from full cooling to full heating. The operation of this control system is described in more detail in Section 4.1.3.3 of this report.

Section 2.4.3.1 - Selector Switch:

The selector switch has only three positions: MANUAL HEAT, MANUAL COOL, and AUTOMATIC.

Section 2.4.3.1.3 - Off:

Power to the thermoelectric coil is turned off by turning the main power circuit breaker switch to the OFF position.

Section 2.4.3.1.5 - Start:

A special start mode of operation is not provided. With the fast response time and the high heat pumping capacity of a thermoelectric unit during start-up, it appears that a special starting mode of operation should not be required.

Section 2.4.3.2.1 - Inside Fan Motor Switch:

The inside fan will run whenever the fan power circuit breaker switch is on.

Section 2.4.3.2.2 - Outside Fan Motor Switch:

The outside fan motor switch has two positions, ON and AUTOMATIC. The system could possibly be damaged if the external fans were turned off when the unit was operating in the cooling mode, consequently the OFF position was eliminated.

Section 2.4.3.5 - Monitor Lights:

A voltmeter and a thermoelectric module selector switch are located on the control and monitor panel. This provides a means of checking the exact voltage drop across each module bank.

Section 2.4.7 - Thermoelectric Modules:

This unit has 12 module banks each comprised of five identical modules.

4.0 SYSTEM OPERATION

4.1 Description of Operation

4.1.1 General. The basic subsystems comprising the thermoelectric environmental control unit are: (1) thermoelectric coil, (2) air handling, and (3) control and power conversion.

Referring to Drawing R-1058-9439, the air flow paths through the fans, manifolds, and thermoelectric coil are shown. Internal air enters the top of the unit just above the internal fans and passes through the fans into the internal air supply manifolds. It then passes through the thermoelectric coil, up through the six return air manifolds and leaves the unit through the top opening near the outside face of the unit.

External air enters through the outside face of the unit, passes through the protective grill and fine mesh screen straight into the external air fins of the thermoelectric coil. After leaving the coil, air passes downward into the external fans and is discharged through a protective grill near the bottom of the outside face. Thus, the two air streams pass through the coil in counter flow. The internal circuit is under positive pressure and the external circuit under negative pressure so that any air leakage will always be from the internal to the external air stream.

The direction of heat flow through the thermoelectric modules is dependent on the polarity of d-c power supplied to the modules. In the cooling mode, heat is pumped from the internal air stream to the external air stream. In the heating mode, heat is not actually extracted from the external air stream, since the external fans are always off. However, the heat equivalent of the power input is rejected to the internal air stream. Control of the d-c current flow quantity and direction is described in Section 4.1.2.

4.1.2 Control and Power Conversion

4.1.2.1 Manual Operation.

Refer to Drawing R-1058-4428. When the system selector switch (SW1) is in the manual cool position, the manual relay (MAN) is energized, the SCR's (SCR1, SCR2, SCR3) are disconnected from the rectifier bridge, and the diodes (D4, D5, D6) are connected to the bridge. The reversing relay (RR) is in the non-energized cooling position and 278 volts d-c is applied to the thermoelectric heat pump.

With the system selector switch in the manual heat position, manual relay (MAN) is again energized, the reversing relay (RR) is energized to the heating position, and 278 volts d-c is applied to the thermoelectric coil. Also, the fan relay (FR) is energized, cutting the external fans off.

4.1.2.2 Automatic Operation.

In the automatic mode of operation, a small voltage signal is produced by the temperature sensor in proportion to the difference between the set point temperature and the temperature of the control thermistor (TH1). The resistance of the thermistor decreases as the temperature increases, and this causes the voltage at the base of transistor TR1 to increase in proportion to the temperature increase. The voltage signal is amplified by transistor TR2 and then supplied to the reversing network consisting of a Schmitt trigger, a control relay (CR1), and the reversing relay (RR). Simultaneously, this amplified signal is supplied to the signal shaping network.

The amplifier and Schmitt trigger are biased so that the reversing occurs at a set point temperature of 67°F. As the temperature rises above 67°F, the control relay (CR1) is energized, opening its normally closed contacts. Also, the reversing relay is de-energized placing a cooling polarity on the thermoelectric coil, and the fan relay (FR) is de-energized turning on the external fans. As the temperature of the control thermistor drops below 67°F, the control relay (CR1) is de-energized which in turn energizes the reversing relay to the heating position, and the fan relay turns off the external fans.

The signal shaping network provides a dead zone of ± 5°F about the set point temperature. When the control thermistor temperature is in this dead zone, no signal is supplied to the firing circuit, and consequently power is not supplied to the thermoelectric coil. As the control thermistor temperature increases above 72°F, the voltage from the signal shaping network increases continuously until the full cooling signal is produced at 77°F. Conversely, as temperature drops below 62°F, the voltage decreases until the full heating signal is produced at 57°F.

The voltage from the signal shaping network is supplied to the firing circuit which controls the conduction time of the SCR's in proportion to the voltage signal. Controlling the conduction time of the SCR's in turn controls the voltage applied to the thermoelectric coil. Figure 7 shows the relation between the control thermistor temperature and the applied system voltage. The firing circuit used here is a unijunction type. In this circuit, a voltage signal is converted to a time signal by charging a capacitor. Thus, a high signal voltage corresponds to a short charging time which in turn results in a long conduction time.

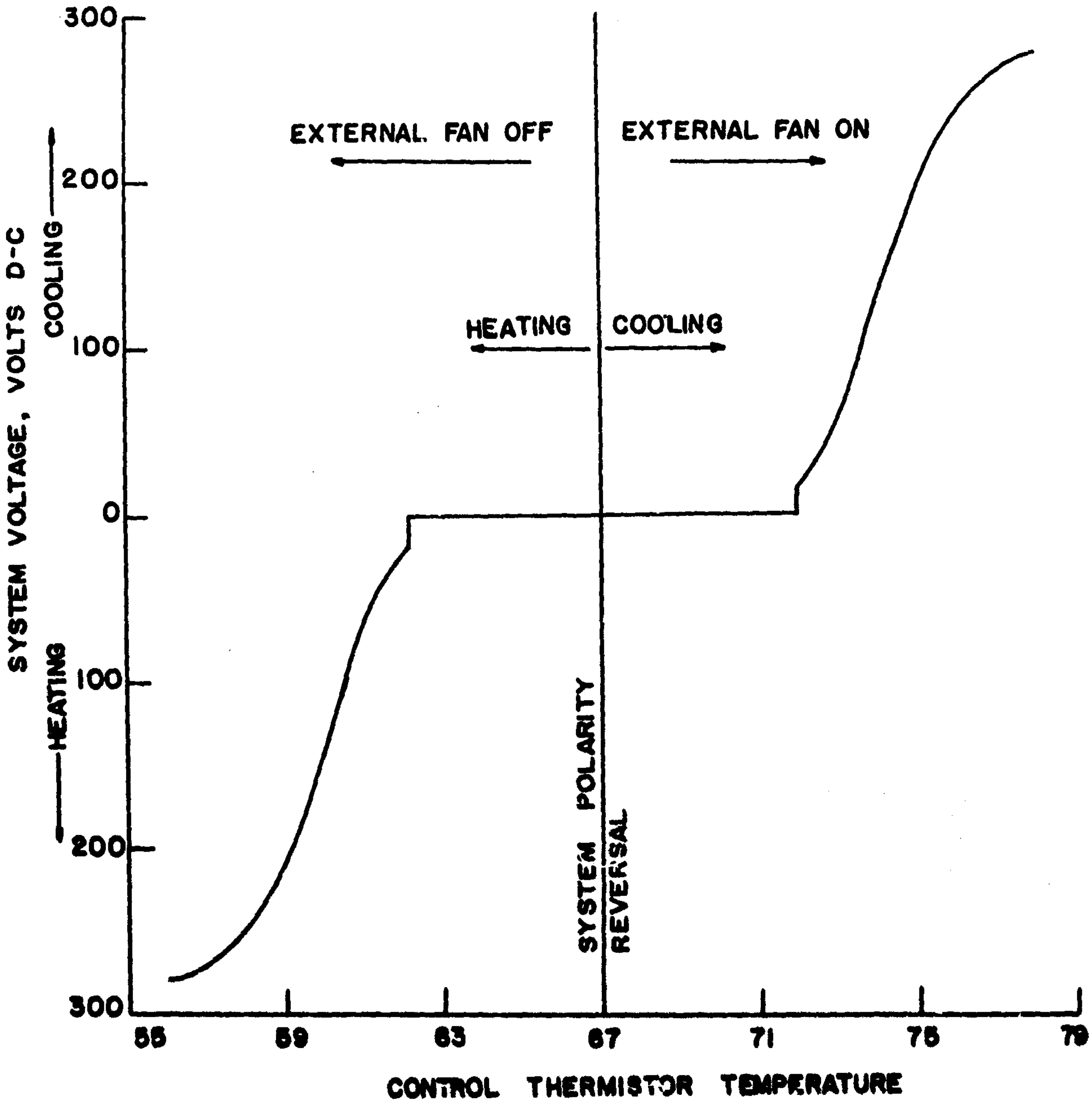


Figure 7. System Control Characteristics

4.1.2.3 Over-Temperature Protection.

In the over-temperature protection circuit, the thermistors (TH2, TH3, TH4, TH5) are located to protect the system against over-temperature conditions which could be caused by an inoperative fan or by a blocked air passage. If the temperature of any one of these thermistors exceeds 160°F during operation, then control relay (CR2) is energized, which in turn de-energizes the main contactor (MC) removing power from the thermoelectric coil. Simultaneously, the reset warning light on the control panel will go on indicating an over-temperature condition has occurred. To resume operation after an over-temperature condition occurs, the "reset" button must be depressed.

4.2 Operating Procedure

4.2.1 Automatic Operation. To operate this unit in the automatic mode, the following sequential procedure should be followed:

1. Selector switch . . . AUTO
2. External fan. . . . . . AUTO
3. Fan power . . . . ON
4. Main power . . . . . . ON

Both the main power and the fan power indicator lights should be on. The reset light should be out; however, if the reset light is on immediately after the fan power switch is turned on, then the reset button should be pushed.

If during automatic operation, or any mode of operation, the operator wants to check the module operation, the voltage drop across any of the 12 module banks may be monitored by setting the module selector switch to the proper module bank number and reading the voltage drop from the meter.

To turn the unit off when operating in the automatic mode, the sequence is:

1. Main power . . . . . . OFF
2. Fan power . . . . OFF

4.2.2 Manual Operation. To operate the unit in either the manual cooling or the manual heating mode:

1. Selector switch. . . . MAN. COOL OR MAN. HEAT
2. External fan. . . . . . AUTO
3. Fan power . . . . ON
4. Main power . . . . . . ON

To turn off unit:

1. Main power . . . . . . OFF
2. Fan power . . . . OFF

4.2.3 Manual Fan Operation. In order to operate the internal fans without operating the thermoelectric coil or the external fan, the sequential operations are:

1. Selector switch . . . . MAN. HEAT
2. External fan . . . . . . AUTO
3. Main power . . . . . . OFF
4. Fan power . . . . ON

To operate both internal and external fans with the thermoelectric coil off:

1. External fan . . . . . . ON
2. Main power . . . . . . OFF
3. Fan power . . . . ON

If the inside air temperature is above 67°F and the outdoor ambient is below 67°F, it may be possible to decrease the inside temperature to 67°F and control at this temperature without operating the thermoelectric coil. This is possible by operating the internal fans and letting the external fans cycle on and off in the automatic operating mode. To accomplish this:

1. Selector switch . . . . AUTO
2. External fan . . . . . . AUTO
3. Main power . . . . . . OFF
4. Fan power . . . . ON

To turn the unit off after any manual fan operation, simply turn the fan power switch off.

4.3 Operating Performance

Electronic analog computer calculations were made to determine the performance characteristics of this system at off-design as well as at design conditions. The operating performance at design condition was described in detail in Section 3.3.2. Figure 8 shows the plotted computer solution for the system operating at design conditions on 60 cycle power. This plot shows how the element junction temperature and the internal and external air temperatures vary with coil location.

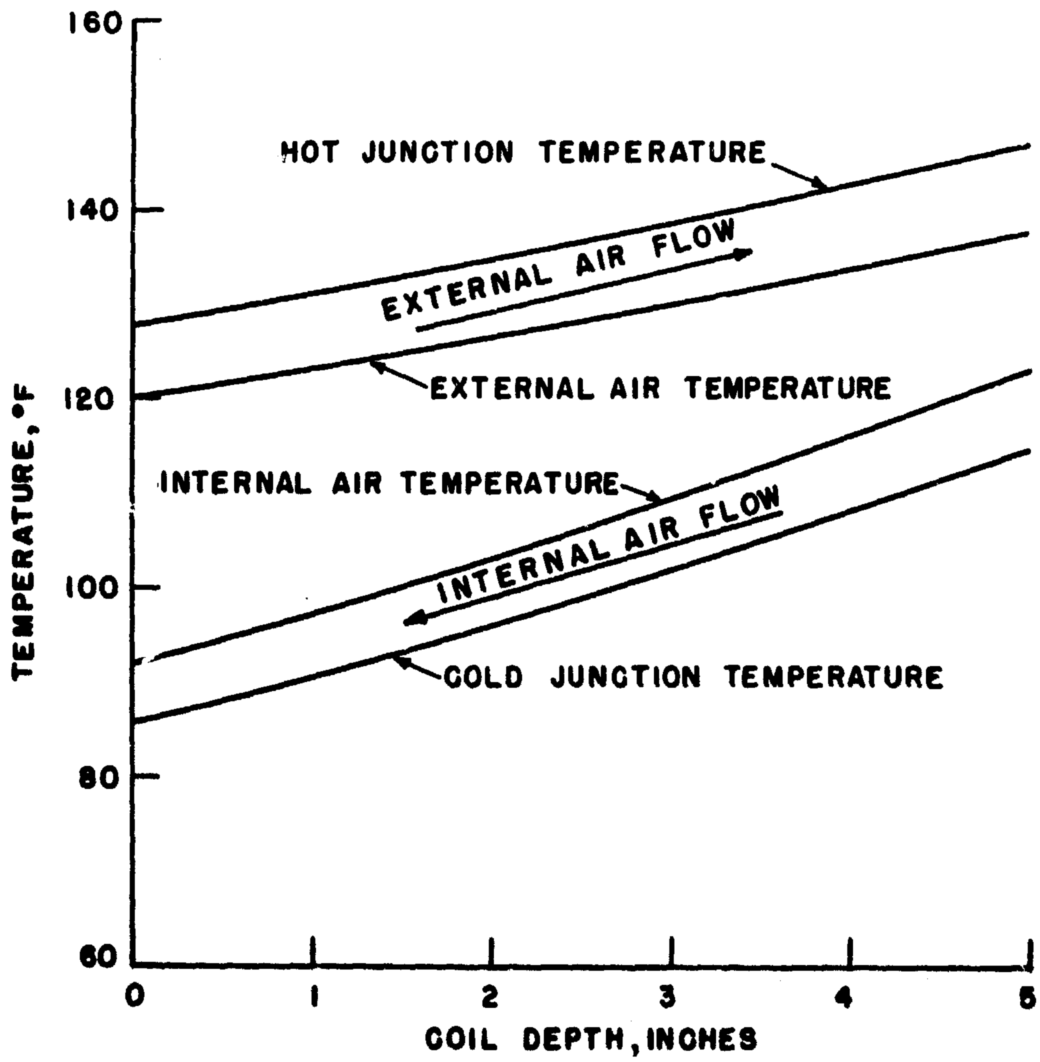


Figure 8. Thermoelectric Coil Temperature Profile at Design Operation

Off-design cooling performance was calculated for variations in outdoor ambient temperature, internal supply air temperature and operating voltage. Heating performance was calculated for variation in operating voltage. All calculations were made for both 60 and 400 cycle operation. The system power draw and COP are significantly affected by main power frequency, whereas the change in cooling capacity is insignificant. Figures 9 and 10 show how system capacity varies with ambient temperature and operating voltage for supply air temperature of 72 and 62°F, respectively. In both of these plots, the heating capacity is based on a return air temperature of 50°F. Note that zero amperage curves are shown rather than zero voltage. The reason for this is that when the SCR's are shut off, there is still a back EMF on the system generated by the thermoelectric coil. In certain cases, this generated voltage may exceed 60 volts. Figures 9 and 10 are of primary interest because they give a good representation of how the system will perform under normally expected conditions of operation. It is interesting to note that there is a large range of operation between zero amperage heating and zero amperage cooling. Within this range, the system will control the inside air temperature at the set point temperature of 67°F by simply turning the external fans off and on as required.

Figure 11 shows how system performance during cooling operation varies with outdoor ambient air temperature and operating voltage. System capacity, power draw and coefficient of performance are all shown for 60 cycle operation and a supply air temperature of 72°F.

Figure 12 shows the same performance information when the supply air temperature is 62°F, and Figures 13 and 14 show similar curves for the system operating on 400 cycle power.

Figures 15 and 16 show how system performance during full cooling operation varies with outdoor ambient air temperature and supply air temperature. Again system capacity, power draw, and coefficient of performance may be determined from the plot. Figure 15 represents 60 cycle operation and Figure 16 represents 400 cycle operation. These two plots are of greatest interest because they represent how the system will operate in the manual cooling mode. They also show the system design operating condition.

The exact procedure used to calculate the performance information is located in the calculation section of Copy No. 1 of this report. Tabulated data is also provided which shows such information as operating current, fan power requirements, etc.

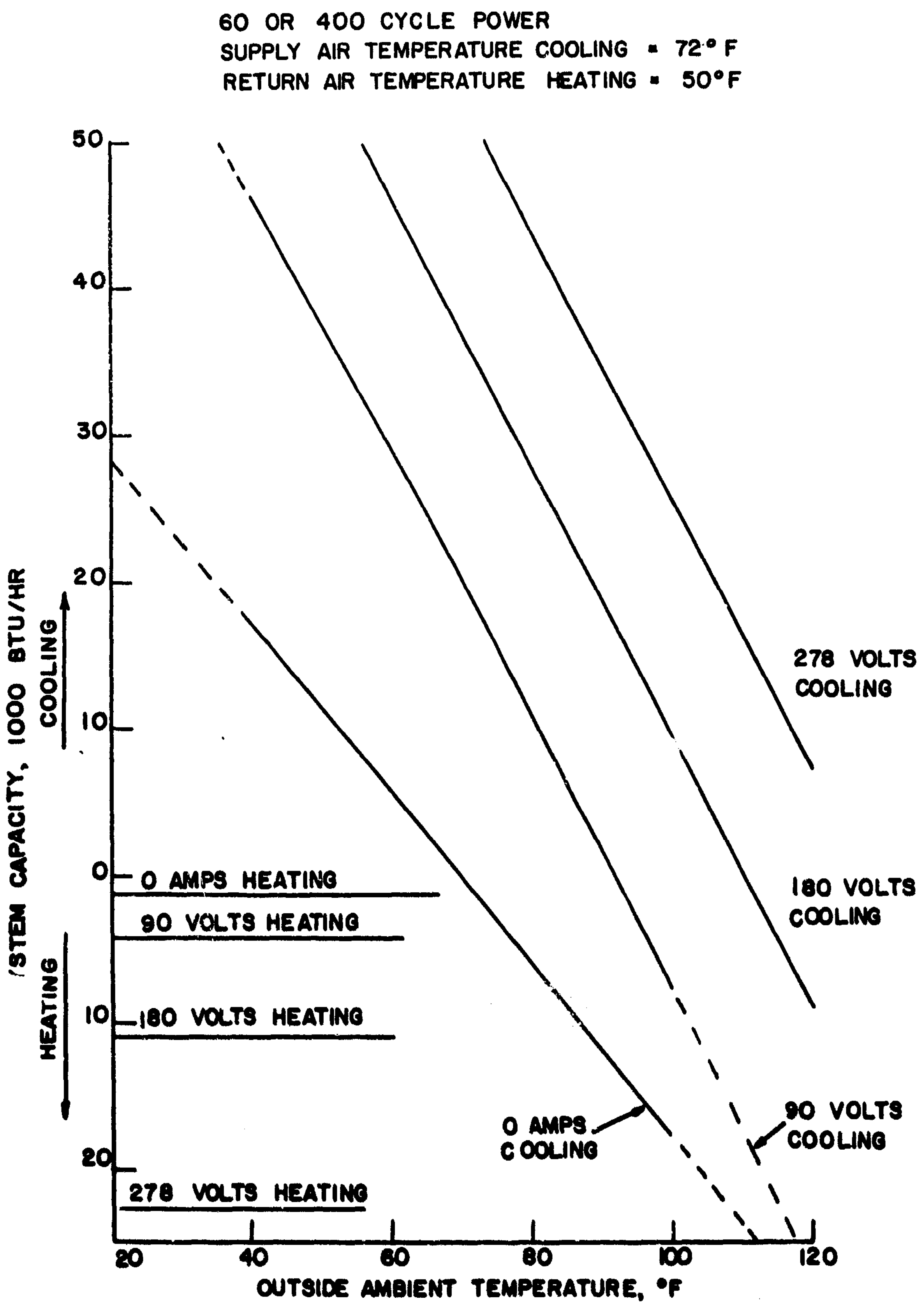


Figure 9. Operating Performance Curve Showing Capacity as a Function of Ambient Temperature and Operating Voltage

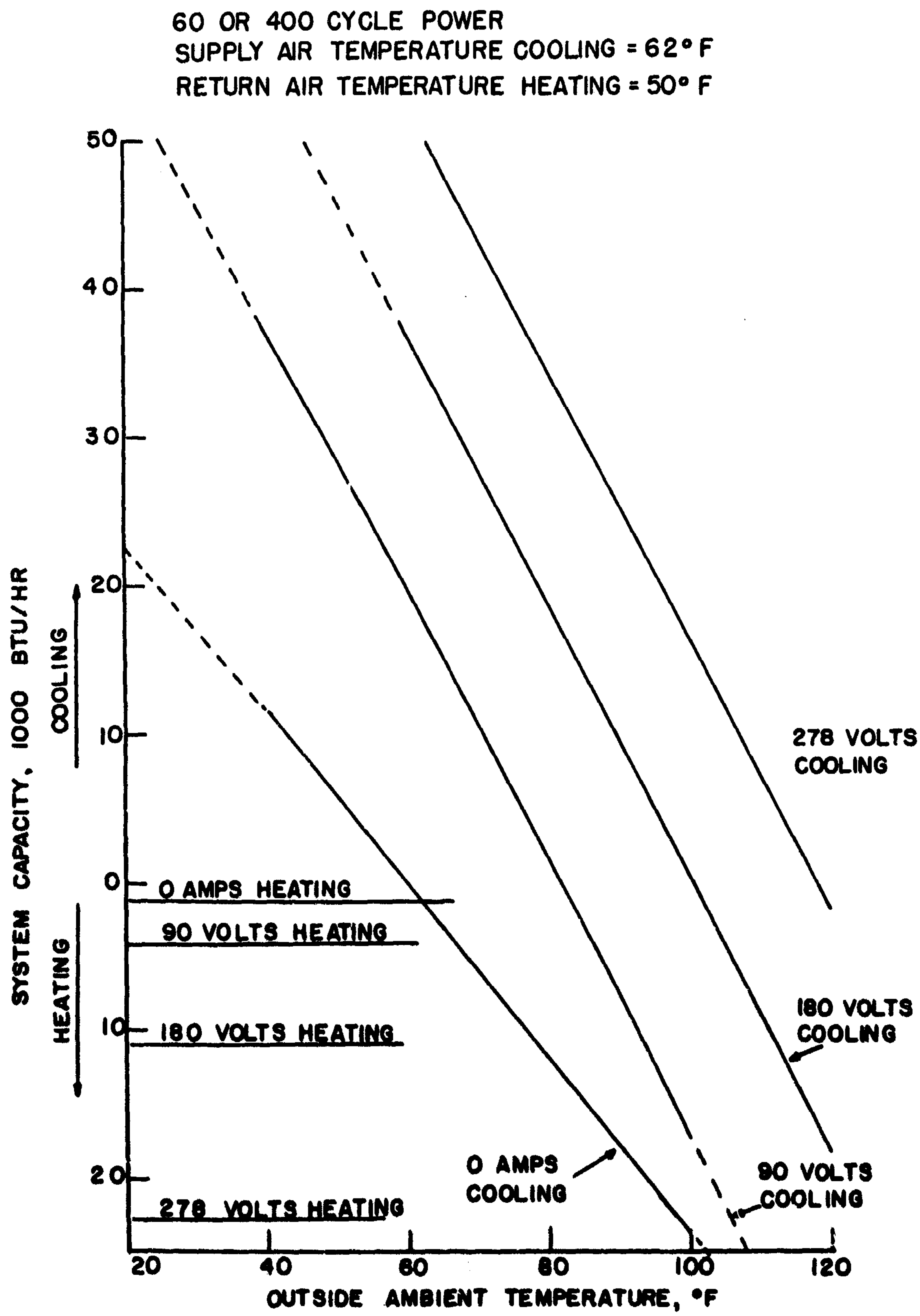


Figure 10. Operating Performance Curve Showing Capacity as a Function of Ambient Temperature and Operating Voltage

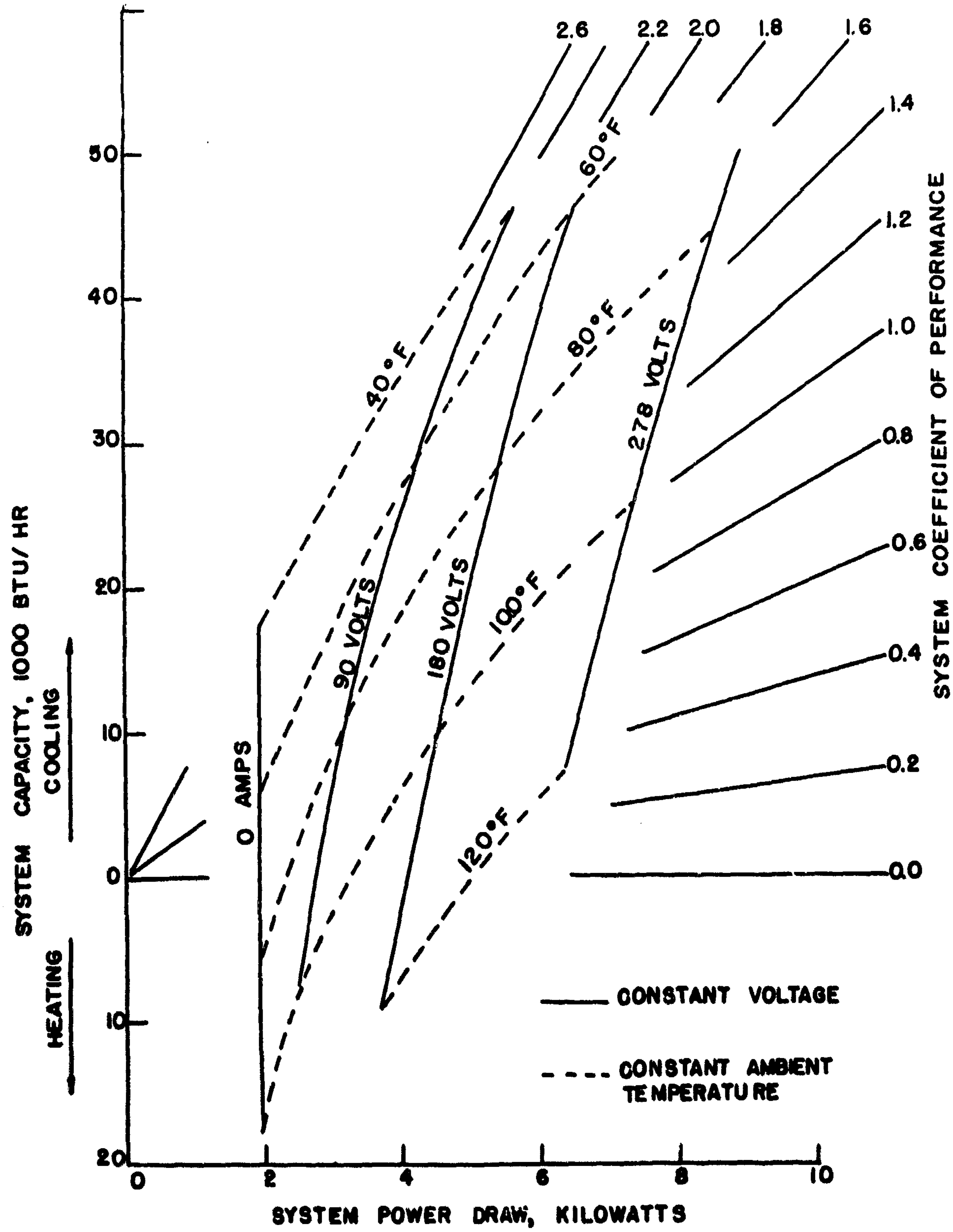


Figure 11. System Cooling Performance
(72°F Supply Air Temperature, 60 Cycle Power)

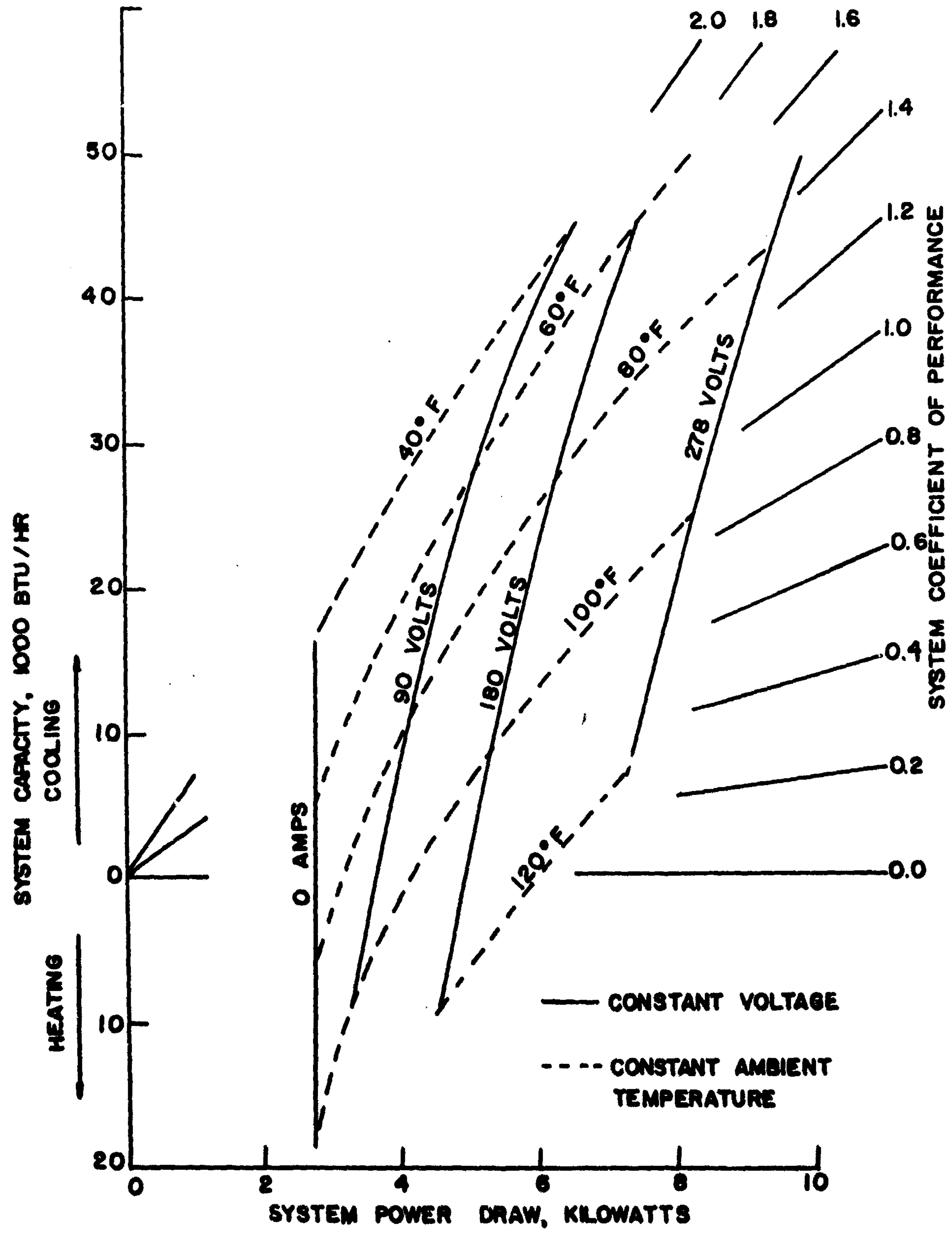


Figure 12. System Cooling Performance
(72°F Supply Air Temperature, 400 Cycle Power)

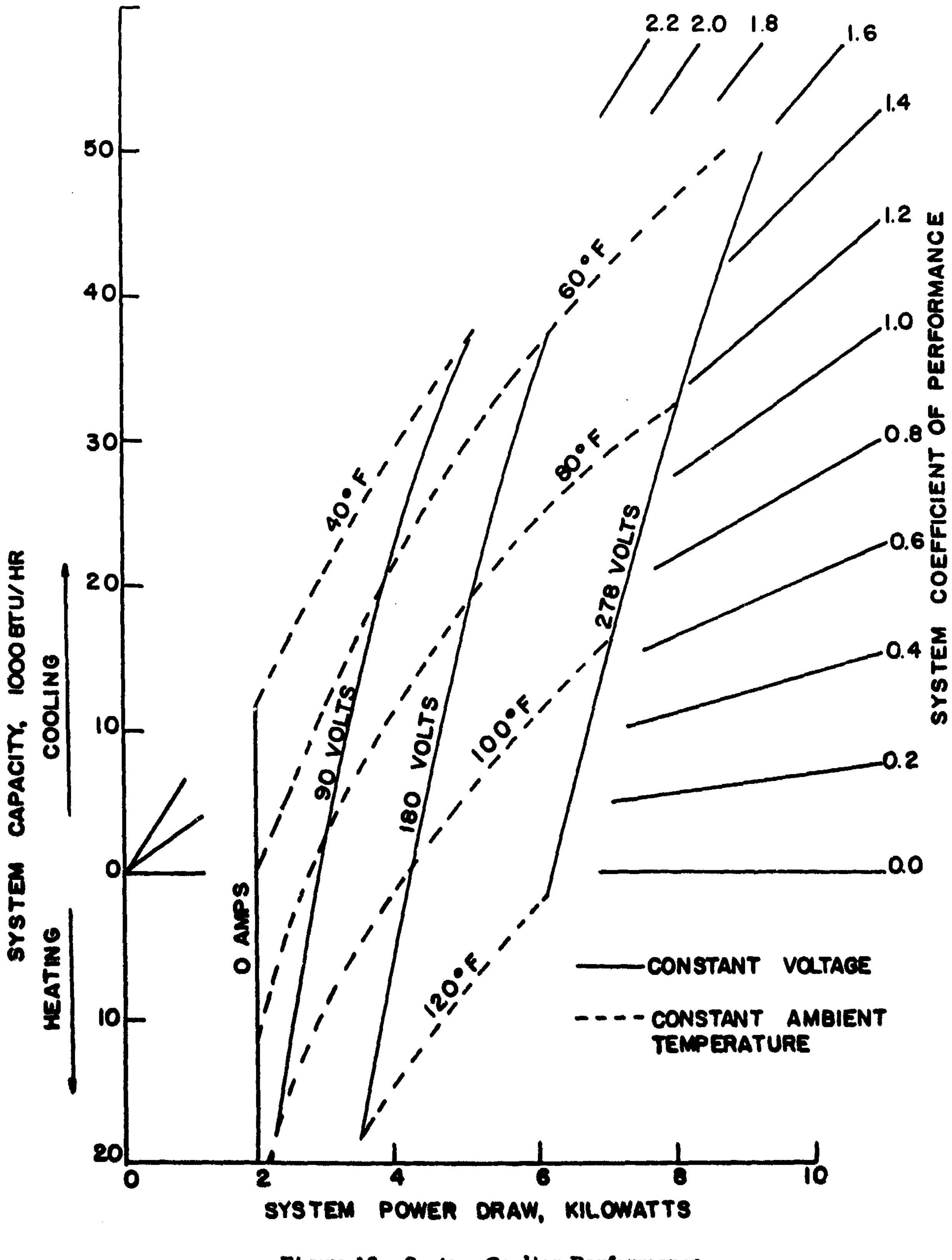


Figure 13. System Cooling Performance (62°F Supply Air Temperature, 60 Cycle Power)

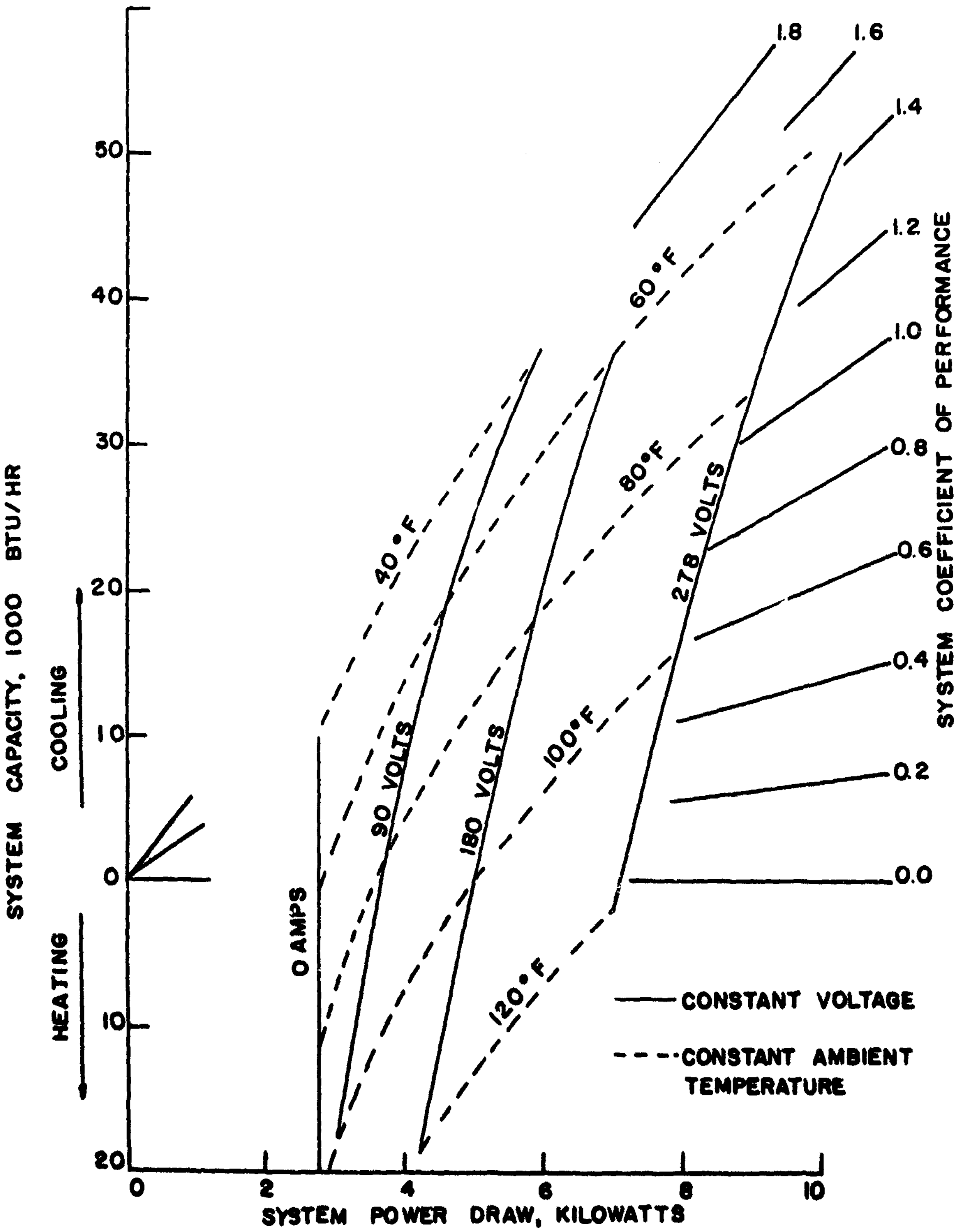


Figure 14. System Cooling Performance
(62°F Supply Air Temperature, 400 Cycle Power)

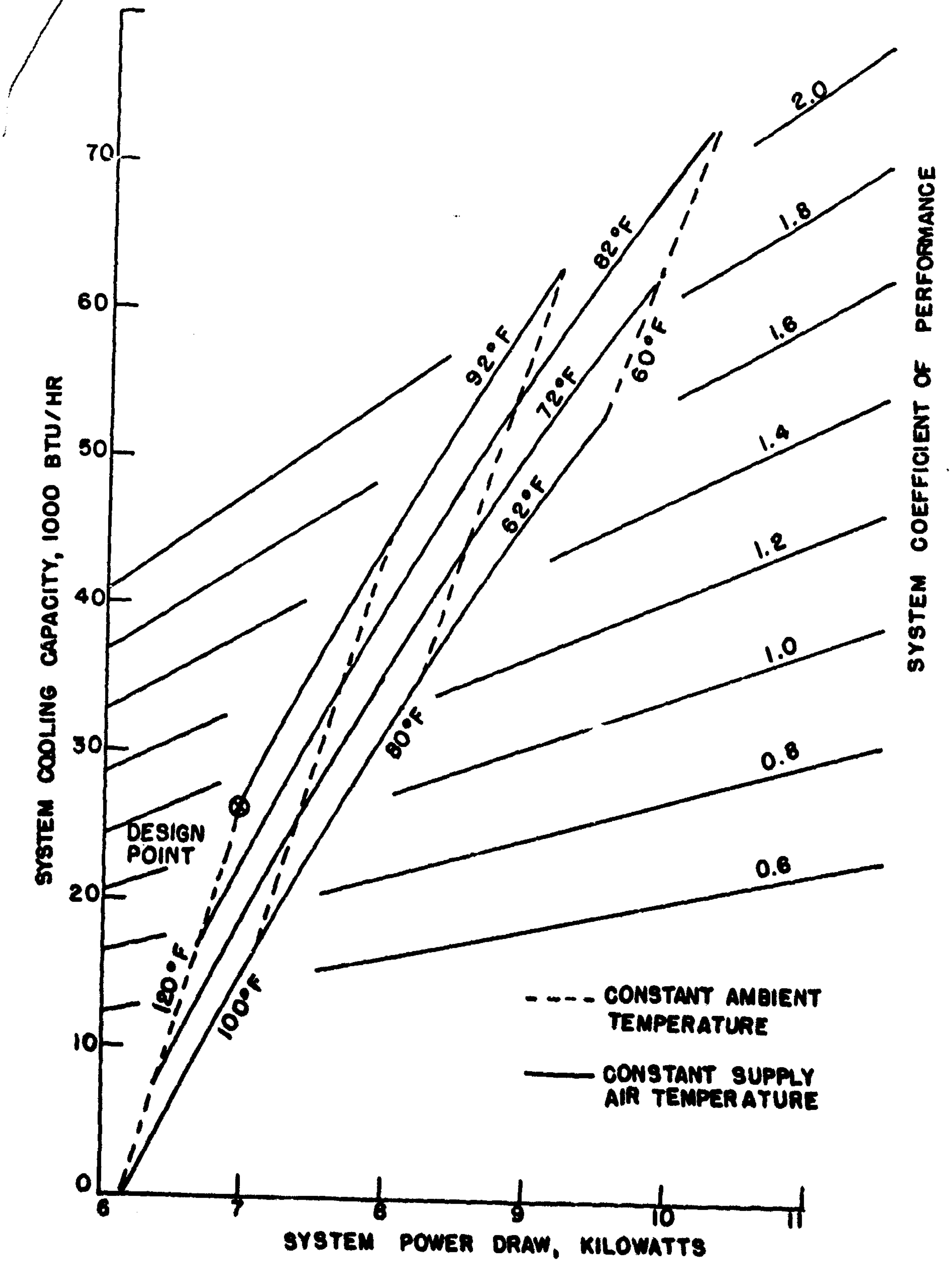


Figure 15. System Cooling Performance
(278 Volt Operation, 60 Cycle Power)

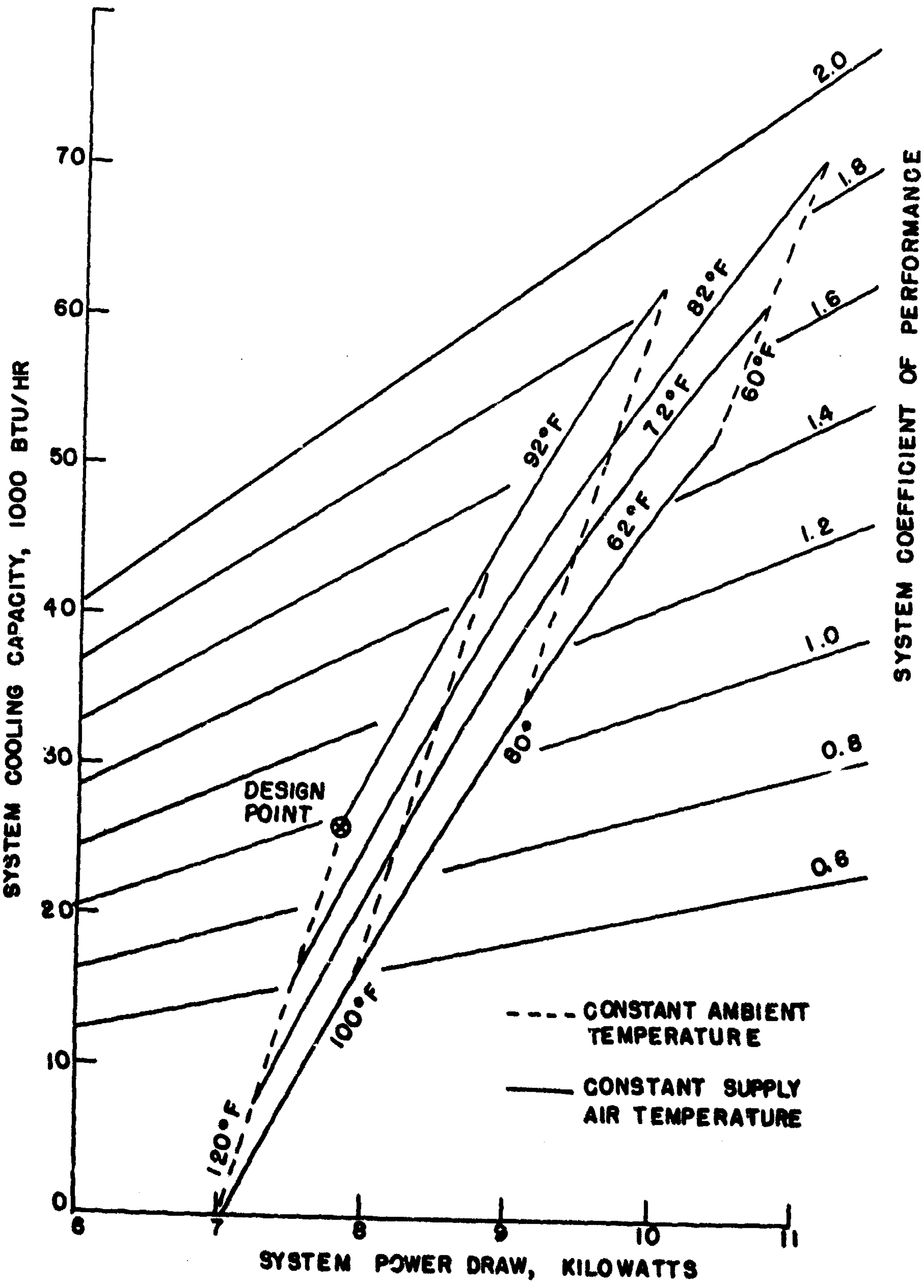


Figure 16. System Cooling Performance
(278 Volt Operation, 400 Cycle Power)

5.0 MAINTENANCE PROCEDURES

5.1 Thermoelectric Module

A thermoelectric module with a broken junction may either be replaced with a spare module or electrically removed from the circuit while it physically remains in the thermoelectric coil. To replace a thermoelectric module:

(1) Remove access cover from outside face.
(2) Identify the bank which contains the defective module.
(3) Remove the top module in this bank by sliding it up about 1 inch and then out.
(4) Remove successive modules from the bank in the same manner until the defective module has been removed.
(5) Replace with a spare module making sure that the module connector pins are properly in place.
(6) Replace the other modules into the bank, again insuring that all connector pins are properly in place.
(7) Replace and fasten down the access cover.

If a spare module is not available, then a defective module may be electrically removed from the circuit by the following procedure:

(1) Remove access cover from outside face.
(2) Remove the top module as described perviously.
(3) Remove successive modules from the bank in the same manner until the defective module has been removed.
(4) After removal of the defective module, replace all other modules into the bank such that each module is one position below its original position.
(5) Leaving the jumper strap in its original position across the top of the uppermost module, replace the bad module into the top position after removing the connector pins.
(6) Replace and fasten down the access cover.

5.2 Internal Fan

In order to remove an internal fan:

(1) Remove access cover from outside face.
(2) Remove the internal air baffle from the front of the fans.
(3) Disconnect fan electrical connector.
(4) Remove fan mounting bolts and remove fan.
(5) Replace fan by reversing steps 1, 2, 3, and 4.

5.3 External Fan

To remove an external fan:

(1) Remove access cover from outside face.
(2) Disconnect fan electrical connector.
(3) Remove fan mounting bolts and remove fan.
(4) Replace fan by rever.. , steps 1, 2, and 3.

5.4 Control and Power Conversion Package

To remove the control and power conversion package:

(1) Remove access cover from outside face.
(2) Remove one external fan.
(3) Remove all electrical connectors from control box.
(4) Remove screws fastening the control box to the unit frame and remove control box.
(5) Replace box by reversing steps 1, 2, 3, and 4.

To remove a printed circuit card from the control and power conversion package:

(1) Remove cover from package.
(2) Slip card from connector and replace with a spare card.
(3) Replace cover.

To remove a bad diode or SCR from the rectifier bridge:

(1) Remove cover from the control box.
(2) Disconnect lead wires from the defective diode or SCR.
(3) Remove the defective component and replace with a spare. Care should be exercised to prevent stripping the copper threads. If a torque wrench is available, the components should be torqued to 30 in.-lb.
(4) Replace the lead wires.
(5) Replace cover.

5.5 Frequency Changeover

The fan motors and the firing circuit for this system are frequency sensitive. Consequently, they must be wired for the proper supply frequency. On the firing circuit, a jumper wire must be removed when the unit is operated at 400 cycles. This wire is marked as indicated on the schematic wiring diagram. Conversely, when operating on 60 cycle this wire must be connected in position.

The fan motors are dual frequency with a separate set of lead wires for each frequency. Each set of wires is connected to an MS connector. The connectors are clearly marked 60 cycle or 400 cycle. The proper connection is determined by the main power supply frequency.

6.0 MANUFACTURING PROCEDURE

The manufacturing procedure used to process thermoelectric panels consists principally of processing semiconductor elements and insulated conductor straps and assembling them into the panel circuit. Detailed process sheets are available which describe the exact step-by-step procedures that have been developed at Carrier's thermoelectric process development and pilot production facility. The applicable process sheets are included in Appendix B.

7.0 COST ESTIMATE

The Purchase Description requests a cost estimate for fabricating one prototype unit and total costs for producing quantities of 10, 50 and 600 units per buy. A detailed price analysis is presented in Figure 17 to show prototype development costs and an estimate for producing ten units. An explanation is in order for these cost estimates as well as for the larger production quantities.

Input data for the price analysis shown has been obtained from actual experience using existing thermoelectric process development facilities and the manufacturing methods described in the previous section. Existing facilities and procedures are adequate for prototype development and for a limited production to meet the requirements of field trial qualification. After absorption of non-recurring development costs, there would be only minor differences in cost per unit up to the maximum capability of the existing facilities and using the manufacturing procedures described earlier. In other words, after the first unit is developed, whether the additional requirement is for three units, five or ten, only slight cost improvement would be possible. The maximum capability of the facility now in use would be about ten units, considering a reasonable delivery time for fabrication. Therefore, the information presented in the price analysis for producing one and ten units should be regarded as reasonably representative for any number within this range, the major difference for quantities smaller than ten being in material costs. Likewise, to reflect substantial reductions in cost, a scale-up to meet volume production requirements would be necessary. This, of course, is not reflected in the price for a range from one to ten units.

For quantities of 50 and 600 units per buy, increased automation of routine procedures would be employed. High volume operations would justify capital expenditures to reduce labor costs and to improve process yield, both of which are significant percentages of unit cost in small quantities as produced by existing methods. One of the major advantages of producing a small number of units, say three to ten, would be to establish production measures which could be employed for large scale-up in capacity.

It is fully recognized that cost will play a major role in determining the ultimate feasibility of thermoelectric systems. The advantages of reliability, size, weight and performance characteristics will, in the final analysis, have to be related to cost in comparison with a conventional system. Carrier believes that the effect of a scale-up to meet true production requirements will be of major significance in reducing thermoelectric system cost to a level where it is competitive with more conventional systems. We do not

CARRIER AIR CONDITIONING COMPANY

MILITARY EQUIPMENT DEPARTMENT
PRICE ANALYSIS

Purchaser USAERDL, Fort Belvoir, Va. Contract No. DA-44-009-AMC-1135(T)
Project Thermoelectric Environmental Control Unit Date September, 1965
Applicable Spec. RFQ No. 65-1816B Estimated by
Type Units Thermoelectric Checked by

PRICE ITEMIZATION	Non-Recurring Preproduction Costs (No. Units 0)	Production Costs (No. Units 1)	Production Costs (No. Units 10)
DIRECT MATERIAL			
Raw Material		5,800	47,000
Purchased Parts		4,700	35,100
FACTORY LABOR			
1,900 Hrs at $ 3.95 /Hr		7,505	
14,500 Hrs at $ 2.50 /Hr			36,250
FACTORY OVERHEAD 145 %		10,882	52,563
ENGINEERING LABOR			
2,000 Hrs at $ 6.50 /Hr	13,000		
500 1,000 Hrs at $ 5.25 /Hr		2,625	5,250
ENGINEERING OVERHEAD 85 %	11,050	2,231	4,463
DRAFTING LABOR			
500 Hrs at $ 4.25 /Hr	2,125		
DRAFTING OVERHEAD 85 %	1,806		
OTHER DIRECT COSTS			
) TESTING MATERIALS - COSTS			
(a) Testing Labor: 100 hrs at 3.95 x 2.45		968	
(b) Testing Labor: 400 hrs at 2.50 x 2.45			2,450
TOTAL MANUFACTURING COSTS	27,981	34,711	183,076
GENERAL & ADMINISTRATIVE EXPENSE 15 %	4,197	5,207	27,461
TOTAL COST	32,178	39,918	210,537
PROFIT 10 %	3,218	3,992	21,054
MISCELLANEOUS COSTS			
(a)			
(b)			
(c)			
TOTAL SELLING PRICE (No. of Units)	35,196	43,910	231,591

Figure 17. Detailed Price Analysis

believe, however, that it is possible, without the experience of prototype development and a limited production for field evaluation purposes, to predict an accurate unit cost for large volume requirements.

It is our belief that no one is in a better position to predict the cost of developing and producing a system of the type described than Carrier. We are the only company to date that has developed and produced a thermoelectric air conditioning system for a commercial application, namely the 28 units provided for the S.C. Johnson application described previously. On the basis of this experience, we believe that a projection of costs to large production quantities would be misleading until after the important first steps of prototype development and limited production for field trial qualification have been completed successfully.

8.0 SUMMARY OF RESULTS

A system analysis has been completed for a 24,000 Btu/hr thermoelectric environmental control unit. In this analysis an electronic analog computer was used to optimize 12 system parameters for minimum weight and maximum efficiency. All important subsystems and sub-system components were also analyzed by weighing the advantages and disadvantages of the design possibilities considered.

From this analysis a design was formulated to meet the system requirements as described in the Purchase Description. A complete set of assembly drawings are provided. The resulting thermoelectric environmental control unit has outside dimensions of 28 inches wide by 18 inches deep by 63 inches high, weighs 380 pounds and will provide 24,000 Btu/hr cooling capacity at an overall system coefficient of performance of 1.12.

Calculations were made to determine the off-design performance characteristics of this system. Performance information is presented in graphical form, and a complete description of how the system operates is included. Operating instructions, maintenance procedures, manufacturing procedures and cost analysis information are also presented.

9.0 RECOMMENDATIONS

On the basis of the results presented herein, it is recommended that development of a prototype unit be initiated. The objectives outlined in the Purchase Description have been met or exceeded by the design provided. Carrier is confident that a successful prototype unit can be built which will be in complete accord with all of the physical and performance characteristics of the design shown.

It is estimated that delivery of a completed unit can be made within nine months from the date of contract award. As shown in the price analysis included in Section 7.0, the estimated cost for producing one unit of the type designed is:

None-recurring developmental costs	$35,196
Production cost	43,910
Total estimated cost	$79,106

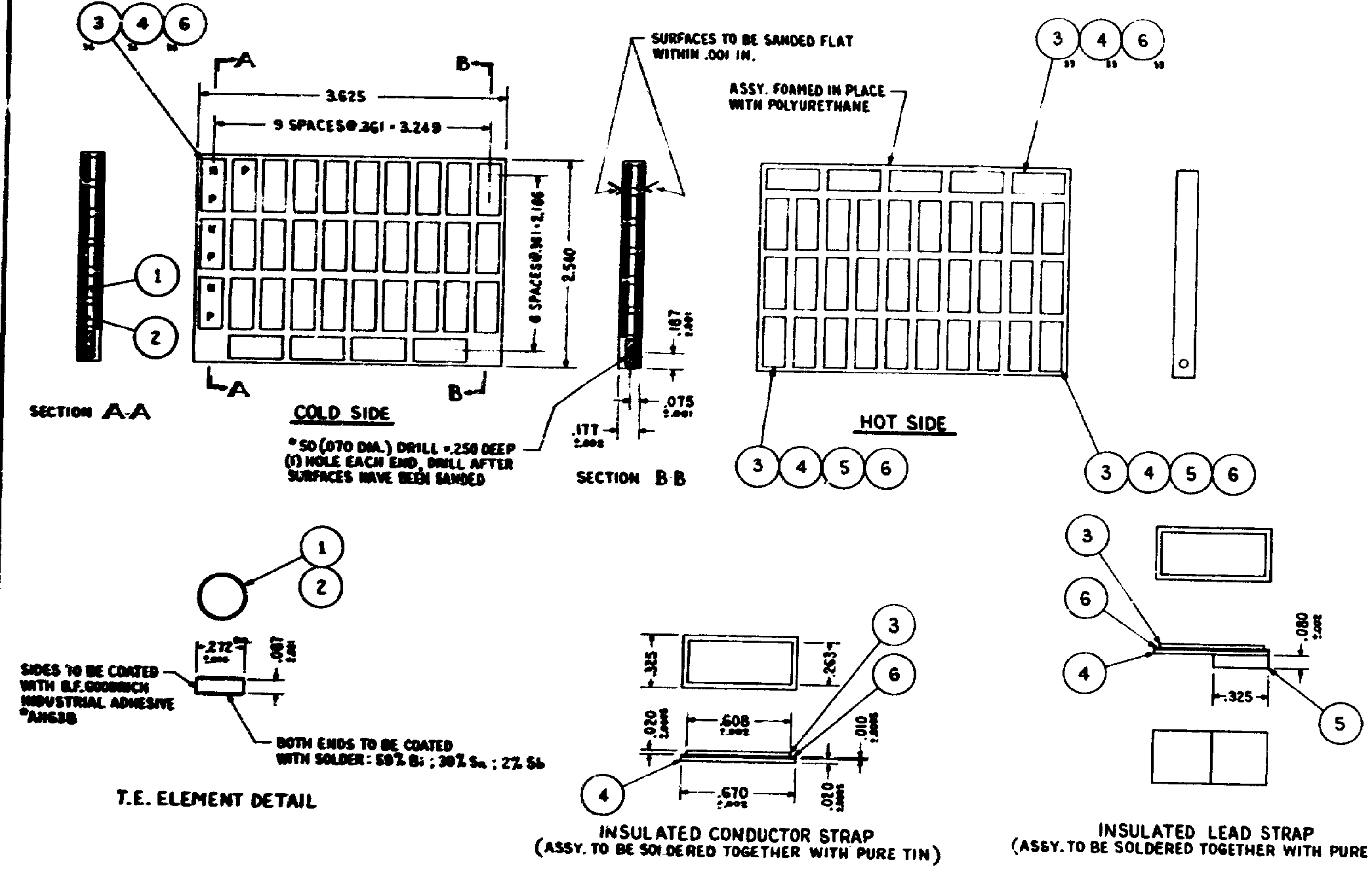
We will welcome the opportunity of working with USAERDL in developing this unit and believe that it is an important and worthwhile step in the application of thermoelectricity to military requirements.

APPENDIX A

LIST OF ASSEMBLY AND SCHEMATIC DRAWINGS

1. R1058-3429 Panel Assy. for T. E. Environmental Control Unit
2. R1058-4430 Module Assy. for T. E. Environmental Control Unit
3. R1058-9434 Frame Assembly for T. E. Environmental Control Unit
4. R1058-9431 Control and Monitor Panel for T. E. Environmental Control Unit
5. R1058-3432 Temperature Sensor Assembly for T. E. Environmental Control Unit
6. R1058-9433 Power Conversion & Control Package for T. E. Environmental Control Unit
7. R1058-4435 Access Cover Assembly for T. E. Environmental Control Unit
8. R1058-9436 Unit Assembly for T. E. Environmental Control Unit
9. R1058-3437 Module Receptacle for T. E. Environmental Control Unit
10. R1058-9439 Air Flow Diagram for T. E. Environmental Control Unit
11. R1058-4428 Schematic Diagram Control and Power Supply for T. E. Environmental Control Unit

ITEM	DWG./PART NO.	REQD.	DESCRIPTION (ROUGH SIZE)	MATERIAL
1	R1058-3429-1	34	"N" TYPE ELEMENT	BISMUTH TELLURIDE
2	-2	34	"P" TYPE ELEMENT	BISMUTH TELLURIDE
3	-3	69	.021 THK. × $\frac{17}{64}$ × $\frac{19}{64}$ LG.	HARD DRAWN COPPER
4	-4	69	.021 THK. × $\frac{21}{64}$ × $\frac{43}{64}$ LG.	HARD DRAWN COPPER
5	-5	2	.081 THK. × $\frac{21}{64}$ × $\frac{21}{64}$ LG.	HARD DRAWN COPPER
6	-6	69	.010 THK. × $\frac{21}{64}$ × $\frac{43}{64}$ LG. (BOTH SIDES METALIZED)	CERAMIC AL_2O_3



USED ON ASSY. R1058-4430
AUTHORIZATION NO. R1058-15

MATERIAL
APPLIED FINISH
TOLERANCES UNLESS OTHERWISE SPECIFIED
DECIMALS ± .005
DR. J. H. COX 8-3-65
SCALE 12"=1'-0" & 24"=1'-0"

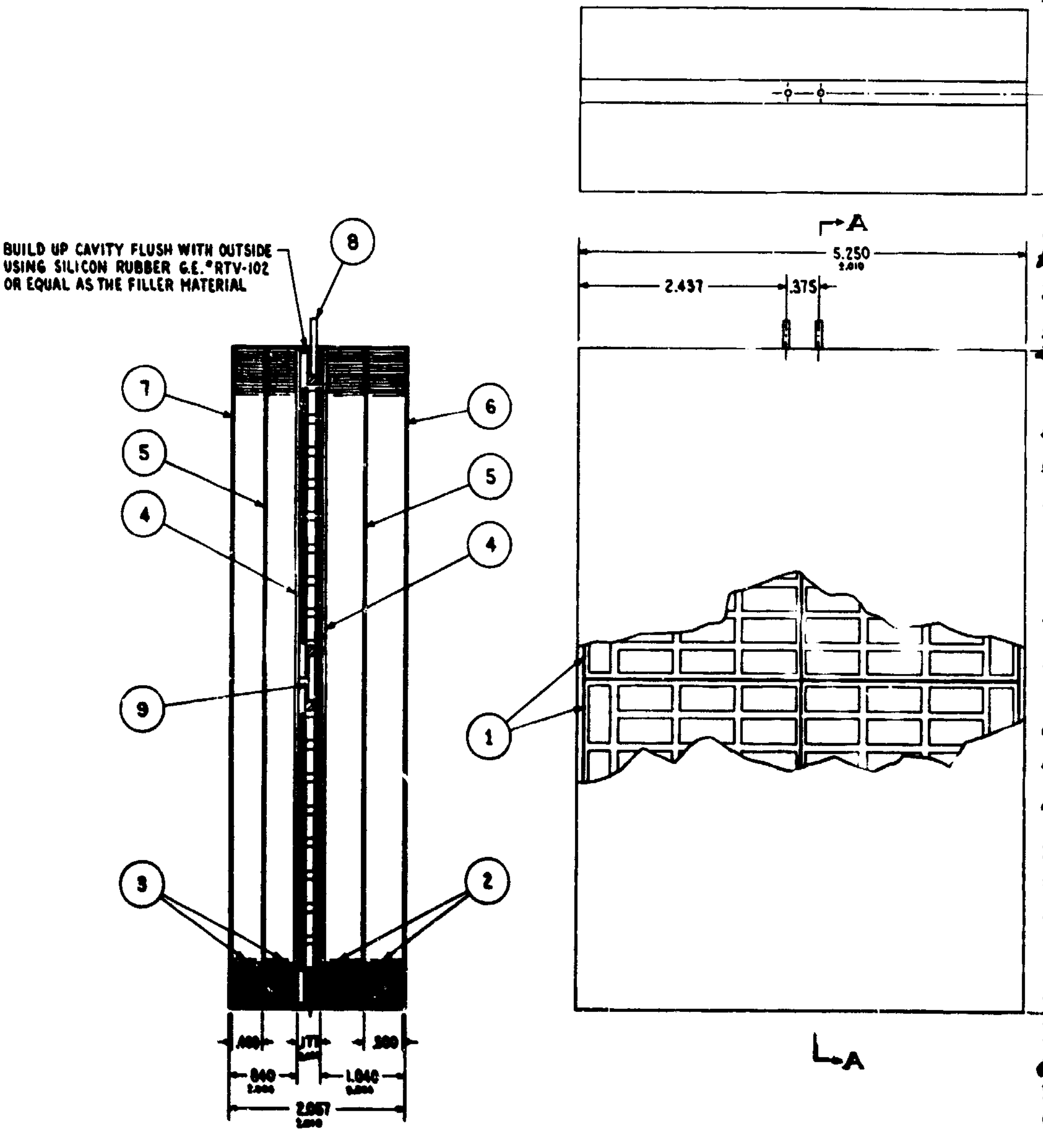
CARRIER CORPORATION
SYRACUSE, NEW YORK, U.S.A.

TITLE: PANEL ASSY. FOR T.E. ENVIRONMENTAL CONTROL UNIT

DWG. NO. R1058-3429

220-008

SUPERSEDED BY



SECTION A-A

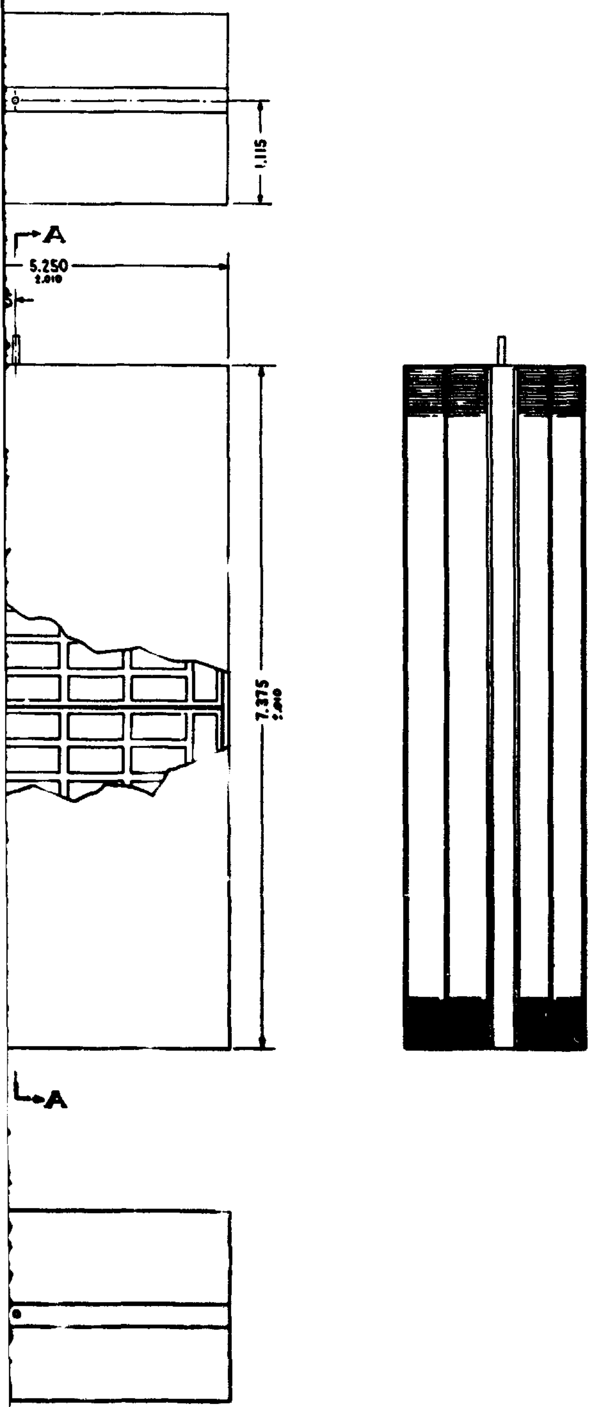
DO NOT REVISE THIS DRAWING WITHOUT REFERRING TO DRAWING NO.

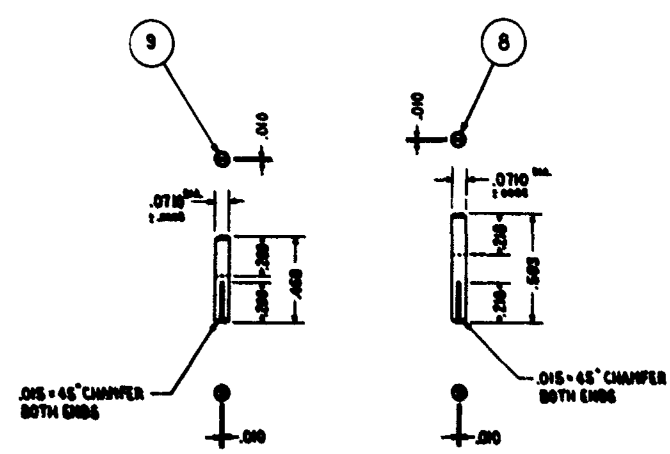
REVISION RECORD

1

REV.	DWG. NO.	SIMILAR TO

ITEM	DWG./PART NO.	REQD.	DESCRIPTION (FINISHED SIZE)	MATERIAL
1	R1058-3429	4	PANEL ASSY.	
2	R1058-4430-2	2	.006 THK. × .500 HIGH × 5.250 × 7.375 LG. FINNED STOCK 30 FINS/INCH STRAIGHT PATTERN	ALUMINUM
3	-3	2	.006 THK. × .400 HIGH × 5.250 × 7.375 LG. FINNED STOCK 30 FINS/INCH STRAIGHT PATTERN	ALUMINUM
4	-4	2	.020 THK. × $5\frac{1}{4}$ × $7\frac{3}{8}$ LG.	ALUMINUM
5	-5	2	.010 THK. × $5\frac{1}{4}$ × $7\frac{3}{8}$ LG.	ALUMINUM
6	-6	1	.010 THK. × $5\frac{1}{4}$ × $9\frac{13}{16}$ LG.	ALUMINUM
7	-7	1	.010 THK. × $5\frac{1}{4}$ × $9\frac{1}{4}$ LG.	ALUMINUM
8	-8	2	$\frac{5}{64}$ DIA. × $\frac{19}{32}$ LG.	FREE CUTTING BRASS
9	-9	2	$\frac{5}{64}$ DIA. × $\frac{15}{32}$ LG.	FREE CUTTING BRASS





CARRIER CORPORATION

SYRACUSE, NEW YORK, U.S.A.

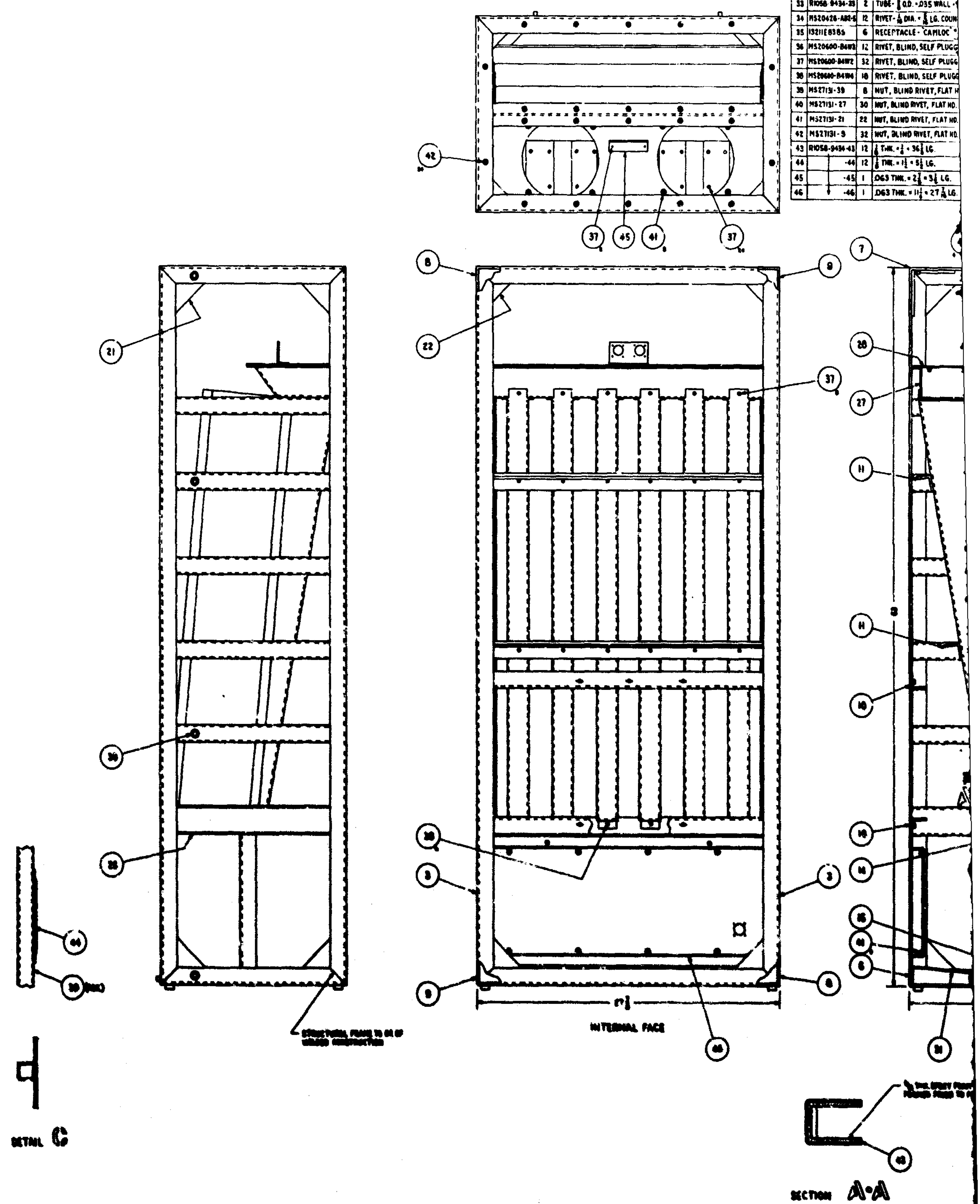
MODULE ASSY.

T.F. ENVIRONMENTAL CONTROL UNIT

DWG. NO. R1058-4430

2

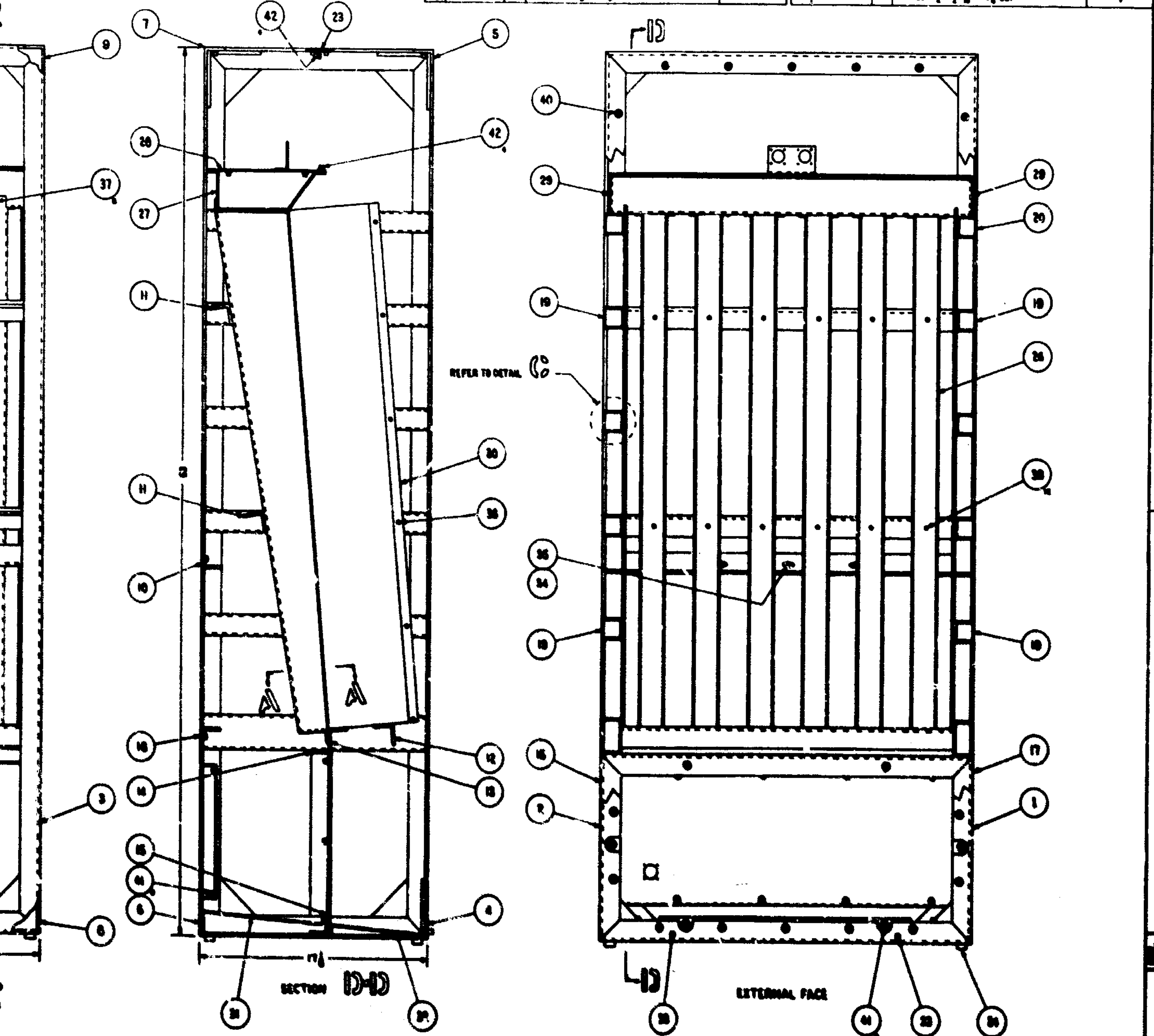
ITEM	DWG./PART NO.	REQD	DESCRIPTION (
33	R1058-9434-33	2	TUBE- $\frac{1}{2}$ O.D. × .035 WALL ×
34	MS20426-AD2-5	12	RIVET- $\frac{1}{16}$ DIA. × $\frac{5}{16}$ LG. COUN
35	13211E8365	6	RECEPTACLE - "CAMLOC"
36	MS20600-B4W3	12	RIVET, BLIND, SELF PLUGG
37	MS20600-B4W2	32	RIVET, BLIND, SELF PLUGG
38	MS20600-B4W4	18	RIVET, BLIND, SELF PLUGG
39	MS27131-39	8	NUT, BLIND RIVET, FLAT H
40	MS27131-27	30	NUT, BLIND RIVET, FLAT HD.
41	MS27131-21	22	NUT, BLIND RIVET, FLAT HD.
42	MS27131-9	32	NUT, BLIND RIVET, FLAT HD.
43	R1058-9434-43	12	$\frac{1}{8}$ THK. × $\frac{1}{2}$ × 36$\frac{3}{4}$ LG.
44	-44	12	$\frac{1}{8}$ THK. × 1$\frac{1}{2}$ × 5$\frac{1}{2}$ LG.
45	-45	1	.063 THK. × 2$\frac{1}{4}$ × 3$\frac{1}{4}$ LG.
46	-46	1	.063 THK. × 11$\frac{1}{4}$ × 27$\frac{7}{16}$ LG.

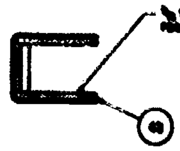


ITEM	DWG./PART NO.	REQ'D	DESCRIPTION (FINISHED SIZE)	MAT'L/PURCHASE
1	R1058-9434-1	1	ANGLE - 1 1/2 × 1 1/2 × 3/16 × 63 LG.	ALUMINUM 6061-T6
2	-2	1	ANGLE - 1 1/2 × 1 1/2 × 3/16 × 63 LG.	
3	-3	2	ANGLE - 1 1/2 × 1 1/2 × 3/16 × 63 LG.	
4	-4	1	ANGLE - 1 1/2 × 1 1/2 × 3/16 × 27 3/8 LG.	
5	-5	1	ANGLE - 1 1/2 × 1 1/2 × 3/16 × 27 3/8 LG.	
6	-6	1	ANGLE - 1 1/2 × 1 1/2 × 3/16 × 27 3/8 LG.	
7	-7	1	ANGLE - 1 1/2 × 1 1/2 × 3/16 × 27 3/8 LG.	
8	-8	2	ANGLE - 1 1/2 × 1 1/2 × 3/16 × 17 1/8 LG.	
9	-9	2	ANGLE - 1 1/2 × 1 1/2 × 3/16 × 17 1/8 LG.	
10	-10	1	ANGLE - 1 1/2 × 1 1/2 × 3/16 × 27 1/2 LG.	
11	-11	2	ANGLE - 1 1/2 × 1 1/2 × 3/16 × 24 3/8 LG.	
12	-12	1	ANGLE - 1 1/2 × 1 1/2 × 3/16 × 24 3/8 LG.	
13	-13	1	ANGLE - 1 1/2 × 1 1/2 × 3/16 × 24 3/8 LG.	
14	-14	1	ANGLE - 1 1/2 × 1 1/2 × 3/16 × 27 3/8 LG.	
15	-15	1	ANGLE - 1 1/2 × 1 1/2 × 3/16 × 27 3/8 LG.	
16	-16	1	ANGLE - 1 1/2 × 1 1/2 × 3/16 × 13 3/8 LG.	

ITEM	DWG./PART NO.	REQ'D	DESCRIPTION (FINISHED SIZE)	MAT'L/PURCHASE
17	R1058-9434-17	1	ANGLE - 1 1/2 × 1 1/2 × 3/16 × 13 1/4 LG.	ALUMINUM 6061-T6
18	-18	1	ANGLE - 1 1/2 × 1 1/2 × 3/16 × 24 3/8 LG.	
19	-19	4	SQUARE TUBE - 1 1/2 × 1/8 WALL × 16 3/4 LG.	ALUMINUM 6063-T5
20	-20	6	SQUARE TUBE - 1 1/2 × 1/8 WALL × 16 3/8 LG.	
21	-21	12	GUSSET - .190 THK. × 2 3/4 × 2 3/4 (MAKES TWO PIECES)	ALUMINUM 6061-T6
22	-22	12	GUSSET - .190 THK. × 4 × 4 (MAKES TWO PIECES)	
23	-23	1	TEE - 2" × " × 1/8 THK. × 27 1/2 LG.	
24	-24	4	BAR - 3/4 DIA. × 3/8 LG.	ALUMINUM 6061-T651
25	-25	2	.125 THK. × 5 1/8 × 16 3/4 LG.	ALUMINUM 6061-T6
26	-26	6	.063 THK. × 6 3/8 × 40 1/4 LG. (REFER TO SECTION A-A)	
27	-27	1	.063 THK. × 15 1/2 × 27 1/4 LG.	
28	-28	1	.063 THK. × 8 3/8 × 27 1/2 LG.	
29	-29	2	.063 THK. × 3 × 11 1/2 LG.	
30	-30	2	.015 THK. × 8 1/8 × 36 3/8 LG.	STAINLESS STL. 302
31	-31	1	.032 THK. × 8 1/4 × 30 1/4 LG.	ALUMINUM 6061-T6
32	-32	1	.032 THK. × 7 3/8 × 28 3/4 LG.	

ITEM	DWG./PART NO.	REQ'D	DESCRIPTION (FINISHED SIZE)	MAT'L/PURCHASE
33	R1058-9434-33	2	TUBE - 3/8 O.D. × .035 WALL × 3/16 LG.	ALUMINUM 6061-T6
34	MS20426-AD2-5	12	RIVET - 1/16 DIA. × 5/16 LG. COUNTERSUNK HD.	ALUMINUM 1100-F
35	132IIE8385	6	RECEPTACLE - "CAMLOC" #12R1-1AA	PURCHASE
36	MS20600-B4W3	12	RIVET, BLIND, SELF PLUGGING - 1/8 DIA.	
37	MS20600-B4W2	32	RIVET, BLIND, SELF PLUGGING - 1/8 DIA.	
38	MS20600-B4W4	18	RIVET, BLIND, SELF PLUGGING - 1/8 DIA.	
39	MS27131-39	8	NUT, BLIND RIVET, FLAT HD. CLOSED END 3/8-24UNF	
40	MS27131-27	30	NUT, BLIND RIVET, FLAT HD. CLOSED END 1/4-28 UNF	
41	MS27131-21	22	NUT, BLIND RIVET, FLAT HD. OPEN END #10-32 UNF	
42	MS27131-9	32	NUT, BLIND RIVET, FLAT HD. CLOSED END #6-32 UNC	
43	R1058-9434-43	12	1/8 THK. × 1/2 × 36 3/8 LG.	[illegible]
44	-44	12	1/8 THK. × 1 1/4 × 7 1/2 LG.	
45	-45	1	.063 THK. × 2 3/8 × 3 1/4 LG.	ALUMINUM 6061-T6
46	-46	1	.063 THK. × 11 1/2 × 27 3/16 LG.	





SECTION A-A

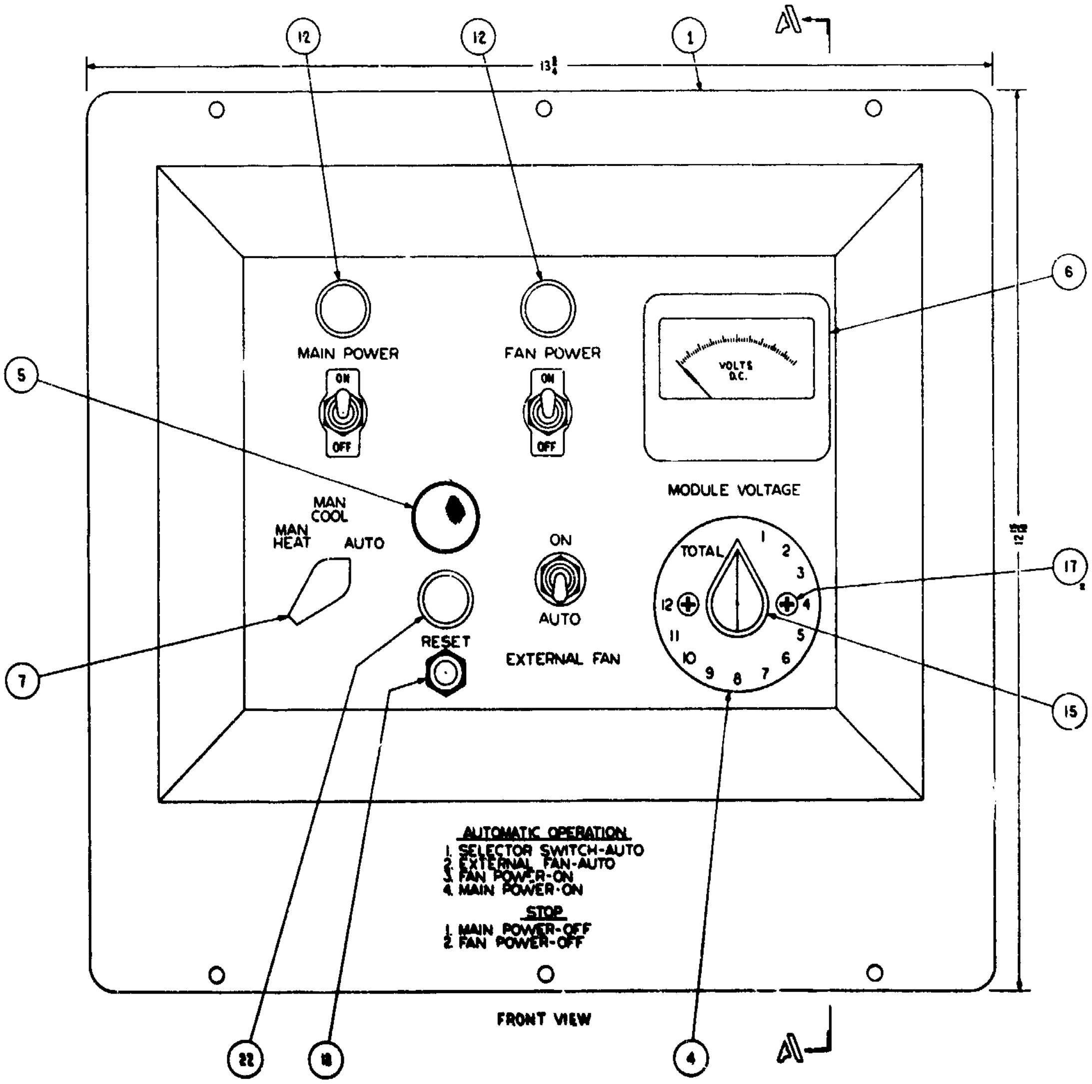
CARRIER CORPORATION

SYRACUSE, NEW YORK, U.S.A.

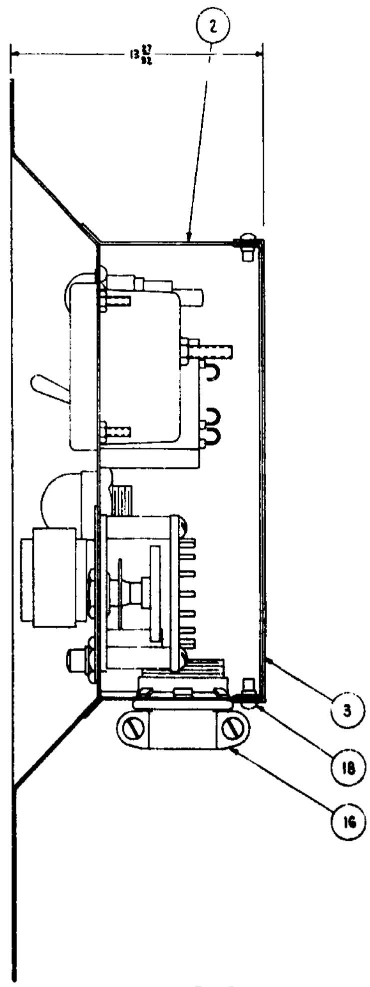
FRAME ASSEMBLY
T.E. ENVIRONMENTAL CONTROL UNIT

DWG. NO. R1058-9434

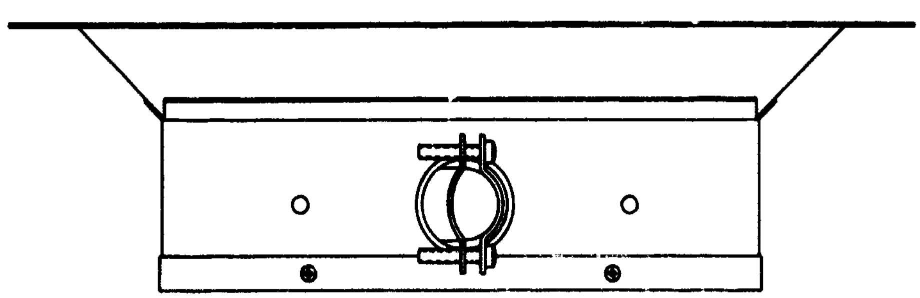
12



FRONT VIEW

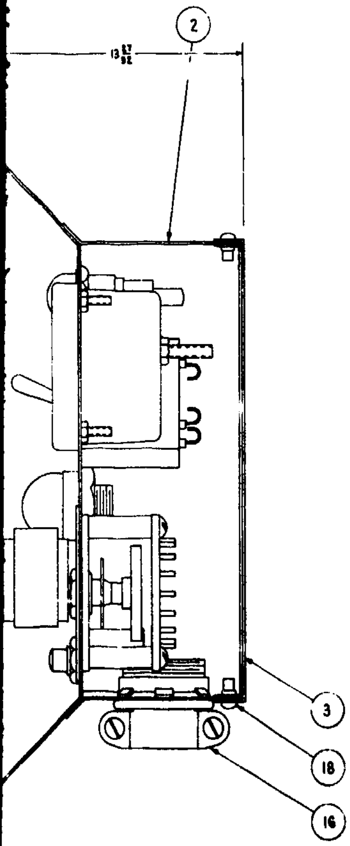


SECTION A-A

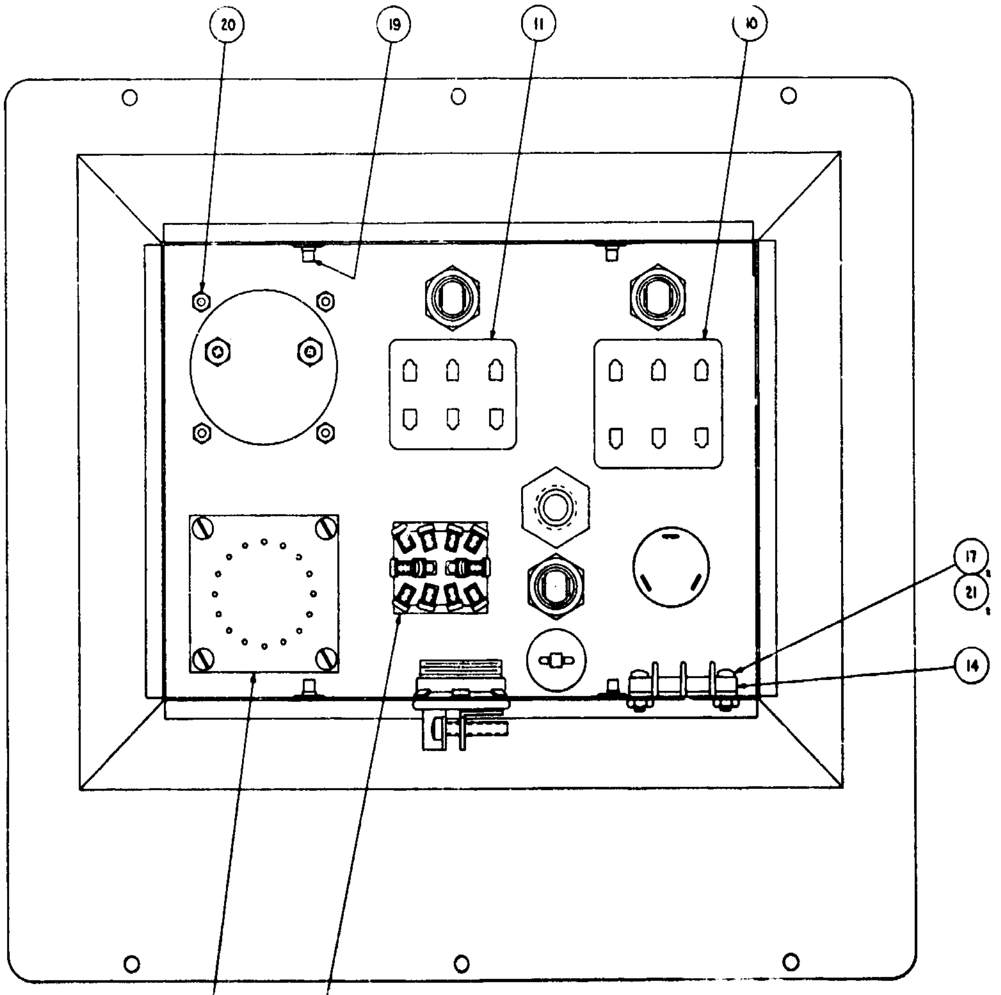


ITEM	SYMBOL	DWG / PART NO.	REQD	DESCRIPTION (FINISHED SIZE)	MATERIAL / PURCHASE
16		R1058-9431-16	1	CONNECTOR "THOMAS & BETTS" [illegible]	PURCHASE
17		MS35206-42	4	#8-32 NC × [illegible] LG PAN HD MACH SCREW	
18		MS35206-16	4	#4-40 NC × [illegible] LG PAN HD MACH SCREW	
19		MS27130-1	4	#4-40 NC NUT, BLIND RIVET, FLAT HD	
20		MS21044-N04	4	#4-40 NC HEX LOCKNUT	
21		MS21044-N08	2	#8-32 NC HEX LOCKNUT	
22	PL3	MS25256-6	1	LIGHT - 14 VOLT LAMP T-1¾	

ITEM	SYMBOL	DWG / PART NO.	REQD	DESCRIPTION (FINISHED SIZE)	MATERIAL / PURCHASE
1		R1058-9431-1	1	PANEL - .063 THK × 12[illegible] × 13[illegible] LG	ALUMINUM 6061-T6
2		-2	1	CLOSURE - .063 THK × 2[illegible] × 9[illegible] LG	
3		-3	1	COVER - .063 THK × 7[illegible] × 9[illegible] LG	
4		-4	1	NAME PLATE - .063 THK × 2[illegible] DIA.	
5	TH1	R1056-3432	1	TEMPERATURE SENSOR ASSY.	
6	VM	R1058-9431-6	1	VOLT METER "WESTON" #1921, PLASTIC FRONT	PURCHASE
7	SW1	-7	1	3 POSITION SWITCH - "CARLING" # 700-12-2-BL	
8	SW2	-8	1	4 POLE SWITCH - J-B-T	
9	SW3	-9	1	ROTARY SWITCH - "DAVEN" #1220B-16A	
10	CB1	-10	1	CIRCUIT BREAKER, 3 POLE - "HEINEMANN" #[illegible] FAST TRIP	
11	CB2	-11	1	CIRCUIT BREAKER, 3 POLE - "HEINEMANN" #[illegible] SLOW TRIP	
12	PL1, PL2	-12	2	LIGHT - "DIALCO" # 95408-933	
13	RESET	MS25089-3C	1	SWITCH - "CONTROLS CO. OF AMERICA"	
14		R1058-9431-14	1	TERMINAL BLOCK - "KULKA" # 601-2	
15		-15	1	KNOB - "FELSENTHAL INST. CO." # FNA-2790/252/[illegible]	



SECTION A-A



REAR VIEW
(WITH COVER REMOVED)

USED ON ASSY. R1058-9430
AUTHORIZATION NO. R1058-[illegible]

MANUFACTURED		PURCHASED		
APPROVED FOR	[illegible]	DATE		DATE

REVISION RECORD | DATE | BY | APPD BY | CHKD BY | E.C.A. NO. | FINAL PROD. | TOOL PROD. RUN

MATERIAL

APPLIED FINISH

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRACTIONS	DECIMALS	ANGLES
±	±	±
SURFACES	HOLE SPACING	HOLE LOCATION
	±	±
	NON-CUMULATIVE	

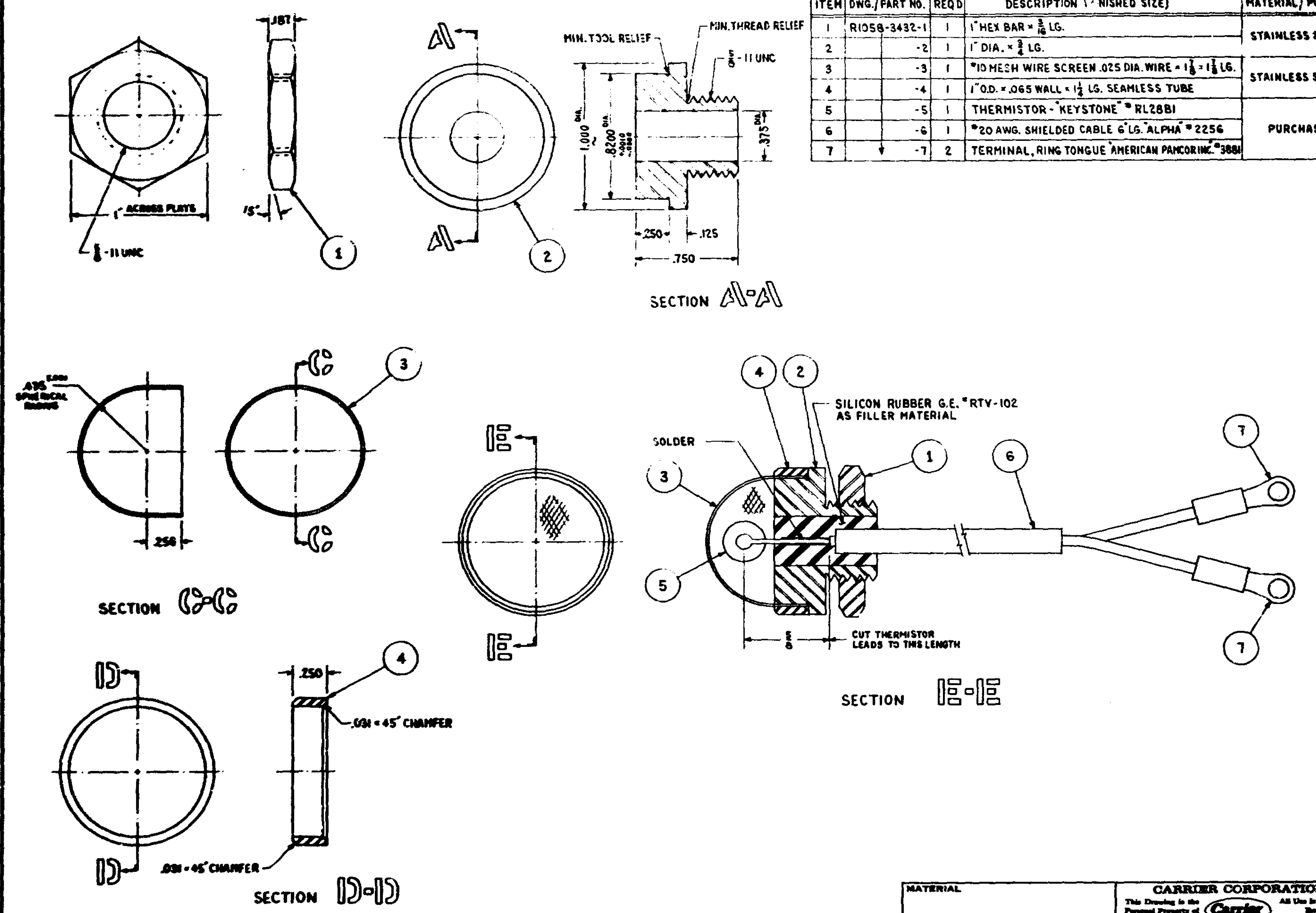
DR. [illegible] | [illegible] | SCALE DO NOT SCALE DRAWING | [illegible]
CHKD.

CARRIER CORPORATION
This Drawing is the Personal Property of Carrier Corporation | Carrier | All Use is Prohibited Except on its Written Consent
SYRACUSE, NEW YORK, U.S.A.

TITLE
CONTROL AND MONITOR PANEL FOR T. E. ENVIRONMENTAL CONTROL UNIT

DWG. NO. R1058-9431

12



ITEM	DWG./PART NO.	REQ'D	DESCRIPTION (FINISHED SIZE)	MATERIAL/PURCHASE
1	R1058-3432-1	1	1" HEX BAR × 3/16 LG.	STAINLESS STL. 303
2	-2	1	1" DIA. × 3/4 LG.	
3	-3	1	#10 MESH WIRE SCREEN .025 DIA. WIRE × 1 7/8 × 1 7/8 LG.	STAINLESS STL. 304
4	-4	1	1" O.D. × .065 WALL × 1 1/4 LG. SEAMLESS TUBE	
5	-5	1	THERMISTOR - "KEYSTONE" # RL28B1	PURCHASE
6	-6	1	#20 AWG. SHIELDED CABLE 6' LG. "ALPHA" # 2256	
7	-7	2	TERMINAL, RING TONGUE "AMERICAN PAMCOR INC." # 3881	

USED ON ASSY. R1058-3431
AUTHORIZATION NO. R1058-13

MATERIAL

APPLIED FINISH

TOLERANCES UNLESS OTHERWISE SPECIFIED: FRACTIONS ± 1/32; DECIMALS ± .010; ANGLES ±; SURFACES 63 √ AIN.

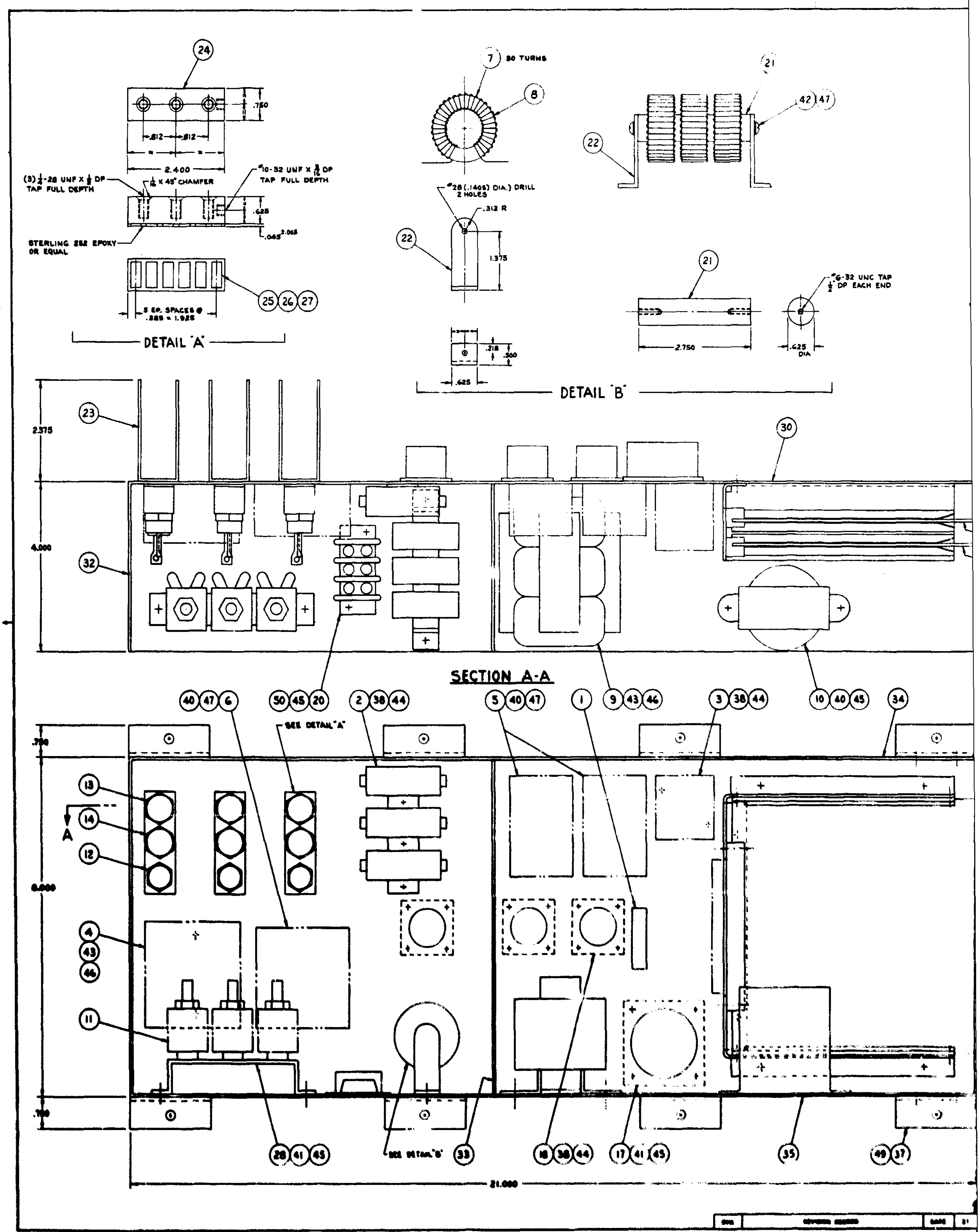
DR. J.H. COX 9-15-65 SCALE 24" = 1'-0"

CARRIER CORPORATION
SYRACUSE, NEW YORK, U.S.A.

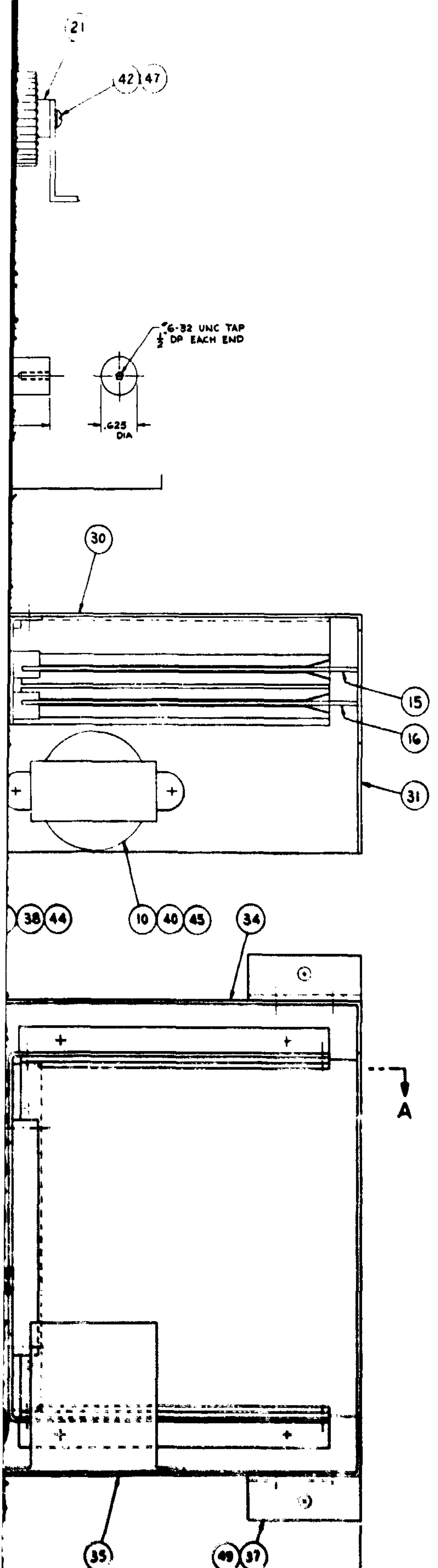
TITLE: TEMPERATURE SENSOR ASSEMBLY FOR T.E. ENVIRONMENTAL CONTROL UNIT

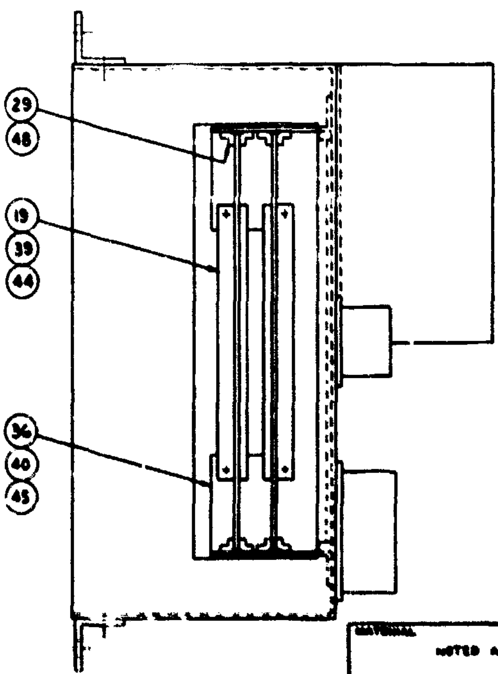
DWG. NO. R1058-3432

220-008



DETAIL "A"
(3) 1/4-28 UNF X 1/2 DP TAP FULL DEPTH
1/16 X 45° CHAMFER
#10-32 UNF X 3/16 DP TAP FULL DEPTH
STERLING 282 EPOXY OR EQUAL
2.400
.812
.750
.625
5 EQ. SPACES @ .385 = 1.925
30 TURNS
#28 (.1405) DIA.) DRILL 2 HOLES
.312 R
1.375
#6-32 UNC TAP 1/2 DP EACH END
2.750
.625 DIA
DETAIL "B"
SECTION A-A
SEE DETAIL "A"
SEE DETAIL "B"
21.000





ITEM	SYMBOL	DWG PART NO.	REQ'D	DESCRIPTION	MAT'L / PURCH
1	C3	[illegible]	1	CAPACITOR 150 MFD 50V	PURCHASE
2	C1, C2	R1058-9433-2	2	CAPACITOR - SPRAGUE # [illegible]	
3	CR1	-3	1	RELAY - RBM CONTROL # 4825-902	
4	RR	-4	1	RELAY, REVERSING - KURMAN # 264.2C24DC	
5	FR, MC	-5	2	RELAY - KURMAN # 263C24DC	
6	MAN	-6	1	RELAY - KURMAN # 264C24DC	
7	L1, L2, L3	-7	3	#14 HF WIRE 30 TURNS	COPPER
8		-8	3	ARNOLD CORE # A-254168-2	PURCHASE
9	TRANS-1	-9	1	TRANSFORMER-"REGULUS" # Q-1167	
10	TRANS-2	-10	1	TRANSFORMER-THORDARSON # 23V160	
11	Z8, Z9, Z10	-11	3	THYRECTOR DIODE-G.E. # 6RS21SA6D6	
12	SCR1,2,3	JAN 2N690	3	SILICON CONTROLLED RECTIFIER 600V 35A	
13	D1, D2, D3	R1058-9433-13	3	DIODE - G.E. # 1N3767 635V 35A	
14	D4, D5, D6	R1058-9433-14	3	DIODE - G.E. # 1N3767R 635V 35A	
15		-15	1	PC BOARD	
16		-16	1	PC BOARD	
17		MS 3102A28-11P	1	CONNECTOR	
18		MS 3102A16-10S	3	CONNECTOR	
19		R1058-9433-19	2	CONNECTOR, PC ELCO # R-616-1	
20		-20	1	TERMINAL STRIP - KULKA # 601-3	
21		-21	1	5/8 x 2 3/4 LG. ROD	ALUMINUM, 6061-T6
22		-22	2	11 GA. (.090) x 7/8 x 2 1/4 LG ROD SUPPORT	
23		-23	3	14 GA (.063) X 4 X 5 3/4 LG FIN	
24		-24	3	5/8 x 3/4 x 2 1/16 LG RECTIFIER MOUNT	COPPER
25		R1058-3429-3	18	.021 THK x 17/64 x 63/64 LG	
26		R1058-3429-4	18	.021 THK x 31/64 x 43/64 LG	
27		R1058-3429-6	18	.010 THK x 31/64 x 43/64 LG	CERAMIC Al_2O_3
28		R1058-9433-28	1	11 GA. (.090) x 3/4 x 6 LG SUPPORT BRKT	ALUMINUM, 6061-T6
29		-29	4	PCB GUIDE - BIRTCHER # 158-11-3	PURCHASE
30		-30	1	11 GA (.090) x 8" x 21" REAR PANEL	ALUMINUM, 6061-T6
31		-31	1	14 GA (.063) x 4" x 8" SIDE PANEL	
32		-32	1	14 GA (.063) x 4" x 8" SIDE PANEL	
33		-33	1	14 GA (.063) x 4" x 8" PARTITION	
34		-34	1	14 GA (.063) X 4" X 21" TOP PANEL	
35		-35	1	14 GA (.063) x 4" x 21" BOTTOM PANEL	
36		-36	1	14 GA (.063) x 2 3/8 x 17 3/4 PCB BRKT	
37		-37	8	11 GA (.090) x 3/4 x 3/4 x 2" LG ANGLE	
38		MS 35206-15	17	#4-40 UNC x 5/16 LG MACH. SCREW, PAN HD	PURCHASE
39		-18	4	#4-40 UNC x 3/4 LG MACH. SCREW, PAN HD	
40		-24	20	#6-32 UNC x 3/8 LG MACH. SCREW, PAN HD	
41		-28	10	#6-32 UNC x 7/8 LG MACH. SCREW, PAN HD	
42		-27	2	#6-32 UNC x 3/4 LG MACH. SCREW, PAN HD	
43		-40	6	#8-32 UNC x 1/2 LG MACH. SCREW, PAN HD	
44		MS21044-N04	21	#4-40 UNC HEX LOCK NUT	
45		-N06	20	#6-32 UNC HEX LOCK NUT	
46		-N08	6	#8-32 UNC HEX LOCK NUT	
47		R1058-9433-47	14	#6 SPLIT LOCK WASHER (STEEL)	
48		MS20470-A[illegible]-3	8	3/32 DIA x 3/16 LG RIVET	
49		MS 20600-[illegible]	16	1/8 DIA x 3/8 LG RIVET	
50		MS 35206-28	2	#6-32 UNC x 1/2 LG MACH. SCREW, PAN HD	

MATERIAL
NOTED ABOVE

CARRIER CORPORATION

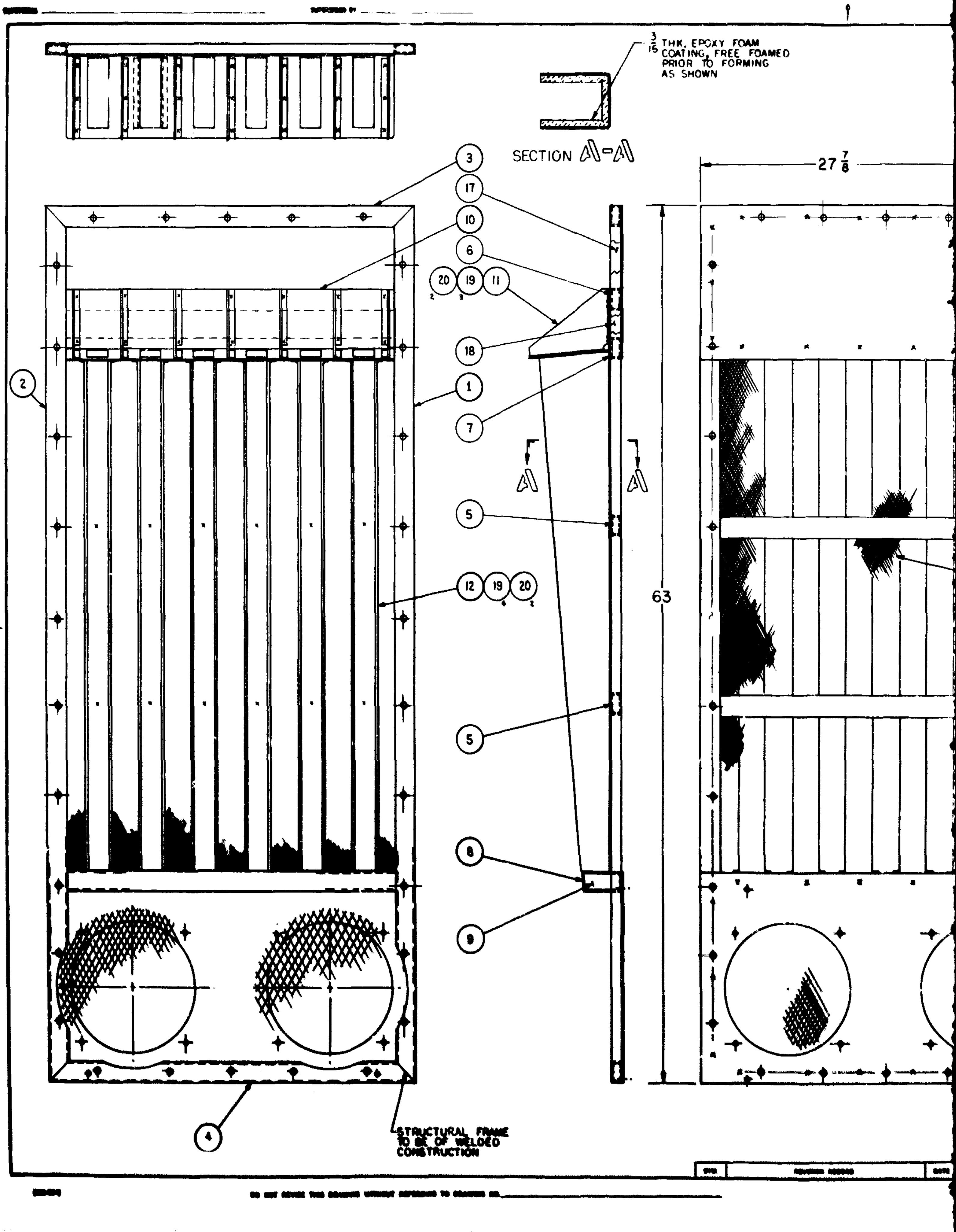
SYRACUSE, NEW YORK, U.S.A.

TITLE POWER CONVERSION & CONTROL PACKAGE FOR T.E. ENVIRONMENTAL CONTROL UNIT

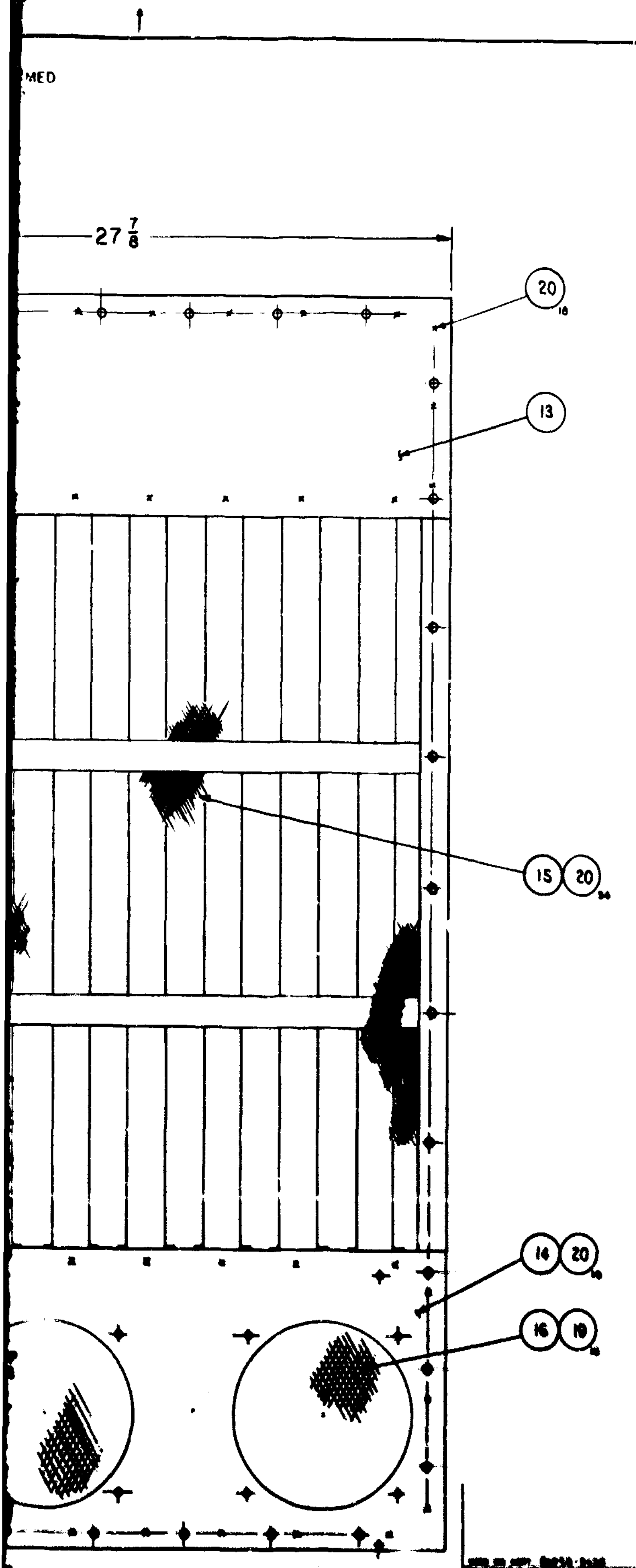
DWG. NO. R1058-9433

REVISION RECORD | DATE | BY

2



3/16 THK. EPOXY FOAM COATING, FREE FOAMED PRIOR TO FORMING AS SHOWN
SECTION A-A
27 7/8
63
A
A
3
17
10
6
20
19
11
18
2
1
7
5
12
19
20
5
8
9
4
STRUCTURAL FRAME TO BE OF WELDED CONSTRUCTION



ITEM	DWG/PART NO	REQ'D.	DESCRIPTION (FINISHED SIZE)	MATERIAL / PURCHASE
1	R1058-4435-1	1	RECTANGULAR TUBE - $\frac{3}{4} \times 1\frac{1}{2} \times .125$ WALL × 63 LG.	ALUMINUM 6063-T6
2	-2	1	RECTANGULAR TUBE - $\frac{3}{4} \times 1\frac{1}{2} \times .125$ WALL × 63 LG.	
3	-3	1	RECTANGULAR TUBE - $\frac{3}{4} \times 1\frac{1}{2} \times .125$ WALL × $27\frac{7}{8}$ LG.	
4	-4	1	RECTANGULAR TUBE - $\frac{3}{4} \times 1\frac{1}{2} \times .125$ WALL × $27\frac{7}{8}$ LG.	
5	-5	2	RECTANGULAR TUBE - $\frac{3}{4} \times 1\frac{1}{2} \times .125$ WALL × $24\frac{7}{8}$ LG.	
6	-6	1	RECTANGULAR TUBE - $\frac{3}{4} \times 1\frac{1}{2} \times .125$ WALL × $24\frac{7}{8}$ LG.	
7	-7	1	RECTANGULAR TUBE - $\frac{3}{4} \times 1\frac{1}{2} \times .125$ WALL × $24\frac{7}{8}$ LG.	
8	-8	1	.063 THK. × 9 × $24\frac{7}{8}$ LG.	ALUMINUM 6061-T6
9	-9	2	.063 THK. × $1\frac{7}{8} \times 3\frac{3}{8}$ LG.	
10	-10	1	.063 THK. × $10\frac{1}{2} \times 24\frac{7}{8}$ LG.	
11	-11	7	.063 THK. × 5 × $6\frac{1}{2}$ LG.	
12	-12	6	.063 THK. × $12\frac{3}{4} \times 38\frac{1}{2}$ LG. (REFER TO SECTION A-A)	
13	-13	1	.063 THK. × 11 × $27\frac{7}{8}$ LG.	
14	-14	1	.063 THK. × $15\frac{1}{4} \times 27\frac{7}{8}$ LG.	
15	-15	1	#30 MESH WIRE SCREEN $25\frac{7}{8} \times 37\frac{3}{4}$ LG.	STAINLESS STL. 304
16	-16	2	EXPANDED METAL - $\frac{1}{2}$" 18 GA. (FLAT) 11" DIA.	STAINLESS STL. 302
17	-17	1	$\frac{3}{4}$ THK. × $4\frac{1}{2} \times 24\frac{7}{8}$ LG.	2½ LB. DENSITY ULTRA FINE CLEAR VINYL OR NEOPRENE COATED BOARD INSULATION GUSTIN BACON CO. OR EQUAL
18	-18	1	$\frac{3}{4}$ THK. × 2 × $24\frac{7}{8}$ LG.	
19	MS20600-B4W2	77	RIVET, BLIND, SELF PUNCHING - $\frac{1}{8}$ DIA.	PURCHASE
20	MS20600-B4W3	96	RIVET, BLIND, SELF PUNCHING - $\frac{1}{8}$ DIA.	

NOTE:

1- BOND INSULATION (ITEMS #17 & 18) IN POSITION USING MINN. MINING & MFG. CO. INSULATION ADHESIVE #33 (RED).

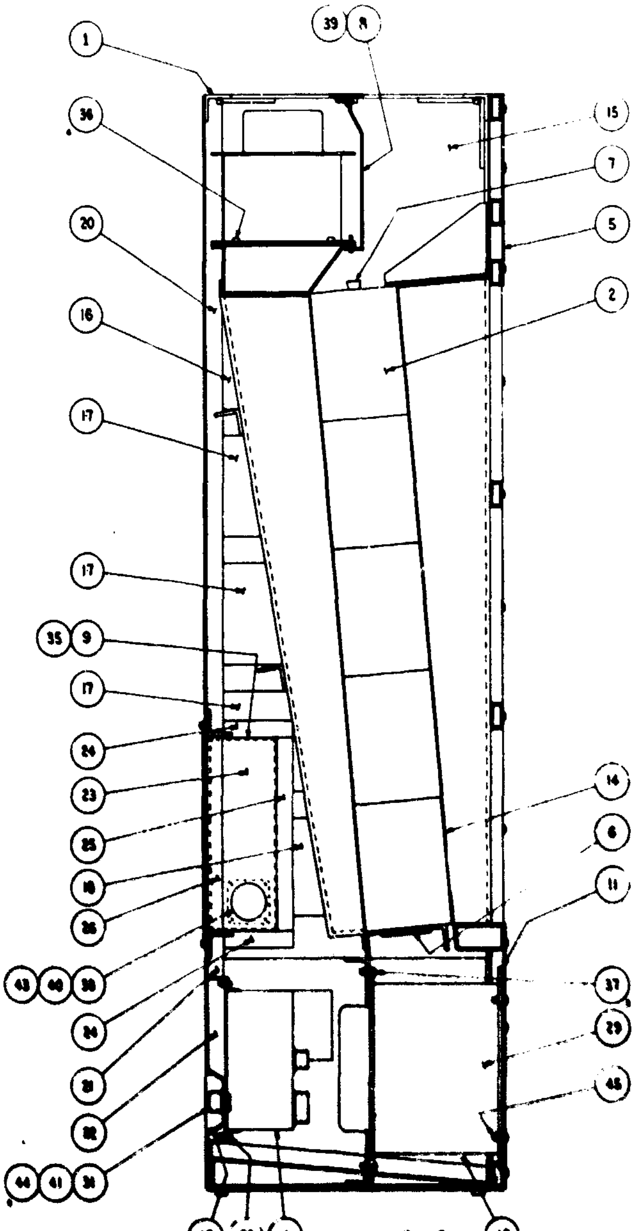
CARRIER CORPORATION

SYRACUSE, NEW YORK, U.S.A.

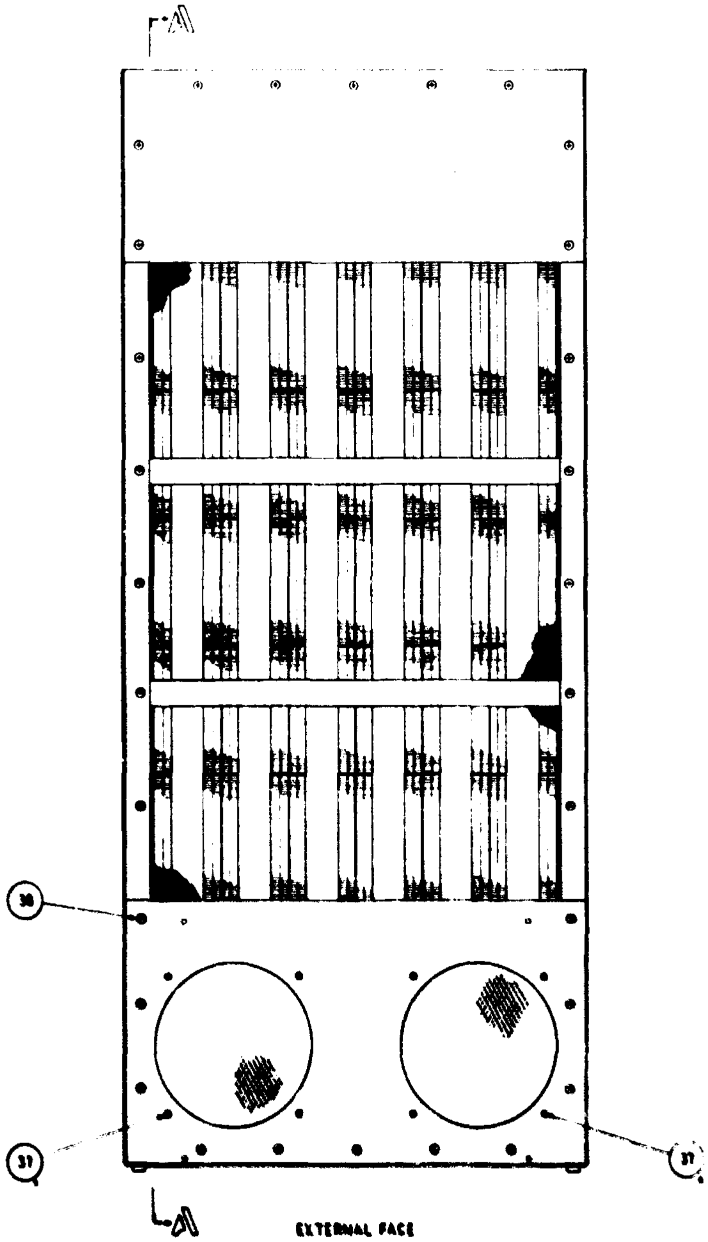
TITLE: ACCESS COVER ASSEMBLY FOR T.E. ENVIRONMENTAL CONTROL UNIT

DWG. NO. R1058-4435

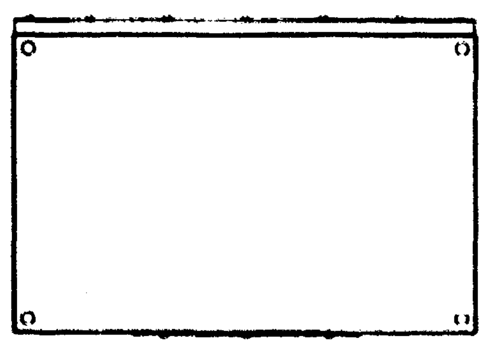
12

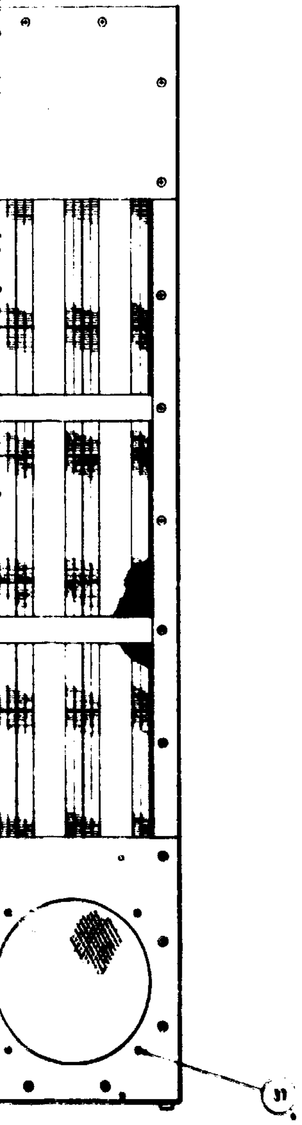


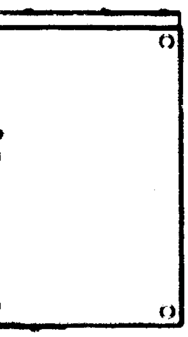
SECTION A-A



EXTERNAL FACE







ITEM	DWG. PART NO.	REQD.	DESCRIPTION (FINISHED SIZE)	MATERIAL/PURCHASE
1	R1058-9434	1	FRAME ASSEMBLY	
2	R1058-4430	60	MODULE ASSEMBLY	
3	R1058-9431	1	CONTROL AND MONITOR PANEL	
4	R1058-9433	1	POWER CONVERSION AND CONTROL PACKAGE	
5	R1058-4435	1	ACCESS COVER ASSEMBLY	
6	R1058-3437	1	MODULE RECEPTACLE	
7	R1058-2438	12	JUMPER STRAP	
8	R1058-9436-8	1	.040 THK. × 10 1/2 × 24 [illegible] LG.	ALUMINUM 6061-T6
9	-9	1	.040 THK. × 19 × 19 [illegible] LG.	
10	-10	1	.040 THK. × 4 1/2 DIA.	
11	-11	2	[illegible] THK. × 11 [illegible] DIA.	SPONGE RUBBER ADHESIVE COATED ONE SIDE
12	-12	2	[illegible] THK. × 1 1/2 × 63 LG.	
13	-13	2	[illegible] THK. × 1 1/2 × 24 [illegible] LG.	
14	-14	12	[illegible] THK. × 1/2 × 36 [illegible] LG.	
15	-15	2	1 1/2 THK. × 11 [illegible] × 16 [illegible] LG.	2 1/2 LB. DENSITY ULTRA FINE, CLEAR VINYL OR NEOPRENE COATED BOARD INSULATION "GUSTIN BACON CO." OR EQUAL
16	-16	2	1 1/2 THK. × 5 × 16 [illegible] LG.	
17	-17	6	1 1/2 THK. × 5 [illegible] × 16 [illegible] LG.	
18	-18	2	1 1/2 THK. × 5 1/2 × 16 [illegible] LG.	
19	-19	2	1 1/2 THK. × 12 × 16 [illegible] LG.	
20	-20	1	1" THK. × 24 [illegible] × 36 1/4 LG.	
21	-21	1	1" THK. × 2 1/2 × 24 [illegible] LG.	
22	-22	1	1" THK. × 9 × 24 [illegible] LG.	
23	-23	2	1" THK. × 3 1/2 × 11 LG.	
24	-24	2	1" THK. × 4 × 13 [illegible] LG.	
25	-25	1	1" THK. × 11 × 13 [illegible] LG.	
26	-26	2	1" THK. × 6 1/2 × 11 LG.	
27	-27	2	.040 THK. × 17 [illegible] × 63 LG.	ALUMINUM 6061-T6
28	-28	1	.040 THK. 27 [illegible] × 63 LG.	
29	-29	2	FAN - "GENERAL DYNAMICS" MODEL #9082A	PURCHASE
30	-30	2	FAN - "GENERAL DYNAMICS" MODEL #9071A	
31	MS3102A-18-[illegible]	1	CONNECTOR, RECEPTACLE "AMPHENOL BORG"	
32	MS3102A-16-10S	2	CONNECTOR, RECEPTACLE "AMPHENOL BORG"	
33	MS3102A-36-7S	1	CONNECTOR, RECEPTACLE "AMPHENOL BORG"	
34	MS20601-[illegible]	140	RIVET, BLIND, SELF PUNCHING - [illegible] DIA.	
35	MS20601-[illegible]	6	RIVET, BLIND, SELF PUNCHING - [illegible] DIA.	
36	MS35207-263	16	#10-32 UNF × [illegible] LG. MACH. SCREW PAN HD.	
37	MS35207-264	14	#10-32 UNF × [illegible] LG. MACH. SCREW PAN HD.	
38	MS35207-285	30	[illegible]-28 UNF × 1 [illegible] LG. MACH. SCREW PAN HD.	
39	MS35206-27	8	#8-32 UNC × [illegible] LG. MACH. SCREW PAN HD.	
40	MS35206-40	4	#8-32 UNC × [illegible] LG. MACH. SCREW PAN HD.	
41	MS35206-14	4	#4-40 UNC × [illegible] LG. MACH. SCREW PAN HD.	
42	MS35206-13	8	#4-40 UNC × [illegible] LG. MACH. SCREW PAN HD.	
43	MS21044-N08	4	#8-32 UNC HEX LOCKNUT	
44	MS21044-N04	12	#4-40 UNC HEX LOCKNUT	
45	MS27131-21	8	NUT, BLIND RIVET, FLAT HD, OPEN END #10-32 UNF	
46	R1058-9436-46	6	STUD - CAMLOC FASTENER CORP. #1231-22-1AA	

NOTE:
1. BOND INSULATION (ITEMS 15 THRU 26) IN POSITION USING [illegible] INSULATION ADHESIVE [illegible]

CARRIER CORPORATION

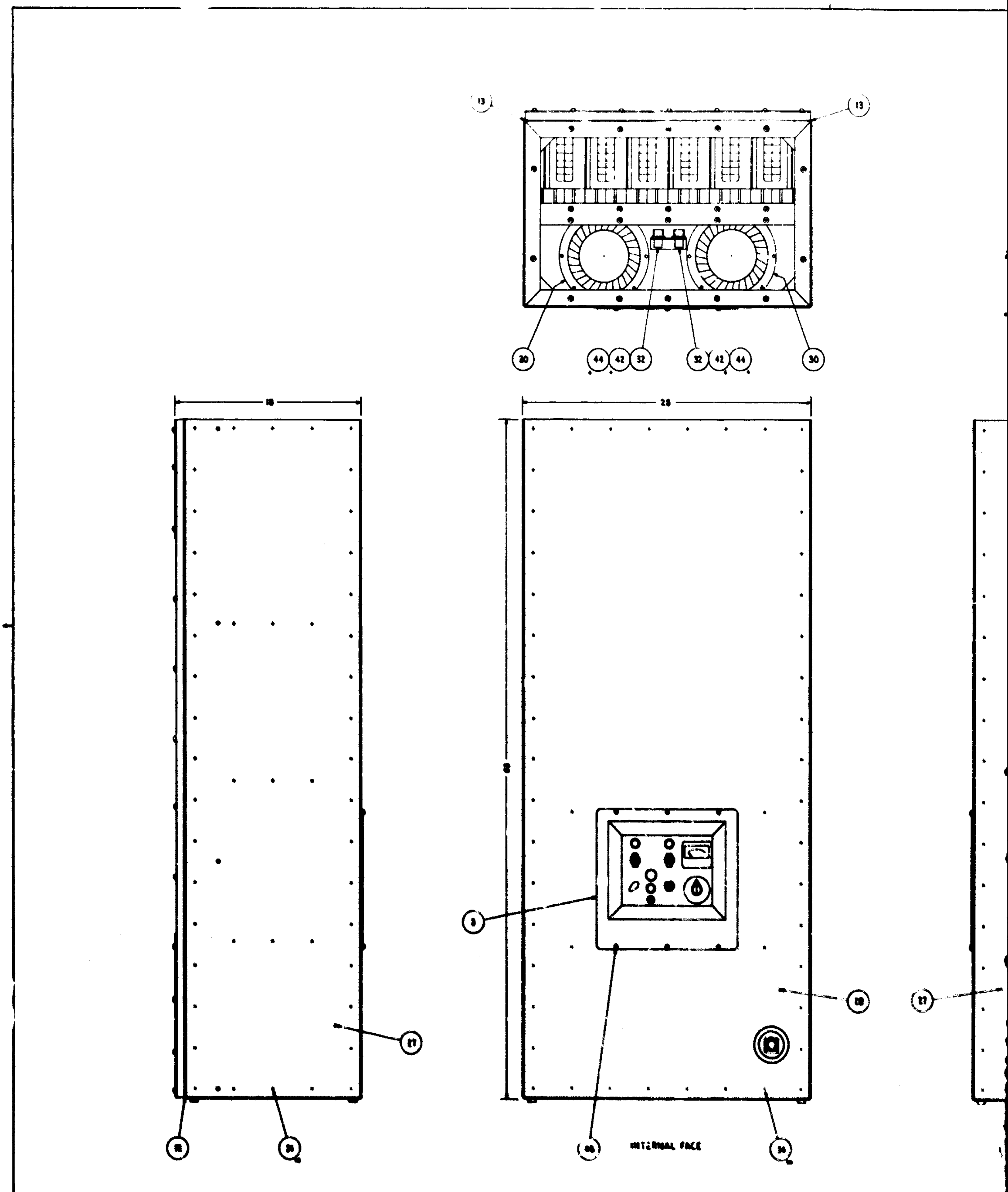
SYRACUSE, NEW YORK, U.S.A.

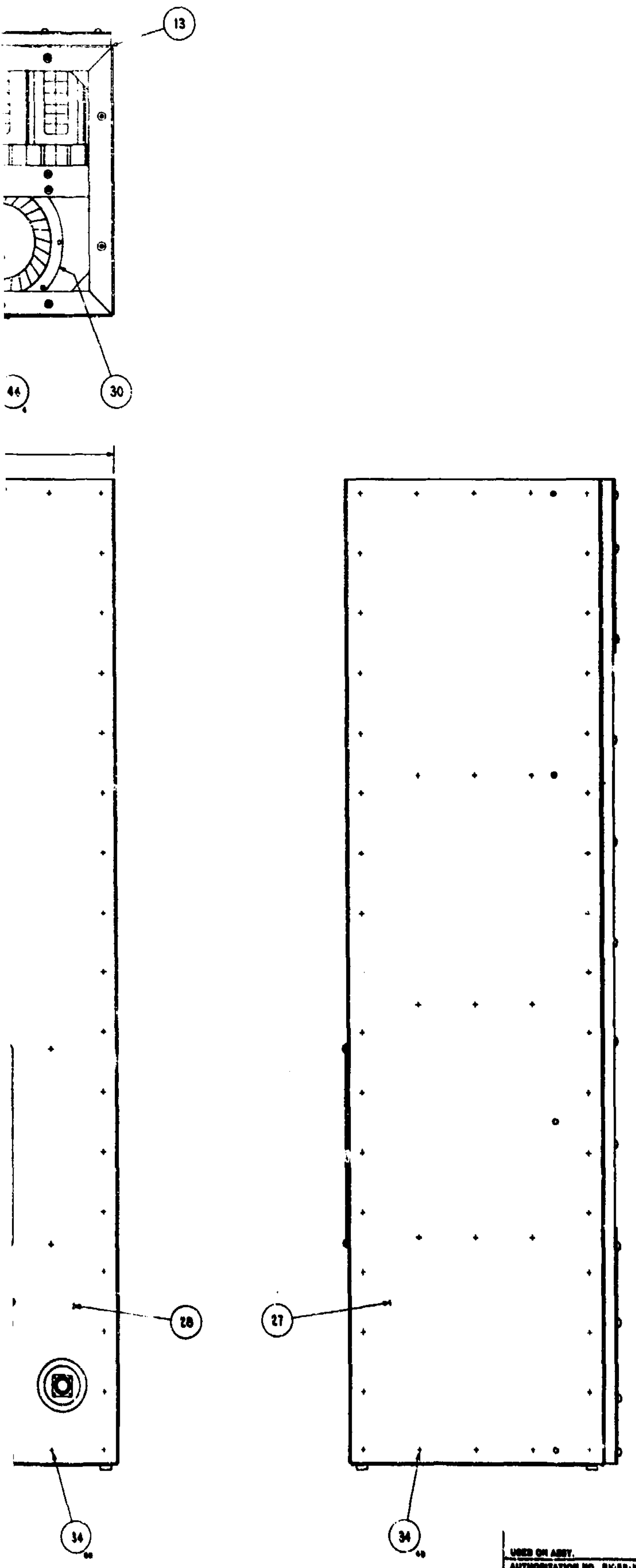
UNIT ASSEMBLY T.E. ENVIRONMENTAL CONTROL UNIT

DWG. NO. R1058-9436

SHEET 1 OF 2

2


13
13
30
44
42
32
32
42
44
30
28
INTERNAL FACE



USED ON ASSY.				
AUTHORIZATION NO. RK58-18				
MANUFACTURED		PURCHASED		
APPROVED FOR	ENGR.	DATE	MFG.	DATE
	GHG	9-14-65		
TRIAL PROD. RUN				
FINAL PROD.				

REVISION RECORD | DATE | BY | APPD. BY | CH'KD. BY | E.C.R. NO.

MATERIAL

APPLIED FINISH

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRACTIONS	DECIMALS	ANGLES
±	±	±
SURFACES	HOLE SPACING	HOLE LOCATION
√ MAX.	±	±
	NON-CUMULATIVE	

DR.	J.H. COX	9-10-64	SCALE
CH'KD.			1"=1'-0"

CARRIER CORPORATION

This Drawing is the Personal Property of Carrier Corporation — Carrier — All Use is Forbidden Except On Its Written Consent

SYRACUSE, NEW YORK, U.S.A.

TITLE

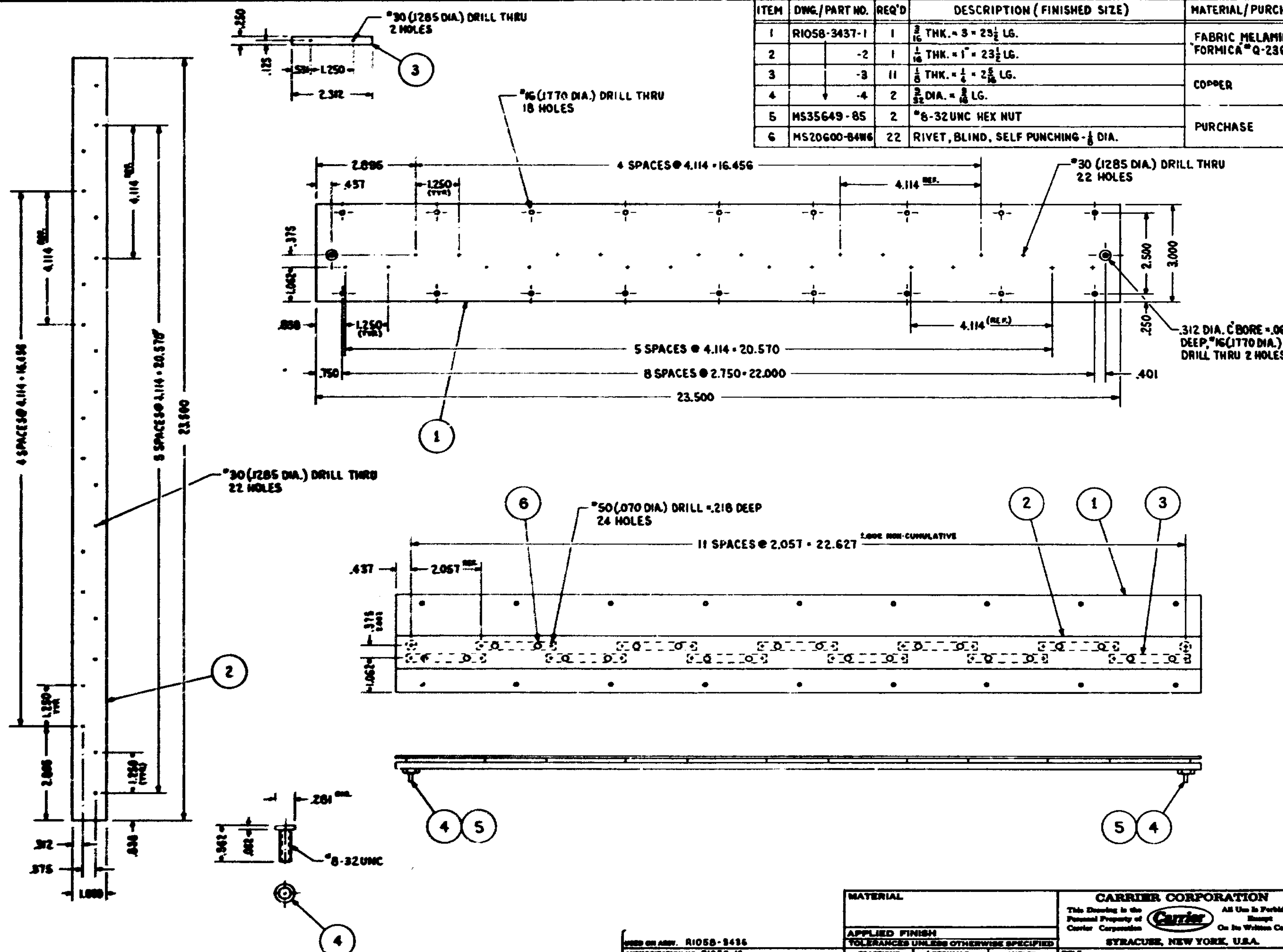
UNIT ASSEMBLY
T.E. ENVIRONMENTAL CONTROL UNIT

DWG. NO. R1058-9436

SHEET 2 OF 2

12

ITEM	DWG./PART NO.	REQ'D	DESCRIPTION (FINISHED SIZE)	MATERIAL/PURCHASE
1	R1058-3437-1	1	$\frac{3}{16}$ THK. × 3 × 23$\frac{1}{2}$ LG.	FABRIC MELAMINE "FORMICA" Q-236
2	-2	1	$\frac{1}{16}$ THK. × 1" × 23$\frac{1}{2}$ LG.	
3	-3	11	$\frac{1}{8}$ THK. × $\frac{1}{4}$ × 2$\frac{5}{16}$ LG.	COPPER
4	-4	2	$\frac{3}{32}$ DIA. × $\frac{3}{16}$ LG.	
5	MS35649-85	2	#8-32UNC HEX NUT	PURCHASE
6	MS20600-B4W6	22	RIVET, BLIND, SELF PUNCHING - $\frac{1}{8}$ DIA.	



MATERIAL	
APPLIED FINISH	
TOLERANCES UNLESS OTHERWISE SPECIFIED	
FRACTIONS ±	1 DECIMALS ±.010 / ANGLES ±
SURFACES 63	HOLE SPACING ±.005 / HOLE LOCATION ±.005 NON-CUMULATIVE
DR. J.H. COX 9-17-65	SCALE 6" = 1'-0"
CH'KD.	

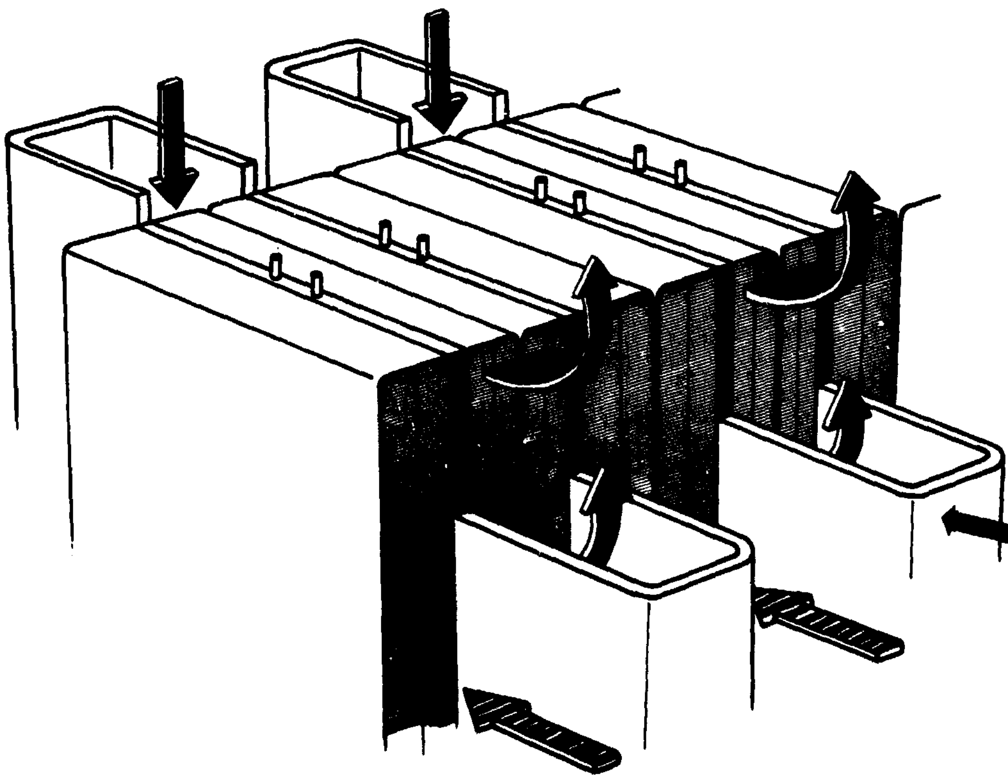
USED ON ASSY. R1058-3436
AUTHORIZATION NO. R1058-15
APPROVED FOR: 6 R.G. 9-17-65

CARRIER CORPORATION
This Drawing is the Personal Property of Carrier Corporation. All Use Is Forbidden Except On Its Written Consent.
SYRACUSE, NEW YORK, U.S.A.

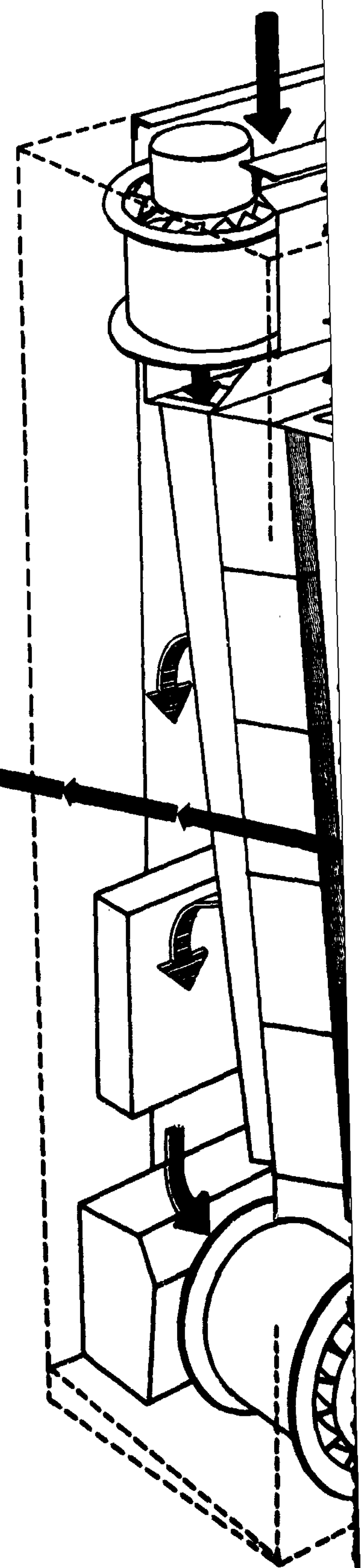
TITLE: MODULE RECEPTACLE FOR T. E. ENVIRONMENTAL CONTROL UNIT

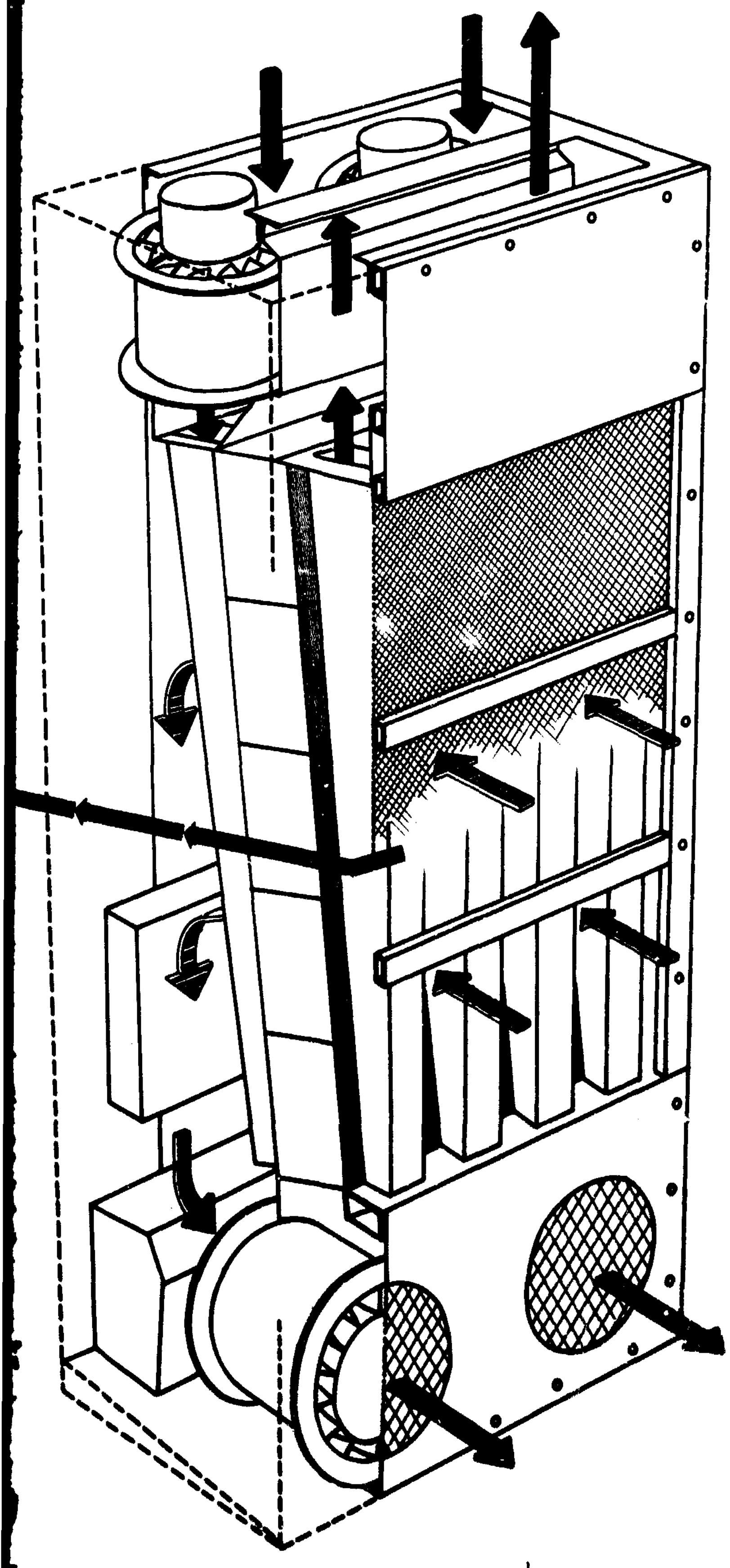
DWG. NO. R1058-3437

220-008



DETAILED MANIFOLD SECTION





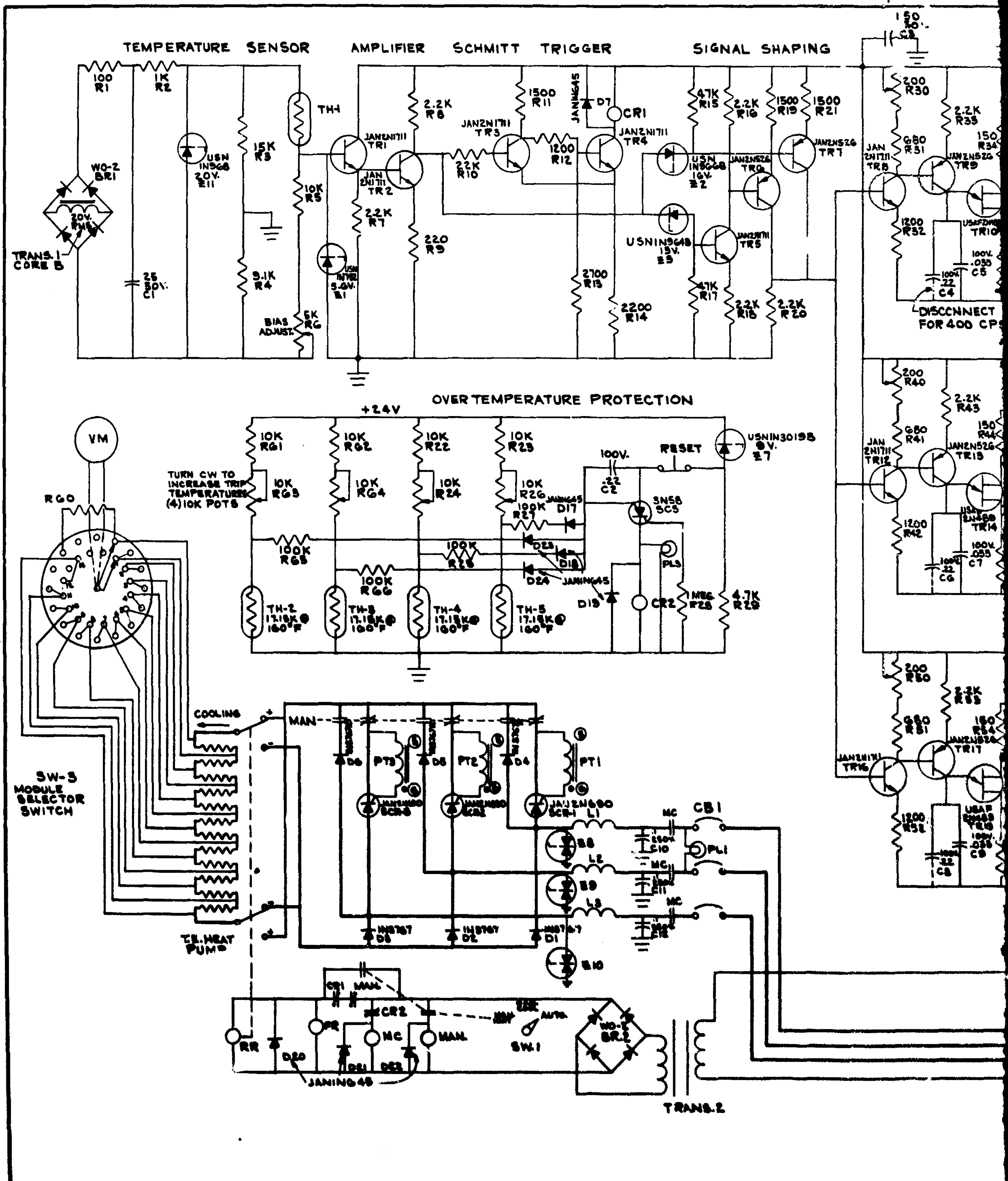
CARRIER CORPORATION

SYRACUSE, NEW YORK, U.S.A.

AIR FLOW DIAGRAM — FOR T.E. ENVIRONMENTAL CONTROL UNIT

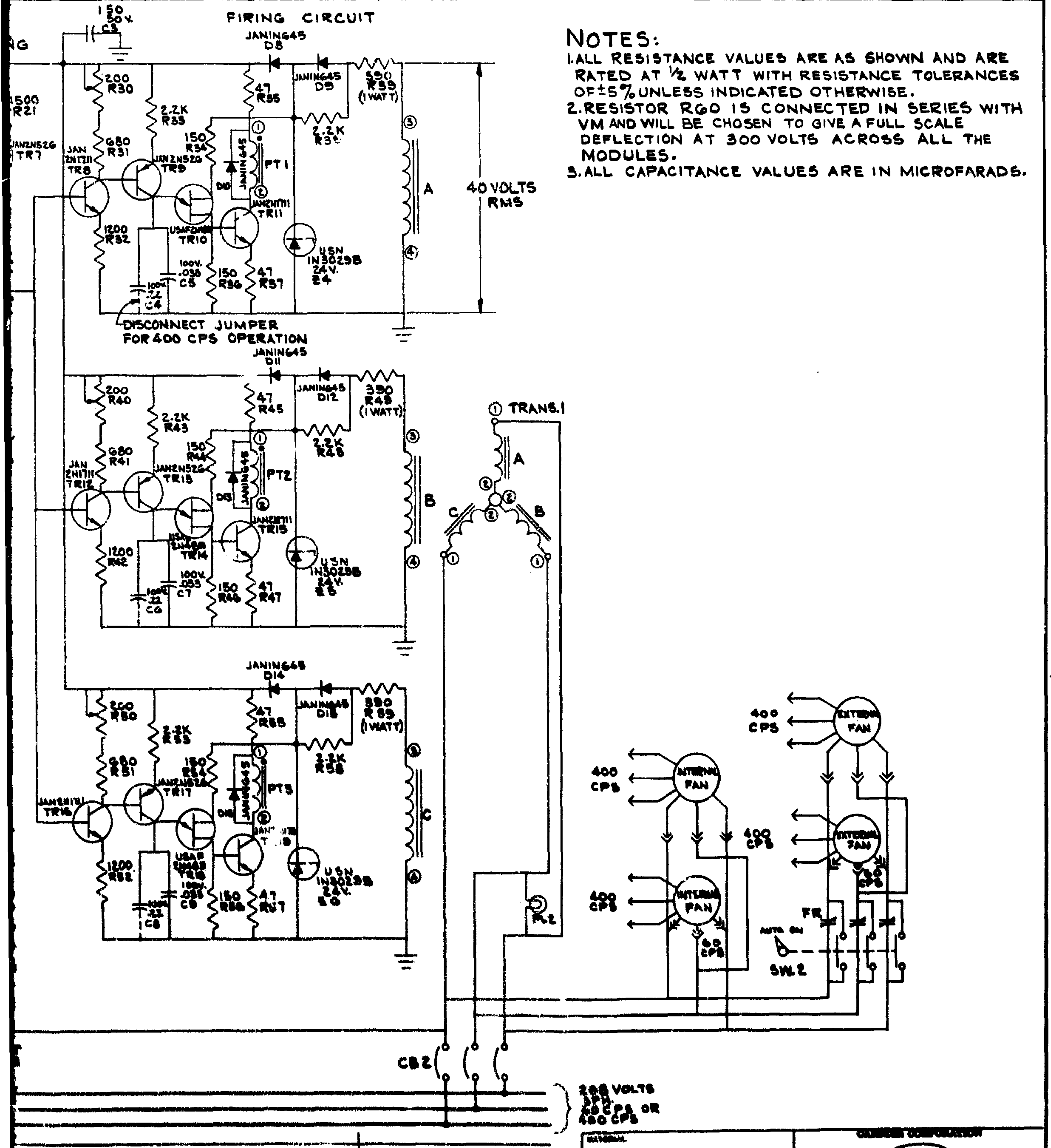
DWG. NO. R1058 — 9439

12



TEMPERATURE SENSOR
AMPLIFIER
SCHMITT TRIGGER
SIGNAL SHAPING
OVER TEMPERATURE PROTECTION
+24V
TURN CW TO INCREASE TRIP TEMPERATURES (4) 10K POTS
RESET
DISCONNECT FOR 400 CPS
SW-3 MODULE SELECTOR SWITCH
COOLING
T.E. HEAT PUMP
MAN.
AUTO.
SW.1
TRANS.1 CORE B
TRANS.2
CB1
JAN1N645

REV. | DWG. NO. | SIMILAR TO



NOTES:

1. ALL RESISTANCE VALUES ARE AS SHOWN AND ARE RATED AT ½ WATT WITH RESISTANCE TOLERANCES OF ±5% UNLESS INDICATED OTHERWISE.
2. RESISTOR R60 IS CONNECTED IN SERIES WITH VM AND WILL BE CHOSEN TO GIVE A FULL SCALE DEFLECTION AT 300 VOLTS ACROSS ALL THE MODULES.
3. ALL CAPACITANCE VALUES ARE IN MICROFARADS.

Carrier

SYRACUSE, NEW YORK, U.S.A.

R1058-18

TITLE SCHEMATIC DIAGRAM CONTROL AND POWER SUPPLY FOR T.E. ENVIRONMENTAL CONTROL UNIT

SCALE NONE

DWG. NO. R1058-4428 SHEET 1 OF 2

2

SUPERSEDES ______ SUPERSEDED BY ______

MAIN WIRING #14 AWG STRANDED ALPHA No. 5119 PVC
FAN WIRING #16 AWG STRANDED ALPHA No. 5117 PVC
CONTROL WIRING #20 AWG STRANDED ALPHA No. 5113 PVC
THERMISTOR WIRING #20 AWG SHIELDED ALPHA No. 2256
PULSE TRANSFORMER WIRING #20AWG SHIELDED ALPHA No. 2256

SYMBOL	REQ'D	DESCRIPT
TR19	1	TRANSIST
C1	1	CAPACITOR
C2	1	
C3	1	
C4	1	
C5	1	
C6	1	
C7	1	
C8	1	
C9	1	
C10	1	
C11	1	
C12	1	
CR1	1	RELAY
CR2	1	
RR	1	REVERSING REL
FR	1	FAN RELAY
MC	1	RELAY
MAN	1	
PT1	1	PULSE TRANSFOR
PT2	1	
PT3	1	
TRANS.1	1	TRANSFORM
TRANS2	1	
R6	1	POTENTIOMETE
R24	1	
R30	1	
R40	1	
R50	1	
L1	1	INDUCTOR
L2	1	
L3	1	
CB1	1	CIRCUIT BREAK
CB2	1	
PL1	1	MAIN POWER LIG
PL2	1	FAN POWER LIG
SW1	1	SWITCH
SW2	1	
SW3	1	
RESET	1	
VM	1	VOLT METER
TH1	1	N.T.C. THERMISTOR
TH2	1	
TH3	1	
R26	1	POTENTIOMETER
R63	1	
R64	1	
TH4	1	N.T.C. THERMISTO
TH5	1	
D23	1	DIODE
D24	1	
PL3	1	RESET LIGHT

DWG. NO. | REV. | SIMILAR TO

DESCRIPTION	MANUFACTURER	TYPE No.	RATING	SYMBOL	REQ'D	DESCRIPTION	MANUFACTURER	TYPE No.	RATING
TRANSISTOR	G.E.	JAN2N1711		Z1	1	ZENER DIODE	GEN. INSTR.	USN1N752	5.6V 400MW
CAPACITOR	SPRAGUE	CL64CJ250MP3	25MFD 50V	Z2	1			USN1N966B	16V 400MW
		CP05A1EB224K	.22MFD 100V	Z3	1			USN1N964B	13V 400MW
		CL25-BJ151TP3	150MFD 50V	Z4	1		HOFFMAN	USN1N3029B	24V 1WATT
		CP05A1EB224K	.22MFD 100V	Z5	1				
		CP05A1EB33K	.033MFD 100V	Z6	1				
		CP05A1EB22K	.22MFD 100V	Z7	1			USN1N3019B	9.1V 1WATT
		CP05A1EB33K	.033MFD 100V	Z8	1	THYRECTOR DIODE	G.E.	6RS21SA6D6	150V
		CP05A1EB224K	.22MFD 100V	Z9	1				
		CP05A1EB33K	.033MFD 100V	Z10	1				
		48P9	.1MFD 250V	Z11	1	ZENER DIODE	GEN. INSTR.	USN1N968	20V 400MW
				SCR-1	1	SILICON CONTROLLED RECTIFIER	G.E.	JAN2N690	600V 35A
				SCR-2	1				
RELAY	R.B.M.	MS25-902		SCR-3	1				
	DUNCO	RR1AM24DC		BR-1	1	RECTIFIER BRIDGE	GEN. INSTR.	WO-2	140V 1.5A
REVERSING RELAY	KURMAN	26L2C24DC		BR-2	1				
FAN RELAY		263C24DC		D1	1	DIODE	G.E.	1N3767	635V 35A
RELAY				D2	1				
		264C2DC		D3	1				
PULSE TRANSFORMER	U.T.C.	H51		D4	1			1N3767R	
				D5	1				
				D6	1				
TRANSFORMER	REGULUS	Q-1167		D7	1			JAN1N645	200V
	THORDARSON	23V160		D8	1				
POTENTIOMETER	SPECTROL	42-2-1-5K	5K	D9	1				
		42-2-1-10K	10K	D10	1				
		42-2-1-200	200Ω	D11	1				
				D12	1				
				D13	1				
INDUCTOR	CARRIER	R1058-[illegible]	100µH	D14	1				
				D15	1				
				D16	1				
CIRCUIT BREAKER	HEINEMANN	AM17-24A	24A FAST TRIP	D17	1				
		SM533-7A	7A SLOW TRIP	D18	1				
MAIN POWER LIGHT	DIALCO	95408-535 NES1 W/[illegible]	250V 1/3W	D19	1				
FAN POWER LIGHT				D20	1				
SWITCH	CARLING	700-12-2-BL	1A 125VDC	D21	1				
	J-B-T	MS25068-23	6A	D22	1				
	DAVEN	122-DB-16A		SCS	1	SILICON CONTROLLED SWITCH		3N58	
	CONTROLS CO. OF AMERICA	MS25089-3C		TR1	1	TRANSISTOR		JAN2N1711	
VOLT METER	WESTON	MODEL 1921	0-50 VOLTS	TR2	1				
N.T.C. THERMISTOR	KEYSTONE	RL28B1		TR3	1				
		RL34E1		TR4	1				
				TR5	1				
POTENTIOMETER	SPECTROL	42-2-1-10K	10K	TR6	1			JAN2N526	
				TR7	1				
				TR8	1			JAN2N1711	
N.T.C. THERMISTOR	KEYSTONE	RL34E1		TR9	1			JAN2N526	
				TR10	1			USAF2N489	
DIODE	G.E.	JAN1N645	200V	TR11	1			JAN2N1711	
				TR12	1				
RESET LIGHT	DIALCO	MS25256-6	14 VOLTS LAMP T-1¾	TR13	1			JAN2N526	
				TR14	1			USAF2N489	
				TR15	1			JAN2N1711	
				TR16	1				
				TR17	1			JAN2N526	
				TR18	1			USAF2N489	

CARRIER CORPORATION
SYRACUSE, NEW YORK, U.S.A.

TITLE SCHEMATIC DIAGRAM CONTROL AND POWER SUPPLY FOR T.E. ENVIRONMENTAL CONTROL UNIT

SCALE NONE

DWG. NO. R1058-4428

12

APPENDIX B

PROCESS SHEETS

R-1058-1149	Waferizing of Thermoelectric Material
R-1058-1225	Polishing Thermoelectric Encapsulated Wafers
R-1058-1162	Tinning of Thermoelectric Elements
R-1058-1185	RF Bonding of Ceramic Sandwiches
R-1058-1299	Thermoelectric Panel Assembly
R-1058-1226	Foaming of Thermoelectric Panels

SUPERSEDES R II | SUPERSEDED BY | SIMILAR TO

SYM.	REVISION RECORD	DATE	BY	APPD. BY	CH'KD. BY	E.C.R. NO.
I	Item E added	12/14/62	JEG	JEG		
II	Drawing No. added--Item E	1/24/64	JEG	JEG		
III	Safety Equip. eliminated; alternate method added	9/11/64	JEG	JEG		

A. Operating Equipment

a. General
1. Waferizing machine
2. Coolant solution for waferizing machine
3. Dummy encapsulated rod
4. Diamond blade size 4" x .012 x 5/8 spindle hole, 180 grit
5. Thickness gauge
6. Premounted Norton dressing stick

b. Ceramic Block Mounting
1. Encapsulated Thermoelectric material mounted on ceramic block
2. Small vertical mounting vise

c. Fixture Mounting
1. Thermoelectric material mounted in fixture
2. Adjustable angle vise

B. Cutting Solution Preparation

a. Bring 750 cc of water to a boil
b. Add 4 oz. of Dash or equivalent low sudsing detergent
c. Boil until solution is homogenious
d. Add this solution to 35 gallons of water in waferizing machine storage tank
e. Add 2 oz. of household sudsy ammonia. Note: This mixture is proportional for larger of smaller mixing quantities.

MATERIAL: Diamond blade, encapsulated TE material, low sudsing detergent, sudsy ammonia

APPLIED FINISH

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRACTIONS	DECIMALS	ANGLES
±	±	±
SURFACES	HOLE SPACING	HOLE LOCATION
√ MIN.	±	±
	NON-CUMULATIVE	

USED ON ASSY. R1058					
AUTHORIZATION NO. R1058					
MANUFACTURED		PURCHASED			
APPROVED FOR	ENGRG.	DATE	MFG.	DATE	
Pilot Oper.	EVH	6/5/62			
TRIAL PROD. RUN					
FINAL PROD.					

DR. | CH'KD. | SCALE (DO NOT SCALE DRAWING)

TITLE: WAFERIZING OF THERMOELECTRIC MATERIAL

DWG. NO. R1058-1149 Rev. III

DO NOT REVISE THIS DRAWING WITHOUT REFERRING TO DRAWING NO. ____ PRINT DISTR. ____ QTY. ____

DWG. NO. R1058-1149 REV. III

SYM.	REVISION RECORD	DATE	BY	APPD. BY	CH'KD. BY	E.C.R. NO.

f. Circulate solution through wafering machine for 15 minutes.
g. pH of solution should be 8.5 to 9.0.
h. Replace solution after 8 hours.

C. Wafering Procedure
a. Set dial on height and depth to be sawed.
b. Install 180 grit diamond saw.
c. Install vertical or adjustable angle vise on magnetic plate, whichever is needed with the used mounting device.
d. Five pieces from every rod sawed should be checked for thickness and taper with thickness gauge. If incorrect notify supervisor, except index setting if 5 samples show correct setting.
e. Install thermoelectric material in vise. Set saw rate at .9"/minute.
f. Set automatic cut-out switch and saw.
g. Remove waferized material and mount from machine.
h. Redress blade after cutting 50 rods.

D. Tolerances
Use Drawing No. R1058-2187 for sawing tolerances

E. Alternate Waferizing Procedure
a. Mount ceramic block on magnetic chuck or vise, whichever is used.
b. Follow C-f,g, and h above.

USED ON ASSY.
AUTHORIZATION NO.

MANUFACTURED		PURCHASED		
APPROVED FOR	ENGRG.	DATE	MFG.	DATE
TRIAL PROD. RUN				
FINAL PROD.				

MATERIAL

APPLIED FINISH

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRACTIONS	DECIMALS	ANGLES
±	±	±
SURFACES	HOLE SPACING	HOLE LOCATION
√ ΜIN.	±	±
	NON-CUMULATIVE	

DR.			SCALE (DO NOT SCALE DRAWING)
CH'KD.			

CARRIER CORPORATION

This Drawing is the Personal Property of Carrier Corporation — Carrier — All Use Is Forbidden Except On Its Written Consent

SYRACUSE, NEW YORK, U.S.A.

TITLE
WAFERIZING OF THERMOELECTRIC MATERIAL

DWG. NO. R1058-1149 Rev. III

DO NOT REVISE THIS DRAWING WITHOUT REFERRING TO DRAWING NO. ____ PRINT DISTR. Page 2 of 2 QTY. ____

SUPERSEDED BY ____ SIMILAR TO ____

REV. III

DWG. NO. R1058-1149

Operating Procedure	SUPERSEDES None

A. Supplies & Tools

Micrometer or Thickness Gauge
One Gallon Polyethylene Bottle
PR Hoffman PR-1 S.S. Lapping Machine
Pellen Paper to fit PR-1 Lapping Machine
One Quart Polyethylene Bottle/Spout
Bottle Agitator (Drawing #R1058-9180)
Weighing Scale
D.I. Water
Ultra-Sonic Cleaner
99.95% Methanol
One Bucket with Handle
Set of Carrier's (Drawing #R1058-3202)

B. Preparing Polishing Compound

1. The one (1) micron Al_2O_3 can be purchased from Geoscience or Linde as certified.
2. Add 1260 gms of the powdered Al_2O_3 to the one (1) gallon polyethylene bottle.
3. Add 1900 cc of deionized water to the bottle and hand agitate the contents thoroughly.
4. Place on rollers of agitator and allow to rotate until ready for use.
5. Keep lid on powder container when not mixing. Room dust will contaminate the Al_2O_3 and cause scratches later on.

REQ.	USED ON ASSEM.	REVISION	DATE	BY	APPR'D BY	CHECKED BY

PROJ. NO. 1058		ENGR. NO.	
JOB NO.		REQ. NO.	

APPROVED FOR	ENGRG.	DATE	MFG.	DATE
SAMPLE UNIT				
TRIAL PROD. RUN-"EX."				
FINAL PROD.				
Pilot Operations	JEG	1/7/63		

TOLERANCES FOR ALL DIMENSIONS ARE ± 0.0005 UNLESS OTHERWISE SPECIFIED

ANGULAR ± | MACHINING ±

HOLE SPACING & LOCATION ± NON-CUMULATIVE

MANUFACTURED R1058-2187 | PURCHASED

MATERIAL
Encapsulated Thermoelectric Wafers, 1 Micron Al_2O_3, Deionized Water

FINISH

Carrier

TITLE
POLISHING THERMOELECTRIC ENCAPSULATED WAFERS

CAUTION ALL DIMENSIONS GIVEN IN INCHES. DO NOT SCALE DRAWING.

DR.		SCALE
CH.		

DWG. No. R1058-1225

REV

DWG. NO. R1058-1225

DO NOT REVISE THIS DRAWING WITHOUT REFERRING TO DRAWING NO. R1058-2187

Operating Procedure	SUPERSEDES None

C. Preparing PR-1 S.S. Lap.

1. Unscrew dust cap and remove dust cap lid.

2. Insert the five conditioning gears.

3. Replace dust cap lid and screw dust cap into position.

4. Secure some 26.5 micron lapping compound mixture, used for finishing copper straps (Drw. No. R1058-1196). Shake bottle vigorously and pour part of contents over the conditioning gears. Do not waste the compound however.

5. Set top lapping plate into position and set against sustaining bar.

6. Turn on main switch, then reostat switch. Wait 10 seconds and then start machine by slowly turning the reostat to full power.

7. Add vigorously mixed lapping compound through the small openings in the top of the upper plate. Continue conditioning and adding the compound until all scratches are removed from both the upper and lower plates.

8. When conditioning has been completed, remove the conditioning gears and clean in Triclene D. Wrap in paper and store.

9. Clean the machine thoroughly with Triclene D. All traces of oil and lapping compound must be removed from the upper gear mechanism and plates. The Triclene D will drain into the bucket provided.

REQ.	USED ON ASSEM.	REVISION	DATE	BY	APPR'D BY	CHECKED BY

PROJ. NO. 1058 ENGR. NO.

JOB NO. REQ. NO.

APPROVED FOR	ENGRG.	DATE	MFG.	DATE
SAMPLE UNIT				
TRIAL PROD. RUN-"EX."				
FINAL PROD.				
Pilot Operations	JEG	1/7/63		

TOLERANCES FOR ALL DIMENSIONS ARE ± 0.0005 UNLESS OTHERWISE SPECIFIED

ANGULAR ± MACHINING ±

HOLE SPACING & LOCATION ± NON-CUMULATIVE

MANUFACTURED R1058-2187 PURCHASED

MATERIAL
Encapsulated Thermoelectric Wafers, 1 Micron Al_2O_3, Deionized Water

FINISH

Carrier

TITLE
POLISHING THERMOELECTRIC ENCAPSULATED WAFERS

CAUTION ALL DIMENSIONS GIVEN IN INCHES. DO NOT SCALE DRAWING.

DR. SCALE

CH.

DWG. NO. R1058-1225

REV DWG. NO. R1058-1225

DO NOT REVISE THIS DRAWING WITHOUT REFERRING TO DRAWING NO. R1058-2187

Operating Procedure | SUPERSEDES None

10. Turn off machine.

11. Dump bucket of oil, compound and Triclene D into a drain of sufficient size that large quantities of water can also be added to prevent settling of the mixture in the sewer.

12. The foregoing procedure is necessary only with new plates and/or if a crash occurs which damages the plates with scratches and gouges

D. <u>Preparing the Stainless Steel Plates with Pellon Paper</u>

1. Clean the plates with fresh Triclene D, and wipe dry.

2. Using a knife or other sharp edge, split the backing loose from the pellon paper and separate into two pieces. Discard the backing.

3. Carefully place the edge of the pellon paper near the edge of the bottom lapping plate surface. Align the paper to the plate and press the paper into position with the palm of the hand. Moving hand slowly from where contact is first made, and holding remainder of paper upward with the other hand, the paper can be pressed into proper position without an encapsulation. If air is trapped, however, lift paper slowly to the point of air bubble and then repress into position.

4. Repeat this same procedure for the top plate. Punch out holes in the paper as are indicated for addition of the polishing compound. Punch from the paper side, to prevent tear in the pellon paper or loosing of the paper

REQ.	USED ON ASSEM.	REVISION	DATE	BY	APPR'D BY	CHECKED BY

PROJ. NO. 1058 | ENGR. NO. | REV

JOB NO. | REQ. NO.

APPROVED FOR	ENGRG.	DATE	MFG.	DATE
SAMPLE UNIT				
TRIAL PROD. RUN-"EX."				
FINAL PROD.				
Pilot Operations	JEG	1/7/63		

TOLERANCES FOR ALL DIMENSIONS ARE ± 0.0005 UNLESS OTHERWISE SPECIFIED

ANGULAR ± | MACHINING ±

HOLE SPACING & LOCATION ± NON-CUMULATIVE

MANUFACTURED R1058-2187 | PURCHASED

MATERIAL
Encapsulated Thermoelectric Wafers, 1 Micron Al_2O_3, Deionized Water

FINISH

Carrier

TITLE
POLISHING THERMOELECTRIC ENCAPSULATED WAFERS

CAUTION ALL DIMENSIONS GIVEN IN INCHES. DO NOT SCALE DRAWING.

DR. | | SCALE

CH.

DWG. No. R1058-1225

DWG. NO. R1058-1225

DO NOT REVISE THIS DRAWING WITHOUT REFERRING TO DRAWING NO. R1058-2187

Operating Procedure	SUPERSEDES None

around the holes.

5. Pour one quart of deionized water on the paper of each plate. Set polishing carriers into position and lower top plate into place. Secure against sustaining bar.

6. Pour part of contents from the one (1) gallon bottle into a one (1) quart bottle/spout. Add compound to the plates via the holes heretofore described.

7. Start the machine using afore-described procedure.

8. Run the machine for 15 minutes adding compound periodically.

9. Machine is now ready to polish the thermoelectric elements

10. If a crash occurs and the paper is torn, repeat this procedure, items D 1 - 9, using deionized water instead of Triclene D for cleaning.

E. <u>Polishing Thermoelectric Encapsulated Wafers</u>

1. Each period the machine is used for the first time that day or when the paper appears dried out, pour deionized water over both plates thoroughly wetting the pellon paper.

2. Set the carriers into position, equally along the gear rims.

3. Place elements or wafers to be polished into the holes of the carriers.

REQ.	USED ON ASSEM.	REVISION	DATE	BY	APPR'D BY	CHECKED BY

PROJ. NO. 1058	ENGR. NO.			
JOB NO.	REQ. NO.			
APPROVED FOR	ENGRG.	DATE	MFG.	DATE
SAMPLE UNIT				
TRIAL PROD. RUN-"EX."				
FINAL PROD.				
Pilot Operations	JEG	1/7/63		

TOLERANCES FOR ALL DIMENSIONS ARE ± 0.0005 UNLESS OTHERWISE SPECIFIED

ANGULAR ± | MACHINING ±

HOLE SPACING & LOCATION ± NON-CUMULATIVE

MANUFACTURED R1058-2187 | PURCHASED

MATERIAL
Encapsulated Thermoelectric Wafers, 1 Micron Al_2O_3, Deionized Water

FINISH

Carrier

TITLE
POLISHING THERMOELECTRIC ENCAPSULATED WAFERS

CAUTION ALL DIMENSIONS GIVEN IN INCHES. DO NOT SCALE DRAWING.

DR. | | SCALE

CH. | |

DWG. No. R1058-1225

REV | DWG. NO. R1058-1225

DO NOT REVISE THIS DRAWING WITHOUT REFERRING TO DRAWING NO. R1058-2187

Operating Procedure

SUPERSEDES: None

4. Pour a thin layer of the Al_2O_3 polishing compound mixture over each of the wafers.

5. Set top plate into position and secure against the retaining bar.

6. Turn on lap and while waiting the 10 seconds warm up period of the switch, pour polishing compound into the holes of the top plate.

7. Slowly increase the speed of the machine until operating at maximum rotation.

8. Periodically add polishing compound to the wafers via the aforementioned holes in the top plate.

9. Establish the surface removal rate by polishing for five minutes and measure the thickness of four or five pieces, cleaned in deionized water. Using this rate per minute, continue polishing until the surface has been brought to the proper dimension.

10. A minimum of 1.5 mils must be removed from each side of the wafers to insure removal of the surface damage, resulting from the waferizing process. Any extra removed is costly in labor and material, so attempt to control all processes to 3.0 - 3.5 total required surface removal.

11. When polishing has been completed, wash machine thoroughly with deionized water and cover completely with a plastic sheet to keep room dust from settling on and contaminating the pellon paper.

REQ.	USED ON ASSEM.	REVISION	DATE	BY	APP'D BY	CHECKED BY

DO NOT REVISE THIS DRAWING WITHOUT REFERRING TO DRAWING NO. R1058-2187

PROJ. NO. 1058 | ENGR. NO.

JOB NO. | REQ. NO.

APPROVED FOR	ENGRG.	DATE	MFG.	DATE
SAMPLE UNIT				
TRIAL PROD. RUN-"EX."				
FINAL PROD.				
Pilot Operations	JEG	1/7/63		

TOLERANCES FOR ALL DIMENSIONS ARE ± 0.0005 UNLESS OTHERWISE SPECIFIED

ANGULAR ± | MACHINING ±

HOLE SPACING & LOCATION ± NON-CUMULATIVE

MANUFACTURED R1058-2187 | PURCHASED

MATERIAL: Encapsulated Thermoelectric Wafers, 1 Micron Al_2O_3, Deionized Water

FINISH

Carrier

THIS DRAWING IS THE PERSONAL PROPERTY OF
CARRIER CORPORATION
SYRACUSE, NEW YORK, U.S.A.
ALL USE IS FORBIDDEN EXCEPT ON ITS WRITTEN CONSENT

TITLE: POLISHING THERMOELECTRIC ENCAPSULATED WAFERS

CAUTION — ALL DIMENSIONS GIVEN IN INCHES. DO NOT SCALE DRAWING.

DR. | | | SCALE

CH. | | |

DWG. NO. R1058-1225

REV | DWG. NO. R1058-1225

Operating Procedure

SUPERSEDES: Hand Tinning

A. Equipment

1. Tweezers
2. Scott paper towels
3. Safety glasses
4. Redford Corp. Model G-200A ultrasonic generator and ultrasonic soldering pot Model 1147
5. Propane torch
6. Solder: 59% Bi; 39% Sn; 2% Sb (see Drawing R1058-1197)

B. Preparing Solder Pot

1. Set the solder pot control dial at 5+. This should give a solder temperature of 440 + 10°F.
2. Using a propane gas torch, melt the BiSn solder into the pot, until the level of the molten material is just above the ultrasonic heads.
3. Scrap off any oxidation residue which might have formed during the solder melting process.
4. Set the generator power dials at 50.
5. Temperature on the built-in dial thermometer should read approximately 400°F, 50°F less than actual temperature of the molten solder.
6. One at a time, tune the transducers. Push the foot switch and adjust the phase dial for the highest pitch available. Shut off this transducer and tune the other.
7. Pick up an element with the tweezers, holding it vertically and the narrow side at right angle to the front of the pot. Insert the element between the two transducer heads and measure remaining space between the elements and the heads.
8. Adjust, by loosening the screws in the holding bracket, to give a spacing of 20 mils more than the elements to be tinned are thick. Tighten screws.

REQ.	USED ON ASS'M.		REVISION	DATE	BY	APP'D BY	CHECKED BY
			Item C-2 Call Engineer				
			Item C-1 Tin, four sec.				
		III	Item A-6 added	1/14/64	JEG	JEG	
		II	Item C and D added	7/8/63	JEG	JEG	
		I	Entire	5/7/63	JEG	JEG	JEG

PROJ. NO. R1058 | ENGR. NO. | JOB NO. | REQ. NO.

APPROVED FOR	ENGRG.	DATE	MFG.	DATE
SAMPLE UNIT				
TRIAL PROD. RUN-"EX."				
FINAL PROD.				
Pilot Operation	APK	11/1/62		

TOLERANCES FOR ALL DIMENSIONS ARE ± UNLESS OTHERWISE SPECIFIED

ANGULAR ± | MACHINING ±

HOLE SPACING & LOCATION ± NON-CUMULATIVE

MANUFACTURED | PURCHASED

MATERIAL
Solder per Drawing R1058-1197
TE Elements per Drawing R1058-2187

FINISH

Carrier

THIS DRAWING IS THE PERSONAL PROPERTY OF
CARRIER CORPORATION
SYRACUSE, NEW YORK, U.S.A.
ALL USE IS FORBIDDEN EXCEPT ON ITS WRITTEN CONSENT

TITLE
Tinning of Thermoelectric Elements

CAUTION — ALL DIMENSIONS GIVEN IN INCHES. DO NOT SCALE DRAWING.

DR. | CH. | SCALE

DWG. No. R1058-1192 Rev. III

REV. III — DWG. NO. R1058-1192

DO NOT REVISE THIS DRAWING WITHOUT REFERRING TO DRAWING NO. ______

Sheet 1 of 2

SUPERSEDES

9. Inspect the element just used for setting the heads and if the epoxy has expanded a crack, discard the piece.

C. Tinning

1. Tinning may now begin by picking up an element as described in B-7. Insert element between the heads and push foot switch. Slowly move element while under the solder, back and forth, always remaining within the area of the two heads. After four seconds, lift piece from solder and then remove foot from switch.

2. Inspect both sides of the element and if tinning is not complete to the outer edges, call Engineer.

3. Lay tinned element on a clean towel. There is no need to wait until solder has solidified.

4. When tinning has been completed, leave solder pot "on" at temperatures heretofore set.

D. Maintenance of Pot

1. Periodically, sample the liquid and have chemical analysis performed to ascertain changes in composition.

2. If there is an indicated change in the Bi, Sn and Sb content of more than 5%, the solder should be removed from the pot and discarded.

3. To remove solder, set the entire pot assembly on a stand or blocks about 6" off the table. Turn screw in rear of pot and catch molten solder in a freezer cup (two may be needed). When completed return emptying screw to normal.

REQ.	USED ON ASSEM.	REVISION	DATE	BY	APPR'D BY	CHECKED BY

PROJ. NO. R1058 | ENGR. NO.
JOB NO. | REQ. NO.

APPROVED FOR	ENGRG.	DATE	MFG.	DATE
SAMPLE UNIT				
TRIAL PROD. RUN-"EX."				
FINAL PROD.				

TOLERANCES FOR ALL DIMENSIONS ARE ± UNLESS OTHERWISE SPECIFIED
ANGULAR ± | MACHINING ±
HOLE SPACING & LOCATION ± NON-CUMULATIVE
MANUFACTURED | PURCHASED
MATERIAL
FINISH

Carrier

TITLE
Tinning of Thermoelectric Elements

CAUTION ALL DIMENSIONS GIVEN IN INCHES. DO NOT SCALE DRAWING.
DR. | SCALE
CH.

DWG. No. R1058-1192 Rev. III

REV III | DWG. NO. R1058-1192

DO NOT REVISE THIS DRAWING WITHOUT REFERRING TO DRAWING NO.

Operating Procedure	SUPERSEDES none

A. Equipment and Supplies

2 1/2 kw Induction Heater, Lepel or Equivalent

Automatic Fixturing, Drawing R1058-9175 and -9203

Tweezers

Flux, Kester 1544 diluted 1:1 with Kester
104 Thinner

Tin Plated Copper Pieces and Ceramic Wafers per drawings.

B. Start Up

1. Turn on cooling water to RF generator.
2. Adjust air supply to hold down fixture to 20-25 psi.
3. Make sure cooling air valves are on.
4. Set start switch on "push button".
5. Turn on RF generator power. Wait 10 minutes for generator to warm up.
6. Set start switch on "foot" switch control.
7. Push foot switch and set grid to read 250 on the meter provided. Power dial to be set at full scale.

REQ.	USED ON ASSEM.		REVISION	DATE	BY	APPR'D BY	CHECKED BY
		1	Type flux used	7/8/63	JEG	JEG	
		2	C-5 "shaking" to "wipe"	1/24/64	RBZ	JEG	
		3	B-2 "28 to 20-25 psi"	9/19/64	JEG	JEG	
			C-13 Use of tweezers				

PROJ. NO. R1058		ENGR. NO.	
JOB NO.		REQ. NO.	

APPROVED FOR	ENGRG.	DATE	MFG.	DATE
SAMPLE UNIT				
TRIAL PROD. RUN-"EX."				
FINAL PROD.				
Pilot Operations	JEG	2/8/63		

TOLERANCES FOR ALL DIMENSIONS ARE ± 1% UNLESS OTHERWISE SPECIFIED

ANGULAR ± | MACHINING ±

HOLE SPACING & LOCATION ± NON-CUMULATIVE

MANUFACTURED x | PURCHASED

MATERIAL copper straps, and spacers, Carrier Drawing R1058-3181, ceramics, Carrier Drawing R1058-1141 or 1166

FINISH

THIS DRAWING IS THE PERSONAL PROPERTY OF
CARRIER CORPORATION
SYRACUSE, NEW YORK, U.S.A.
ALL USE IS FORBIDDEN EXCEPT ON ITS WRITTEN CONSENT

TITLE

RF BONDING OF CERAMIC SANDWICHES

CAUTION ALL DIMENSIONS GIVEN IN INCHES. DO NOT SCALE DRAWING.

DR.		SCALE
CH.		

DWG. No. R1058-1185 Rev. III

REV. III | DWG. NO. R1058-1185

DO NOT REVISE THIS DRAWING WITHOUT REFERRING TO DRAWING NO. R1058-3181, 1141, 1166, 9175, 9203

Operating Procedure	SUPERSEDES none

C. Operating Procedure

1. Select the sliding fixture, 12 or 7 mm type, to be used.

2. Hold down retaining pin and slide the fixture into slot of the larger retaining fixture.

3. With slide in place release retaining pin. Move slide back and forth to check for freedom of movement and binding.

4. Move slide to either left or right and set one copper spacer into each of two counter sunk spaces provided. Use tweezer to handle the spacers.

5. With tweezers, pick up a ceramic wafer, dip in flux, wipe off excess; then set into counter sunk slot on top of the previous positioned spacer. Repeat for second wafer.

6. Again using tweezers, set one copper strap into counter sunk slot on top of the fluxed ceramic wafer. Repeat for second stra, .

7. When sure all three components of each slot are in proper position, move the sliding fixture in the opposite direction until it stops. The ceramic-copper sandwich components are now located directly under the top portion of the RF coil.

8. Push the foot switch. The RF coil will become active and heating of the copper pieces is automatic. At the same time, the three fingered holder will push downward through the coil and hold the sandwich components into position firmly.

REQ.	USED ON ASSEM.		REVISION	DATE	BY	APPR'D BY	CHECKED BY

PROJ. NO. R1058		ENGR. NO.		
JOB NO.		REQ. NO.		
APPROVED FOR	ENGRG.	DATE	MFG.	DATE
SAMPLE UNIT				
TRIAL PROD. RUN-"EX."				
FINAL PROD.				
Pilot Operations	JEG	2/8/63		

TOLERANCES FOR ALL DIMENSIONS ARE ± UNLESS OTHERWISE SPECIFILD 1%

ANGULAR ± | MACHINING ±

HOLE SPACING & LOCATION ± NON-CUMULATIVE

MANUFACTURED x | PURCHASED

MATERIAL copper straps and spacers, Carrier Drawing R1058-3181, ceramics, Carrier Drawing R1058-1141 or 1166

FINISH

Carrier

TITLE

RF BONDING OF CERAMIC SANDWICHES

CAUTION ALL DIMENSIONS GIVEN IN INCHES. DO NOT SCALE DRAWING.

DR.			SCALE
CH.			

DWG. No. R1058-1185 Rev. III

REV III

DWG. NO. R1058-1185

DO NOT REVISE THIS DRAWING WITHOUT REFERRING TO DRAWING NO. R1058-3181, 1141, 1166, 9175, 9203.

Operating Procedure	SUPERSEDES none

9. The induction heating cycle will continue for the period set on the automatic timer, which for components shown on Carrier drawing R1058-3181 is approximately 16 seconds at a grid setting of 250.

10. Immediately upon conclusion of the heating cycle (red light goes off), the compressed air is turned automatically on and cools the sandwich to a point below the melting point of the plated tin. This time cycle may vary between the 12 and 7 mm pieces and may also be a function of the compressed air temperature. The cycle can be adjusted on the clock-timer provided in the circuit.

11. Immediately upon completion of the cooling cycle, the three fingered holder will rise and slide can now be moved.

12. Move the slide in the opposite direction until the sandwiches are directly over the discharge air holes.

13. Push foot switch provided and an air blast will push the hot sandwiches out of their slots into a trough and finally into a metal container where they will finally cool to room temperature. Sandwiches may also be removed with tweezer, if foot switch is not used.

14. After the operator has become familiar with the aforegoing procedure, he then can load the empty side of the fixture while the full side is going through the melting and cooling cycles. In this manner, a new set of sandwich components are always ready for bonding as the completed ones are removed by air pressure from the fixture.

15. When the machine is not in use, the start switch should be set on "push button" to avoid accidental tripping of the foot switch

REQ.	USED ON ASSEM.	REVISION	DATE	BY	APPR'D BY	CHECKED BY

PROJ. NO. R1058		ENGR. NO.	
JOB NO.		REQ. NO.	

APPROVED FOR	ENGRG.	DATE	MFG.	DATE
SAMPLE UNIT				
TRIAL PROD. RUN-"EX."				
FINAL PROD.				
Pilot Operations	JEG	2/8/63		

TOLERANCES FOR ALL DIMENSIONS ARE ± 1% UNLESS OTHERWISE SPECIFIED

ANGULAR ± | MACHINING ±

HOLE SPACING & LOCATION ± NON-CUMULATIVE

MANUFACTURED X | PURCHASED

MATERIAL copper straps and spacers, Carrier Drawing R1058-3181, ceramics, Carrier Drawing R1058-1141 or 1166

FINISH

Carrier

THIS DRAWING IS THE PERSONAL PROPERTY OF
CARRIER CORPORATION
SYRACUSE, NEW YORK, U.S.A.
ALL USE IS FORBIDDEN EXCEPT ON ITS WRITTEN CONSENT

TITLE

RF BONDING OF CERAMIC SANDWICHES

CAUTION ALL DIMENSIONS GIVEN IN INCHES. DO NOT SCALE DRAWING.

DR.		SCALE
CH.		

DWG. No. R1058-1185 Rev. III

DWG. NO. R1058-1185 REV III

DO NOT REVISE THIS DRAWING WITHOUT REFERRING TO DRAWING NO. R1058-3181, 1141, 1166, 9175, 9203, Sheet 3 of 4

Operating Procedure

SUPERSEDES None

D.Safety Precautions

1. Operator should remove all rings and if worn, wrist watch; to avoid possible coupling with the R.F. coil by the metalic objects.

2. Care should be used to hold tweezers away from the R.F. coil when it is energized.

3. All flux spillage should be cleaned up immediately with triclene solvent. Use care not to breathe the fumes and wear protective hand covering.

4. Do not breathe the flux fumes that may escape from sandwiches during bonding process.

PROJ. NO. R1058			ENGR. NO.		
JOB NO.			REQ. NO.		
APPROVED FOR	ENGRG.	DATE	MFG.	DATE	
SAMPLE UNIT					
TRIAL PROD. RUN-"EX."					
FINAL PROD.					
Pilot Operation	JEG	2/14/63			

TOLERANCES FOR ALL DIMENSIONS ARE ± UNLESS OTHERWISE SPECIFIED

ANGULAR ± MACHINING ±

HOLE SPACING & LOCATION ± NON-CUMULATIVE

MANUFACTURED PURCHASED

MATERIAL

FINISH

Carrier

TITLE

R.F. Bonding of Ceramic Sandwiches

CAUTION ALL DIMENSIONS GIVEN IN INCHES. DO NOT SCALE DRAWING.

DR. | SCALE

CH.

DWG. No. R1058-1185 Rev. III

REQ.	USED ON ASSEM.	REVISION	DATE	BY	APPR'D BY	CHECKED BY

DO NOT REVISE THIS DRAWING WITHOUT REFERRING TO DRAWING NO. R1058-3181, 1141, 1166, 9175, 9203

SUPERSEDED BY: SIMILAR TO:

SYM.	REVISION RECORD	DATE	BY	APPD. BY	CH'KD. BY	E.C.R. NO.

REV.

DWG. NO. R1058-1299

A. **Operating Supplies and Equipment**

1. Tweezers (Teflon coated)
2. Transite matrix fixtures, R1058
3. Mylar lattice cut and assembled for type panel to be fabricated
4. Kester 1429 flux
5. Flux brush, standard size with bristles cut to 1/4"
6. Scott paper towels
7. Small beaker
8. 5KW Westinghouse RF generator or equivalent with coil
9. Compressed dry air supply
10. 1/16" aluminum plate cut to panel size

B. **Assembly Procedure**

1. Turn on generator and allow to warm up for 15 minutes
2. Set lattice into position on matrix plate and remove top cross pieces
3. Lay into position, ceramic sandwiches on matrix plate in configuration equal panel being assembled, spacer side down. Do not mix sandwiches, premeasured to tolerance of .0005" and previously separated into size lots

4. Set lead strap into position
5. Using Teflon coated tweezers, pick up elements vertically, dip in flux and then blot excess runoff on Scott towel

MATERIAL
TE Wafers - R1058-2187
Ceramic Sandwiches - R1058-3181

APPLIED FINISH

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRACTIONS	DECIMALS	ANGLES
±	±	±
SURFACES	HOLE SPACING	HOLE LOCATION
√ MIN.	±	±
	NON-CUMULATIVE	

CARRIER CORPORATION

This Drawing is the Personal Property of Carrier Corporation — Carrier — All Use Is Forbidden Except On Its Written Consent

SYRACUSE, NEW YORK, U.S.A.

USED ON ASSY. All R1058

AUTHORIZATION NO.

MANUFACTURED		PURCHASED		
APPROVED FOR	ENGRG.	DATE	MFG.	DATE
Pilot Oper.	APK	1/31/64		
TRIAL PROD. RUN				
FINAL PROD.				

DR.			SCALE (DO NOT SCALE DRAWING)
CH'KD.			

TITLE
THERMOELECTRIC PANEL ASSEMBLY
(RF BONDING)

DWG. NO. R1058-1299

DO NOT REVISE THIS DRAWING WITHOUT REFERRING TO DRAWING NO. ______ PRINT DISTR. Page 1 of 3 QTY. ______

SUPERSEDED BY ______ SIMILAR TO ______

SYM.	REVISION RECORD	DATE	BY	APPD. BY	CH'KD. BY	E.C.R. NO.

6. Lay top cross pieces on lattice and fit into position.
7. Left lead strap is <u>always</u> negative. First element will <u>therefore</u> be p-type.
8. Starting with p-type, set all p-type elements into position, alternating checkerboard style.
9. Set all n-type elements into position in the remaining alternate spaces.
10. Adjust centering of each element with tweezers.
11. Holding the ceramic sandwich, strap side down, with tweezers, lower into the flux wetting on the strap portion.
12. Set ceramic sandwiches into position on top of elements.
13. Set top of matrix plate on unbonded panel. Care must be used to fit the rubber cushions between the lattice sections. Check to assure a good fit before inserting the small nylon screws or bolts into transite.
14. Set nuts on bolts. Tighten nuts in center band tight. Tighten remaining nuts.
15. With a socket wrench, draw nuts up snug.

USED ON ASSY.					
AUTHORIZATION NO.					
MANUFACTURED		PURCHASED			
APPROVED FOR	ENGRG.	DATE	MFG.	DATE	
TRIAL PROD. RUN					
FINAL PROD.					

MATERIAL		
APPLIED FINISH		
TOLERANCES UNLESS OTHERWISE SPECIFIED		
FRACTIONS ±	DECIMALS ±	ANGLES ±
SURFACES √ AIN.	HOLE SPACING ±	HOLE LOCATION ±
	NON-CUMULATIVE	
DR.		SCALE (DO NOT SCALE DRAWING)
CH'KD.		

CARRIER CORPORATION

SYRACUSE, NEW YORK, U.S.A.

TITLE: THERMOELECTRIC PANEL ASSEMBLY (RF BONDING)

DWG. NO. R1058-1299

SUPERSEDED BY ... SIMILAR TO ...

SYM.	REVISION RECORD	DATE	BY	APPD. BY	CH'KD. BY	E.C.R. NO

REV.

DWG. NO. R1058-1299

C. Bonding

1. Tune generator to predetermined settings.

2. Set timer to appropriate setting.

3. Place and center panel assembly in coil.

4. Push "on" button.

5. After set time interval has elapsed and power is off, remove panel from coil. Cool with forced air directed between transite plates for approximately 2 minutes.

D. Calibrating RF

Various output and time cycles will differ as change in panel sizes occurs from time to time. Check operating manual for establishing new settings.

USED ON ASSY.					MATERIAL			APPLIED FINISH	
AUTHORIZATION NO.					TOLERANCES UNLESS OTHERWISE SPECIFIED				
MANUFACTURED		PURCHASED			FRACTIONS ±	DECIMALS ±	ANGLES ±		
APPROVED FOR	ENGRG.	DATE	MFG.	DATE	SURFACES √ µIN.	HOLE SPACING ±	HOLE LOCATION ±	NON-CUMULATIVE	
TRIAL PROD. RUN					DR.			SCALE (DO NOT SCALE DRAWING)	
FINAL PROD.					CH'KD.				

CARRIER CORPORATION

This Drawing is the Personal Property of Carrier Corporation — Carrier — All Use Is Forbidden Except On Its Written Consent

SYRACUSE, NEW YORK, U.S.A.

TITLE

THERMOELECTRIC PANEL ASSEMBLY
(RF BONDING)

DWG. NO. R1058-1299

DO NOT REVISE THIS DRAWING WITHOUT REFERRING TO DRAWING NO. ______ PRINT DISTR. QTY. ______

PER Panel Foaming Panel SUPERSEDED BY SIMILAR TO

REV. 4 — DWG. NO. R1058-1226

SYM.	REVISION RECORD	DATE	BY	APPD. BY	CH'KD. BY	E.C.R. NO.
1	B-7 Omitted C-1 Revised	2/28/63	APK	APK	JEG	
2	Entire	7/ 8/63	APK	APK	JEG	
3	Entire	1/29/64	JEG	APK	RHZ	

A. <u>Operating Equipment and Supplies</u>

1. Balance
2. Paper cup to hold foaming materials
3. Mold for panels
4. Curing oven with temperature control
5. Electric hand mixer
6. Foaming compound - Callery 2527-25 (Polyurethane)
7. Tongue depresser
8. Plastic gloves
9. Rubber pad and weight
10. Saran wrap

B. <u>Set Up</u>

1. Place panel in oven which has been pre-set at 150°F. Panel will remain in oven for 10 minutes
2. Cover locating block with Saran wrap
3. Obtain mold and weigh out polyurethane resin on actuator

MATERIAL: Thermoelectric Panels, Callery 2527-25 Foaming Compound

APPLIED FINISH

USED ON ASSY. All R1058 Assemblies

AUTHORIZATION NO.

MANUFACTURED		PURCHASED		
APPROVED FOR	ENGRG.	DATE	MFG.	DATE
Pilot Oper.	APK	1/9/64		
TRIAL PROD. RUN				
FINAL PROD.				

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRACTIONS	DECIMALS	ANGLES
±	±	±
SURFACES	HOLE SPACING	HOLE LOCATION
√ RIN.	±	±
	NON-CUMULATIVE	

DR.

CH'KD.

SCALE (DO NOT SCALE DRAWING)

CARRIER CORPORATION

SYRACUSE, NEW YORK, U.S.A.

TITLE: FOAMING OF THERMOELECTRIC PANELS

DWG. NO. R1058-1226 (Rev. 4)

DO NOT REVISE THIS DRAWING WITHOUT REFERRING TO DRAWING NO. PRINT DISTR. Page 1 of 2 QTY.

JPER SUPERSEDED BY SIMILAR TO

SYM.	REVISION RECORD	DATE	BY	APPD. BY	CH'KD. BY	E.C.R. NO.

REV. 4

DWG. NO. R1058-1226

C. Foaming of Panel

1. Set panel, hot side up, on locating block covered with Saran wrap
2. Pour about one-third of mixed foam on bottom (hot side) of panel
3. Set mold on top of panel
4. Invert panel and mold to right side up
5. Remove locating block
6. Pour remainder of foam, quickly, on panel
7. Lay rubber pad on top of foam covered panel
8. Lay weight on rubber pad
9. After foaming ceases and foam is hard to the touch, set panel into oven at 150°F for 10 minutes to cure
10. Remove panel from oven, and remove mold from foamed panel
11. Cut away excess flash with a sharp instrument

USED ON ASSY.

AUTHORIZATION NO.

MANUFACTURED		PURCHASED		
APPROVED FOR	ENGRG.	DATE	MFG.	DATE
TRIAL PROD. RUN				
FINAL PROD.				

MATERIAL

APPLIED FINISH

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRACTIONS	DECIMALS	ANGLES
±	±	±
SURFACES √ µIN.	HOLE SPACING ±	HOLE LOCATION ±
	NON-CUMULATIVE	

DR.			SCALE (DO NOT SCALE DRAWING)
CH'KD.			

CARRIER CORPORATION

This Drawing is the Personal Property of Carrier Corporation — Carrier — All Use Is Forbidden Except On Its Written Consent

SYRACUSE, NEW YORK, U.S.A.

TITLE

FOAMING OF THERMOELECTRIC PANELS

DWG. NO. R1058-1226 (Rev. 4)

DO NOT REVISE THIS DRAWING WITHOUT REFERRING TO DRAWING NO.

PRINT DISTR. Page 2 of 2 QTY.

45

Unclassified
Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Carrier Air Conditioning Company Military Equipment Department	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP
3. REPORT TITLE Thermoelectric Environmental Control Unit	
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Final Engineering Design Report	
5. AUTHOR(S) (Last name, first name, initial) Hudelson, G.D.; Gable, G.K.; Beck, A.A.	

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
2? September 1965	100	

8a. CONTRACT OR GRANT NO. DA 44-009-AMC-1135(T) b. PROJECT NO. 1L 643303D545 c. 1L 643303D54503 d.	9a. ORIGINATOR'S REPORT NUMBER(S) ~~Project No. R1058-S13~~ 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. AVAILABILITY/LIMITATION NOTICES
U.S. Government agencies may obtain copies of this report directly from DDC. Other qualified users shall request through OMEFB-HH, USAERDL, Ft. Belvoir, Va.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army ERDL Fort Belvoir, Virginia

13. ABSTRACT

A detailed engineering design is presented for a 24,000 Btu/hr Thermoelectric Environmental Control Unit. System design is based on an optimization analysis performed on an analog computer. Procedures followed and results obtained are described. Twelve design parameters were optimized for minimum weight and maximum efficiency.

System is 28 in. wide x 18 in. deep x 63 in. high, weighs 380 lbs. and operates at an overall C.O.P. (including fans) of 1.12 with a net cooling capacity of 24,000 Btu/hr at design operating conditions. Dual frequency (60 and 400 cps) fans are used. Power rectifier furnishes 3 phase, full wave d-c power without voltage transformation. Modulated capacity control is provided from full cooling to full heating as required by system load. The design is based on air-to-air heat exchange utilizing aluminum heat transfer surface.

Operating instructions, maintenance procedures, manufacturing procedures and cost analysis information are included.

Recommendation is made to develop a prototype unit.

DD FORM 1 JAN 64 1473

Unclassified
Security Classification

Security Classification

14. KEY WORDS	LINK A ROLE	LINK A WT	LINK B ROLE	LINK B WT	LINK C ROLE	LINK C WT
Thermoelectric Heat Pump						
Thermoelectric Environmental Control Unit						

INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization *(corporate author)* issuing the report.

2a. REPORT SECURITY CLASSIFICATION: Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2b. GROUP: Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. REPORT TITLE: Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. DESCRIPTIVE NOTES: If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. AUTHOR(S): Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. REPORT DATE: Enter the date of the report as day, month, year, or month, year. If more than one date appears on the report, use date of publication.

7a. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. NUMBER OF REFERENCES: Enter the total number of references cited in the report.

8a. CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which the report was written.

8b, 8c, & 8d. PROJECT NUMBER: Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9a. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9b. OTHER REPORT NUMBER(S): If the report has been assigned any other report numbers *(either by the originator or by the sponsor)*, also enter this number(s).

10. AVAILABILITY/LIMITATION NOTICES: Enter any limitations on further dissemination of the report, other than those imposed by security classification, using standard statements such as:

(1) "Qualified requesters may obtain copies of this report from DDC."

(2) "Foreign announcement and dissemination of this report by DDC is not authorized."

(3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through ______________."

(4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through ______________."

(5) "All distribution of this report is controlled. Qualified DDC users shall request through ______________."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.

12. SPONSORING MILITARY ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring *(paying for)* the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as *(TS)*, *(S)*, *(C)*, or *(U)*.

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, rules, and weights is optional.

Security Classification