DOE/NASA CONTRACTOR REPORT

DOE/NASA CR-161588

SOLAR HEATING SYSTEM INSTALLED AT TROY, OHIO -- FINAL REPORT

Prepared from documents furnished by

Troy-Miami County Public Library
419 West Main Street
Troy, Ohio 45373

Under DOE Contract EX-76-C-01-2375

Monitored by

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

For the U. S. Department of Energy

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This work was done under the Technical Management of Mr. Douglas W. Westrope, George, C. Marshall Space Flight Center, Alabama 35812.

16. ABSTRACT

This document is the Final Report of the Solar Energy System located at Troy-Miami County Public Library, Troy, Ohio. The completed system is composed of three basic subsystems: The Collector System consisting of 3, 264 square feet of Owens Illinois evacuated glass tube collectors; The Storage System which includes a 5,000-gallon insulated steel tank; and The Distribution and Control System which includes piping, pumping and heat transfer components as well as the solenoid-activated valves and control logic for the efficient and safe operation of the entire system. This Solar Heating System was installed in an existing facility and is, therefore, a Retrofit System.

This report includes extracts from the site files, specifications, drawings, installation, operation and maintenance instructions.

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PREFACE

The efforts reported herein were conducted by a project team assembled by the Troy-Miami County Public Library under the Department of Energy, Solar Heating Demonstraton Project for Nonresidential Buildings, Contract No. EX-76-C-01-2375. This work, sponsored by the Department of Energy (DOE), was managed by the National Aeronautics and Space Administration (NASA), Marshall Space Flight Center, Huntsville, Alabama. The NASA Program Managers were Mr. Chet May from July 1976 through December 1977 and Mr. Douglas W. Westrope from January 1978 through contract completion. This report covers work conducted during the period from July 1976 through November 1979.

The author, Mr. Richard G. Coy, University of Dayton Research Institute, would like to acknowledge the cooperation and contributions of all of the project team whose members are: Troy-Miami County Public Library, project director, Mr. W. E. Paplinski, and former director, Mr. J. Dennis Day; Levin, Porter, Smith, Inc., architects, Mr. L. G. Davis; Heapy and Associates, mechanical engineering consultants, Mr. R. J. Pearson, Mr. G. Walls, and Mr. R. Strawser; University of Dayton Research Institute, solar system design consultants, Dr. J. E. Minardi, Mr. R. K. Newman, Mr. D. H. Whitford, and Mr. G. J. Roth; Owens-Illinois, Inc., solar collector manufacturers, Mr. V. R. Daiga and Mr. R. E. Ford; and Starco, Inc., general contractors, Mr. F. Ossenberg and Mr. B. Krisher.

We want to especially acknowledge the financial support provided to the project by the: Dayton Association of Plumbing Contractor; City of Troy, Concord Township; and the Troy Foundation.

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SECTION 1

INTRODUCTION AND SUMMARY

In July 1976 the Troy-Miami County Public Library was selected as one of 34 recipients of the nonresidential solar energy demonstration contracts awarded by the Department of Energy (DOE). There were 308 proposals submitted in response to Program Opportunity Notice DSE-75-2, and Troy was the only library in the United States and the only facility in Ohio to receive one of these contracts.

The city of Troy, Ohio, which is the county seat of Miami County, is situated on the Great Miami River, 21 miles north of Dayton, Ohio. Troy's location in Ohio, shown in Figure 1-1, is immediately east of Interstate 75 and 15 miles north of Interstate 70. The library building, located in the downtown area of the city, has a floor area of over 23,000 square feet and houses over 115,000 books and nonprint materials. The location of the building within the city and the library building prior to installation of the solar system are shown in Figures 1-2 and 1-3, respectively.

This project was directed towards the design, development, installation, and demonstration of a solar heating system in a nonresidential building. The overall program was managed by the National Aeronautics and Space Administration (NASA) at the Marshall Space Flight Center, Alabama, and was sponsored by DOE. The efforts discussed in this report were conducted by a project team, whose members were: Troy-Miami County Public Library, project director; Levin, Porter, Smith, Inc., architects; Heapy and Associates, mechanical engineering consultants; University of Dayton Research Institute, solar system design consultants; Owens-Illinois, Inc., solar collector manufacturer; and Starco, Inc., general contractor. Major subcontractors included: Honeywell Automation, system controls; Dayton Fabricated Steel, solar collector mounts; and the Design Display Company, lobby display.

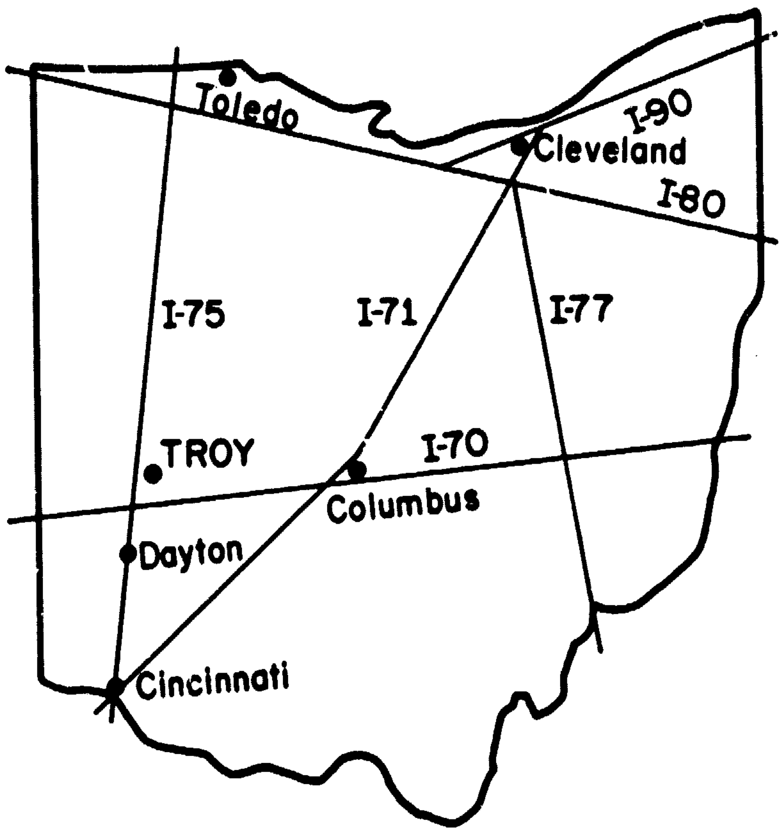

Figure 1-1. Location of Troy, Ohio.

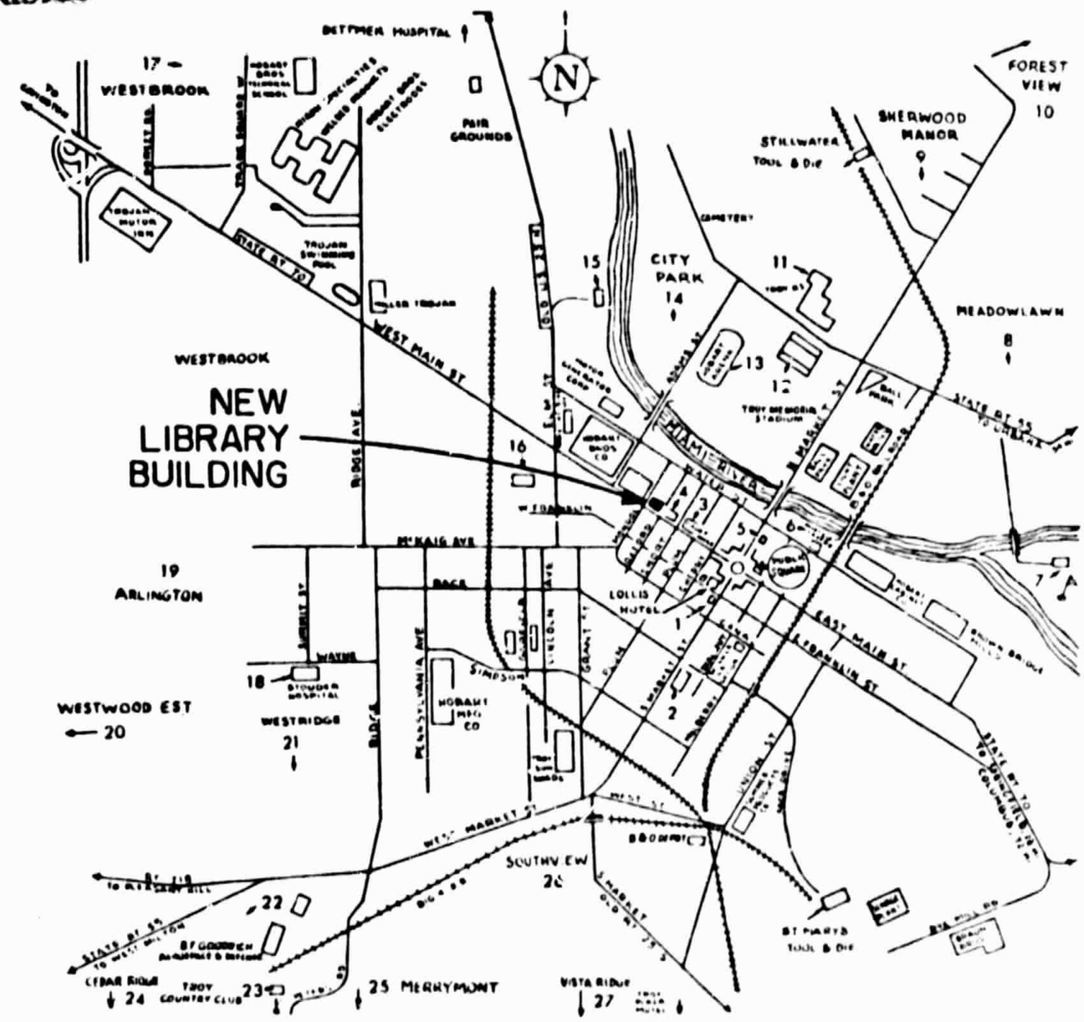

Figure 1-2. Location of New Troy-Miami County Public Library Building.

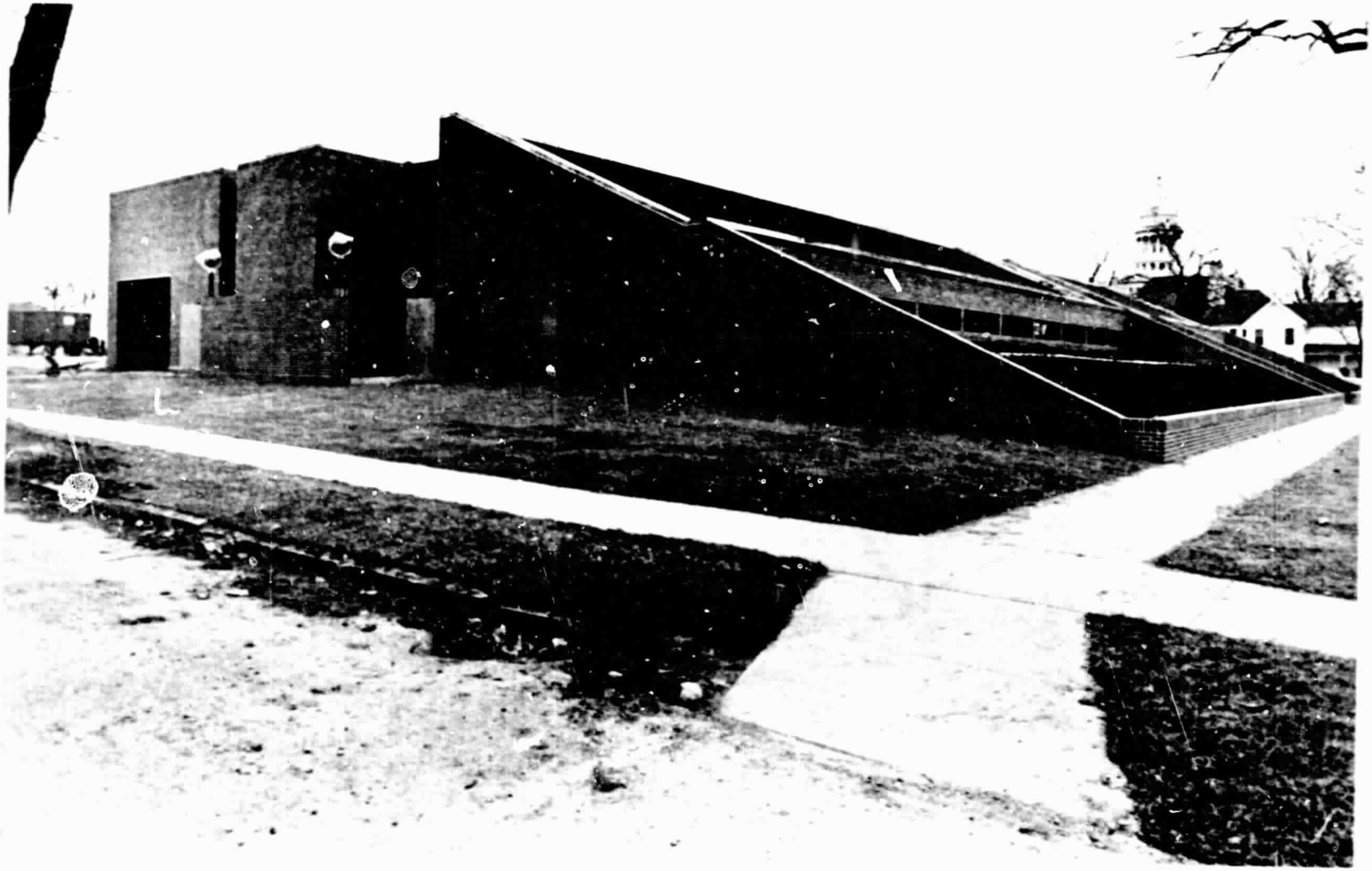

Figure 1-3. Library Building.

The solar heating system which was interfaced with the original Heating, Ventilating, and Air Conditioning (HVAC) systems consists of 3,264 gross square-feet of solar collector collector modules. The collector modules were interconnected to form six arrays with 11 modules in each array and six arrays with six modules in each array as shown in Figure 1-4. A front view of the building with all 12 arrays is shown in Figure 3-1. Also incorporated in the system is a 5,000-gallon insulated steel tank for storage of water and a distribution and control sub-system including the required piping, pumping, and heat transfer components.

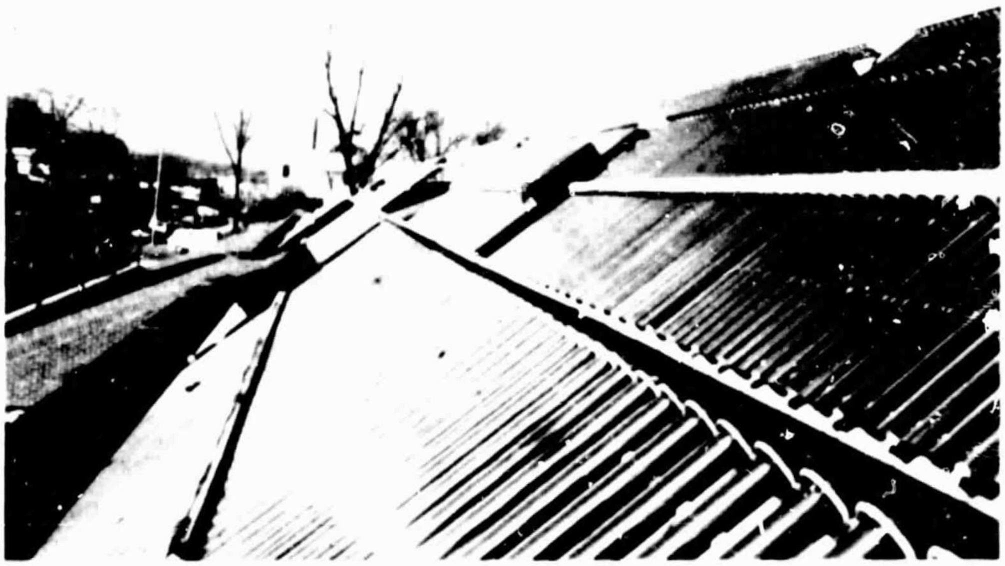

Figure 1-4. Solar Collector Arrays.

In addition, this demonstration site includes a comprehensive instrumentation system, supplied by DOE, for monitoring and evaluating the system's performance. This instrumentation system is part of the National Solar Data Network and serves to meet the data collection performance evaluation and data dissimination goals of the National Program for Solar Heating and Cooling. Also included at this site is an attractive lobby display which shows, in animated schematic form, the functioning of the solar heating system and provides real time operational data on the performance of the system.

Installation of the solar heating system was completed in late March 1978. However, several problems were encountered during and subsequent to the system checkout. These problems included conventional air binding problems that may have been aggravated by low flow rates in the collector; improper adjustment of air flow dampers; leaking control valves, improperly installed valves; and failure of space thermostats. Following a detailed analysis and after approval by DOE, the system was reconfigured in order to ensure a more balanced flow within the system. System reconfiguration was completed and the system activated in late November 1978.

System performance information during the 1978-1979 heating season was not available because of sensor failure and inaccurate calibration data in the instrumentation monitoring system. Visual observations would indicate low performance of the system because of. low tank temperature at the beginning of the heating season; excessive cloud cover in November and December 1978; and excessive wet snow which stuck on the collectors in the January and February 1979 period. It is also believed that total system control problems existed during this period but were not identified.

Final system acceptance testing was conducted by Heapy and Associates in conjunction with NASA/DOE in early June 1979. During this period NASDA/DOE replaced and recalibrated all site instrumentation associated with the National Solar Data Network. It is anticipated that system performance data will be available from DOE for the 1979-1980 heating season.

SECTION 2
SITE DESCRIPTION

The new Troy-Miami County Public Library, officially occupied in February 1976, is located on the four hundred block of West Main Street, Troy, Ohio, 40" North Latitude and 84° 10' West Longitude. The library is a one-story building with basement, having a total fl r area 23,200 square feet. Drawings of the site and building are presented in Figures 2-1 through 2-5.

The Troy-Miami County Library Board had made energy conservation a top priority in the design and development of the new library and had made preliminary plans to include a solar energy component in the total energy program for the facility. The roof on the south and north sides of the building slopes at about 23.5° downward from the center of the building with the building oriented such that the sloping south roof, where solar collectors would be installed, faces about 23° west of south. This orientation of west of south as stated in the reference, "Solar Collector Performance Evaluation with the NASA-LEWIS Solar Simulator - Results for an All-Glass-Evacuated-Tubular Selectively-Coated Collector with a Diffuse Reflector," NASA TM X-71695, April 1975, Frederick Simon, would actually result in higher collector efficiencies.

A description of energy conservation provisions incorporated into the building are listed below.

1. The building was oriented such that the maximum roof area could be used for the location of solar collectors without sacrificing efficiency.

2. A portion of the building was constructed in effect below grade. Some of the usable areas are in a sub-level completely enclosed for making use of the constant ground temperature. The ground has been used to equalize the differential between indoor and outdoor temperature in as many instances as possible, as witnessed by the fact that the Reading Areas are from 50 to 70 percent below grade along the south side of the building.

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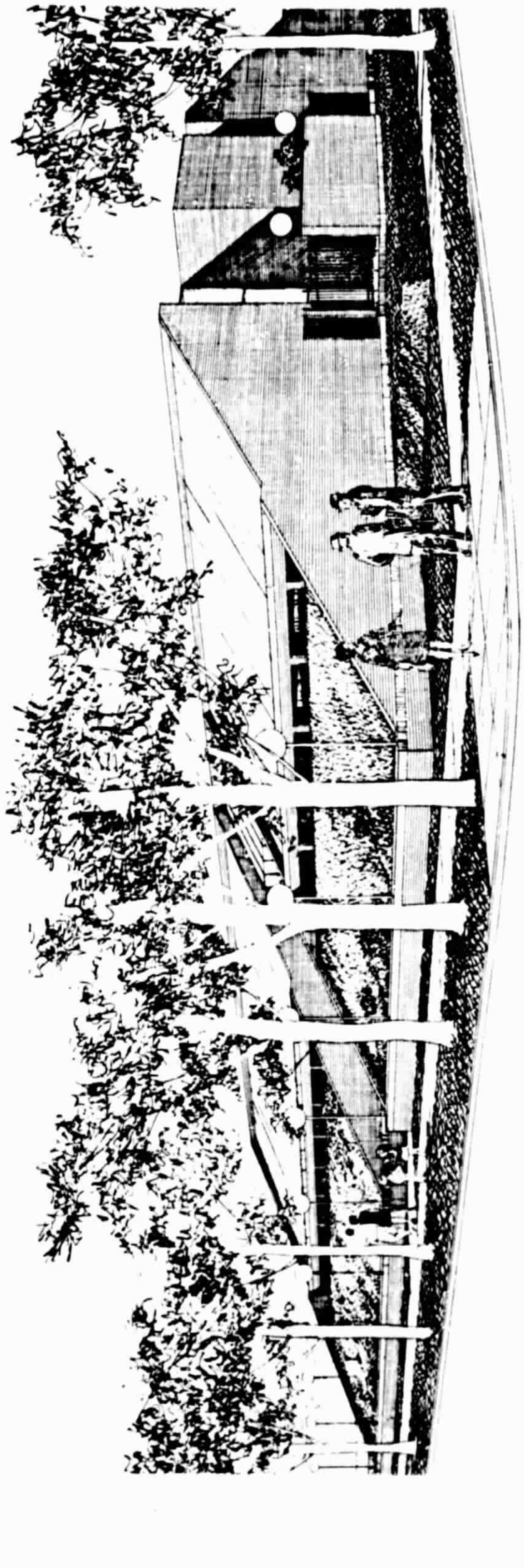

Figure 2-1. Rendering of Troy-Miami County Public Library Building.

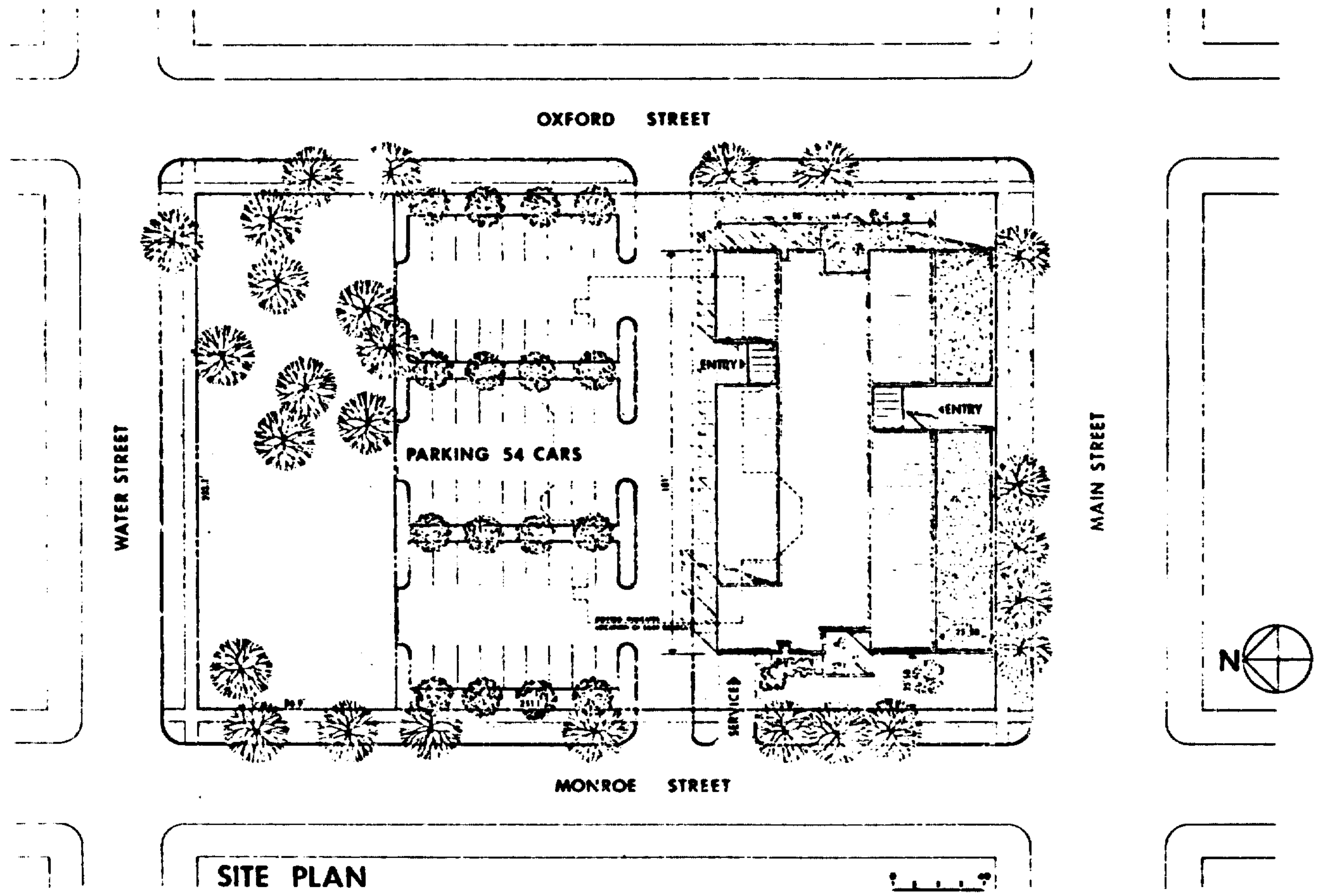

Figure 2-2. Landscaping of the Troy-Miami County Library.

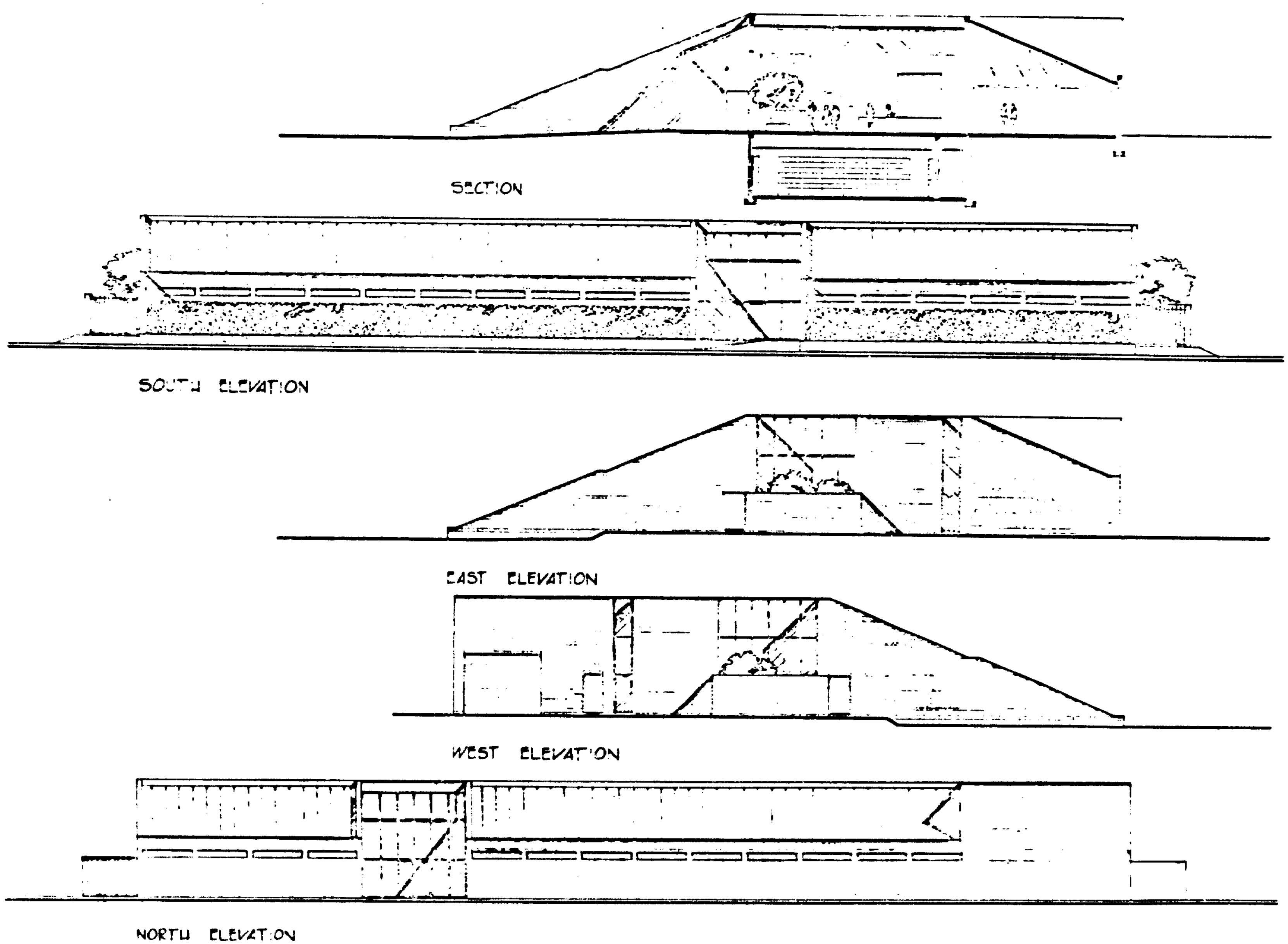

Figure 2-3. Elevation of the Troy-Miami County Library.

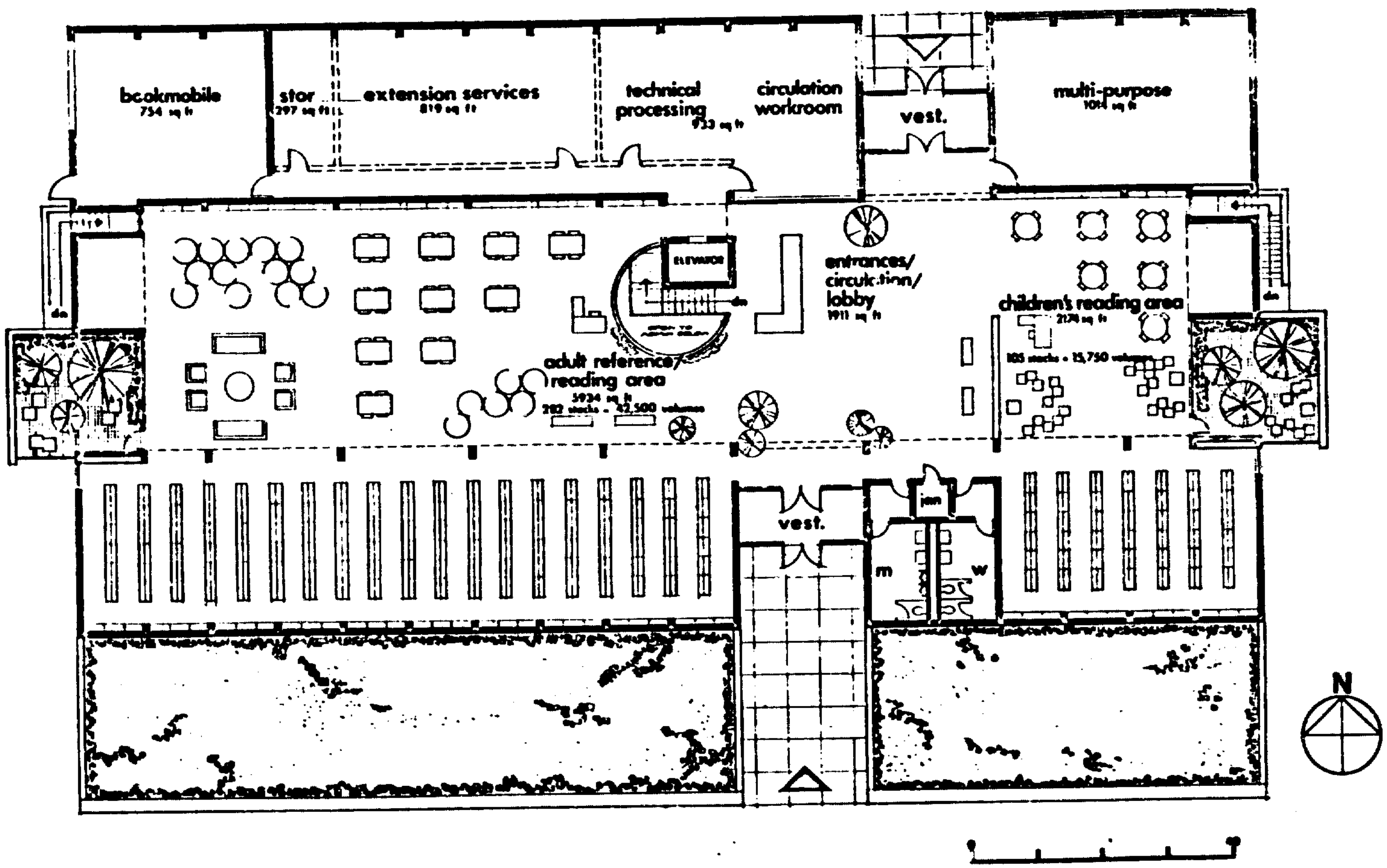

Figure 2-4. Main Floor Plan.

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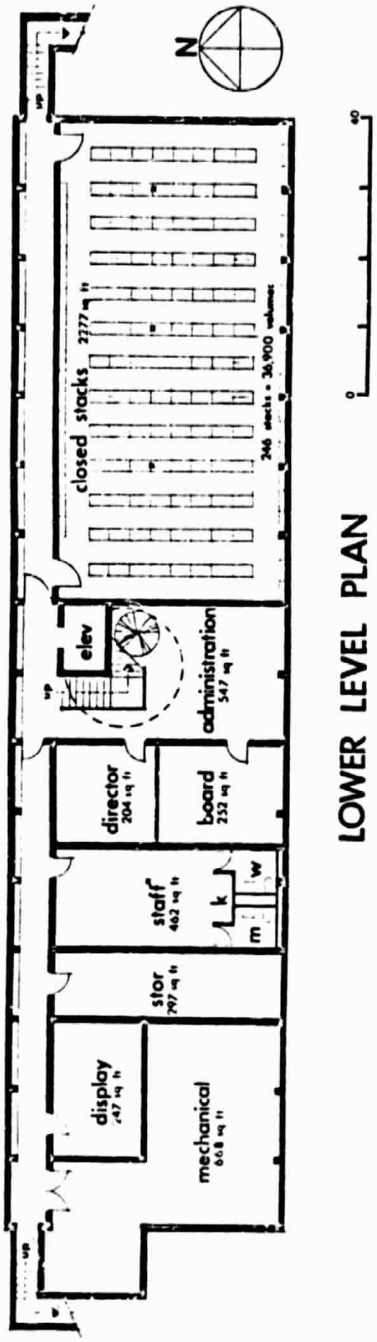

Figure 2-5. Lower Level Floor Plan.

3. Building insulation was used extensively. A considerable amount of time was spent improving the original recommendations regarding insulation.

4. Wherever possible, windows were installed in deep recesses so as to eliminate as much of the direct heat buildup as possible during the summer months and, insofar as possible, were located away from seated persons to eliminate cold drafts.

5. The area of glass was held to a minimum. The ratio of glass to masonary wall being less than 20 percent.

6. The design also takes into account that the population is on the interior of the building so that the comfort, particularly in the winter, can be maintained more draft-free without sacrificing windows located in the Stack Area.

7. Existing trees were trimmed in accordance with sun exposure for the various seasons by the landscaper after instructions regarding the intended installation of solar collectors. After careful study, the trees were trimmed to promote the maximum exposure to solar collector and maintain maximum shading to the south-west during the summer months.

Building construction was initiated in late November 1974 and completed in early February 1976 prior to the award of the solar energy demonstration contract. The majority of the required funds for the construction of the library were raised through a public subscription drive. The balance of the funds were raised from the Library Service and Construction Act, the City of Troy, and the Concord Township.

SECTION 3

SOLAR HEATING SYSTEM DESCRIPTION AND INSTALLATION

The installed solar energy heating system provides an attractive addition to the library building and is highly visible to the public as can be seen in Figure 3-1. The completed system is composed of three basic subsystems: the collector system consisting of 3,264 gross square feet of solar collector area; the storage system which includes a 5,000-gallon insulated steel tank; and the distribution and control system which includes the piping, pumping, and heat transfer components as well as the solenoid-activated valves and control logic for the efficient and safe operation of the entire system. This solar heating system was installed in an existing facility and is, therefore, a retrofit system.

As indicated previously, preliminary plans were made, during design and development of the library, to include a solar energy component in the total energy program for the facility. This approach minimized the amount of building modification and simplified the interfacing of the solar heating system with the existing Heating, Ventilating, and Air Conditioning (HVAC) system. The existing HVAC system in the building consists of five single zone air handling units, each with an electric heating coil and a chilled water cooling coil to condition the various spaces in the building. Chilled water is provided by a central chilled water piping system connected to a single packaged electric air-cooled chiller located on the roof of the building. Auxiliary heat in the form of electric baseboard and electric unit heaters is provided near entry ways in the bookmobile garage.

Interfacing the solar heating system with the standard HVAC system was accomplished by adding changeover valves to utilize the existing chilled water piping and cooling coils in each of the five air handling units for solar heat transfer. A schematic of the solar heating system which shows the interfacing to the HVAC system and the additional piping, pumping, and major components is presented in Figure 3-2.

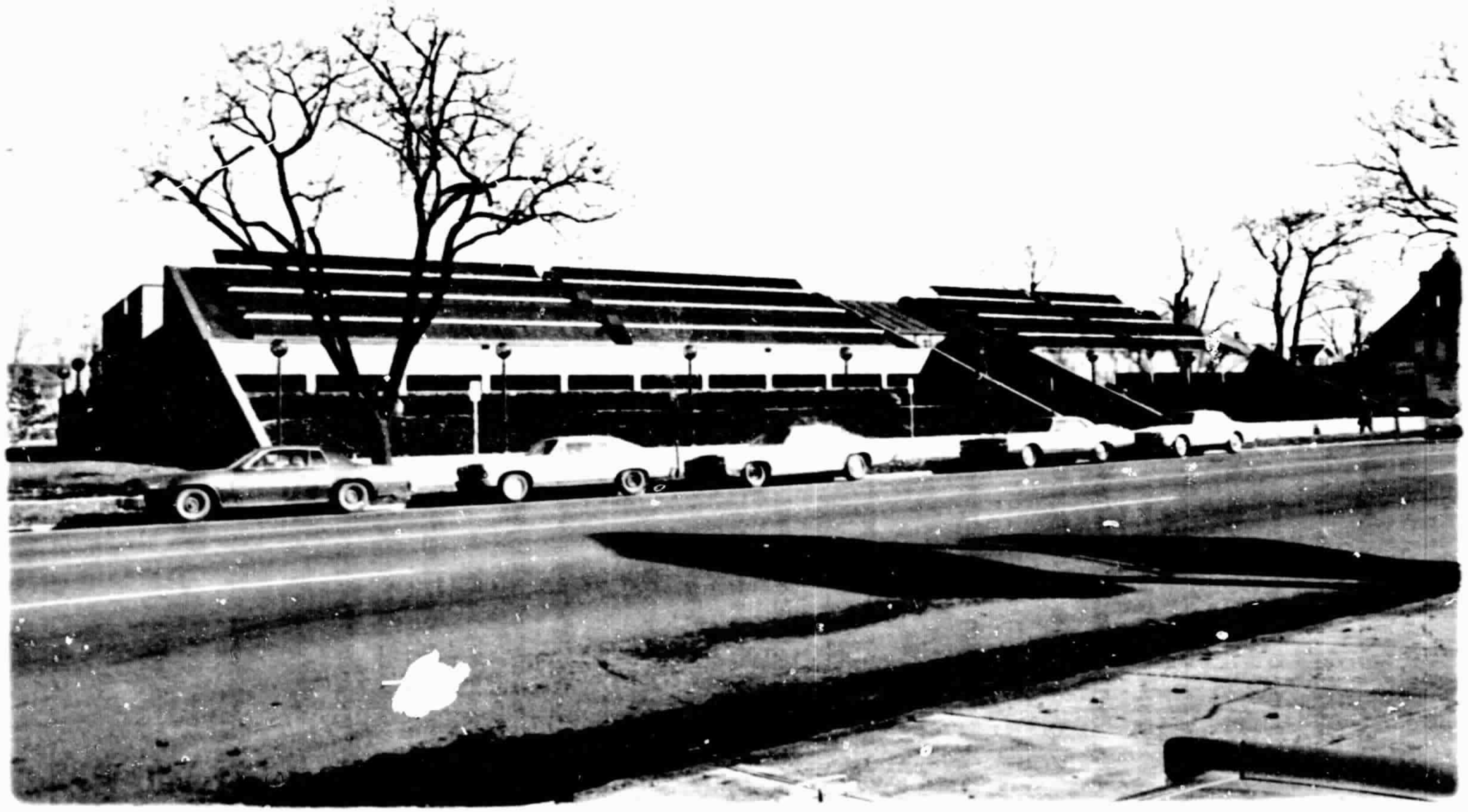

Figure 3-1. Library Building with Solar Heating System.

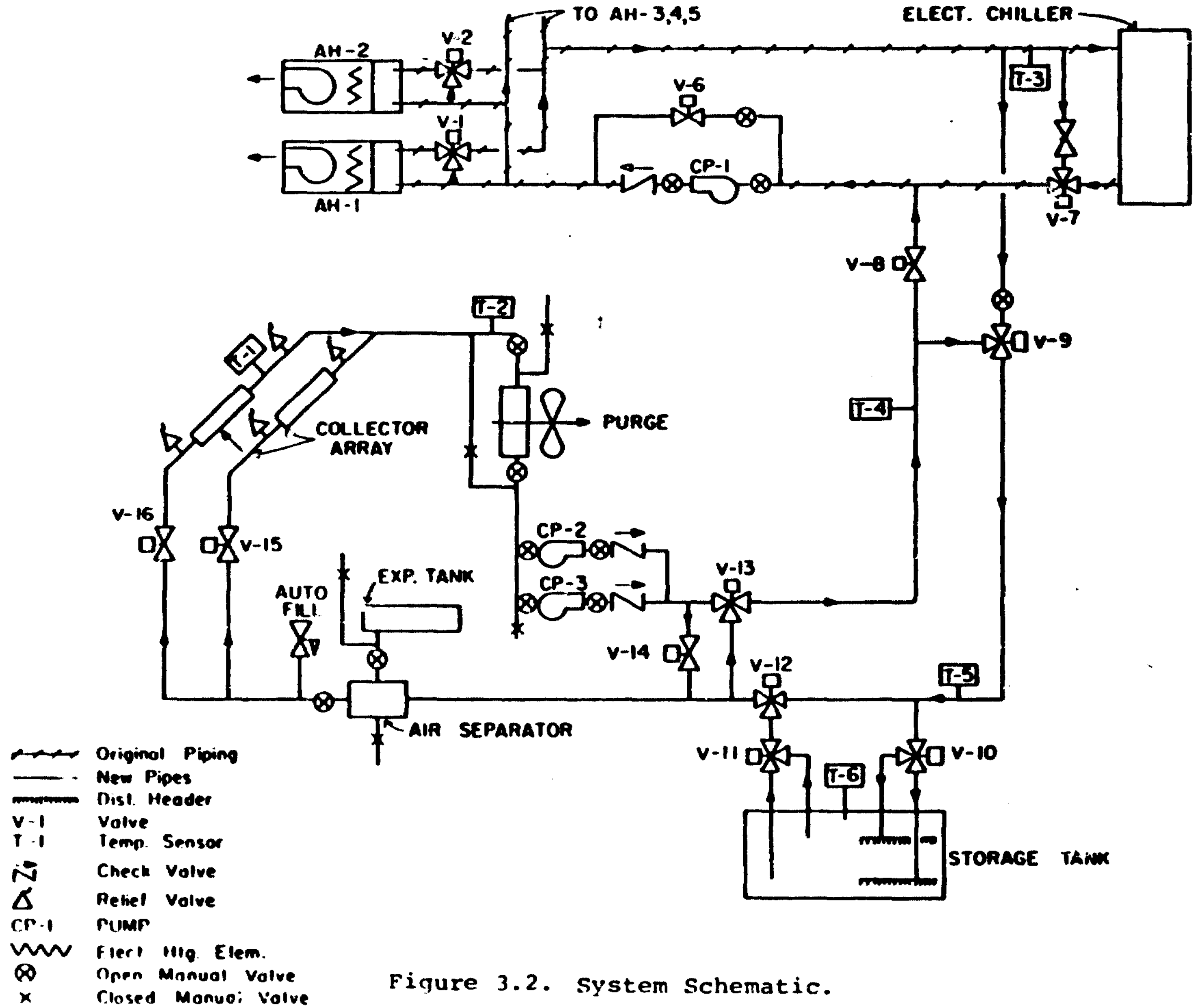

Figure 3.2. System Schematic.

In this systems operation, the solar insolation (radiation) captured by the solar collector heats water that is circulated through the collectors. The heated water is then channeled to the building heating loop if heat is required, to the storage tank for later use in the building heating loop, or through the purge (heat rejection) unit if excessive temperatures are encountered. Although this basically explains the system operation, there are actually several operating modes for the efficient and safe operation of the entire system. The various operating flow paths for summer and winter operations (see Figure 3-2) are listed below.

Summer Operation

Collector → Storage → Collector

Collector → Purge (Operating) → Collector

Winter Operation

Collector → Building Heating → Collector

Collector → Building Heating → Storage → Collector

Storage → Building Heating → Storage

Collector → Purge (Operating) → Collector

Collector → Storage → Collector (Energy storage or freeze protection)

Collector → Purge (Off) → Collector (Freeze protection)

A brief description of the solar system components, equipment, installation and physical locations, are discussed in the following paragraphs. System drawings, manuals, and vendor items are presented in Appendices A through D.

3.1 SOLAR COLLECTOR SUBSYSTEM

One-hundred-two SUNPAK™ solar collector modules with shaped reflectors were used on this project. These collectors are the advanced, high-performance, evacuated, tubular collectors manufactured by Owens-Illinois, Inc. Each module consists of 24 individual collector tubes with an integral manifold as shown in Figure 3-3 and occupies 32-square-feet in the assembled configuration. The effective collector area of the standard SUNPAK™

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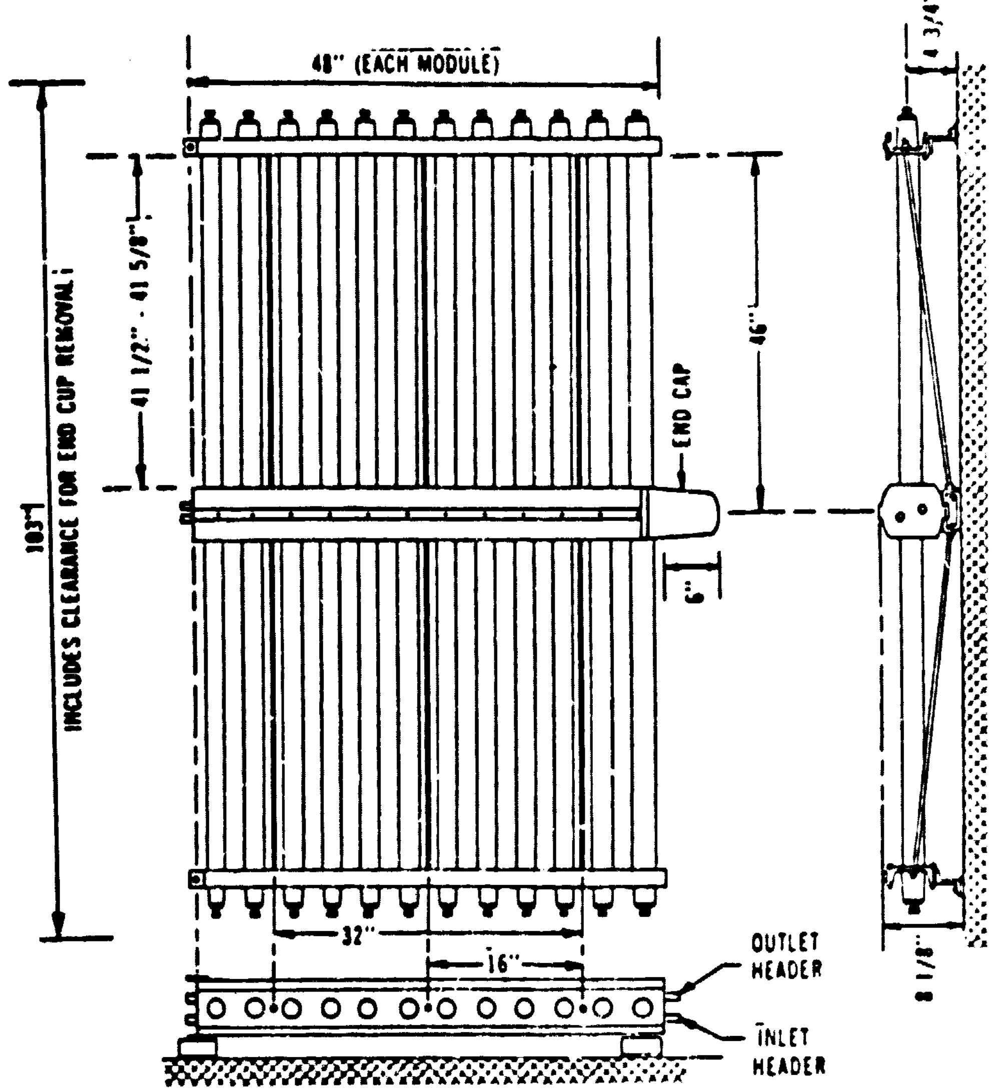

Figure 3-3. Drawing of SUNPAK™ Solar Collector Module.

module is 27.4-square-feet which is used as the basis for describing the collector performance. Therefore, the effective collection area available on this project, with 102 collector modules, is 2,794.8-square feet. A complete description of the Owens-Illinois, Inc. collector is presented in Appendix B, SUNPAK™ Solar Collector Installation Service and Operating Manual.

The solar collector modules were interconnected to form 12 arrays and were mounted on 12 steel trusses which were bolted on the south-facing sloping roof. The steel trusses were fabricated such as to provide a collector angle of 40° above the horizontal. Installation details of the mounts and solar collector modules are shown in Figure 3-4 and 3-5. Structural details are shown in Appendix A, drawing numbers S-1, S-2, S-3, and M-2. Six arrays containing six modules per array were mounted on the south-east sloping roof as shown in Figure 3-5. The remaining six arrays contained 11 modules per array and were similarly mounted on the south-west sloping roof.

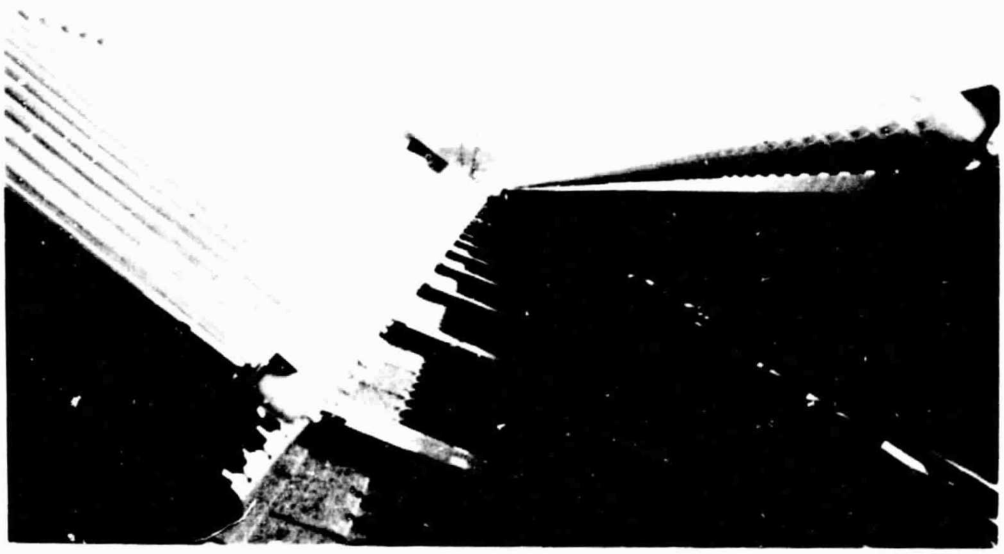

Figure 3-4. Solar Collector Installation - West Roof Area.

Figure 3-5. Solar Collector Installation - East Roof Area.

3.2 STORAGE SUBSYSTEM

The capability of storing excess collected energy was provided by incorporating a 5,000-gallon steel tank into the total system. In an effort to minimize heat loss the storage tank was insulated with 3-inches of polyurethane and a minimum of 1/8-inches of fiberglass waterproof jacket. Tank cradles were welded to the tank so the weight of the tank would be transferred to the cradles and not to the polyurethane and fiberglass. The assembly was buried on top of a concrete slab to the west of the building and south (adjacent) to the service entrance to the bookmobile room (see Figure 2-2). Construction and installation details of the storage facilities are shown in Appendix A, drawing number M-4. Details of the storage tank and insulating materials are presented in Appendix D, Vendor Items.

3.3 DISTRIBUTION AND CONTROL SUBSYSTEM

This subsystem includes all piping, pumping, and heat transfer components as well as the required control logic for the efficient operation of the entire system. The system schematic presented in Figure 3-2 shows all major components of the distribution subsystem as well as the control valves and sensors. In should be noted that the original HVAC system included, in addition to the piping identified in Figure 3-2, the heat transfer components AH-1 through AH-5, the control valves V-1 through V-5, pump CP-1, and the electric chiller. Heat transfer component AH-1 and corresponding control valve V-1,located in the lower level mechanical room, are shown in Figure 3-6. Circulating pump CP-1, also in the mechanical room, and the electric chiller, located in the north-west corner of the roof, are shown in Figures 3-7 and 3-8, respectively.

All piping in the distribution system was installed within the building with the exception of the short below-grade piping to the storage tank and that piping integral to the solar collector manifold assembly which is extremely well-insulated with expanded

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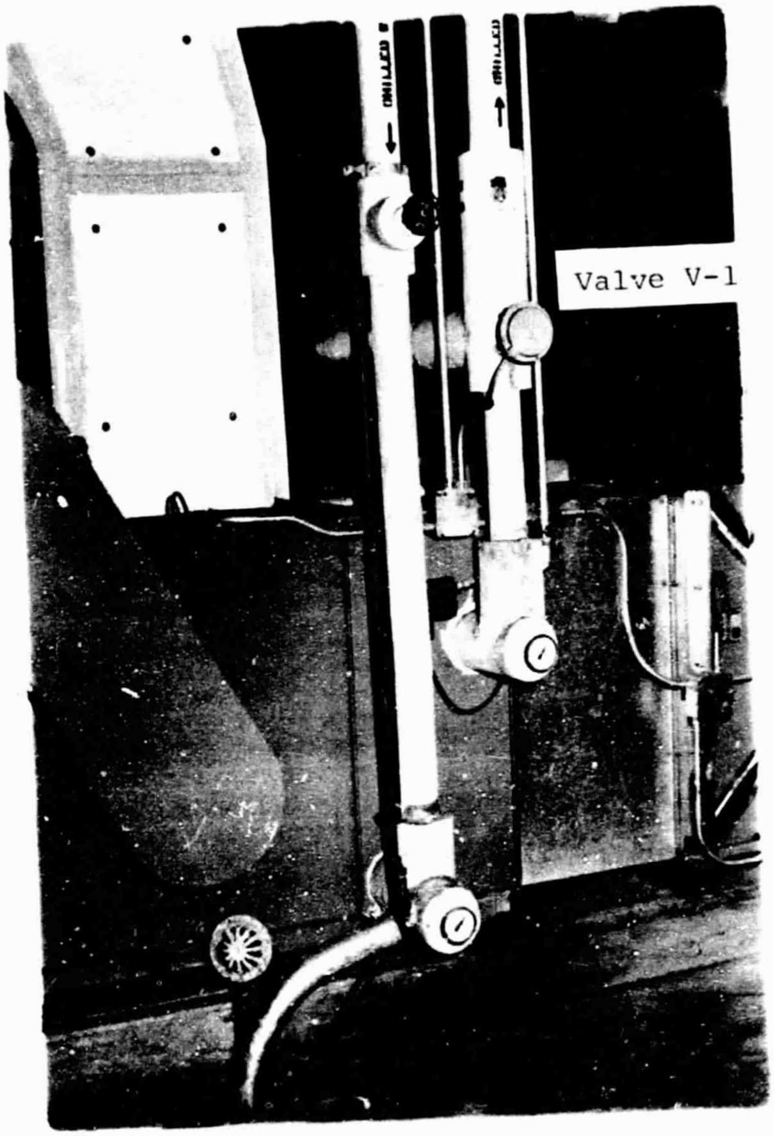


Figure 3-6. Air Handling Unit, AH-1 -Mechanical Room.

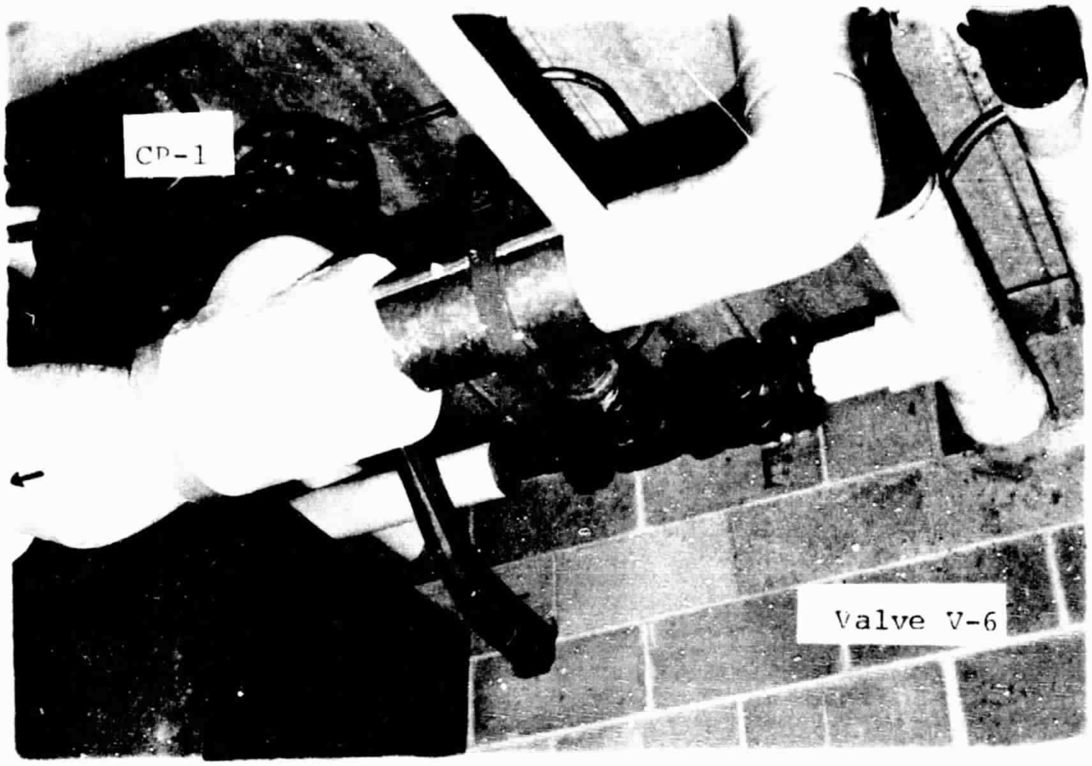


Figure 3-7. Circulating Pump, CP-1 and Control Valve V-6—
Mechanical Room.

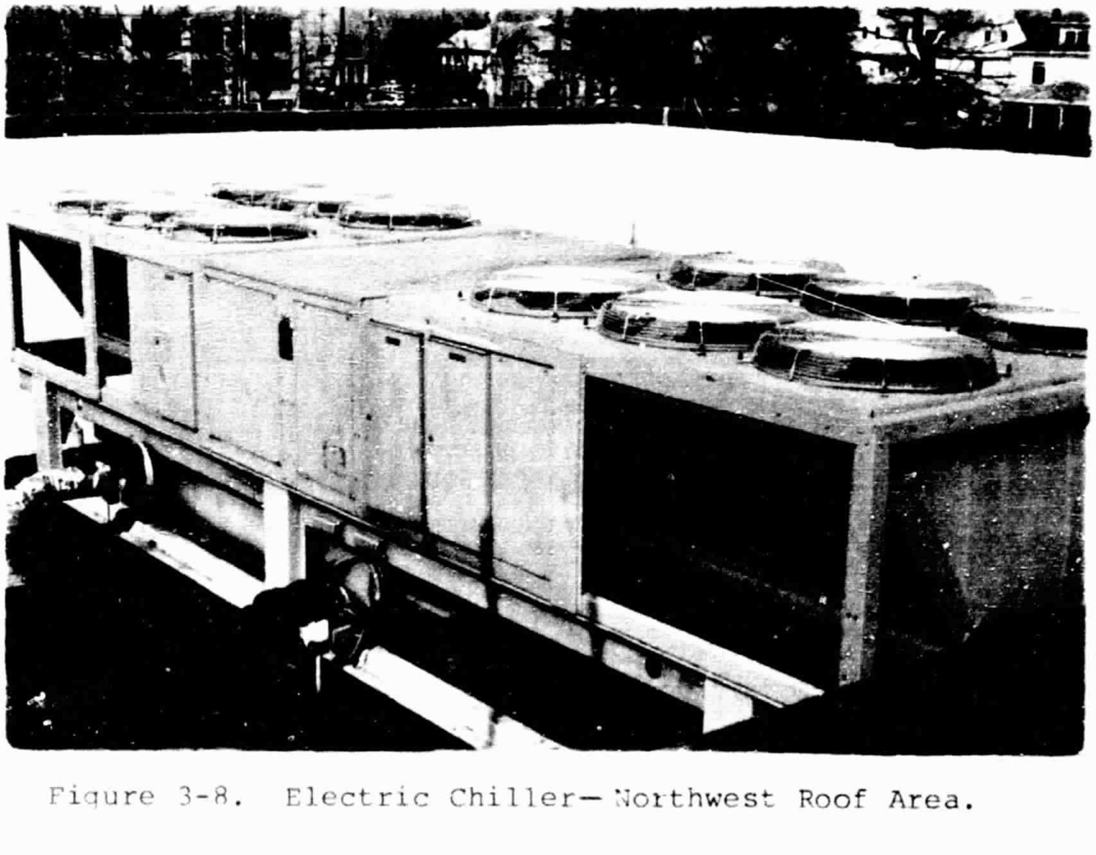


Figure 3-8. Electric Chiller—Northwest Roof Area.

urethane foam. The majority of the new piping, including major interfaces with the existing HVAC system, was installed on the south wall of the bookmobile room located at ground level in the north-west corner of the building as shown in Figure 3-9. Additional piping interfaces for by-passing the existing pump CP-1 and for the automatic filling functions were installed in the mechanical room located at the west end of the lower level as shown in Figures 3-7 and 3-10, respectively. Piping from the bookmobile room to the collectors was suspended beneath the ceiling of the adult reference reading area and painted to match the internal wood beam trusses, see Figure 3-11. This piping was then routed above the false ceiling in the stack area and then into external boxes resting on the roof, called roof curbs which were constructed adjacent to each collector array as shown in Figure 3-5. Each roof curb was well-insulated and was vented to the warm air inside the building. Piping from adjacent collector arrays was joined inside each roof curb as shown in Figure 3-12. Details of the piping and roof curb installation are presented in Appendix A, Drawing Numbers M-1, M-2, M-3, and M-4.

Two additional pumps, CP-2 and CP-3 (see Figure 3-2), were installed in parallel so that failure of one pump would permit continued system operation at a reduced but satisfactory flow rate of approximately 30 gpm. The existing pump CP-1 would only be used when building heat is being supplied directly from storage or when the chiller is operating in the normal HVAC cooling mode. The additional pumps were installed on the south wall of the bookmobile room as shown in Figure 3-9. A close-up view of these circulating pumps with starters, check valves, and isolating mechanical valves is shown in Figure 3-13. A detailed description of these pumps, starters, and valves is presented in Appendix D, Vendor Items.

The main heat transfer components, AH-1 through AH-5, were part of the original HVAC system and were incorporated into the overall system as shown in Figure 3-2. However, an additional heat transfer component, "purge unit," was installed to reject

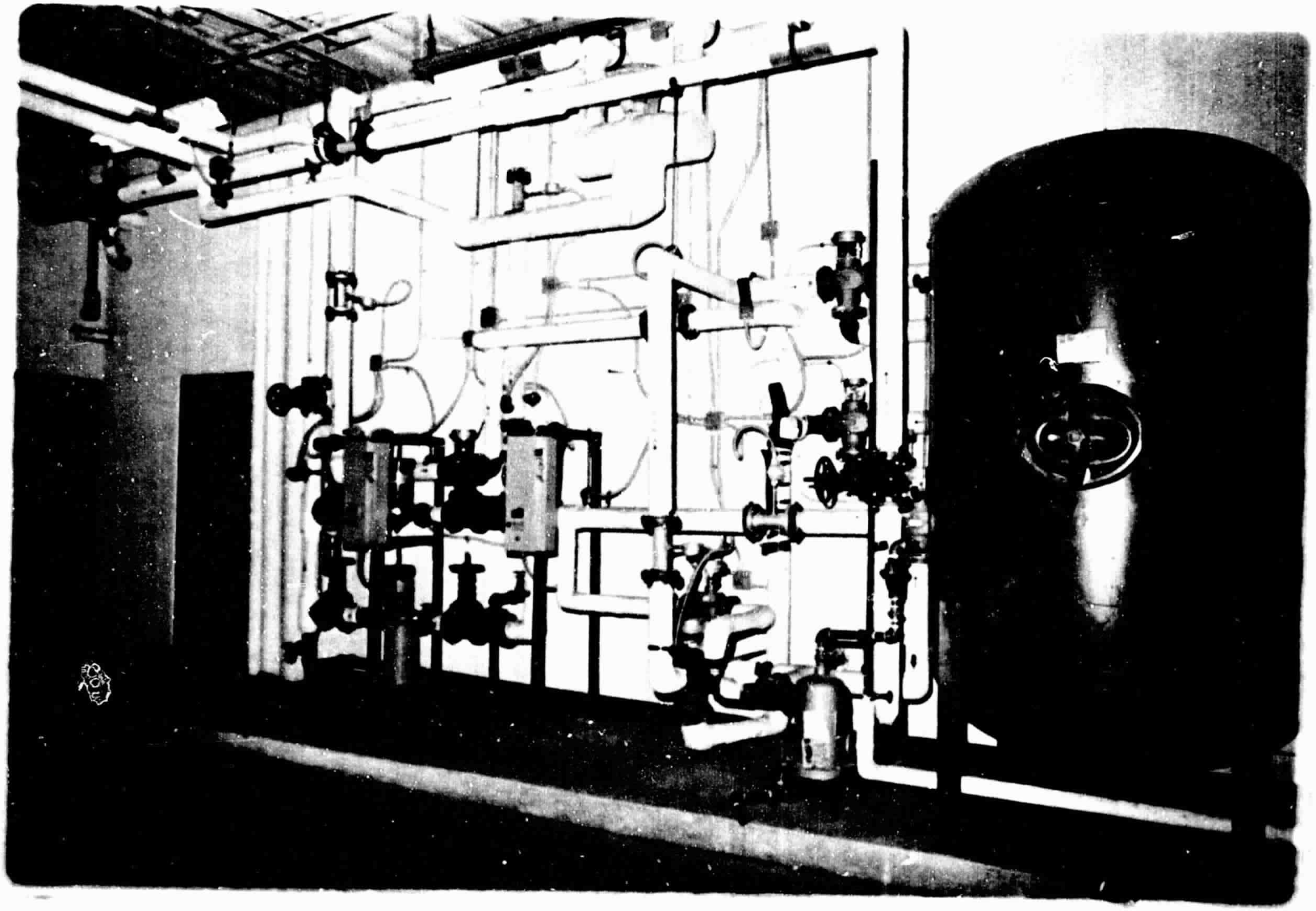


Figure 3-9. Installed Solar Piping—Bookmobile Room.

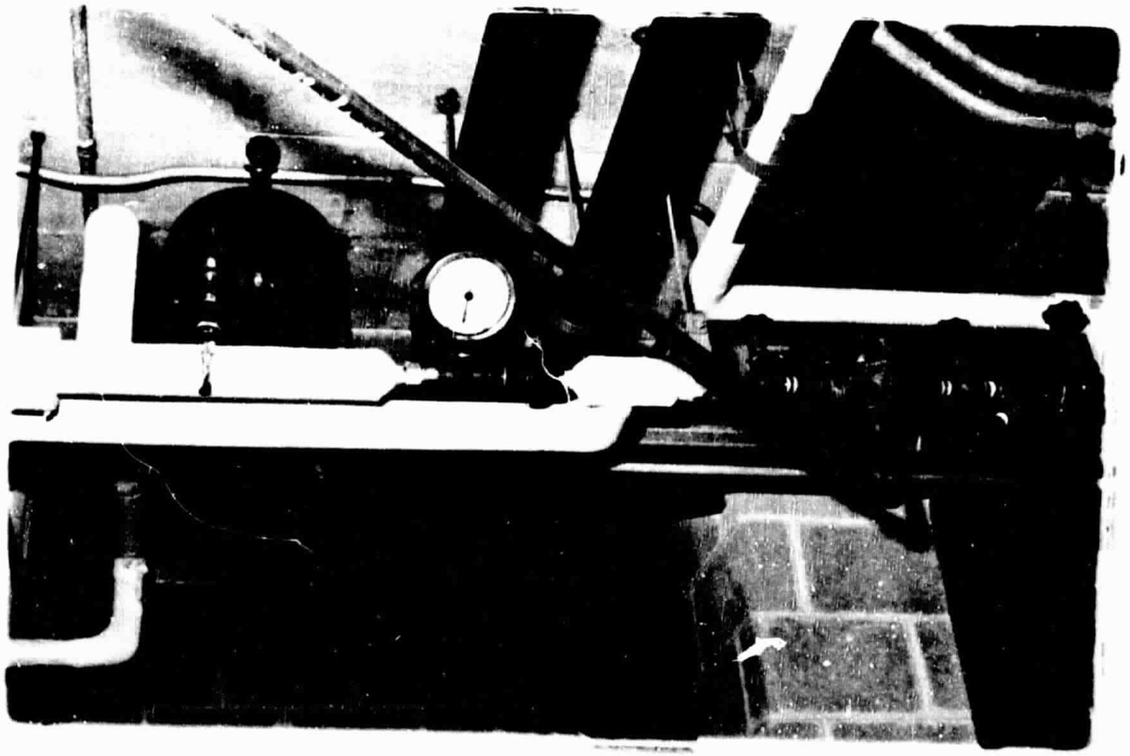


Figure 3-10. Automatic Fill Valve— Mechanical Room.

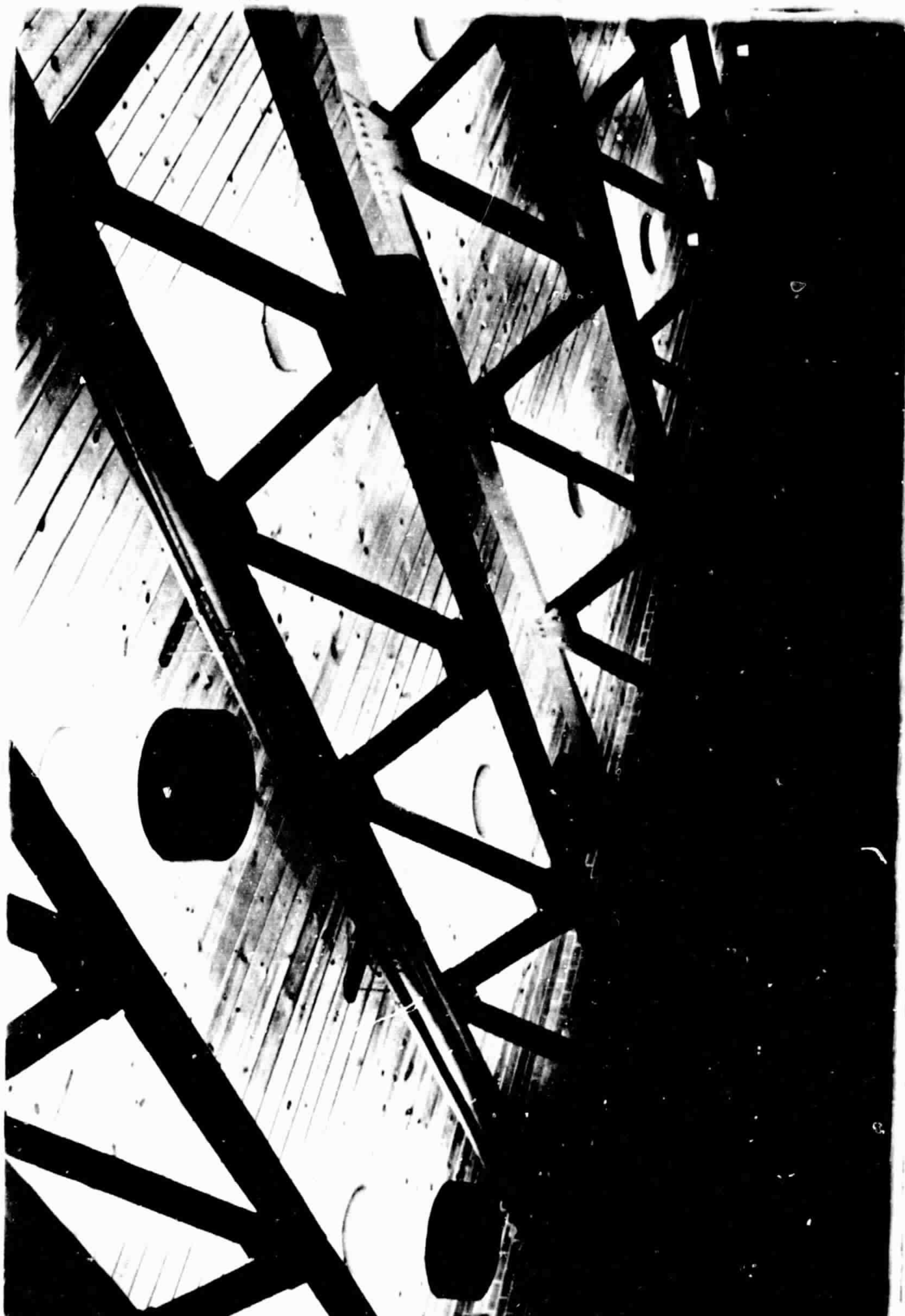
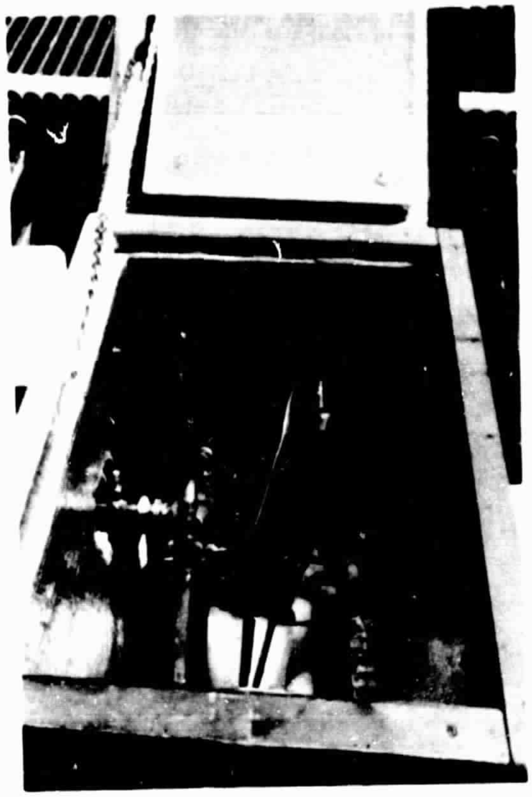
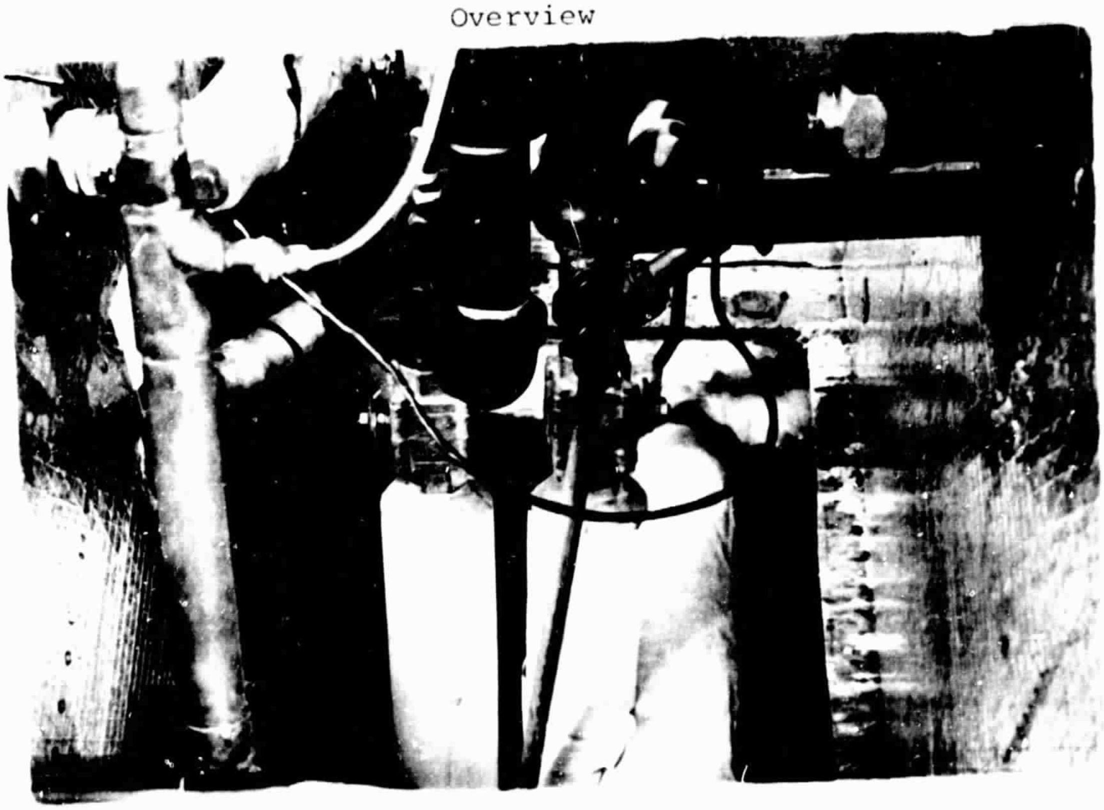


Figure 3-11. Collector Supply/Return Piping--Adult Reference/Reading Area.

Insulated
Container



Overview



Internal View

Figure 3-12. Piping Inside Extended Roof Curb.

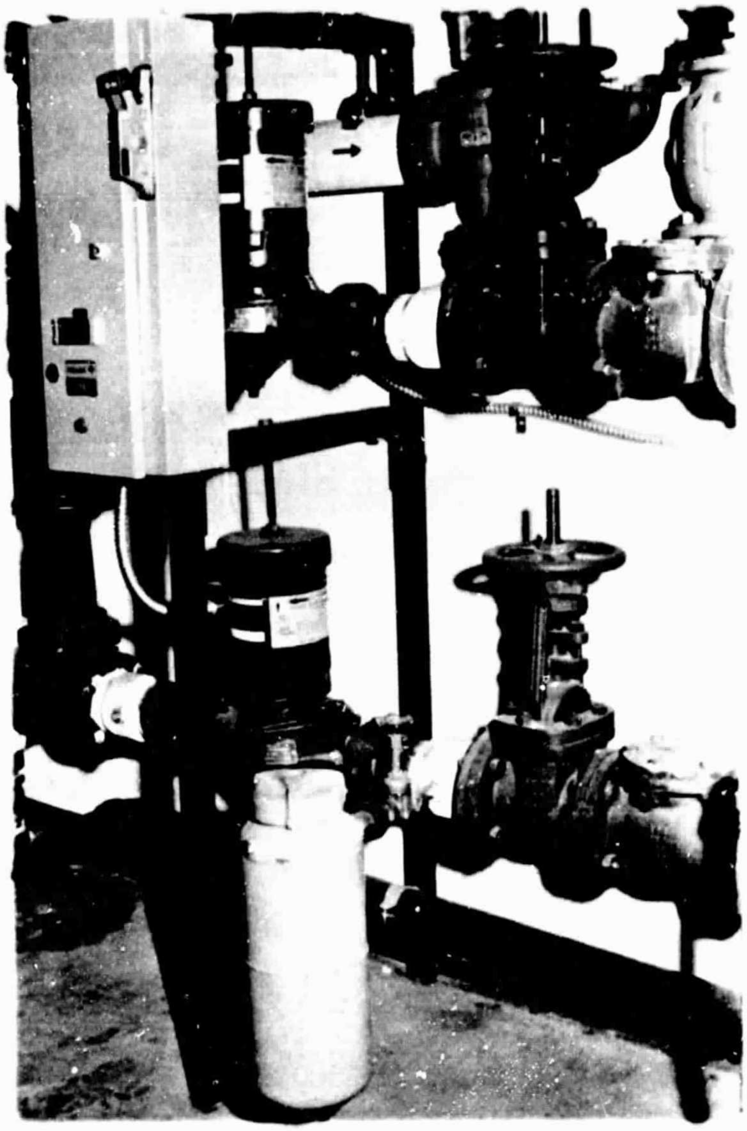


Figure 3-13. Circulating Pumps, CP-2 and CP-3— Bookmobile Room.

excess heat which cannot be used by the system. This heat rejection unit will be used primarily in the summer until suitable solar energy equipment can be obtained for summer cooling. Since the library had no use for heat in the summer, heat rejection was necessary because the collector tubes could not be drained conveniently and because their limiting stagnation temperature of 600°F could be reached or exceeded during the summer months. This purge unit installed on the north wall of the bookmobile building (see Figures 3-14 and 3-15) utilizes outdoor air to cool the system hot water if it exceeds 220°F. Installation details of the purge unit are presented in Appendix A, drawing number 101 and M-4. A detailed description and specifications for the purge unit and damper is presented in Appendix D-Vendor Items.

A pneumatic control system was provided by Honeywell Inc., Honeywell Automation. The system control panels containing the system control logic with the associated timers, controllers, relays, and switches are located on the west wall of the storage room adjacent to the bookmobile room (see Figures 3-16 and 3-17).

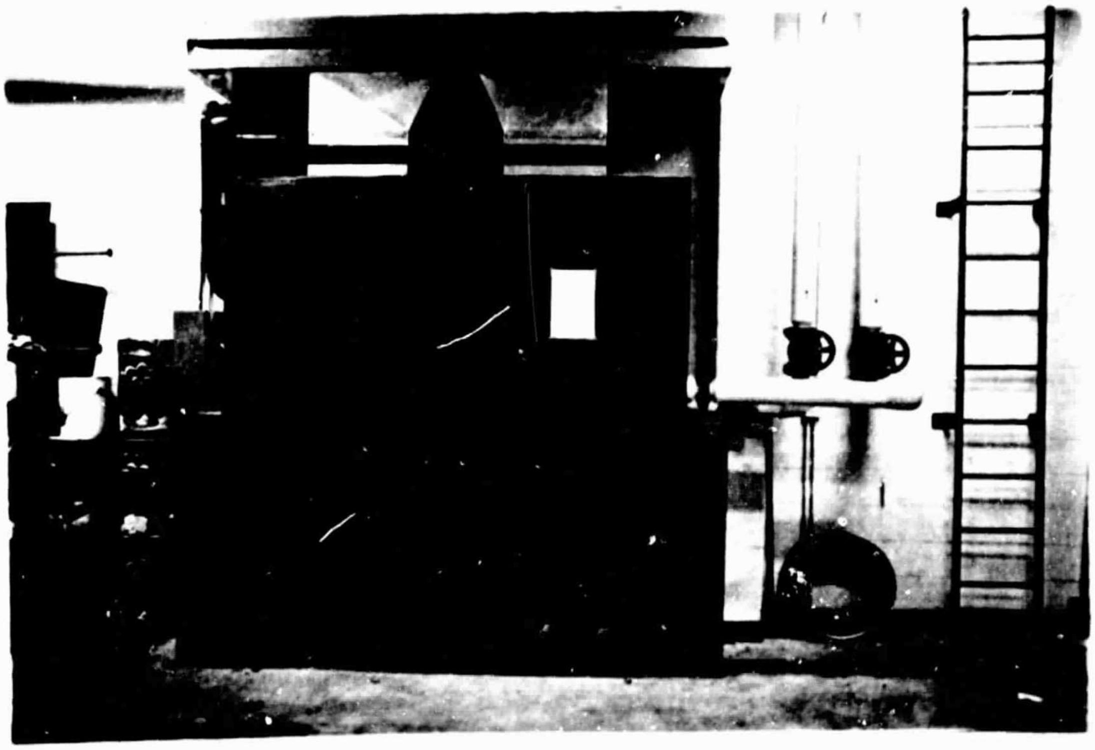


Figure 3-14. Purge Unit— Bookmobile Room.

Figure 3-15. Purge Unit Dampers.

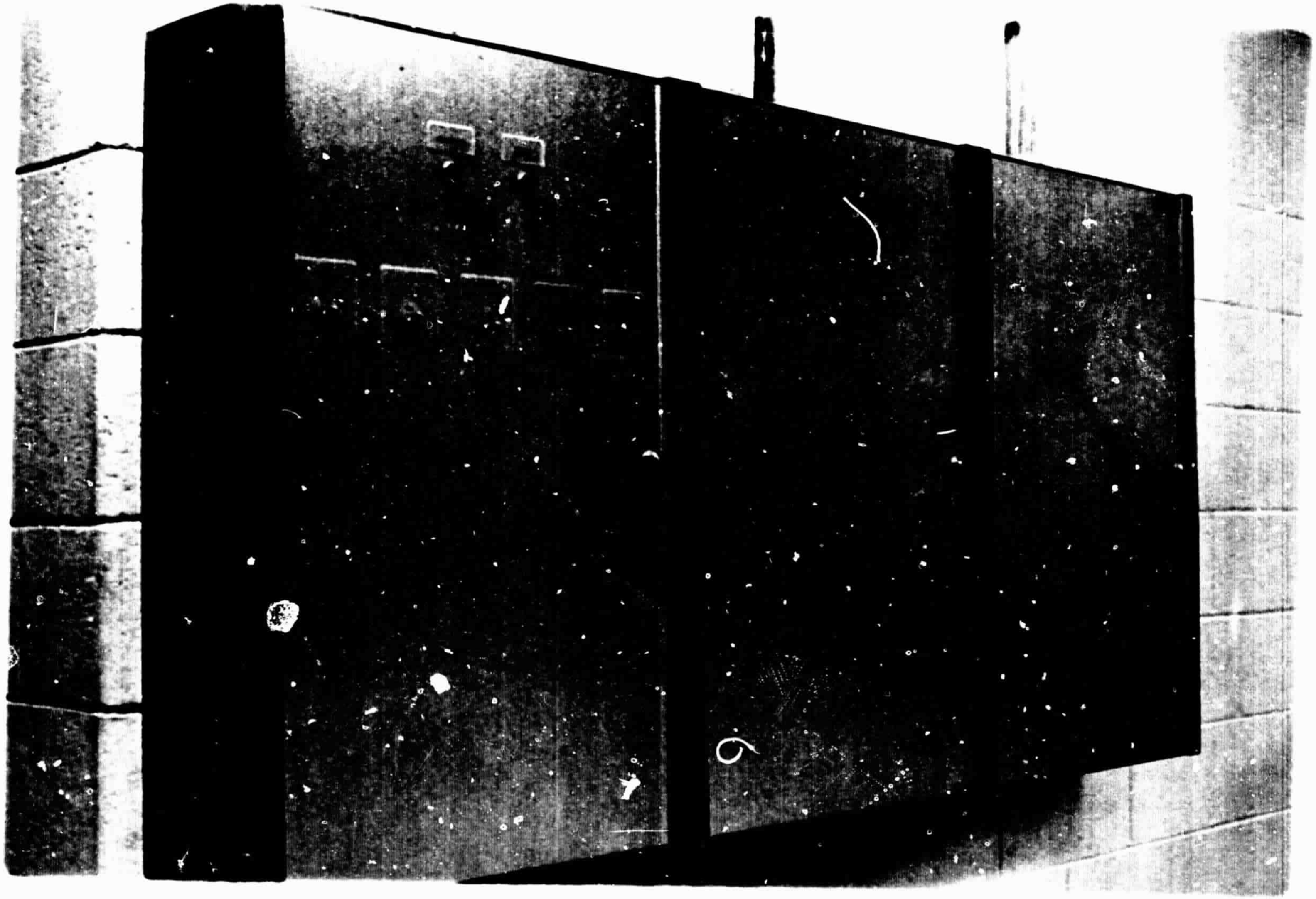
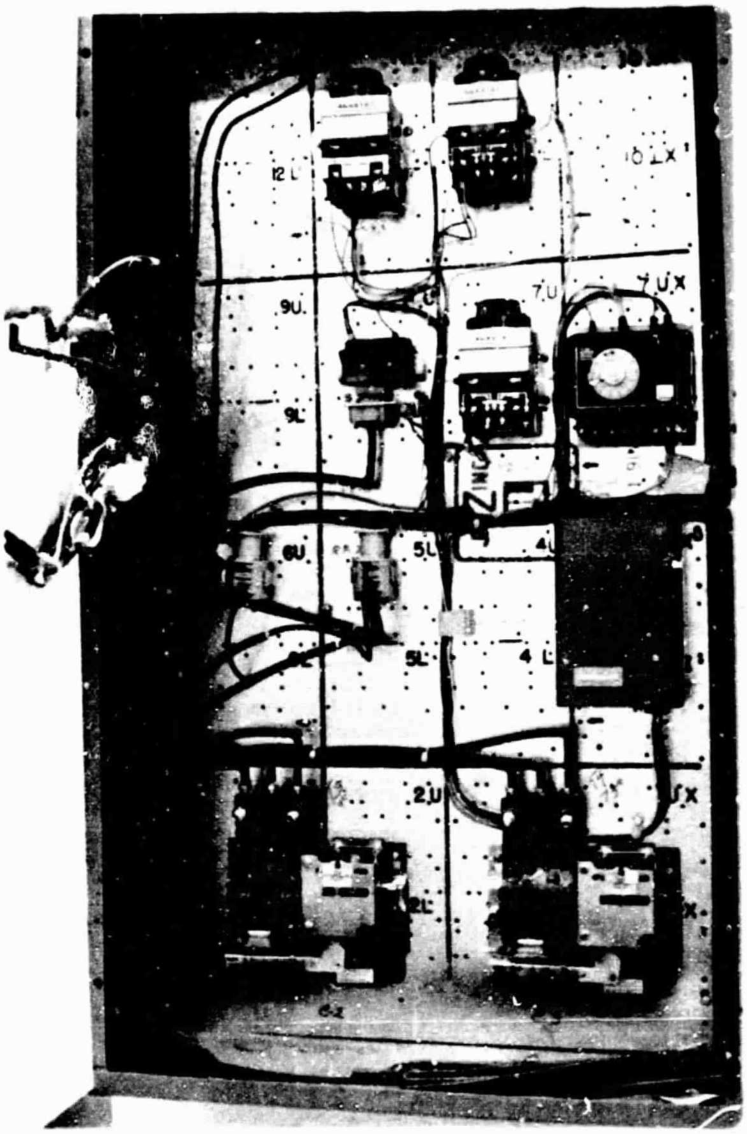
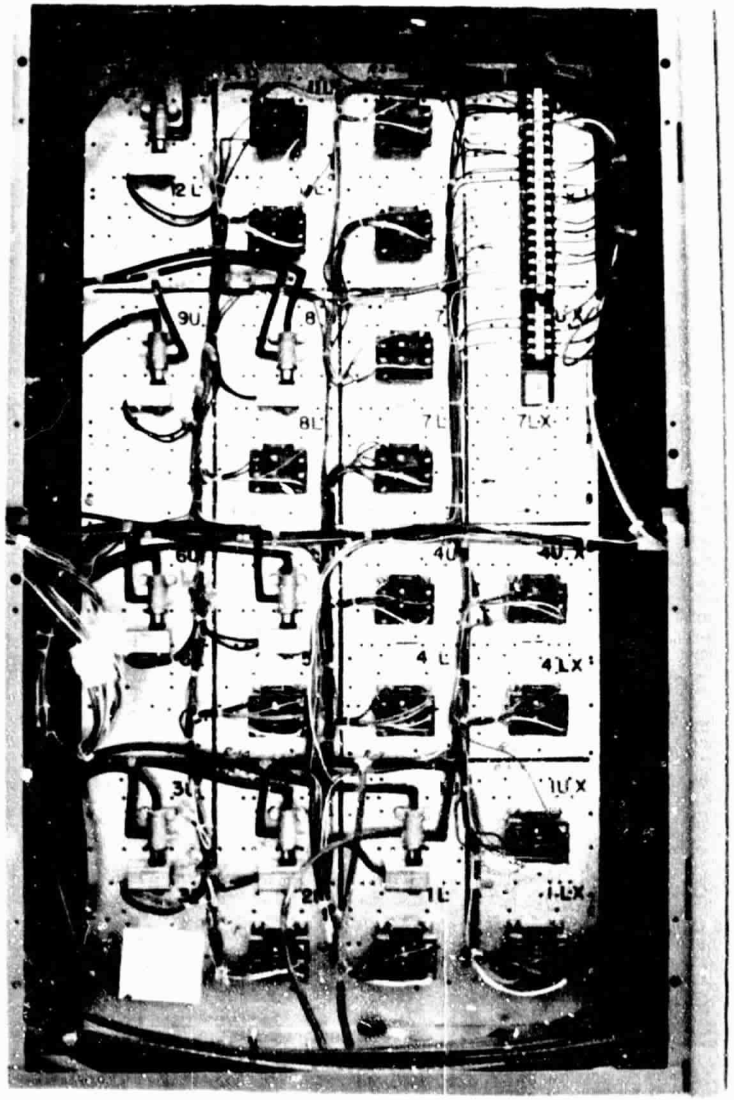


Figure 3-16. Solar System Control Panels—Main Floor Storage Room.

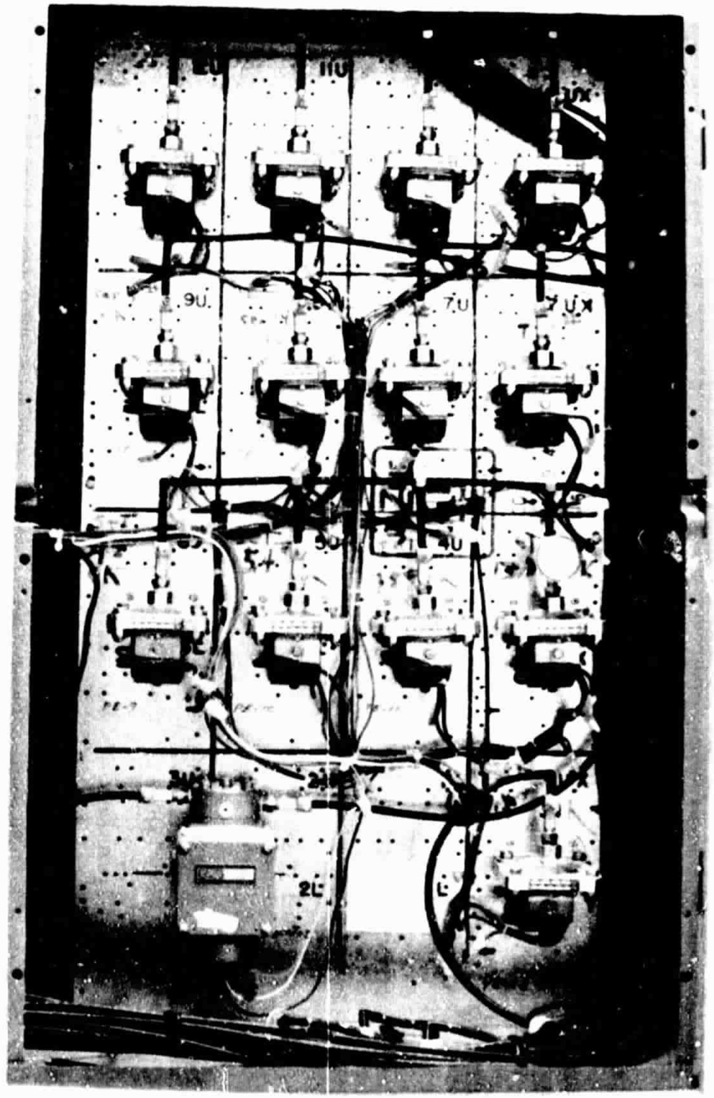


Left Hand Panel

Figure 3-17 (a). Solar System Control Panels— Interior View.



Center Panel



Right Hand Panel

Figure 3-17 (b). Solar System Control Panels—Interior View.

All system control valves are installed in the distribution piping as shown in Figure 3-2. Valves V-1 through V-5 are part of the original HVAC system and are located with the existing heat transfer units AH-1 through AH-5 as shown in Figure 3-6. Valve V-6 which by-passes circulating pump CP-1 is located in the mechanical room on the lower-level of the building (see Figure 3-7). Valves V-7 through V-14 are all located on the north wall of the bookmobile room as shown in Figure 3-9. Valves V-15 and V-16 are located in the space above the false ceiling in the south-west stack area of the building. All other system control sensors (temperature, pressure, and flow) were installed in the distribution piping, storage tank, and solar collector tubes with the exception of the outside air temperature sensor which is located on the outside north wall of the building. Valves and sensor locations are also shown in Appendix A, drawing M-4. A detailed description of the control system with specifications is presented in Appendix C— Engineering Data for Troy Library-Honeywell Automation. Specification sheets for the system control valves is presented in Appendix D— Vendors Items.

Other components installed in the distribution and control system included: an 850-gallon expansion tank to provide the required air cushion to maintain system pressures between 20 to 30 psi while the entire volume of water (approximately 6,000 gallons) varies from 70°F to 220°F; an air separator to remove air from the system, and a by-pass chemical feeder for use if water conditioning were required. In addition, standard mechanical valves and water system specialties were installed as required to complete the system considering system installation, maintenance, checkout, and operational requirements. Most of these components are located on the south wall of the bookmobile room. A few of the mechanical valves, relief valves, and water vents are located in the mechanical room and in the extended roof curbs between each collector array. Descriptions and specifications for these various components are presented in Appendix D— Vendor Items.

SECTION 4

DATA COLLECTION AND LOBBY DISPLAY INSTRUMENTATION

The Troy-Miami County Public Library Solar Heating Demonstration Program was selected by the Department of Energy for the installation of a comprehensive instrumentation system in order to meet the data collection, performance evaluation, and data dissemination goals of the National Program for Solar Heating and Cooling. This instrumentation system is part of the National Solar Data Network which includes: a Site Data Acquisition Subsystem (SDAS); a Data Access Arrangement; a Central Data Processing System (CDPS) and Host Computer; and a Technical Information Center. The sensors, SDAS, and communication link are located at the demonstration site. The CDPS and Host Computer are located at Vitro Engineering Laboratory, Silver Springs, Maryland, where the data is retrieved, evaluated, analyzed, and system evaluation reports are produced. These reports will be made available to the demonstration site and to others through the DOE Technical Information Center, P. O. Box 62, Oak Ridge, Tennessee 37820.

In addition to the above, an attractive lobby display was installed on the north wall of the main floor lobby. This display was designed to attract attention of the library patrons and to explain the concept of the solar system operation. The display shows, in an animated schematic form, the functioning of the solar heating system and provides, in real-time, operational data of the performance of the system.

A brief description of these instrumentation systems, as well as their installation and physical locations, are discussed in the following paragraphs.

4.1 DATA COLLECTION/MONITORING SYSTEM

The data collection system requirements are described in DOE Report, "Instrumentation Installation Guidelines," dated 1976. This report was used to select the type, number, and location of the required sensors. A total of 43 sensors, listed in Table 4-1, were approved and supplied by DOE for installation in the system. All sensors installed are independent from those installed for the control system and for the lobby display. Details of the instrumentation wiring and the transducer connections are presented in Appendix A, drawing number M-2.

The majority of the 13 temperature and four flow-rate transducers, listed in Table 4-1, were installed in the distribution system (located in the bookmobile room) at locations shown in Figures 4-1 and 4-2. Ambient air temperature sensor T001 is located on the west end of the building as shown in Figure 4-3. The return air temperature sensor T006 was installed inside the return air chamber of Air Handling Unit AH-5 located in the attic area north of the janitor room in the south side of the building.

The total and diffuse insolation sensors (pyranometers) were mounted on special fixtures at an angle of 40° above the horizontal which is in the same plane as the collector arrays. These fixtures were installed above the roof line on the north wall of the center of the building as shown in Figure 4-4. It should be noted that the lower total insolation sensor shown in Figure 4-4 is used only for the lobby display.

The 24 electrical power sensors (wattmeters) were installed in two special enclosures near the existing main power panels. The enclosure in the main floor janitor room contains all wattmeters to measure the electrical energy used in the east half of the building. The remaining electrical energy use is measured by wattmeters installed in the enclosure located in the lower level mechanical room (see Figures 4-5 and 4-6) beside the SDAS. Detailed wiring and connection diagrams are presented in Appendix A, drawing number M-2. Enclosure/panel specifications are presented in Appendix D - Vendor Items.

Data collection and transmission is accomplished through the SDAS which was installed in the lower level mechanical room.

TABLE 4-1

LIST OF INSTRUMENTATION FOR DATA COLLECTION/MONITORING

Identification Number	Description	On-Site Monitor[1] Channel Number
Temperature Sensors (Monitor reads in °F)		
T 001	Ambient	1800
T 100	Collector Inlet	1002
T 180	Collector Outlet	1202
T 182	Purge Outlet	0202
T 601	Load Return Air (Bldg)	3200
T 403	Load Inlet	2602
T 483	Load Return	0802
T 401	Storage Inlet	2402
T 481	Storage Bypass	0402
T 451	Storage Outlet	1102
T 201	Storage Top	2002
T 202	Storage Mid	2202
T 203	Storage Bottom	3002
Flow Sensors (Display reads in gpm)		
W 100	Collector	0361
W 403	Load	3562
W 401	Storage (Load Return)	0562
W 402	Storage Bypass	3362
Insulation (Sensors Monitors reads in Btu/hr/sq.ft.)		
I 001	Total	0725
I 002	Diffuse	3423
Power (Sensors Monitor reads in kW)		
EP 101	Solar Pumps CP-2 and CP-3	1344
EP 402	Load Pump CP-3	1646*
EP 103	Purge	1446*
EP 411	AH-1 Fan (Basement)	1746*
EP 421	AH-1 Heat	2847
EP 412	AH-2 Fan (Services and multi-purpose)	0946*
EP 431	Reheat No. 1 (Services)	2746*

(continued next page)

TABLE 4-1 (Concluded)

LIST OF INSTRUMENTATION FOR DATA COLLECTION/MONITORING

Identification Number	Description	On-Site Monitor Channel Number
Power Sensors (Monitor reads in kW)		
EP 432	Reheat No. 2 (Services)	3646*
EP 433	Reheat No. 3 (Multipurpose)	3747
EP 413	AH-3 Fan (West)	
EP 423	AH-3 Heat	2947
EP 414	AH-4 Fan (East)	2146*
EP 424	AH-4 Heat	2347
EP 415	AH-5 Fan (Stacks)	2547
EP 434	Reheat No. 4 (Adult Stacks)	3847
EP 435	Reheat No. 5 (Child Stacks)	3947
EP 441	EUH 1 (S Vestibule)	4047
EP 442	EUH 2 (Garage)	4247
EP 443	EUH 3 (N. Vestibule)	4347
EP 451	EC-1 (East)	4446*
EP 452	EC-1 (West)	4546*
EP 453	EC-2 (Men)	4643
EP 454	EC-2 (Women)	4743
EP 455	EC-3 (Mobile Storage)	4843

*If reading exceeds 12 kW, change last digit to 7.

(1) The on-site monitor is currently available on-site and can be used by the system operator to obtain instantaneous displays of all sensor outputs for system evaluation. This device is temporary and can be removed by DOE when needed for system checkout at other installations. Use of the monitor is as follows.

Power on - Scan switch up into "Scan" Position— all points should up date continuously. If scan switch is pressed down and then positioned at its mid-position, all readings taken should be as of the moment that the switch was pressed down—no updating will occur until switch is returned to "Scan" position.

Channel Number Code, XXYZ
where:

XX ≡ Channel Number
Y ≡ Type of Sensor
Z ≡ Assigned Range of Sensor

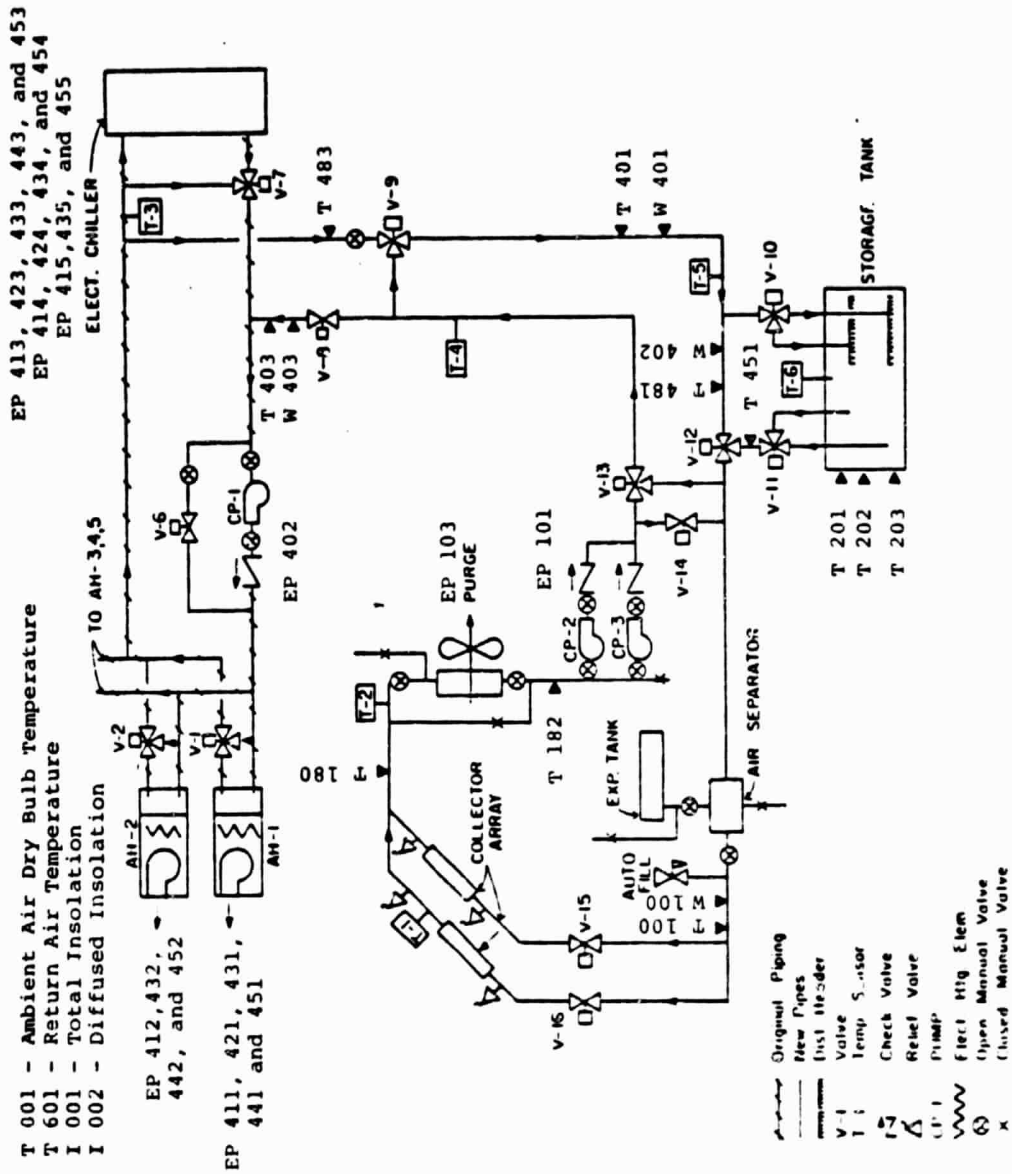


Figure 4-1. System Schematic - Data Collection/Monitoring Sensors.

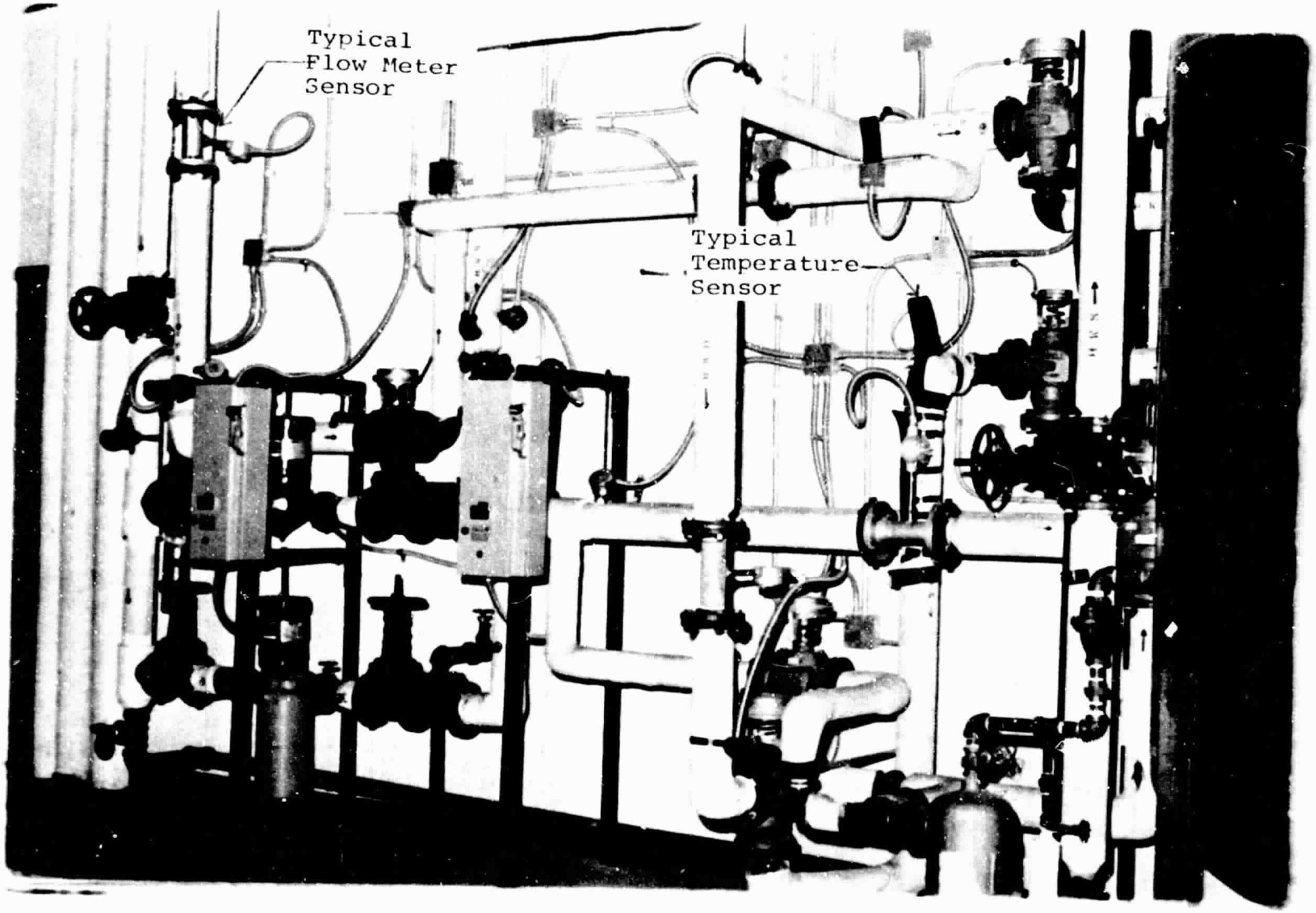


Figure 4-2. Typical Sensor Installation in System Piping—Bookmobile Room.

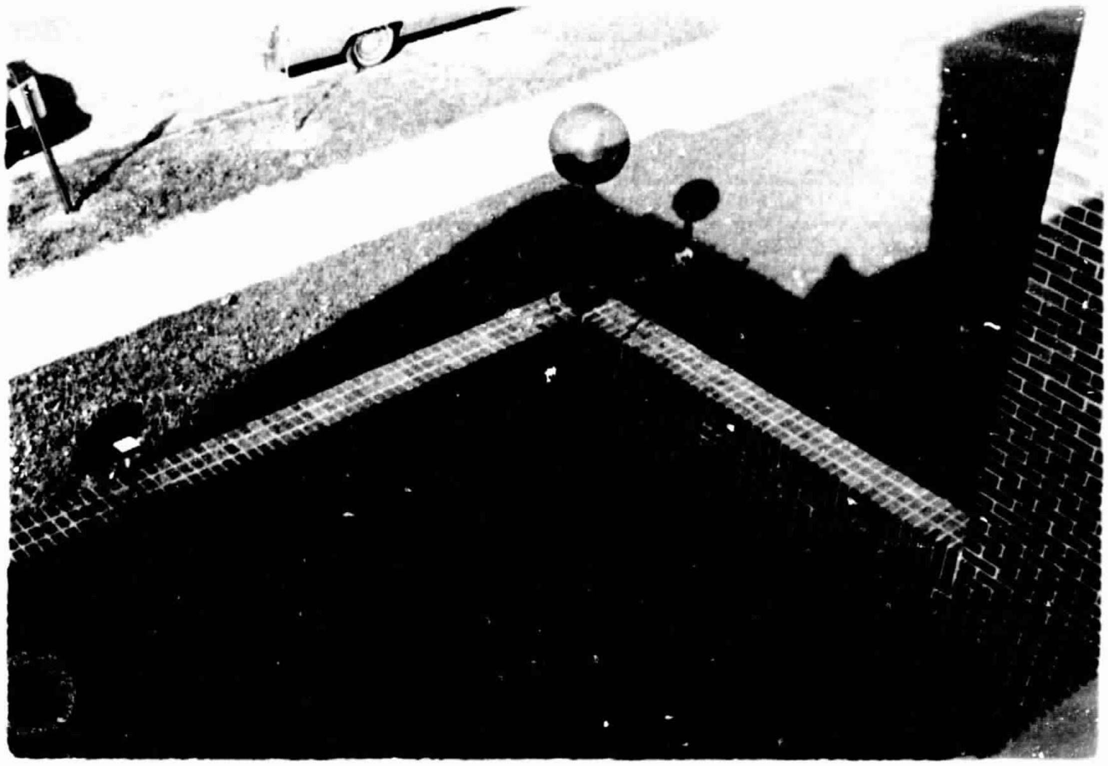
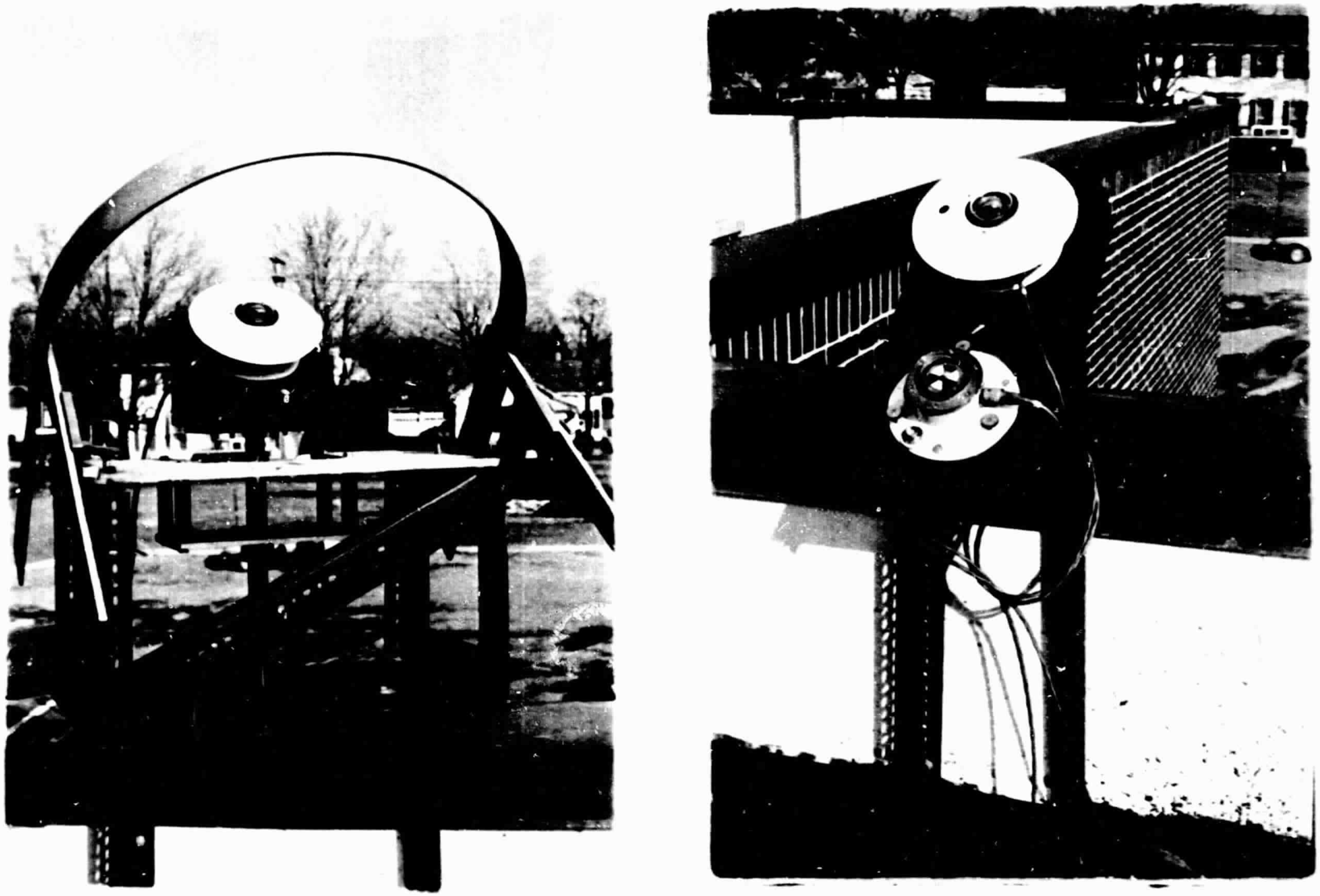


Figure 4-3. Ambient Air Temperture Sensor Location.



Diffuse Insolation Sensor. Total Insolation Sensor.

Figure 4-4. Solar Insolation Sensors.

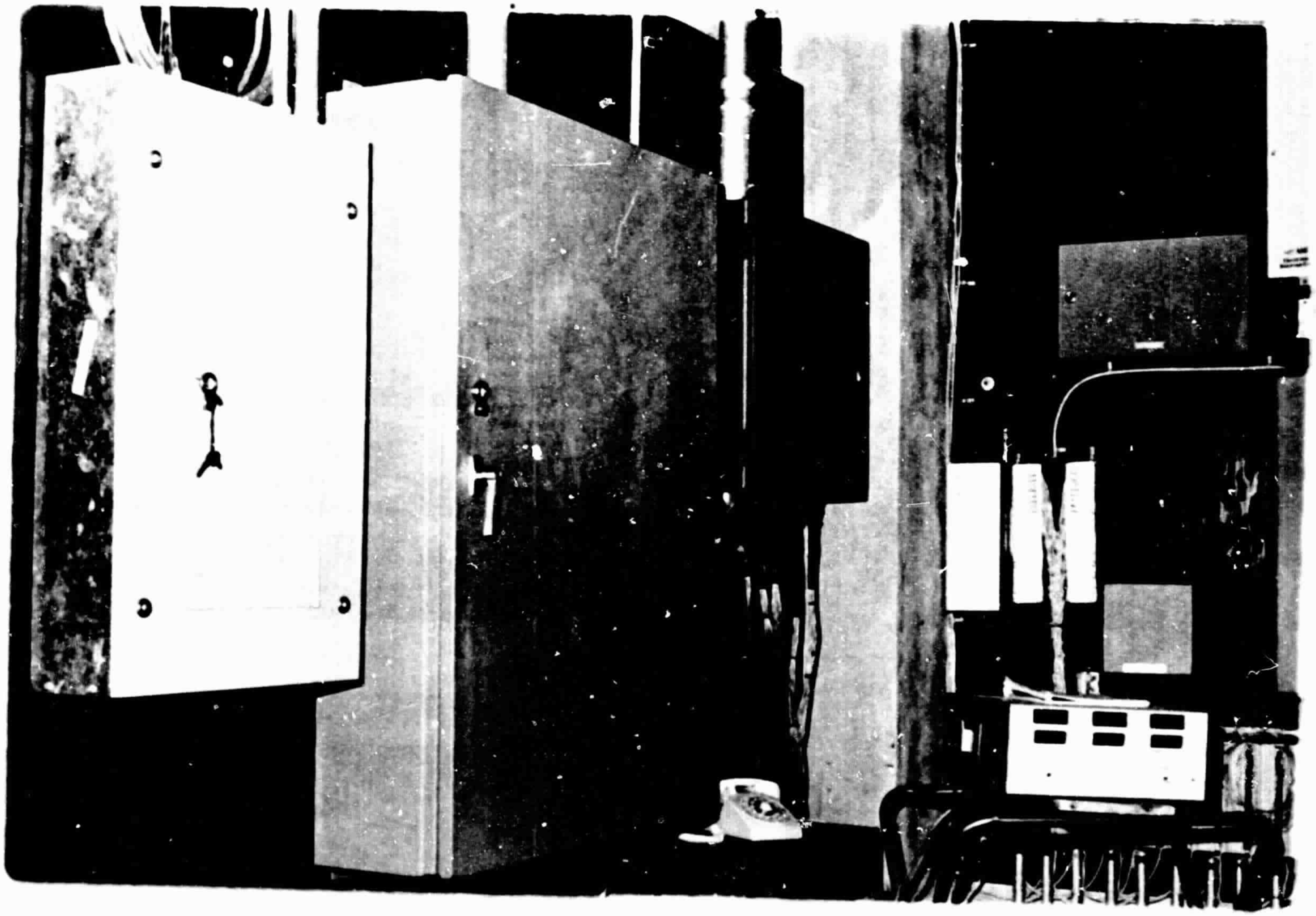


Figure 4-5. SDAS and Electric Power Sensor Enclosure—Mechanical Room.

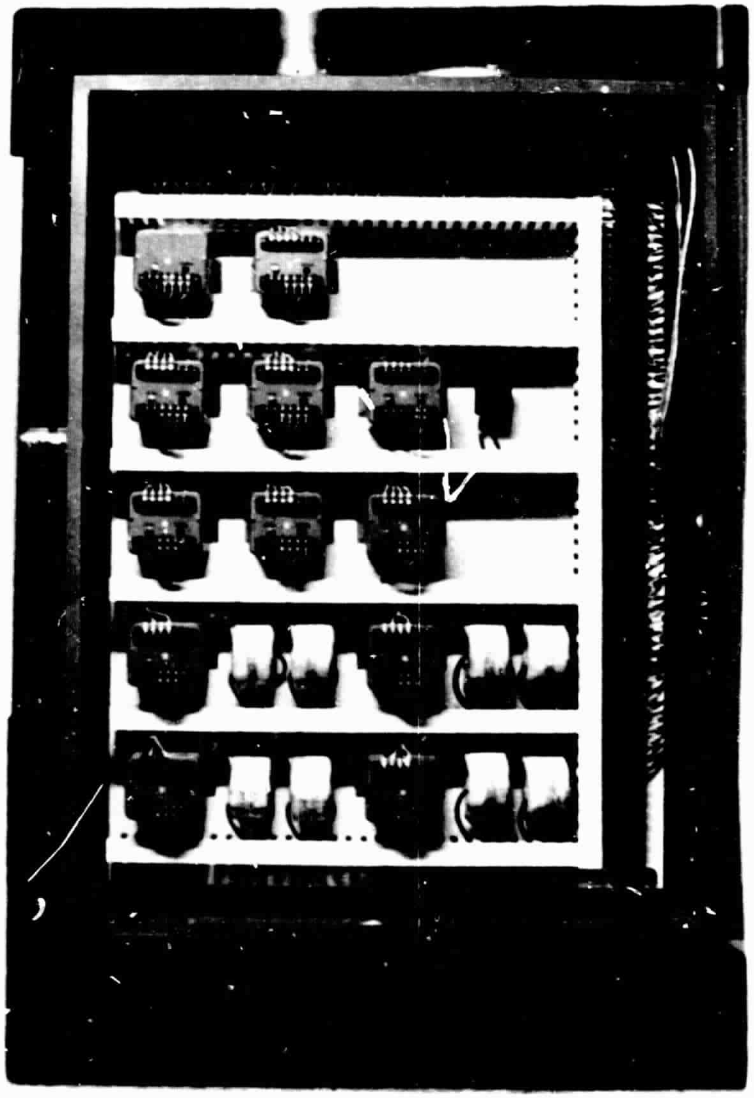


Figure 4-6. Electric Power Sensor—Mechanical Room.

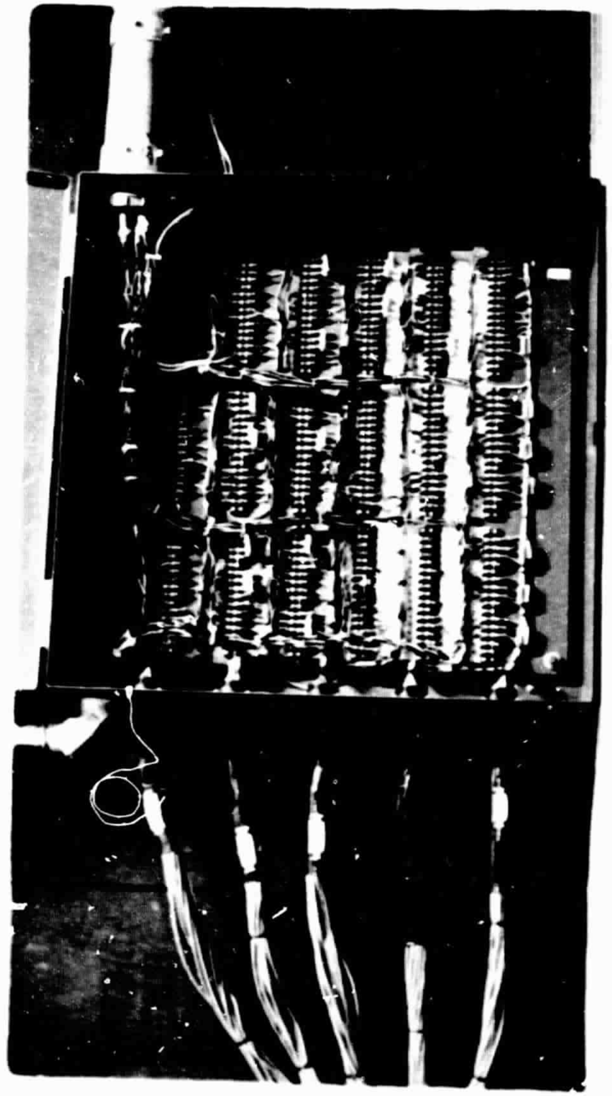


Figure 4-7. SDAS Junction Box.

All instrumentation wires from the various sensors were terminated in a special prewired junction box (provided by DOE) which was located above the SDAS. Final connections of the interface cables and system checkout was accomplished by DOE. An on-site monitor is currently available to allow a direct readout of the system measurements and thereby verify that the solar system and SDAS is performing correctly. The SDAS and an internal view of the prewired junction box are shown in Figures 4-5 and 4-7, respectively. The four-digit identification code, XXYZ, for the various parameters listed in Table 4-1 is for use with the on-site monitor. This code refers to the channel number, XX, the type of sensor, Y, and the assigned sensor range, Z.

4.2 LOBBY DISPLAY SYSTEM

The lobby display was installed in the Troy Library to serve as a public educational function which is one of the primary objectives of this demonstration program; that is, to disseminate to the public, information on the design, installation, and operation of solar systems. This display, shown in Figure 4-8 and 4-9, is located on the north wall of the main floor lobby. The left-hand portion of the display presents a three-dimensional representation of the solar heating system showing the major components, their location in the building, and the interconnecting piping. By pressing a button, visitors can see, in an animated schematic form, the functioning of the solar system in its three basic modes of operation. The right-hand portion of the display also contains a series of digital numeric readouts which provide in real time, operational data on the performance of the system. These digital readouts show cost of energy saved in dollars and other measurements in familiar units such as °F, kilowatts, and kilowatt-hours.

The lobby display instrumentation is independent from the control system and the data collection/monitoring system. A total of nine sensors were installed in the system, seven in the distribution system as shown in Figure 4-10, one inside a collector tube

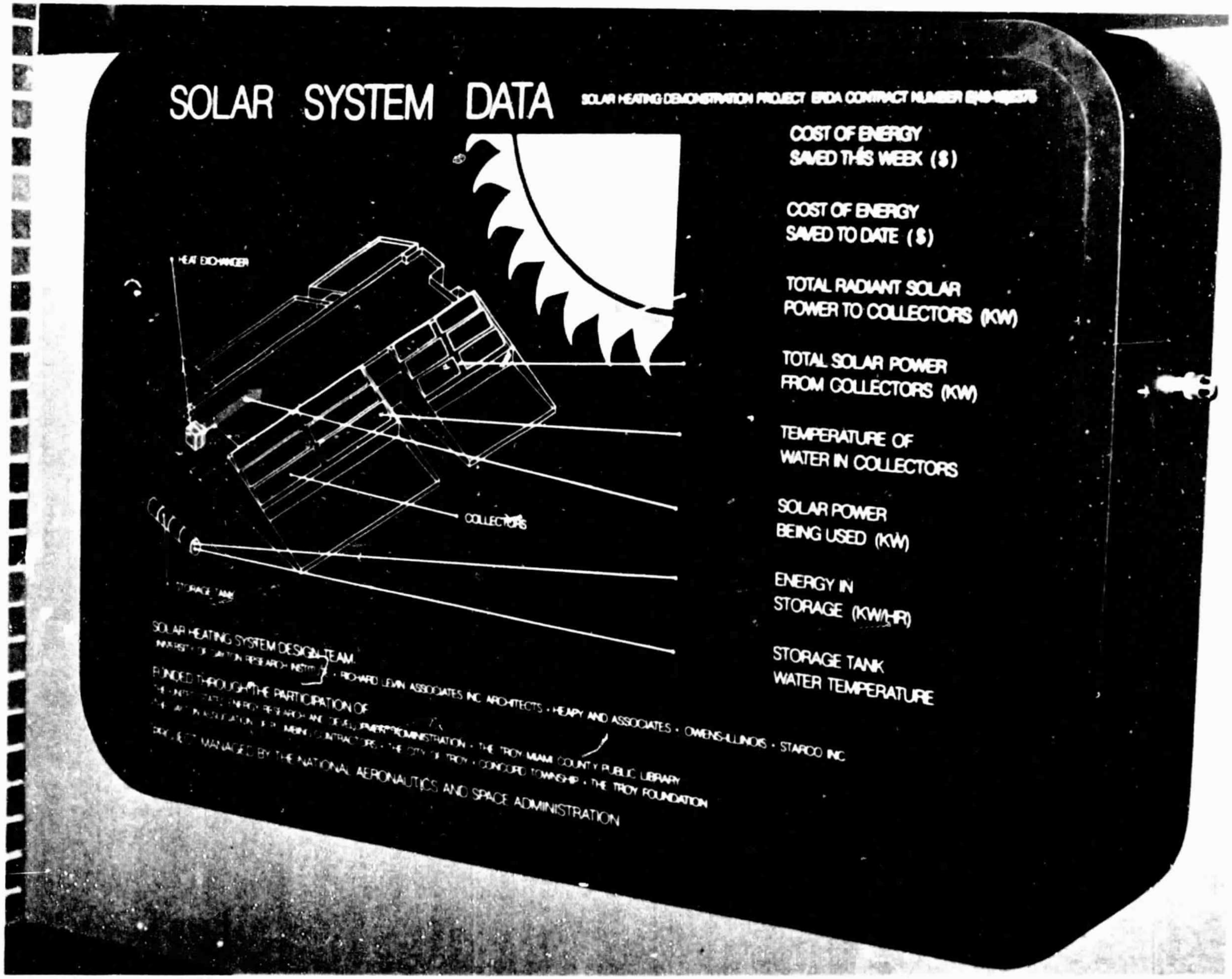


Figure 4-8. Lobby Display - Main Floor.

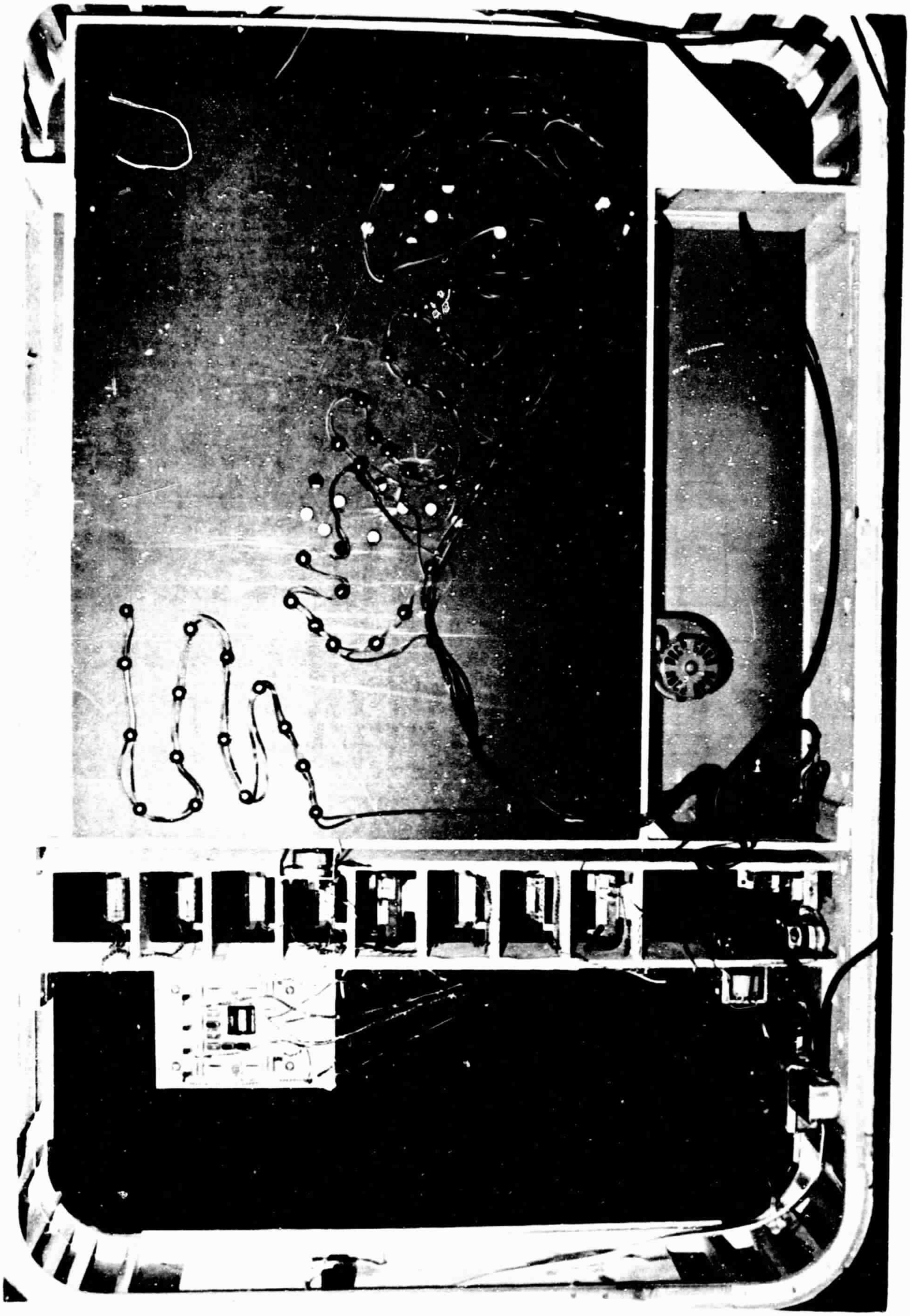


Figure 4-9. Lobby Display - Rear View.

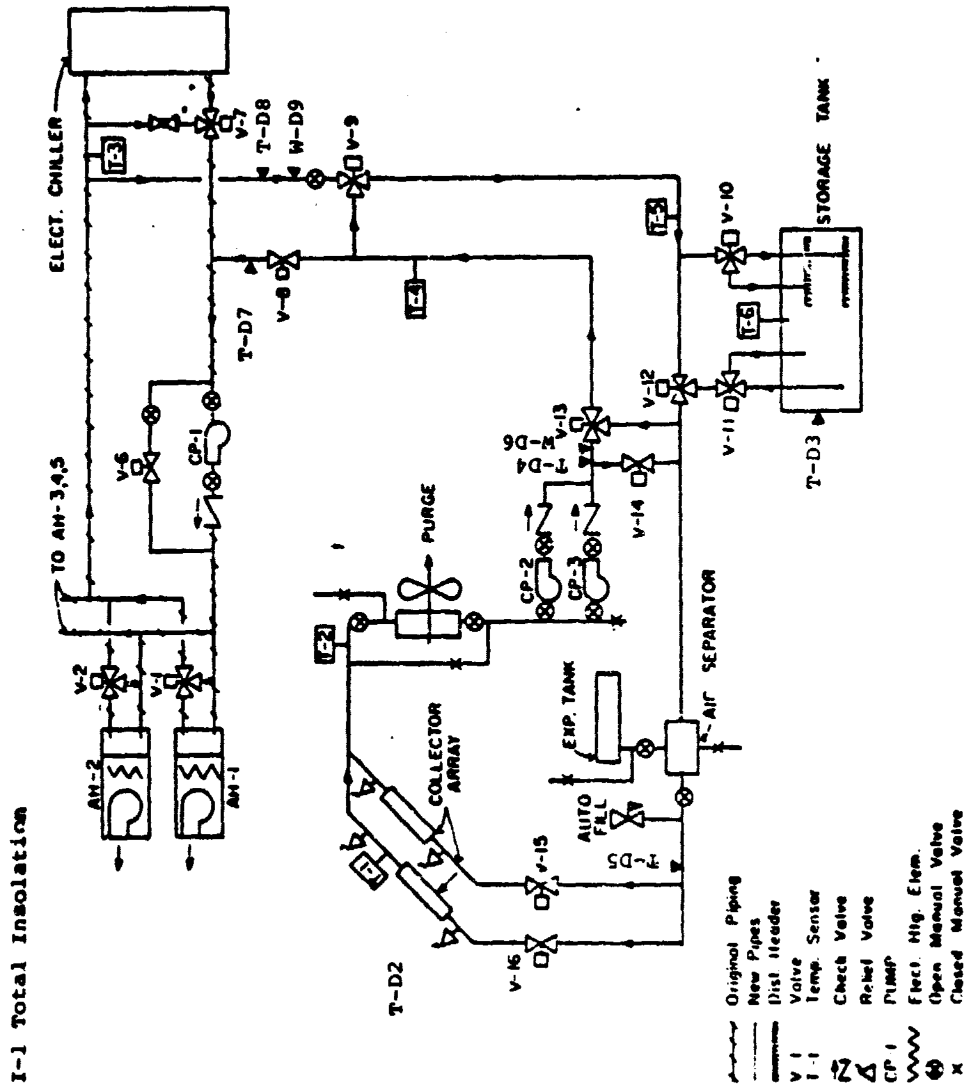


Figure 4-10. System Schematic—Lobby Display Sensors.

to measure collector output temperature, and the solar insolation sensor shown in Figure 4-4. Details of the installation and wiring are presented in Appendix A, drawing number 101, I-1, M-2, M-3, and M-4.

SECTION 5
SYSTEM OPERATION

The solar heating system operational controls have been interfaced with the standard HVAC controls. The operation of this combined solar heating— HVAC system is keyed to the solar collector output temperature; the ambient air temperature; temperature within the solar distribution system and standard air handling units; and the building space thermostats. Operation of the combined system is automatic and should require no action by the operator except for adjusting or setting building space thermostats, changing from the heating mode to the cooling mode,or in emergency conditions such as power or component failures and system leaks or freezing. A detailed description of the sequence of operation and the associated wiring schematic and diagram for the combined system is presented in Appendix C: Engineering Data for Troy Library— Honeywell Automation. Detailed system drawings and information on the solar collectors are presented in Appendices A and B, respectively.

Presented in this section is general information to assist the system operators and HVAC consultants in the operation, maintenance, and evaluation of the operational status of the overall system. Also included in this section is information describing the system operators actions for normal operating (automatic) conditions, energency conditions, and data collection requirements as well as system safety considerations. In addition, the system filling/draining functions are discussed and simulated operating conditions for summer and winter modes are presented to assist the HVAC consultants in evaluating the system status.

5.1 GENERAL INFORMATION

In subsequent paragraphs numerous references are made to various control panel switch settings, control valves and sensors, and valve action which control the direction of flow within the system. A discussion of these items is summarized below to assist the operators in locating the various components within the system and generate an understanding of the operation of the system control valves. Additional information on the installation and location of the system components is presented in Section 3.

(a) Solar System Control Panels

The solar system control panels (see Figure 3-16) for the pneumatic control systems are located on the west wall of the storage room adjacent to the bookmobile room. The main control panel contains five toggle switches and two warning lights, indicated below, in addition to an internal audible alarm which signals a collector leak or low temperature (equal to or less than 38°F).

<u>Toggle Switch Function</u>

V-15 Open/V-15 Closed
V-16 Open/V-16 Closed
Collector Filled/Collector Drained
Solar Heat/off/Electric Chilling
T-1 Main/T-1 Backup

<u>Warning Light Function</u>

Collector Leak Light
Collector Low Temperature Light

(b) Building Space Thermostats

The demand for heating or cooling is controlled by the building space thermostats. The location of these thermostats within the building is indicated in Table 5-1. Also indicated in Table 5-1 is the type and location of the electric heating devices controlled and the main circuit breaker panel designation. The main power panel locations which contain these circuit breakers are shown in Appendix A: Drawings M-1 and M-3.

(c) System Components/Piping/Control Valves/Sensors

The majority of the solar system piping, control valves, and control sensors are installed in the bookmobile room as shown in Figure 5-1. A schematic of the system, prepared to

TABLE 5-1

THERMOSTATS FOR AUXILIARY ELECTRIC HEATING UNITS

Device	Description	Type Control	Thermostat Location (Served By)	Panel Designation
EC-1	Bsbd	Pneu - Independent	Children's East	P2-14
EC-1	Bsbd	Pneu - Independent	Adult West	P1-16
EC-2	Bsbd	Electric	1st Floor Men's	P2-13
EC-2	Bsbd	Electric	1st Floor Women's	P1-15
EC-3	Bsbd	Electric	Mobile Storage	P1-14
EUH-1	Unit htr	Electric	Southwest	P2-10
EUH-2	Unit htr	Electric	Garage	P1-10
EUH-3	Unit htr	Electric	Northwest	P2-4
UH	Unit htr	Electric - Solar	Purge Unit	(Switch at unit)
AH-1	Air hand	Pneu - Solar	Basement	P1-2
AH-3	Air hand	Pneu - Solar	Adult West	P1-1
AH-4	Air hand	Pneu - Solar	Children's East	P2-1
ERH-1	Reheat	Pneu - Independent	Services/Processing (AH-2)	P2-6
ERH-2	Reheat	Pneu - Independent	Services/Processing (AH-2)	P1-12
ERH-3	Reheat	Pneu - Solar	Multi-Pump (AH-2)	P2-3
ERH-4	Reheat	Pneu - Solar	Adult Stack (AH-5)	P2-2
ERH-5	Reheat	Pneu - Independent	Children's Stack (AH-5)	P2-9

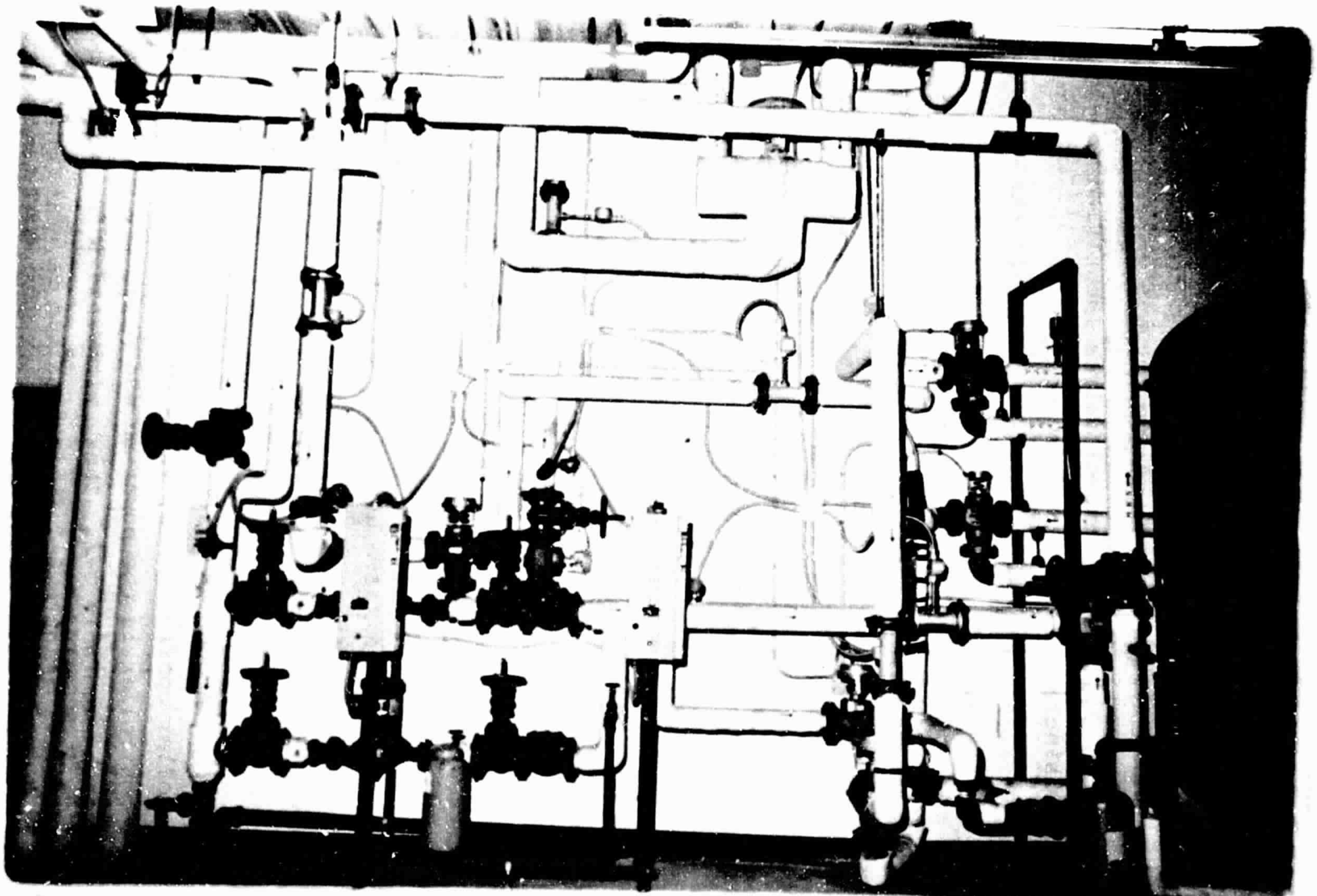


Figure 5.1. Solar System Distribution Piping with Control Valves and Sensors.

emphasize the piping arrangement in the bookmobile room, is presented in Figure 5-2. This schematic which also includes the general piping arrangement to all other control valves and system components can be used by the operator to locate those components, valves, and sensors which are referenced in subsequent paragraphs.

(d) System Control Valves/Pneumatic Controller

The system control valves identified in Figure 5-2 are either single-seated valves (normally open or normally closed) or three-way valves used to divert and control the direction of flow within the system. Actuation of these control valves is accomplished through the use of pneumatic controllers. In this system two configurations of pneumatic controllers are used and have been identified as Configuration A and Configuration B as shown in Figure 5-3 in the unactivated (power off) position.

In the power off position for Configuration A (see Figure 5-3) the lower collar on the controller spring is fixed to the control valve stem. When Configuration A is activated (power on) the controller spring is compressed upward which pulls the valve stem up. The action can be visually observed and is shown in Figure 5-4.

In the power off position for Configuration B (see Figure 5-3) the upper collar on the controller spring is fixed to the control valve stem. When Configuration B is activated (power on) the controller spring is compressed downward which pushes the valve stem down. This valve action can also be visually observed and is depicted in the drawing presented in Figure 5-5 which shows both the power on and power off positions of the Configuration B controller.

A complete listing of all system control valves by controller configuration, valve type, and direction of flow, with the controller in the power on and power off conditions, is presented in Table 5-2. Thus, with this information and the schematic in Figure 5-2 it is possible to determine, visually, the control valve status and direction of flow within the entire system for all operating conditions.

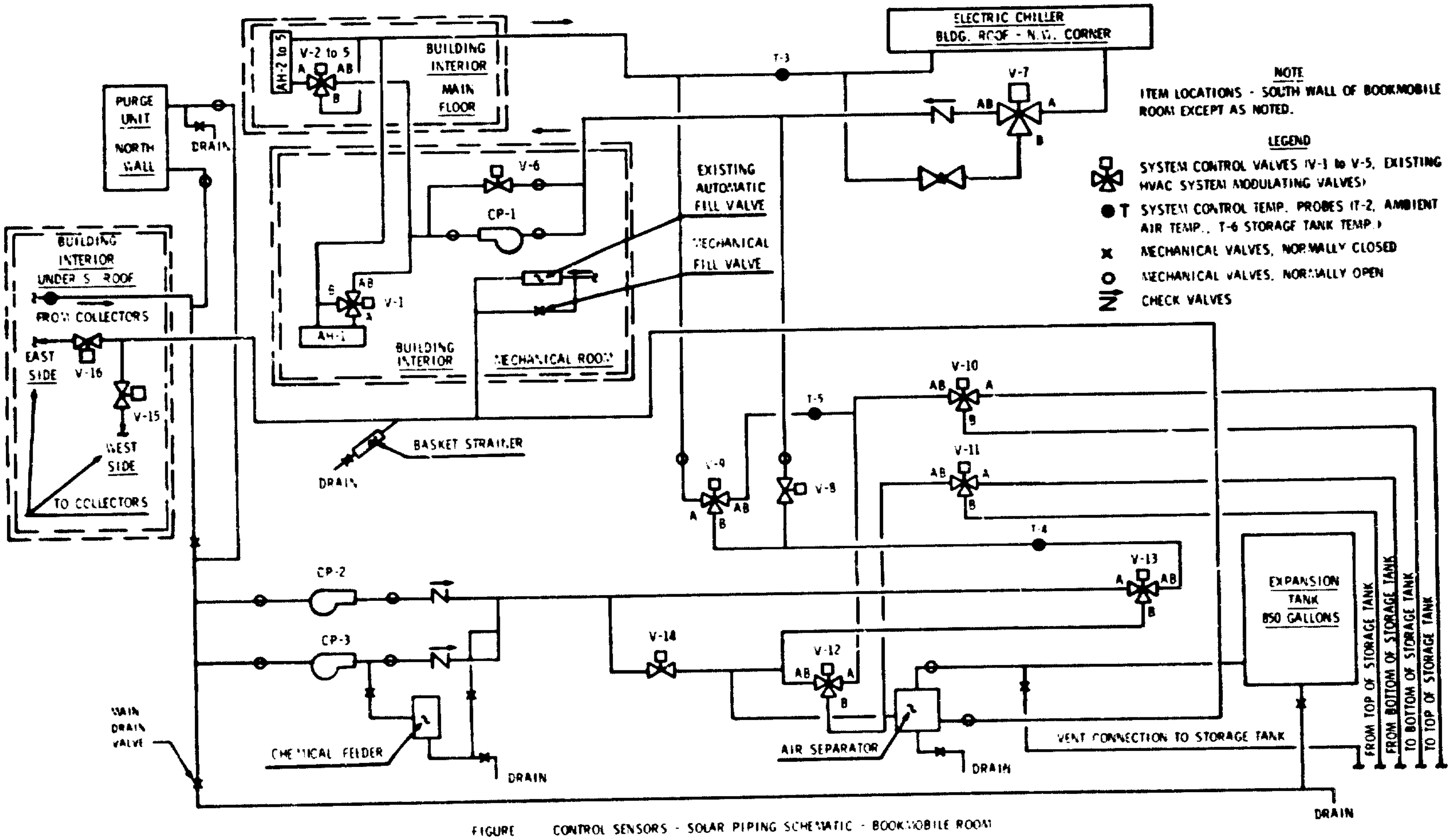


Figure 5.2. Schematic of Solar System Distribution Piping with Control Valves and Sensors.

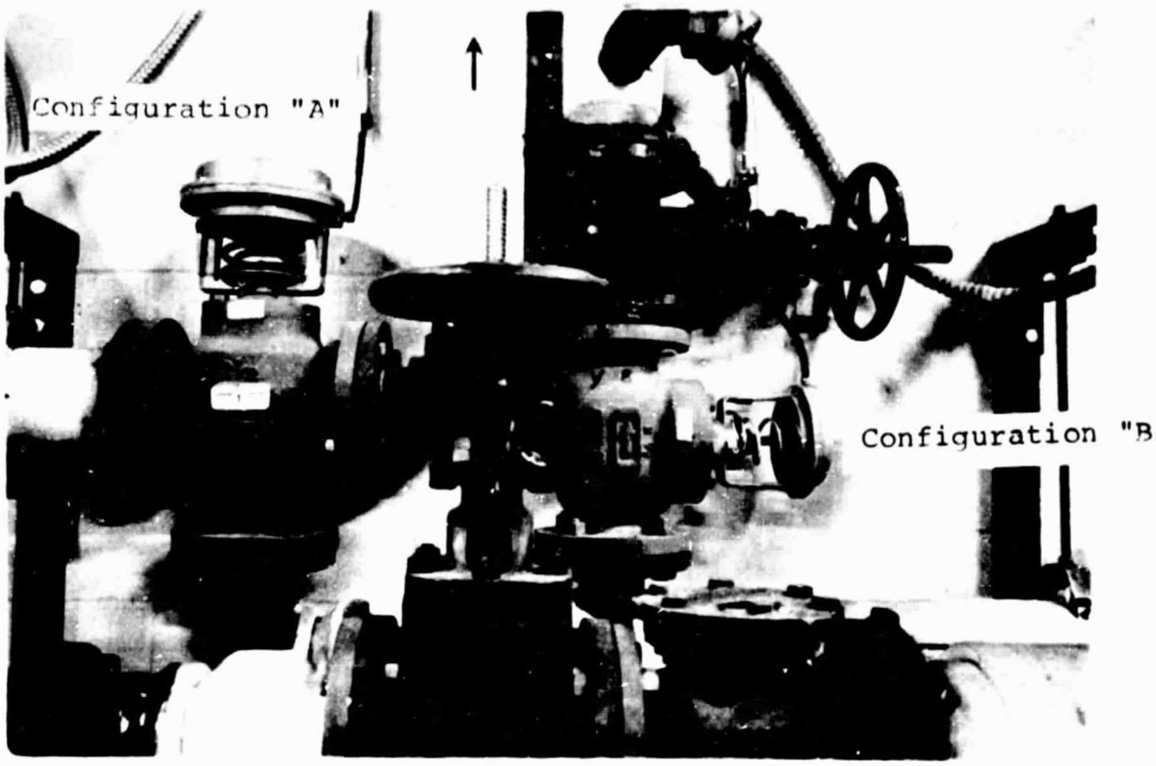


Figure 5-3. Control Valve Controller Configuration — Power "Off" Condition.

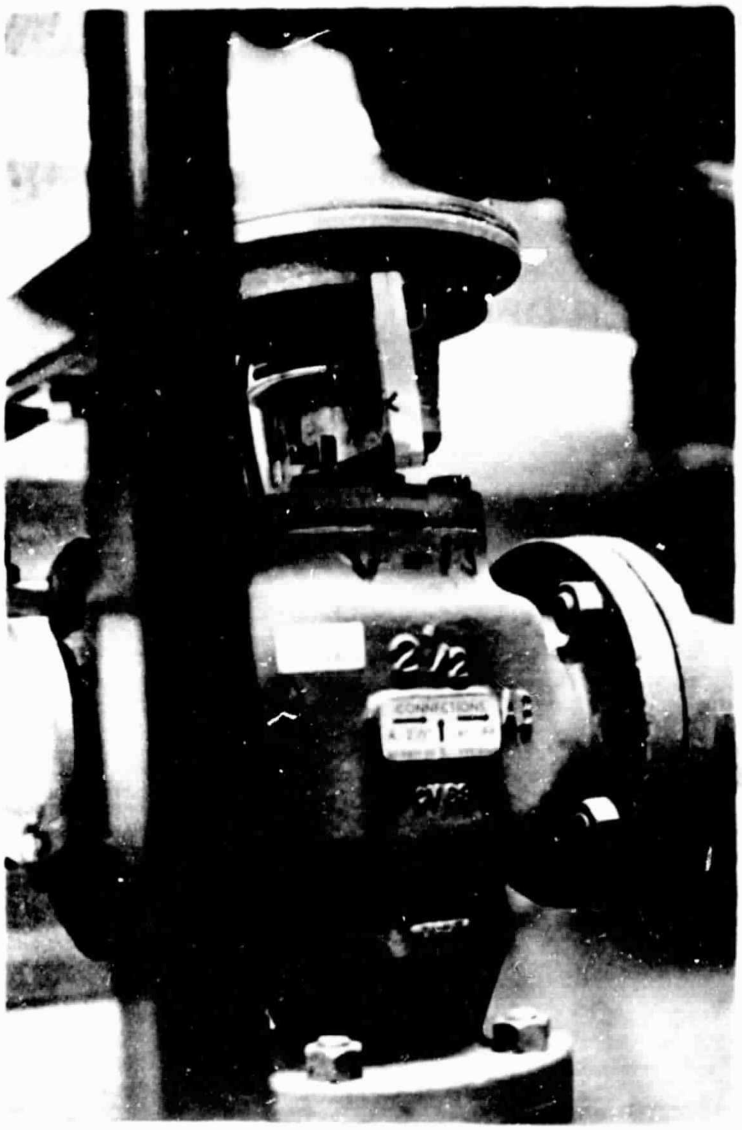


Figure 5-4. Control Valve Controller, Configuration "A"—
Power On Condition.

Figure 5-5. Drawing of Control Valve Controller, Configuration "B".

TABLE 5-2

LISTING OF SYSTEM CONTROL VALVES BY CONFIGURATION AND DIRECTION OF FLOW

Control Valve Number	Controller Con-figuration	Valve Type	Direction of Flow Power Off	Power On
1	B	3-Way	B-AB	A-AB
2	B	3-Way	B-AB	A-AB
3	B	3-Way	B-AB	A-AB
4	B	3-Way	B-AB	A-AB
5	B	3-Way	B-AB	A-AB
6	B	Single Seated	Open	Closed
7	B	3-Way	B-AB	A-AB
8	B	Single Seated	Open	Closed
9	A	3-Way	A-AB	B-AB
10	A	3-Way	AB-A	AB-B
11	B	3-Way	B-AB	A-AB
12	B	3-Way	B-AB	A-AB
13	A	3-Way	A-AB	B-AB
14	A	Single Seated	Closed	Open
15	B	Single Seated	Open	Closed
16	B	Single Seated	Open	Closed

5.2 NORMAL OPERATING (AUTOMATIC) CONDITIONS

Operation of the combined system, as indicated previously, is automatic. The operator actions described below will normally be limited to adjusting or setting the building space thermostats, changing the operation of the system from the heating mode to the cooling mode, and performing certain functions under emergency conditions such as power or component failures and system leaks or freezing. In addition, minor adjustments are required in the data collection system to assist the Department of Energy in meeting the data collection, performance evaluation, and dissemination goals of the National Program for Solar Heating and Cooling.

5.2.1 Building Space Thermostat Settings

Operation of the combined system requires that the total system controls be properly adjusted and maintained in order to optimize the use of the solar system. During the heating and cooling season the system operator should set the control thermostats for all electric heating devices (see Table 5-1) to operate at a temperature lower than those designated as AH-1, AH-3, AH-4, ERH-3, and ERH-4. Properly set thermostats will optimize the use of solar heat in the heating season and prevent the activation of electric reheat units during the cooling season.

In addition to the above the system operator could turn off some of the noncritical electric heating devices in moderate weather to ensure the use of the solar system to heat the building.

5.2.2 System Mode Change

Changing the mode of operation from cooling to heating and from heating to cooling must be accomplished in sequential steps in order to prevent damage to the solar system and the existing electric chiller. The system operator actions required for changing the mode of operation of the system are discussed below.

a. Solar Heating to Electric Chilling Mode

When the system is operating in the Solar Heating Mode, the Solar System Control Panel Toggle Switches are set as follows:

- V-15 Open
- V-16 Open
- Solar Heat
- Collector Filled
- T-1 Main

The following steps must be accomplishea by the system operator to change the mode of operation to electric chilling. The system operator should contact the HVAC serviceman to resolve any problem that might occur during this changeover process.

Step	Action Required
(1)	Move the system mode slector toggle switch on the Solar Control Panel to "Electric Chilling." NOTE: Make certain that the chiller power is "on" for 72 hours before positioning switch for Electric Chilling to prevent damage to the chiller.
(2)	Open the mechanical valve adjacent to V-7 to allow chiller bypass flow until water in the chilled system is below 90°F. This mechanical valve can be left open until changing the system back to solar heating.
(3)	Check position of control valves V-7, V-8, and V-9. Valve V-7 should be positioned for flow from port A to AB (power on) only if the air handler system water temperature at T-3 is below 90°F. The system water temperature can be checked visually on the dial gauge located in the return line from AH-1. Valve V-8 should be closed (power on) and valve V-9 should be positioned for flow from port B to AB (power on). NOTE: Circulating pump CP-1 should be "On" at all occupied times when in this mode and will circulate water through the building loop by-passing the electric chiller until the water temperature at T-3 is below 90°F.
(4)	Check with pressure gauge for flow in the Solar Collector loop. (In the event that flow should be restricted in the solar system, open the center cabinet of the Solar Control system in the bookmobile storage room and position the pneumatic toggle switch SP-3 to open V-14 to give short loop flow through the

Step	Action Required
	collectors until the problem causing interrupted flow can be corrected. Return toggle switch to original position after problem is corrected.)
(5)	Rotate the lever on the Mechanical Valve, next to port A of control valve V-9, 90° from the position shown in Figure 5-6 (perpendicular to the system piping). NOTE: This action is performed as a preventive measure. If valve V-9 does not seat properly, which apparently is common, solar water will leak into the chiller system through the original piping from the automatic fill valve (not shown in Figure 5-2) which completes the flow path. Thus, the chiller will cool the solar system water.
(6)	If chiller fails to operate after V-7 positions for flow A to AB and the water is between 90°F and 50°F, check power to the chiller, ensure that the chiller control panel switch is "on" and ensure that the flow switch is indicating flow if there is flow through the chiller. If the chiller still fails to operate, call the HVAC serviceman.

b. Electric Chilling to Solar Heating Mode

When the system is operating in the Electric Chilling Mode, the Solar System Control Panel Toggle switches are set as follows:

- V-15 Open
- V-16 Open
- Electric Chilling
- Collector Filled
- T-1 Main

The following steps must be accomplished by the system operator to change the mode of operation to solar heat. The system operators should contact the HVAC serviceman to resolve any problems that might occur during this changeover process.

Step	Action Required
(1)	Rotate the lever on the Mechanical Valve, next to port A of control valve V-9 90°. The final position of this valve should be parallel to the system piping as shown in Figure 5-6.
(2)	Manual Gate Valve located directly above V-8 should be opened.

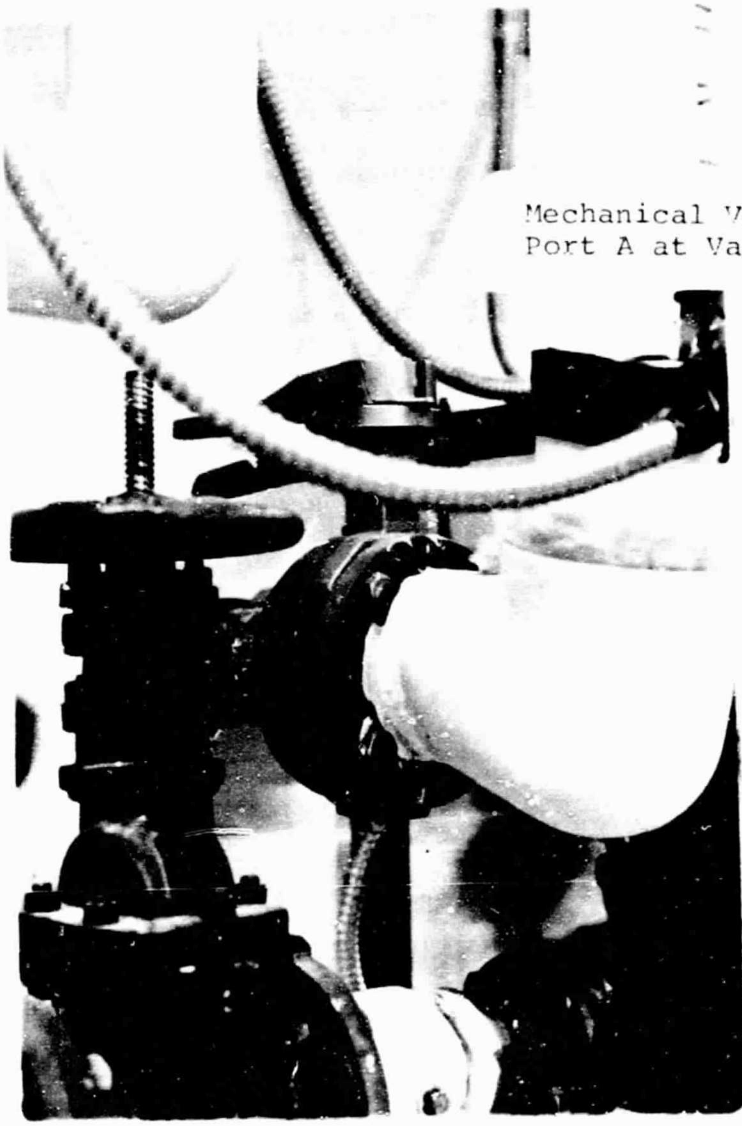


Figure 5-6. Manual Butterfly Valve.

with little or no insolation, during a major power interruption or failure of both solar circulating pumps.

Steps	Action Required
(1)	Open the makeup water bypass (mechanical fill) valve full open.
(2)	Place the handle on the main drain valve and open it only far enough to ensure full flow through the collectors. Proper flow can be determined by placing a pressure gauge in the "PT" plug immediately adjacent to the expansion tank in the supply line to the collectors. Adjust flow through the drain valve to maintain approximately 20 lb on the gauge.
	WARNING: Do not open this valve fully, as the collectors may become air-bound.
(3)	If collector arrays are exposed to sunshine it may be desirable to shade them with an opaque material such as thin black polyethylene sheets.
(4)	After pump operation is re-established, close the main drain valve, remove the handle, and close the makeup water bypass (mechanical fill) valve.
(5)	Collector operation should be closely watched for a period after operating the system under the "Emergency Function" since much air will be introduced into the system with the introduction of city water and air can cause restricted flow and boiling of the collectors.

A system leak detection device has been incorporated into the system and is located on the building side of the automatic fill valve. If a leak occurs, the device will activate the collector leak light located on the Solar Control Panel as well as the audible alarm within the panel. If this condition occurs, the following action should be initiated by the system operator.

Step	Action Required
(1)	Visually inspect and locate the damaged or leaking collector array.
(2)	Shade the affected array with an opaque material if exposed to the sunshine, as well as the array located on the opposite side of the roof curb (the entire row).
(3)	Isolate the entire row from the system by closing the supply and return valves in the roof curb.

Step	Action Required
(4)	Complete repair when water has cooled.
(5)	Open the vent valve and water supply valve in the roof curb.
(6)	Open the makeup water bypass (mechanical fill) valve full open.
(7)	When water is flowing freely, with no air bubbles, from the vent drain line at the roof curb, close the mechanical fill valve.
(8)	Then close the vent valve and open the water return valve in the roof curb.
(9)	Remove cover if used.
(10)	Collector operation should be closely watched for a period after operating the system under the "Emergency Function" since much air will be introduced into the system with the introduction of city water and air can cause restricted flow and boiling of the collectors.

5.2.4 Data Collection and Lobby Display

The basic operation of the data collection/monitoring system is automatic. The Site Data Acquisition System automatically scans the sensor inputs at preselected time intervals and stores the raw data on a cassette tape. Data is then transferred, through a commercial telephone network, each day or on demand to the Central Data Processing System and Host Computer for processing, analysis, and documentation.

In order to evaluate the diffuse insolation data, it will be necessary for the on-site operators to reset the shadow band (see Figure 4-4) along the polar axis in accordance with the changing solar declination. Generally, the shadow cast on the radiometer should be checked daily (no less than twice a week) when the sun is unobscured by clouds. This is easily accomplished by loosening the two wing nuts clamping the side bars and resetting the band to maintain the shadow on the radiometer. These adjustments should be made at noon, and records indicating the date of adjustment, time of day, and declination angle indicated on the side bars must be kept. The DOE representative should have access to these records for system documentation.

The lobby display is a self-contained unit with instrumentation that is independent from the control system and data collection/monitoring system. The system is operated by library patrons and delivers to them the concept of solar heating.

5.3 SAFETY CONSIDERATION

System safety was a prime consideration in the design and installation of the solar heating system in the Troy-Miami County Public Library. All work was performed in accordance with the Occupational Safety and Health Act (OSHA) and all other state and local laws, ordnances, rules, and regulations relating to the work and in accordance with the "Specifications for Solar Heating Demonstration Project, Troy-Miami County Public Library," prepared by Levin, Porter, Smith, Inc., and Heapy and Associates.

There are, in addition, specific safety considerations regarding the operation and maintenance of the collector system which should be followed by all assigned operating personnel. These safety considerations are documented in Appendix B— SUNPAK^{TM} Solar Collector Installation, Service, and Operating Manual. Some of these safety considerations are repeated below because of their importance.

a. Extreme caution should be exercised when performing maintenance on the collector. Accidental breakage of a tube in a system operating under pressure at temperatures above 140°F could result in serious burns to personnel. Tubes should not be removed from an array during periods of bright sunlight if there is a possibility that the module being serviced could be air locked. This could lead to the release of pressurized steam, even though the inlet and outlet headers may be at atmospheric pressure.

b. Care should be exercised in handling partially filled tubes which have reached elevated stagnation temperatures in the unfilled portion of the tube. Pouring water from the tube could cause flashing of the water as it contacts the high temperature region of the tube and in some cases this may result in breakage of the tube.

c. Personnel handling the evacuated collector tubes should wear gloves and safety glasses. This is standard procedure for any routine glass handling work. Failure of a tube due to rough handling results in an implosion and does not generate a serious problem due to flying glass.

d. Persons servicing the collector array should wear nonslip sole shoes. Care should be exercised because of the sloping roof, 23° above the horizontal, where the collector arrays are located.

5.4 SYSTEM FILLING/DRAINING

These critical functions should not be performed routinely and should, therefore, be accomplished by or under the direction of an HVAC consultant or his representative. This approach is recommended because the solar system is more complex than a conventional system and because of: the potential for operator injury due high temperatures within the collector tubes (600°F); possible damage to the collector tubes due to thermal shock; and possible system damage due to air entrapment or low flow conditions. Detailed information concerning the operation of the solar collector system and safety considerations are presented in Appendix B —SUNPAK™ Solar Collector Installation, Service and Operating Manual, which should be read by all personnel assigned to operate and maintain the collector system.

> WARNING: Improper procedures in draining the system could result in severe steam burns received by the system operator.

5.5 SIMULATED OPERATING CONDITIONS

During the early phases of system operation the HVAC consultant may be required to adjust both the standard HVAC and solar system controls for proper sequencing in order to optimize the use of the combined system. To assist the HVAC consultant in these efforts, as well as for trouble shooting and evaluating the system operational status, ten simulated operating conditions were developed which functionally demonstrate actual operating conditions that may be encountered.

Three of the simulated operating conditions were developed for the summer (cooling) mode and the remaining seven conditions for the winter (heating) mode. The system functions demonstrated while operating under these simulated conditions are identified in Table 5-3. Presented in Table 5-4, for each condition listed in Table 5-3, is the corresponding simulated system, control temperatures, valve and equipment status, : system control panel switch settings.

The system operational ranges for each of the ten simulated operating conditions, along with diagnostic comments, are presented in the following paragraphs. It should be noted that these operating conditions can be demonstrated by simulating the various system control and building temperatures and setting building thermostats as indicated in Table 5-4.

5.5.1 Summer Mode — Condition 1 — Solar Heat to Storage and Building Cooling

This condition will be maintained under the following system control temperature ranges, building temperatures and thermostat settings.

System Operating Ranges

$80°F < T\text{-}1 \quad 220°F$

$T\text{-}3 \leq 90°F$

$T\text{-}5 \geq (T\text{-}6 + 5°F)$

Building Temperature $\geq$ (HVAC pneumatic thermostat setting + 3°F)

TABLE 5-3

SYSTEM FUNCTIONS DEMONSTRATED VERSUS SIMULATED OPERATING CONDITION NUMBER

System Function Demonstrated	Simulated Operating Condition Number									
	Summer Mode			Winter Mode						
	1	2	3	4	5	6	7	8	9	10
Solar Heat to Building				X	X		X			
Solar Heat to Storage	X		X		X		X	X		
Building Heat from Storage						X				
Electric Heat to Building									X	X
Heat Purged		X					X			
Building Cooling	X	X								
Freeze Protection										
40°F < T-1 ≤ 70°F									X	
T-2 ≤ 40°F									X	X
T-1 ≤ 40°F										X
Low Collector Temperature 50°F										
Light - T-1 ≤ 38°F										X
Alarm - T-1 ≤ 38°F										X

TABLE 5-4

SIMULATED SOLAR SYSTEM OPERATING CONDITIONS

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	Simulated Operations Condition Number: Summer Mode			Winter Mode						
	1	2	3	4	5	6	7	8	9	10
System Control Temperatures, °F										
T-1 Collector Outlet	195	220	140	170	180	79	220	125	65	38
T-2 Ambient Air	90	90	75	40	40	40	50	65	35	30
T-3 Chiller Inlet	80	80	75	145	158	128	198	123	74	74
T-4 Building Load Inlet or Storage Inlet	193	193	138	169	178	78	205	124	73	39
T-5 Building Load Return or Storage Inlet	192	192	136	144	157	125	195	123	73	39 **
T-6 Storage Tank	100	199	100	150	150	150	180	100	74	75
Valve Status										
V-1 through V-5	M	M	M	M	M	M	M	B-AB	B-AB	B-AB
V-6	C	C	C	O	O	C	O	O	O	O
V-7	A-AB	A-AB	A-AB	B-AB	B-AB	B-AB	B-AB	B-AB	B-AB	B-AB
V-8	C	C	C	O	O	O	O	C	C	C
V-9	B-AB	B-AB	B-AB	A-AB	A-AB	A-AB	A-AB	B-AB	B-AB	B-AB
V-10	AB-A	AB-A	AB-A	AB-B	AB-A	AB-B	AB-A	AB-A	AB-B	AB-B
V-11	A-AB	B-AB	A-AB	B-AB	A-AB	B-AB	B-AB	A-AB	B-AB	B-AB
V-12	B-AB	A-AB	B-AB	A-AB	B-AB	B-AB	B-AB	B-AB	B-AB	B-AB
V-13	A-AB	A-AB	A-AB	A-AB	A-AB	B-AB	B-AB	B-AB	B-AB	A-AB
V-14	C	O	C	C	C	C	C	C	O	C
V-15	O	O	O	O	O	O	O	O	O	O
V-16	O	O	O	O	O	O	O	O	O	O
Equipment Status										
Circulating Pump CP-1	On	On	On	Off	Off	On	Off	Off	Off	Off
Circulating Pump CP-2 **	On	On	On	On	On	Off	On	On	*On/ Off	On
Circulating Pump CP-3 **	On	On	On	On	On	Off	On	On	*On/ Off	On
Purge Unit	Off	On	Off	Off	Off	Off	On	Off	Off	Off
Electric Chiller	On	On	Off	Off	Off	Off	Off	Off	Off	Off
Air Handling Units AH-1 through AH-5	On	On	Off	On	On	On	On	Off	On	On
Building										
HVAC Electric Thermostat Settings, °F	58	58	58	58	58	58	58	58	58	58
HVAC Pneumatic Thermostat Settings, °F	75	75	75	65	65	65	65	65	65	65
Solar Pneumatic Thermostat Settings, °F	78	78	78	68	68	68	68	68	68	68
Building Temperature Reading, °F	82	82	78	66	66	66	66	70	63	63
Solar Control Panel Switch Settings/ Indicators										
V-15 Open/Closed	O	O	O	O	O	O	O	O	O	O
V-16 Open/Closed	O	O	O	O	O	O	O	O	O	O
Solar Heat/Off/Elect.Chilling	E.C.	E.C.	E.C.	S.H.	S.H.	S.H.	S.H.	S.H.	S.H.	S.H.
Collectors Filled/Drained	F	F	F	F	F	F	F	F	F	F
T-1 Main/Backup	M	M	M	M	M	M	M	M	M	M
Collector Leak Light	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
Collector Leak/Low Temperature Alarm (Internal)	Off	Off	Off	Off	Off	Off	Off	Off	Off	On
Collector Low Temperature Light	Off	Off	Off	Off	Off	Off	Off	Off	Off	On

Notes:
a. See Table 5.2 for system functions demonstrated.
b. See Figure 5-1 for locations at major system control components.
c. M - Modulating Valves on Main; C - Closed; O - Open; E.C. - Electric Chilling; S.H. - Solar Heat; E.H. - Electric Heat; F- Filled.
d. Notations A-B, AB-A, etc. refer to direction of flow through the three-way control valves.
* Pumps run for 10 minutes out of every four hours.
** CP -2 and CP-3 are stopped by photocells during periods of low insolation, except for freeze protection operation, indicated by *.

Diagnostic Comments

a. If T-1 $\leq$ 80°F, CP-2 and CP-3 will stop and will restart when T-1 $\geq$ 90°F. CP-2 and CP-3 are also stopped by photocells during periods of low insoluation. If T-1 $\geq$ 220°F the purge unit will start and continue operation until T-1 $\leq$ 190°F.

b. If T-3 > 90°F, the electric chiller will stop to prevent damage to the chiller and will restart when T-3 $\leq$ 90°F.

c. If T-5 < (T-6 + 5°F) valve V-12 will index for flow from port A to AB thereby bypassing the storage tank.

d. If the building temperature < (HVAC pneumatic thermostat setting +3°F), the electric chiller will stop, AH-1 through AH-5 circulating fans will stop, and modulating valves V-1 through V-5 will index for flow from port AB to B.

5.5.2 Summer Mode - Condition 2- Heat Purged and Building Cooling

This condition will be maintained under the following system control temperature ranges, building temperatures, and thermostat settings.

System Operating Ranges

T-1 $\geq$ 220°F

T-3 < 90°F

T-5 < (T-6 + 5°F)

Building temperature $\geq$ (HVAC pneumatic thermostat setting +3°F)

Diagnostic Comments

a. If T-1 $\leq$ 190°F the purge fan will stop and will restart when T-1 $\geq$ 220°F.

b. If T-3 > 90°F, the electric chiller will stop to prevent damage to the chiller and will restart when T-3 $\leq$ 90°F.

c. If T-5 $\geq$ (T-6 + 5°F) valve V-12 will index for flow from port B to AB for flow through the storage tank.

d. If the building temperature < (HVAC pneumatic thermostat setting +3°F), the electric chiller will stop, AH-1 through AH-5 circulating fans will stop, and modulating valves V-1 through V-5 will index for flow from port AB to B.

5.5.3 Summer Mode - Condition 3 - Solar Heat to Storage

This condition will be maintained under the following system control temperature ranges, building temperatures, and thermostat settings.

System Operating Ranges

80°F < T-1 < 220°F

T-3 ≤ 90°F

T-5 ≥ (T-6 + 5°F)

Building temperature < (HVAC pneumatic thermostat setting +3°F)

Diagnostic Comments

a. If T-1 ≤ 80°F, CP-2 and CP-3 will stop and will restart when T-1 ≥ 90°F. CP-2 and CP-3 are also stopped by photocells during periods of low insolation. If T-1 ≥ 220°F, the purge unit will start and continue operation until T-1 ≤ 190°F.

b. If T-3 > 90°F, the chiller will stop to prevent damage and restart when T-3 ≤ 90°F.

c. If T-5 < (T-6 + 5°F), valve V-12 will index for flow from port A to AB thereby bypassing the storage tank.

d. If the building temperature ≥ (HVAC pneumatic thermostat setting +3°F), the electric chiller will start, AH-1 through AH-5 circulating fan will start, and valves V-1 through V-5 will modulate flow through the air handlers until the desired building temperatures are achieved.

5.5.4 Winter Mode - Condition 4 - Solar Heat to Building

This condition will be maintained under the following system control temperature ranges, building temperatures, and thermostat settings.

80°F < T-1 < 220°F

T-5 < (T-6 + 5°F)

Building temperature ≤ (solar pneumatic thermostat setting -2°F).

Diagnostic Comments

a. If T-1 ≤ 80°F, CP-2 and CP-3 will stop and will restart when T-1 ≥ 90°F. CP-2 and CP-3 are also stopped by photocells during periods of low insolation. If T-1 ≥ 220°F the purge unit will start and continue operation until T-1 ≤ 190°F.

b. If T-5 ≥ (T-6 + 5°F), valve V-12 will index for flow from port B to AB for flow through the storage tank.

c. If the building temperature ≤ (HVAC pneumatic thermostat setting -2°F) the electric heat will be energized. When the electric heat is energized in AH-1, 3, and 4, valves V-1, 3, and 4 will be indexed for flow from port AB to B since the electric coil is first in the air stream and should not be used to warm up the solar heated water.

d. If the building temperature > (solar pneumatic thermostat setting -2°F) the circulating fans AH-1 through AH-5 will stop and valves V-1 through V-5 will index for flow from port AB to B.

5.5.5 Winter Mode - Condition 5 - Solar Heat to Building and Storage

This condition will be maintained under the following system control temperature ranges, building temperatures, and thermostat settings.

System Operating Ranges

80°F < T-1 < 220°F

T-5 ≥ (T-6 +5°F)

Building Temperature ≤ (solar pneumatic thermostat setting -2°F)

Diagnostic Comments

a. If T-1 ≤ 80°F, CP-2 and CP-3 will stop and will restart when T-1 ≥ 90°F. CP-2 and CP-3 are also stopped by photocells during periods of low insolation. If T-1 ≥ 220°F the purge unit will start and continue operation until T-1 ≤ 190°F.

b. If T-5 < (T-6 + 5°F), valve V-12 will index for flow from port A to AB thereby bypassing the storage tank.

c. If the building temperature ≤ (HVAC pneumatic thermostat setting -2°F), the electric heat will be energized. When the electric heat is energized in AH-1, 3, and 4, valves V-1, 3, and 4 will be indexed for flow from port AB to B since the electric coil is first in the air stream and should not be used to warm up the solar heated water.

d. If the building temperature > (solar pneumatic thermostat setting -2°F), the circulating fans AH-1 through AH-5 will stop and valves V-1 through V-5 will index for flow from port AB to B.

5.5.6 Winter Mode - Condition 6 - Building Heat from Storage

This condition will be maintained under the following system control temperature ranges, building temperatures, and thermostat settings.

System Operating Ranges

T-1 ≤ 80°F

T-4 ≥ 75°F

Building Temperature ≤ (solar pneumatic thermostat setting -2°F).

Diagnostic Comments

a. If T-1 ≥ 120°F, CP-1 will stop, CP-2 and CP-3 will start, and valve V-13 will index for flow from port A to AB.

b. If T-4 < 75°F, CP-1 will stop, Valve V-8 will close, and valve V-9 will index for flow from port B to AB. In this condition, conventional electric heat will be used to satisfy the heating load.

c. If the building temperature $\leq$ (HVAC pneumatic thermostat setting -2°F), the electric heat will be energized. When the electric heat is energized AH-1, 3, and 4, valves V-1, 3, and 4, will be indexed for flow from port AB to B since the electric coil is first in the air stream and should not be used to warm up the solar heated water.

d. If the building temperature > (solar pneumatic thermostat setting -2°F), the circulating fans AH-1 through AH-5 will stop and valves V-1 through V-5 will index for flow from port AB to B.

5.5.7 Winter Mode - Condition 7 - Solar Heat to Building and Storage and Heat Purged

This condition will be maintained under the following system control temperature ranges, building temperatures, and thermostat settings.

System Operating Ranges

T-1 $\geq$ 220°F

T-5 $\geq$ (T-6 + 5°F)

Building temperature $\leq$ (solar pneumatic setting -2°F).

Diagnostic Comments

a. If T-1 $\leq$ 190°F, the purge fan will stop and will restart when T-1 $\geq$ 220°F.

b. If T-5 < (T-6 + 5°F), valve V-12 will index for flow from port A to AB thereby bypassing the storage tank.

c. If the building temperature $\leq$ (HVAC pneumatic thermostat setting -2°F), the electric heat will be energized. When the electric heat is energized in AH-1, 3, and 4, valves V-1, 3, and 4 will be indexed for flow from port AB to B since the electric coil is first in the air stream and should not be used to warm up the solar heated water.

d. If the building temperature > (solar pneumatic thermostat setting -2°F), the circulating fans AH-1 through AH-5 will stop and valves V-1 through V-5 will index for flow from port AB to B.

5.5.8 Winter Mode - Condition 8 - Solar Heat to Storage

This condition will be maintained under the following system control temperature ranges, building temperatures, and thermostat settings.

System Operating Ranges

80°F < T-1 < 220°F

T-5 ≥ (T-6 + 5°F)

Building Temperature < (solar pneumatic thermostat setting -2°F).

Diagnostic Comments

a. If T-1 ≤ 80°F, CP-2 and CP-3 will stop and will restart when T-1 ≥ 90°F. If T-1 ≥ 220°F the purge unit will start and continue operation until T-1 ≤ 190°F.

b. If T-5 < (T-6 + 5°F), valve V-12 will index for flow from port A to AB thereby bypassing the storage tank.

c. If the building temperature ≤ (HVAC pneumatic thermostat setting -2°F), the electric heat will be energized. When the electric heat is energized in AH-1, 3, and 4, valves V-1, 3, and 4 will be indexed for flow from port AB to B since the electric coil is first in the air stream and should not be used to warm up the solar heated water.

d. If the building temperature ≤ (solar pneumatic thermostat setting -2°F), the circulating fans AH-1 through AH-5 will start.

5.5.9 Winter Mode - Condition 9 - Electric Heat to Building and Freeze Protection

This condition will be maintained under the following system control temperature ranges, building temperatures, and thermostat settings.

System Operating Ranges

$40°F < T\text{-}1 \leq 70°F$ and $T\text{-}2 \leq 40°F$

$T\text{-}4 < 75°F$

Building temperature $\leq$ (HVAC pneumatic thermostat setting -2°F).

Diagnostic Comments

a. If $T\text{-}1 \leq 40°F$, winter mode, condition 10 is activated.

b. If $50°F < T\text{-}1 < 90°F$, or if photocells indicate low insolation, circulating pumps CP-2 and CP-3 will stop, valve V-13 will be indexed for flow from port A to AB, and valve V-14 will close.

c. If $T\text{-}4 \geq 75°F$, valve V-8 will open, valve V-9 will be indexed for flow from port A to AB, and CP-1 will start.

d. If the building temperature > (HVAC pneumatic thermostat setting -2°F), the electric heating coils will be turned off and the circulating fans AH-1 through AH-5 will stop.

5.5.10 Winter Mode - Condition 10 - Electric Heat to Building, Freeze Protection, and Low Collector Temperature

This condition will be maintained under the following system control temperature ranges, building temperatures, and thermostat settings.

System Operating Ranges

$T\text{-}1 \leq 38°F$ and $T\text{-}2 \leq 40°F$

$T\text{-}4 < 75°F$

Building Temperature $\leq$ (HVAC pneumatic thermostat setting -2°F).

Diagnostic Comments

a. If 40°F ≤ T-1 ≤ 70°F, winter mode - condition 9 is activated.

b. If 50°F ≤ T-1 ≤ 90°F, or if photocells indicate low insolation, circulating pumps CP-2 and CP-3 will stop, valve V-13 will be indexed for flow from port A to AB, and valve V-14 will close.

c. If T-4 ≥ 75°F, valve V-8 will open, valve V-9 will be indexed for flow from port A to AB, and CP-1 will start.

d. If the building temperature > (HVAC pneumatic thermostat setting -2°F), the electric heating coils will be turned off and the circulating fans AH-1 through AH-5 will stop.

SECTION 6
ACCEPTANCE TESTING AND PERFORMANCE

6.1 ACCEPTANCE TESTING

Initial filling and testing of the solar heating system was completed in late March 1978. However, as mentioned earlier, several problems were encountered during and subsequent to the system checkout. These problems were resolved and the system reactivated in late November 1978. The acceptance test plan and acceptance test work sheets used by the HVAC contractor are presented in Table 6-1 and 6-2, respectively. Final acceptance testing was completed satisfactorily, requiring no corrective action.

During evaluation and repair of the data collection/monitoring system, in December 1979, several significant problems were discovered in the solar control system and basic HVAC control systems which were affecting the overall system performance. These problems involved leaking pneumatic controls, improper temperature differential settings in the solar system, and improper thermostat settings on the HVAC electric heating devices. These problems are being corrected and controls are being adjusted to optimize the use of the solar heating system.

6.2 PERFORMANCE

In order to estimate the performance of a solar heating system one must first compute the heating load requirement of the structure as accurately as possible. The heating loads on a monthly basis were hand calculated for the proposal using published average monthly temperature for Columbus, Ohio. The building data and assumptions used are shown in Table 6.3. During the preliminary design phase of the project, the NBSLD[1] loads program in

[1]Kusuda, T., "NBSLD, the Computer Program for Heating and Cooling Loads in Buildings," National Bureau of Standards, July 1976.

conjunction with a weather data tape for Dayton, Ohio, were used to calculate the loads on an hourly basis. Two different heating seasons were run with the NBSLD program. The first season selected was 1961-1962 because the heating degree days was nearest to the historic average for the area. After further study it was determined that 1961 and 1962 had the least solar insolation for the months of December, January, February, and March of the ten years on the weather tape. Therefore, 1958 and 1959 was selected since it had only a few more degree days, but the greatest solar insolation for the four winter months. The monthly load requirements from the hand calculations and the two NBSLD runs are shown in Table 6.4.

The next step in estimating the solar system performance is that of matching the solar energy collected with the building load and accounting for losses in the system. In order to accomplish this, one must have good estimates of the incident solar energy. In the proposal phase, these estimates of incident solar energy, on a monthly basis, were obtained from the Climatic Atlas[2] of the United States. In the preliminary design phase, the hourly solar insolation was computed by the NBSLD program using the Cloud Cover Modifier (CCM) technique. Table 6.5 shows the solar insolation on a horizontal surface from the Climatic Atlas and for the two heating seasons using NBSLD. The first question one might ask about this data is why are the results of NBSLD almost always lower than the Climatic Atlas data? If we are to assume that the Climatic Atlas data is valid, the answer to this question lies in the method of computation of the solar insolation in the NBSLD code. Study of the computer code indicated that no big problem exists in the computation of the clear day insolation. Therefore, the problem probably lies in the computation of the cloud cover factors. A change in the code has since been made to bring the NBSLD computation of solar insolation more closely in agreement with the Climatic Atlas data.

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[2] "Climatic Atlas of the United States," U.S. Department of Commerce, Environmental Science Services Administration, Environmental Date Services, June 1968.

Estimation of the fraction of the heating load carried by the solar system was accomplished through the use of the F-chart[3] technique for the proposal phase. During the preliminary design phase, TRNSYS[4] was used extensively to provide data on the effect of varying storage size, number of collectors, and control system techniques. These TRNSYS studies showed that decreasing the storage size from 10,000 to 5,000 gallons would only decrease the solar fraction by about 2.5 percent. By using the designed control system which supplies heated water directly from the collectors to the building load as opposed to a system which would deliver heated water to the storage tank and thence from the tank to the load, an increase in system performance of about 2.5 percent was realized. The use of the shaped reflectors on the collector as opposed to the diffuse background reflector was also found to yield an increase in system performance of about 11 percent. The 40° tilt of the collectors was chosen with the idea of future incorporation of solar cooling as part of the total system.

The final performance estimate using the F-chart technique and the Climatic Atlas data indicates that the solar system will supply 72 percent of the heating needs. This value is for 102 collectors with shaped reflectors and a 5,000-gallon storage tank.

The data collection, processing, and analysis for monitoring the operation of the total system and for evaluating the system's performance is being accomplished by the Department of Energy as part of the National Solar Data Program. A "Monthly Performance Report" will be prepared by DOE and distributed to each demonstration site participating in the program. The monthly reports will include a system description, performance evaluation, problem status, and detailed report forms listing daily measurements of individual subsystems and of environmental and isolation sensors.

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[3]Beckman, W. A., Klein, S. A., and Duffie, J. A., "Solar Heating Design by the F-Chart Method, John Wiley & Sons, 1977.

[4]"TRNSYS A Transient Simulation Program," Solar Energy Laboratory, University of Wisconsin-Madison.

As of this date, very little data has been made available because of problems with the data collection/monitoring system associated with the National Solar Data Network. However, the data we have received, while not representative of the solar system performance capability, does report the current conditions, and more importantly, the data has helped to identify potential problem areas in the total system. It was this data which helped to identify the total system control problems discussed above in Paragraph 6.1. These monthly reports should be an invaluable source of information for the Solar/HVAC consultant and system operators in maintaining the total system to optimize the use of the solar system to heat the building and for demonstrating the use of solar energy in nonresidential buildings.

TABLE 6-1
ACCEPTANCE TEST PLAN

Acceptance tests will be performed before the heating system is put into operation to verify that the system meets performance requirements. The tests will demonstrate that the system operates in conformance with the design specifications.

a. ITEMS TO BE TESTED

The items to be tested will include all parts of the operating and control systems. Specifically, the plumbing system, the pumps, the control transducers, the control actuators, and the system safety and warning components will be tested.

b. TEST OBJECTIVES

The objectives of the test program are to determine and to demonstrate that the system is functionally operable, that it meets the design specifications, and that it is safe for use.

c. TEST REQUIREMENTS

Test requirement to be met are as follows:

1. All plumbing system components, including piping and fittings, solar collectors, storage tanks, and heat exchangers, shall be tested in the system to at least 150 percent of design working pressures. Leaks, if any, shall be made tight, and retests performed until no discernible leaks are found.

2. Flow rates shall be determined throughout the system under all modes of operation to determine that pumps are delivering design fluid flows and that obstructions are not present in the system.

3. All control and operational components shall be exercised. This shall be accomplished by inducing transducer signals or detector actuations. Functional operability to the design specifications shall be shown in each of the system's operational modes.

(continued next page)

TABLE 6-1 (Concluded)

ACCEPTANCE TEST PLAN

d. TEST PROCEDURES

The following test procedures will be performed:

1. Pressure tests will be performed on all segments of the fluid system after installation is completed to demonstrate the integrity and safety of the system. Pressure relief valves will be replaced with plugs as necessary and each segment of the system will be pressurized to 150 percent of its design working pressure. The lack of necessity for makeup of the pressurizing fluid for ten minutes at this pressure shall demonstrate integrity of the fluid system. System pressure relief valves then shall be reinstalled and the system shall be pressurized to show actuation of the relief valves at specification pressure set points.

2. The operation of the system in each of its three operating modes, i.e., collector heat to storage, collector heat to the building, or storage heat to the building, shall be induced by falsifying the appropriate transducer or thermostat signals. Flow rates and pressures shall be measured in appropriate segments of the system to verify design operation of the pumps and control valves. Satisfactory operation in the design modes shall be sufficient to verify adequacy of the control and operational systems and to demonstrate a lack of blockage to fluid flows. This test may be performed by monitoring actual operation of the system in each of its operating modes if the system is completed during the solar heating season.

3. Operation of the overheat and freeze protection systems shall be verified by falsifying the signal from the solar collector outlet water temperature transducer to the appropriate controller off and on set point signal levels. Operation of the components of the system to design specifications shall be demonstrated by satisfactory operation of the systems in this mode of operation.

Satisfactory completion of these procedures shall be deemed sufficient to demonstrate the adequacy of the system to meet its performance requirements.

TABLE 6-2

ACCEPTANCE TEST WORK SHEETS

To facilitate the testing of the control sequence of this sytem at this time of year, it will require the owner's assistance. It is requested that both solar pumps be turned on manually, that Valve V-14 be manually opened to bypass the solar storage tank and the purge unit be placed in manual operation. These conditions should be established at approximately 5:00 p.m. on June 4, 1979. These procedures will drop the temperature in the solar collector loop to a low enough temperature to enable the control system to be sequenced without endangering the collectors through stagnation with high temperature water in them.

Since the chiller is in service, it is imperative that solar heated water be prevented from entering the chilled water system.

1. CONTROL SEQUENCE CHECK

The following check will be performed by artifically simulating various temperatures in the collectors through the pneumatic line from Sensor TP-1 to the various P.E.'s.

A. Solar heating - Electric chilling selector switch (close manual valves to isolate solar and chilled water).

   1. Check Position of Valves V-7, V-8, and V-9 in Each Mode ____________

   2. Check Operation of CP-1 and V-6 ____________

B. Collectors Filled/Drain Selector

   1. Check position V-13 ____________

C. Freeze Protection Mode

   1. Simulate 38° (with outside air simulated below 38°)

      a. Alarm ____________

      b. Light ____________

(continued next page)

TABLE 6-2

ACCEPTANCE TEST WORK SHEETS (Concluded)

Collector Arrays	- West Top	Press In ____	Press Out ____		
		Temp In ____	Temp Out ____		
	- West Middle	Press In ____	Press Out ____		
		Temp In ____	Temp Out ____		
	- West Bottom	Press In ____	Press Out ____		
		Temp In ____	Temp Out ____		
	- East Top	Press In ____	Press Out ____		
		Temp In ____	Temp Out ____		
	- East Middle	Press In ____	Press Out ____		
		Temp In ____	Temp Out ____		
	- East Bottom	Press In ____	Press Out ____		
		Temp In ____	Temp Out ____		

TABLE 6-2

ACCEPTANCE TEST WORK SHEETS (Continued)

2. Simulate 40° (with outside air simulated below 40°)
   a. Check timer operation (minimum timing) ________
   b. Pumps CP-2 and CP-3 run ________
   c. Valve V-14 position ________
   d. Return to normal at 55° ________

D. Normal Collection Sequence

1. Simulate 90°
   a. Pumps CP-2 and 3 start. ________
2. Simulate water in tank warmer than in piping
   a. Winter ________
   b. Summer ________
3. Simulate water in piping warmer than in tank. ________

E. High Temperature Protection (simulate 220°)

1. Purge unit runs ________

2. CHECK EQUIPMENT PERFORMANCE

Pump CP-1- Volt A/B______ B/C______ A/C______
Amps ______ ______ ______
Press In ______ Press Out ______

	Pumps Running Singly	Pumps Running Together
Pump CP-2	Volt A/B__ B/C__ A/C__	Volt A/B__ B/C__ A/C__
	Amps A__ B__ C__	Amps A__ B__ C__
	Press In ____ Press Out ____	Press In ____ Press Out ____
Pump CP-3	Volt A/B__ B/C__ A/C__	Volt A/B__ B/C__ A/C__
	Amps A__ B__ C__	Amps A__ B__ C__
	Press In ____ Press Out ____	Press In ____ Press Out ____

(continued next page)

TABLE 6.3

DATA USED FOR LOAD CALCULATIONS

Ground Floor Area	15,989 ft^2
Lower Level Area	6,647 ft^2
Total Floor Area	22,636 ft^2
Total Volume Used	335,165 ft^2
Daytime Building Temperature	75°
Nighttime Building Temperature	69°

1. Floors and Below Grade Wall

Well Water Temperature	55°
Edge Loss Coefficient	0.32 Btu-hr/ft/°F
Edge Length	470 ft
Below Grade Wall and Floor Area	21,401 ft^2
Below Grade Wall and Floor U	0.1 Btu-hr/ft/°F
Heat Loss/Gain	36,380 + 150 ΔT

2. Walls

	Glass		Wall	
Side	Area	U	Area	U
South East	484 ft^2	0.69	1,136 ft^2	0.091
North West	484	0.69	1,136	0.091
North East	162	0.69	1,278	0.091
	130	1.13		
South West	252	0.69	1,188	0.091
	275	1.13		
Entries			1,224	0.091

Heat Loss/Gain 1,954 ΔT

3. Roofs

	Glass		Roof	
Location	Area	U	Area	U
All Flat	----	----	7,726	0.042
Sloping North	130	1.20	4,800	0.047
Sloping South	275	1.20	4,222	0.047

Heat Loss/Gain 1,235 ΔT

(continued next page)

TABLE 6.3 (Concluded)

DATA USED FOR LOAD CALCULATIONS

4. Air Changes

Q = N x 6,000 ΔT where N = Number of Air Changes per Hour

Use N = 0.25

Heat Loss/Gain 1,500 ΔT

5. Lights

Lights = 47,900 watts = 163,400 Btu-hr

Use 80%

Heat Gain During Day 130,000 Btu-hr

6. People

Assume 100 people on the average

Sensible Load	245 Btu-hr/person
Latent Load	150 btu-hr/person

Heat Gain During Day	25,500 Btu-hr	Sensible
	15,000 Btu-hr	Latent

7. Motors

Air Handling Units and Water Circulation	37.5 hp
Elevation 20 hp Assume Average of 5 hp	
Solar Circulation Pump	2 hp
Total	44.5 hp daytime use

Heat Gain 113,000 Btu-hr - Daytime Use

TABLE 6.4

BUILDING HEATING LOADS: (1) AVERAGE YEAR (HAND CALCULATION), (2) 1961-62 (NBSLD), AND (3) 1958-59 (NBSLD)

	AVERAGE YEAR	NBSLD 61-62	NBSLD 58-59
January	94.7 x 10^6 Btu	90.42 x 10^6 Btu	93.24 x 10^6 Btu
Febraury	77.8	71.34	68.72
March	65.9	64.57	63.25
April	40.6	37.62	35.55
May	29.2	9.37	13.05
June	--	--	--
July	--	--	--
August	--	--	--
September	22.0	6.11	11.89
October	40.0	29.25	30.39
November	62.8	50.28	50.97
December	78.8	78.46	94.84
	511.8 x 10^6 Btu	437.42 x 10^6 Btu	461.9 x 10^6 Btu

TABLE 6.5

HORIZONTAL SOLAR RADIATION FOR THE VARIOUS "YEARS"

	Climatic Atlas	61-62 NBSLD	58-59 NBSLD
January	472	423	428 Btu/Day/Ft^2
February	737	484	598
March	1,095	786	965
April	1,442	1,461	1,248
May	1,737	1,654	1,429
----	----	----	----
September	1,556	1,494	1,163
October	1,054	812	1,037
November	649	494	484
December	476	313	401
	9,218	7,920	7,753

SECTION 7

PROBLEMS ENCOUNTERED/LESSONS LEARNED

This section includes a discussion of the major problems encountered and a listing of the lessons learned which may be beneficial to other contractors in the design, fabrication, installation and operation of solar heating systems in nonresidential buildings.

7.1 PROBLEMS ENCOUNTERED

1. Draining/Boiling

Since the collector selected for this project can only be drained by partial disassembly of each module, and since high stagnation temperatures (in excess of 600°F) can be achieved, the purge system must be utilized throughout the summer months because draining is too time-consuming. This purge system requires auxiliary energy for the purge fan and the solar circulating pumps which is essentially wasted energy, which is estimated to be approximately five percent of the winter energy saved. The manufacturer's original scheme for draining the system involved opening the relief valves and boiling the water from the collectors in a stagnant condition. However, since tube failures caused by percolating water during boil off had occurred at other installations, this method was deemed unacceptable and was abandoned. At this time, the most promising correction to this problem appears to be the installation of a solar-powered cooling system or use of other devices which would utilize energy collected during summer months.

2. Pressure/Expansion

Since the collector selected needs no antifreeze for freeze protection, no heat exchanger is installed between the storage system and the collector system. Therefore, the entire volume of water (approximately 6,200 gallons) is contained within one system. Although individual components of the collector selected are tested to 350 psi, the assembly is rated at a maximum of 30 psi. Considering the minimum pressure needed to fill the system, and the minimum pressure required at the collector outlet to avoid boiling, the resultant allowable pressure fluctuation from a 70° system to a 220° system is approximately 10 psi. Using a conventional expansion tank sizing technique with the above parameters results in an extremely large expansion tank for such a system. Location of the pump and the specific point of connection of the expansion tank to the system becomes extremely crucial under such conditions. It has been found that utilizing a diaphragm type expansion tank results in a significant size reduction under these conditions. An additional size reduction can be accomplished by applying controlled compressed air to a diaphragm type expansion tank.

3. Flow Rates

To optimize system performance, it appears desirable to supply solar heated water directly from the solar collectors to heating units whenever possible. However, it is customarily difficult to reduce the flow rates inherent to a typical heating system to the flow rates often established for a collector system. Obviously, this task becomes easier as the size of the collector array is increased. Extremely careful sizing of all system components is required to match collector and heating system flow rates.

4. System Checkout Problems

a. The system was filled toward the end of the heating season in March of 1978. Although the solar system is complex when compared to conventional heating systems, we cannot disregard the ordinary problems associated with them. Some conventional air binding problems were encountered on filling of the system that were aggravated because of the low flow rates associated with the model of the solar collectors then being used. Additional air bleeds were added to solve the problems caused by the low flow velocities.

b. A second problem encountered shortly after start up was associated with the purge unit located in the bookmobile garage. The damper linkage had not been properly adjusted on installation to affect air tight closure of the dampers. Natural convection of air through the unit at night caused the coils to freeze. Proper adjustment of the dampers and the installation of a strip heater prevented a recurrence of the problem. However, on future projects the best grade of insulated dampers should be used to ensure against freezing in purge units using water.

c. Although the system had been dry run before it was filled, problems were encountered after filling since some valves were installed backwards. In future projects "false" signals will be sent to the control system and the actual position of the valves will be checked to ensure that they move in the right direction.

d. It was found that valve V-9 was faulty and leaked when the solar system was set up for summer operation. Although Valve V-8 was closed and was in good condition, another flow path was available to close the flow loop. The auto fill valve is connected to the solar system near the expansion tank but it also connects to the chiller system at an expansion tank that was originally installed in the cooling loop. (The connection and original expansion tank are not shown on Figure 5-1.) Thus, hot solar water leaked into the chiller and back through Valve V-9 into storage; i.e., the chiller was cooling the water in storage. The manual valve near Valve V-9 was closed by the piping contractors representative to solve the immediate problem by isolating the solar system from the chilled water system.

Shortly thereafter, another problem, unrelated to the solar system, occurred when a space thermostat failed and over cooled the space during the spring of the year. To "solve" this problem, a different representative from the piping contractor switched the system to the winter mode to stop operation of the chiller since the weather was still mild. This caused Valve V-8 to open and Valve V-9 to position for flow from port A to AB. However, flow in the collector loop was blocked which resulted in boiling in the collectors because the manual valve near Valve V-9 was still closed. In order to stop the boiling, and being unaware of the closed manual valve, tubes were manually removed from the collectors since the collectors could not be drained. In order to prevent a recurrence of this type of problem, a detailed maintenance log will be kept. This incident caused a reevaluation of the flow in the collector loops. It was determined that replacing the large feeder tubes actually supplied in the collector with smaller ones upon which the design was based would ensure a more balanced flow; so the change was made.

e. The solar heating system installed in the library building is a retrofit system which was interfaced with the existing standard HVAC system. The HVAC system includes independent electric heating devices controlled by separate thermostats as well as combined solar and electric heating in one unit controlled by different thermostats. It was found that a number of the independent electric heating devices were energizing before, rather than after, the solar heating devices; and thus solar heat was not being used in the building as much as possible. This solar heat, which could have been used, was either stored, wasted by circulation through the collector loop, or purged if excessive temperatures were achieved. To solve this problem, the combined Solar-HVAC system controls are currently being evaluated and adjusted to ensure the proper sequencing of all of the heating/cooling demand thermostats.

7.2 LESSONS LEARNED

1. To obtain realistic bids from Plumbing and Mechanical contractors, a bidders conference was held to demonstrate that solar systems are not so unusual that they should include a "fear factor" in their bids. At this meeting the contractor was shown how the collectors were assembled and obtained "hands on" experience from which he could make his cost estimates. On subsequent programs we have held meetings of this type, and educational lectures were given by the collector manufacturer and the HVAC engineer. This procedure seems to aid in obtaining reasonable construction bids.

2. The use of roof curbs to keep all piping on the interior of the building is a good technique for preventing freezing and heat losses in the collector loop. Any heat "losses" from the pipe go into the heated space inside the building and therefore are not lost.

3. The use of diaphragm type expansion tanks with controlled compressed air can significantly reduce the required size of the expansion tank.

4. A design which allows for the use of low solar water temperature with booster heat gave up to 4 percent improvement in the heat delivered by the solar system.

5. The use of collectors with internal headers reduces on-site construction costs and manifold heat losses and appears to be cost effective.

6. The use of the best quality air dampers with insulated dampers is recommended for use with heat exchangers where freezing can occur.

7. It is recommended that system control valves be pretested to ensure proper functioning before installation. Leaking valves can seriously degrade system performance while improper operation can block intended flow paths and damage the system.

8. Glass breakage during installation of OI SUNPAK™ collectors system contains 2,448 collector tubes and 2,448 feeder tubes. During installation, glass breakage was limited to only seven collector tubes and approximately twelve feeder tubes.

9. System damage due to vandalism has not been a problem, even though the sytem is highly visible, being located on the relatively low sloping roof, facing a main street in the city.

10. Dry running the control system with false signals to simulate all operating modes and a visual check of all components and valves to see that they move in the right direction is essential, yet it is not a standard construction industry practice. Care must be exercised to assure that this procedure is adopted.

11. System leaks during filling were minimal. Only six connections out of more than 2,900 mechanical slip-type connections required minor adjustments to correct the conditions.

12. Low flow velocities in collector loops may require more careful attention to air bleeding on filling.

13. The combined solar-HVAC system controls must be evaluated and adjusted for proper sequencing in order to optimize the use of the solar heating system.

14. Those persons familiar with the operation and maintenance of the entire system should be the only ones permitted to make system control changes or change thermostat settings.

15. The use of a detailed service log is recommended from the start of the debug phase as well as during normal operation.

16. System protection against freezing has not been a problem since filled in March 1978 even though the winter of 1978-1979 was very severe. To our knowledge, the low temperature collector freeze protection mode has never been activated during system operation.

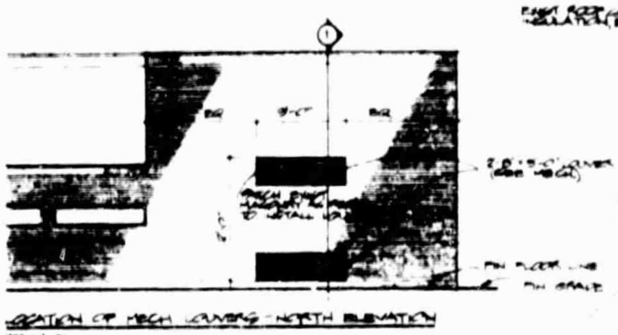
17. High performance evacuated tube-type solar collectors (nondrainable version) appear to be effective. However, consideration should be given to the use of the new drainable version of these collectors such as those currently being built by Owens-Illinois, Inc. and others.

18. Because of high stagnation temperatures that can be achieved in evacuated tube-type collectors, it is possible to shade the collector, if exposed to sunlight during system filling, draining, or repair. This is easily accomplished by using a light weight opaque material such as thin black polyethylene sheets. This approach was used successfully on another program to cool the system and complete the filling sequence in bright sunlight.

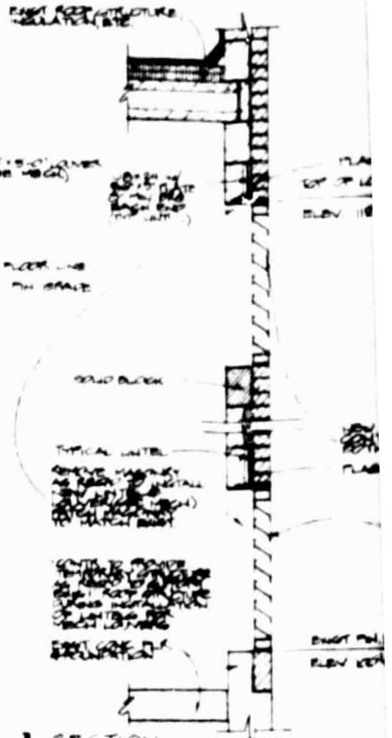
APPENDIX A

AS-BUILT DRAWINGS

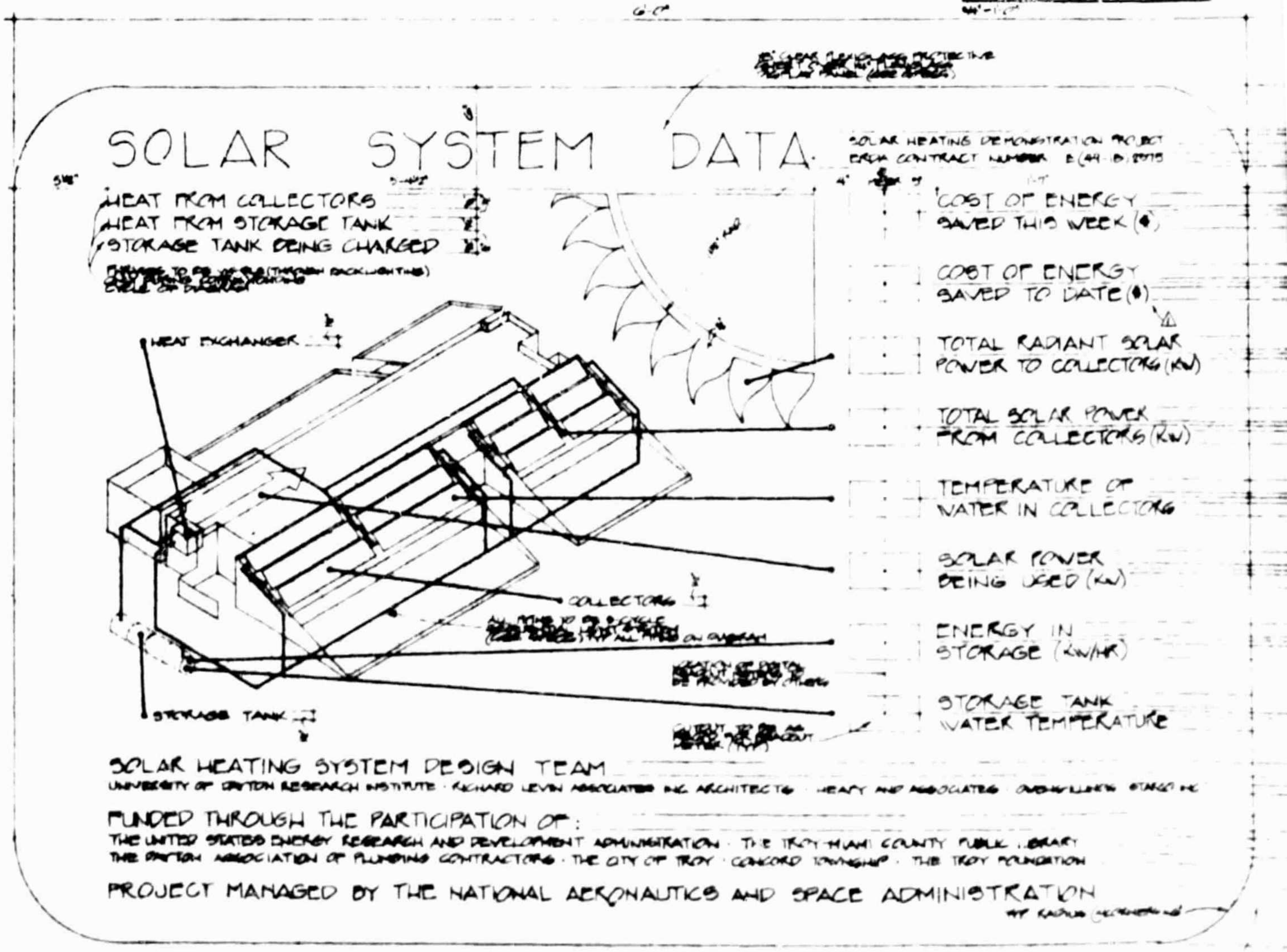
LOCATION MAP
NO SCALE



LOCATION OF MECH LOUVERS - NORTH ELEVATION



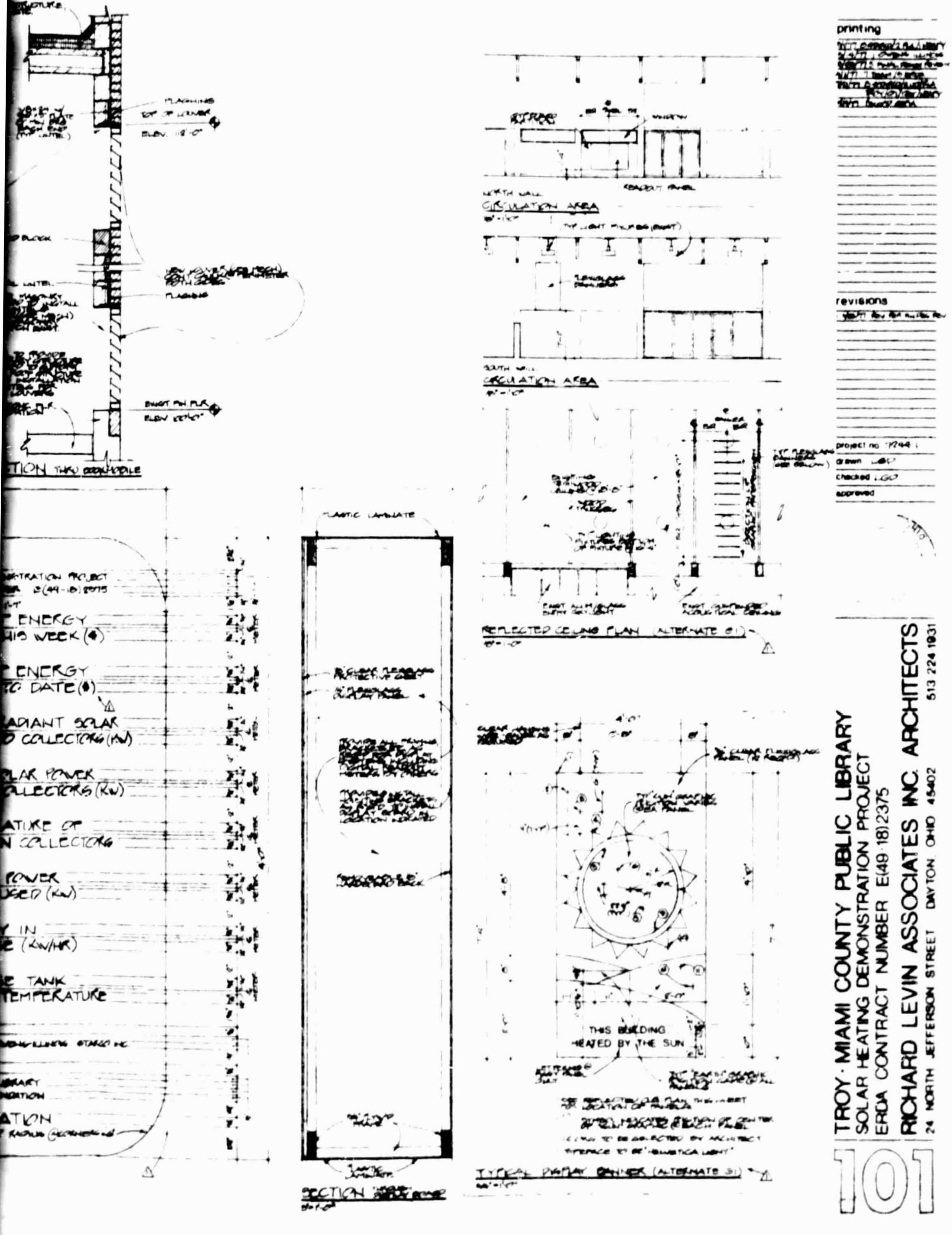
SECTION



SOLAR SYSTEM DIGITAL READOUT DISPLAY BOARD

NOTE:

FOLDOUT FRAME


printing
revisions
project no. 7244
drawn
checked
approved
NORTH WALL
CIRCULATION AREA
SOUTH WALL
CIRCULATION AREA
REFLECTED CEILING PLAN (ALTERNATE #1)
PLASTIC LAMINATE
SECTION
TYPICAL DISPLAY BANNER (ALTERNATE #1)
THIS BUILDING HEATED BY THE SUN
FLASHING
TOP OF LOUVER
ELEV. 118'-0"
ENERGY
THIS WEEK
ENERGY
TO DATE
RADIANT SOLAR
COLLECTORS (KW)
SOLAR POWER
COLLECTORS (KW)
TEMPERATURE OF
COLLECTORS
POWER
USED (KW)
TANK
TEMPERATURE
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SOLAR HEATING DEMONSTRATION PROJECT
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513 224 1931
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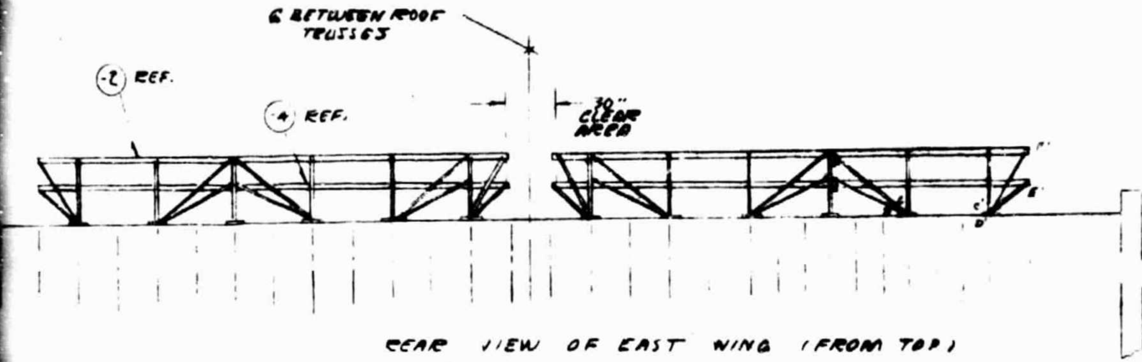
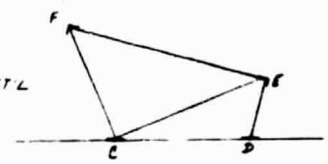


REAR VIEW OF EAST WING (FROM TOP)
PARALLEL WITH SLOPE OF ROOF

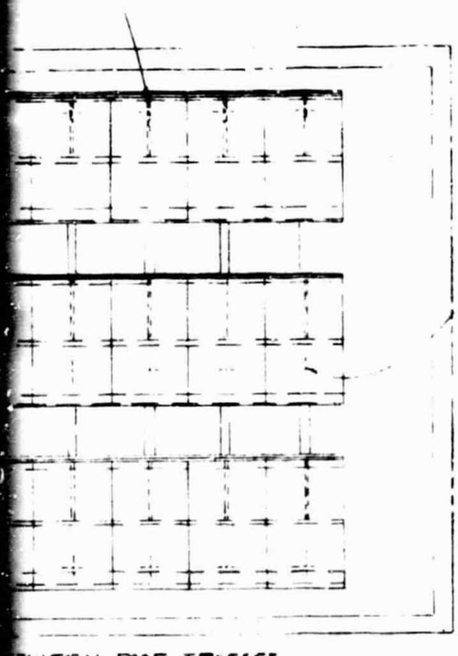
NC HEX HD SCREW
REQ'D PER CHANNEL

(8) CROSS SUPPORTS
18 FC REQ'D
18 ED REQ'D
MAT'L = 1" x 1" x 20 Ga. ST'L
SEE NOTE

12 F'C' REQ'D
12 E'D' REQ'D



(-5) IS 3" OFF ℄ OF PANEL



TWEEN ROOF TRUSSES

FOLDOUT FRAME

TOLERANCES:
FRACTIONS ± 1/16
ANGLES ± 1°

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CHECKED				
ENGINEER				
APPROVAL		SCALE AS MARKED · U.D. ACCOUNT 93283 · CODE	SHEET 1 OF 3	D77D01

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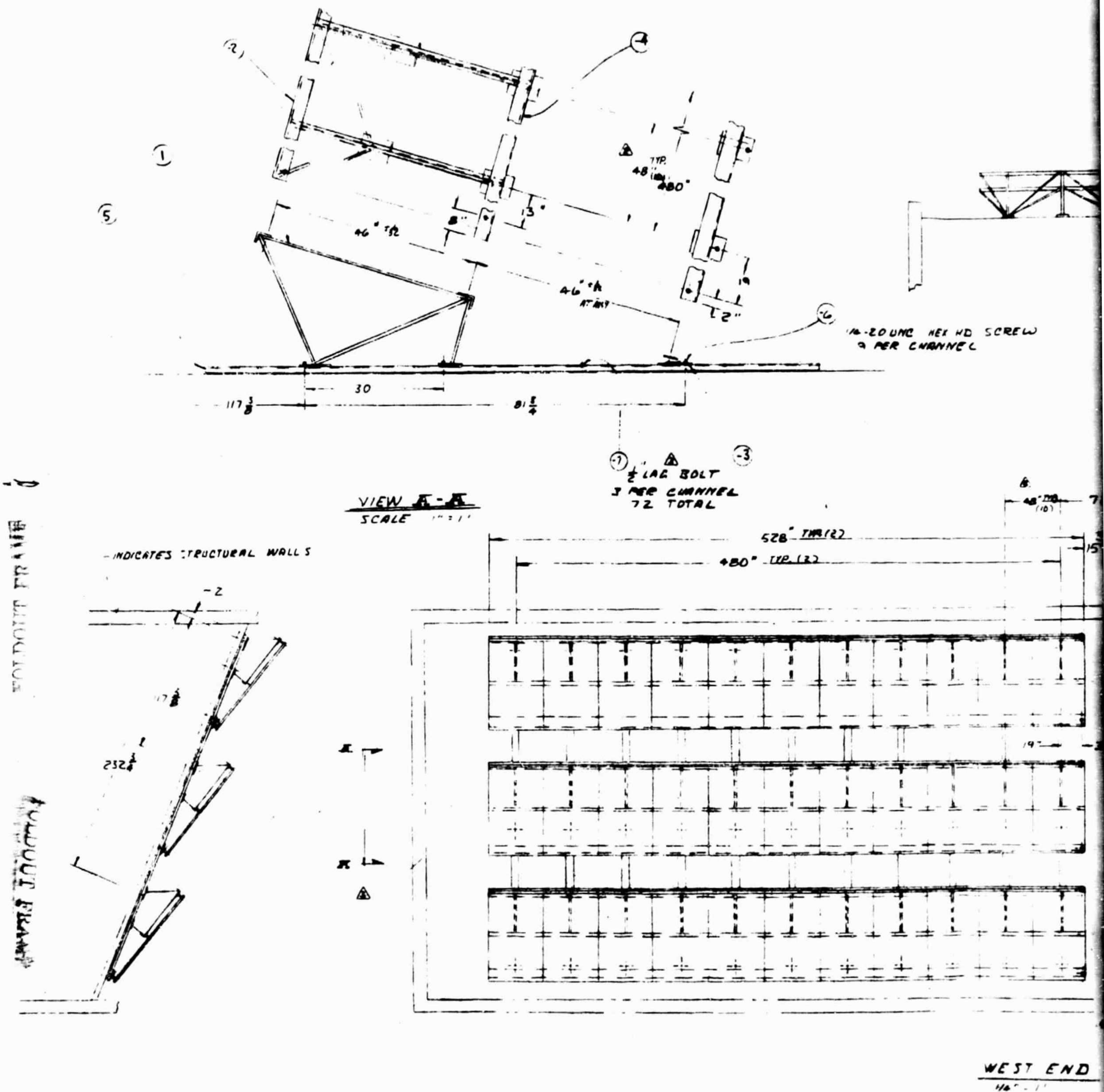
S1

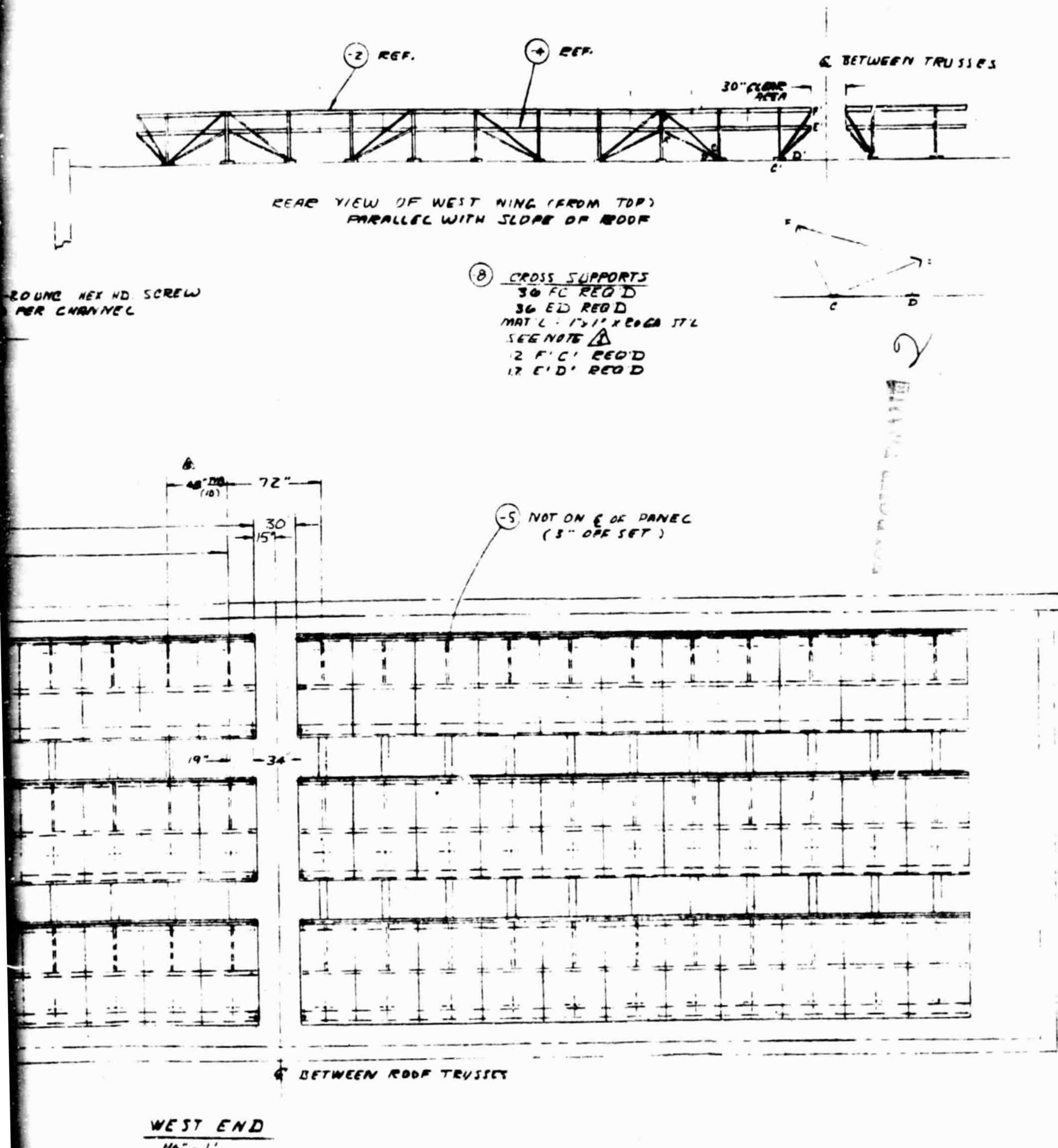


ALL 1/2" LAG BOLTS TO MAKE FULL CONTACT WITH EACH TRUSS.

NO ACCUMULATION OF TOLERANCE IS ALLOWED ON THESE DIMENSIONS.

ALL WELDS ARE TO BE OF STRUCTURAL QUALITY AND IN ACCORDANCE WITH AREA INDUSTRIAL STANDARDS.

Note:



TOLERANCES:
FRACTIONS ± 1/16
ANGLES ± 1°

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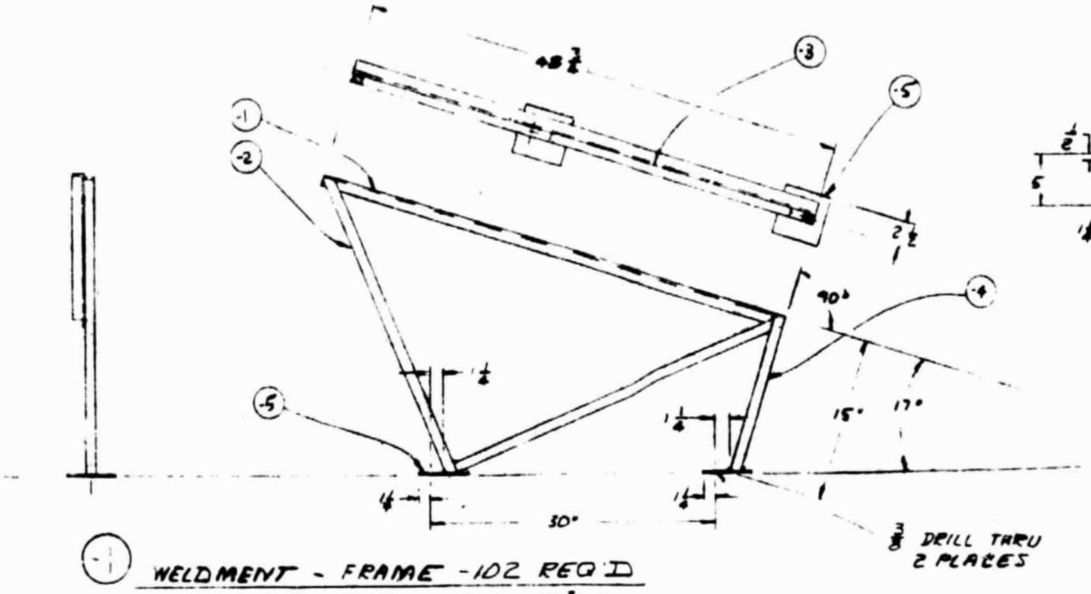
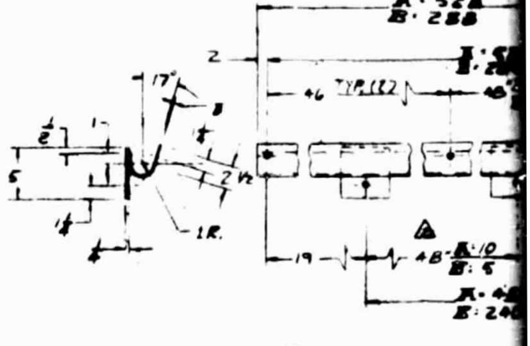
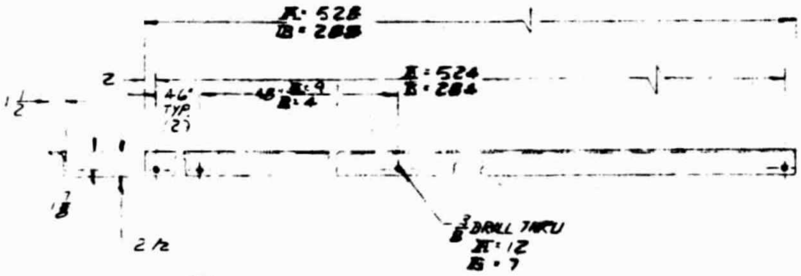


(1) WELDMENT - FRAME - 102 REQ'D

1. - 1 REQ'D STEEL ANGLE 1 3/16 x 1 3/16 x 3/16 x 48 1/4 Lg.
2. - 1 REQ'D STEEL TUBE 1 x 1 x 20 Ga. x 33 1/2 Lg.
3. - 1 REQ'D STEEL TUBE 1 x 1 x 20 Ga. x 37 3/4 Lg.
4. - 1 REQ'D STEEL TUBE 1 x 1 x 20 GA. x 15 Lg.
5. - 2 REQ'D STEEL PLATE 5 x 5 x 3/16

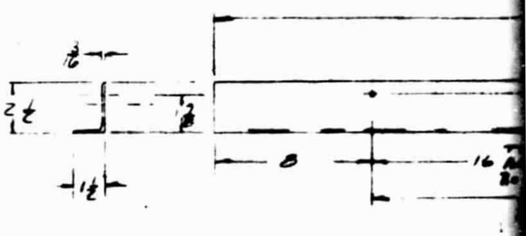


(3) WELDMENT -



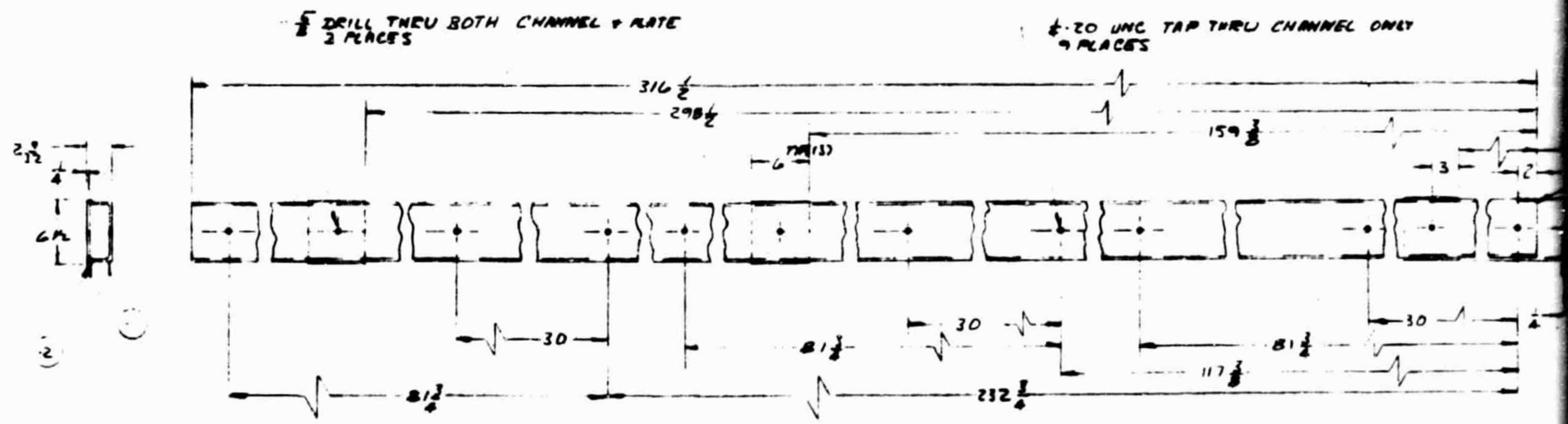
(2) ANGLE A · 6 REQ'D B · 6 REQ'D

MAT'L · 3/16 THK x 1 1/2 x 2 1/2 STEEL



(4) ANGLE A · 6

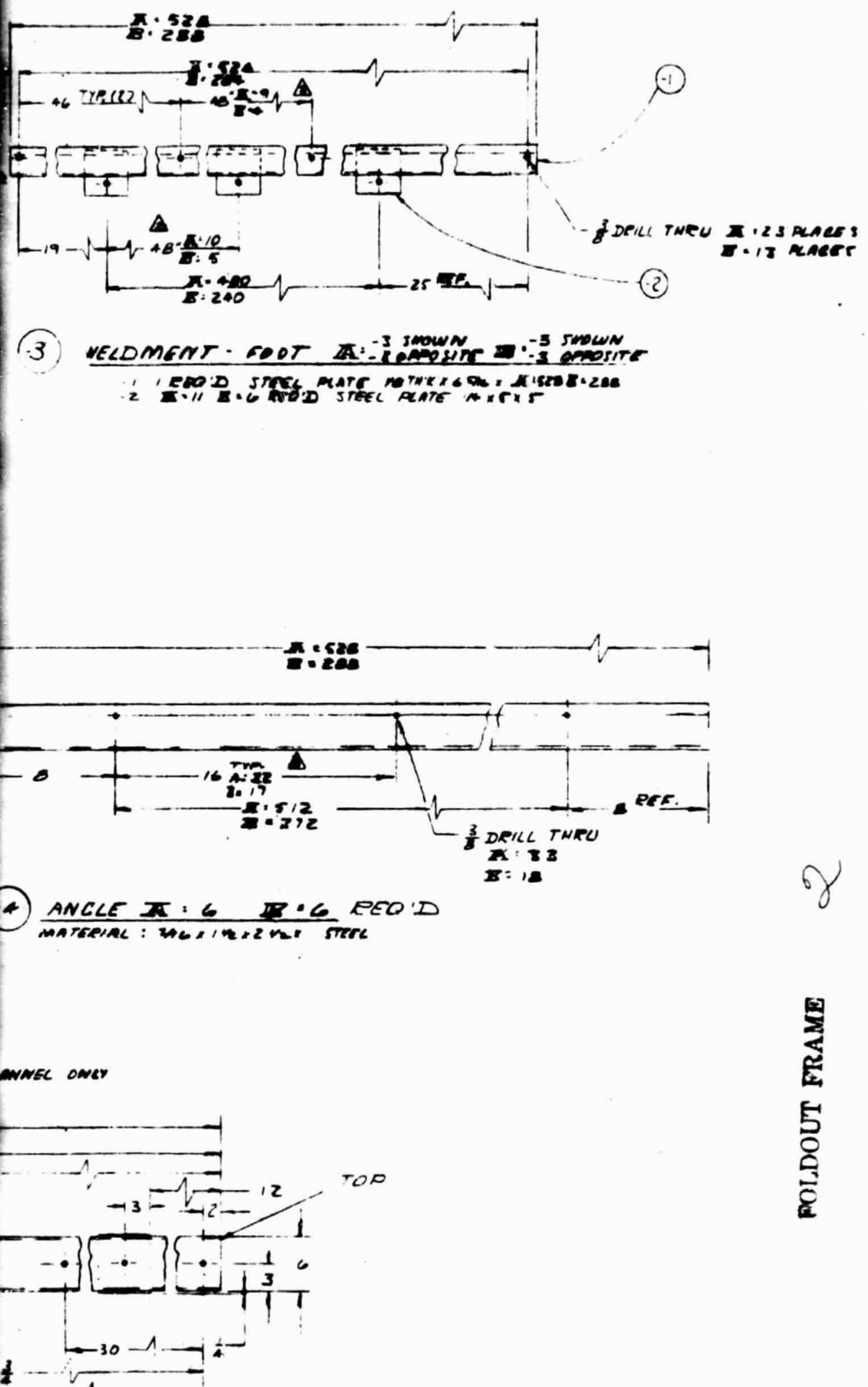
MATERIAL :



WELD ALL POINTS OF CONTACT

(5) WELDMENT CHANNEL 34 REQ'D

-1 6 x 2034 x 10.5 lbs. CHANNEL - STEEL 1 EACH REQ'D
-2 6 x 6 x 1/2 Lg PLATE - STEEL 3 EACH REQ'D



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approved

FOLDOUT FRAME

TOLERANCES:
FRACTIONS ± 1/16
ANGLES ± 1°

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DRAFTSMAN W. R. Clay	DATE FEB. 8	DETAILS	UNIVERSITY OF DAYTON RESEARCH INSTITUTE DAYTON OHIO	
CHECKED				
ENGINEER				
APPROVAL		SCALE 1/8" = 1" · R.I. ACCOUNT 93283	SHEET 3 - 3	D77D01

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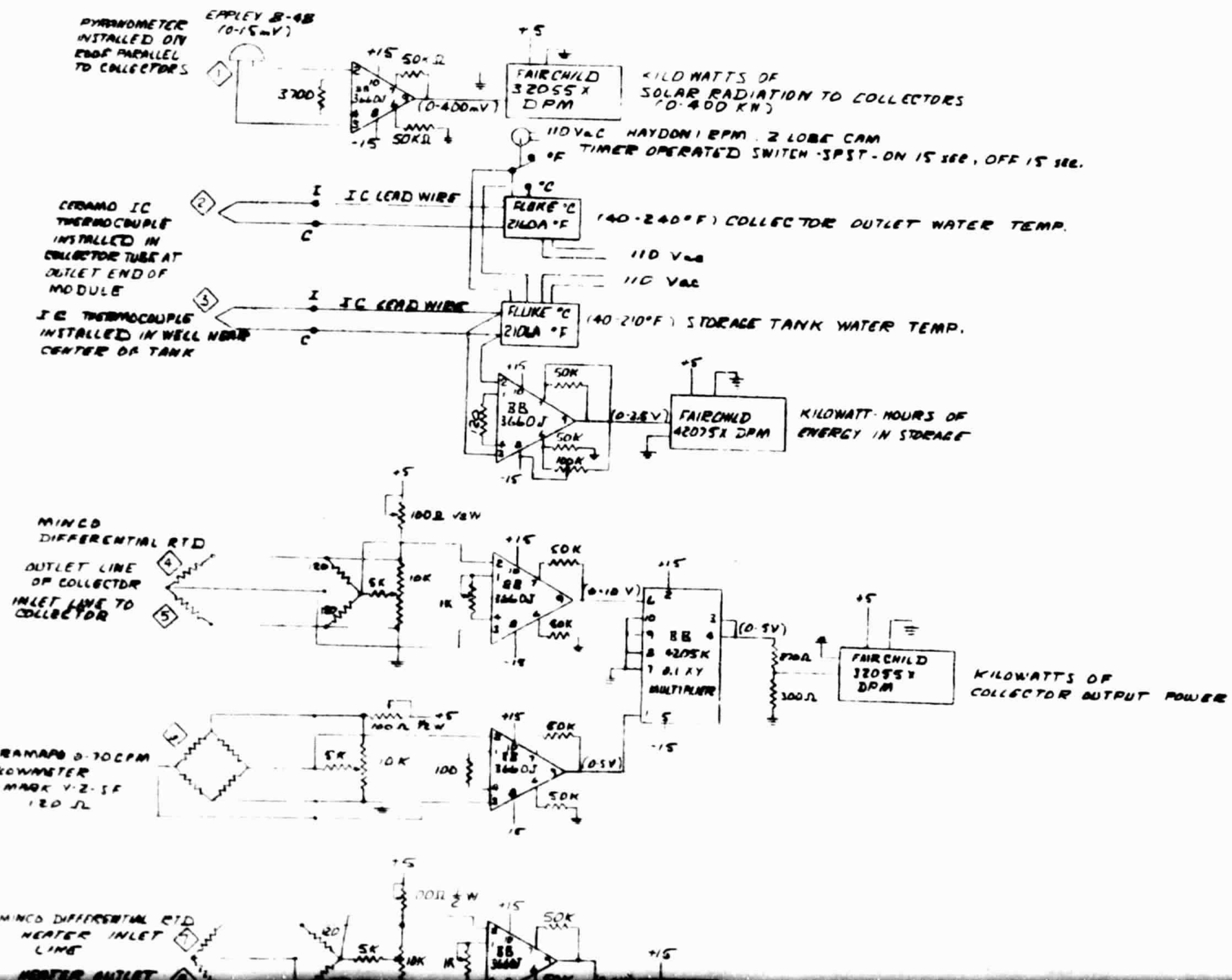
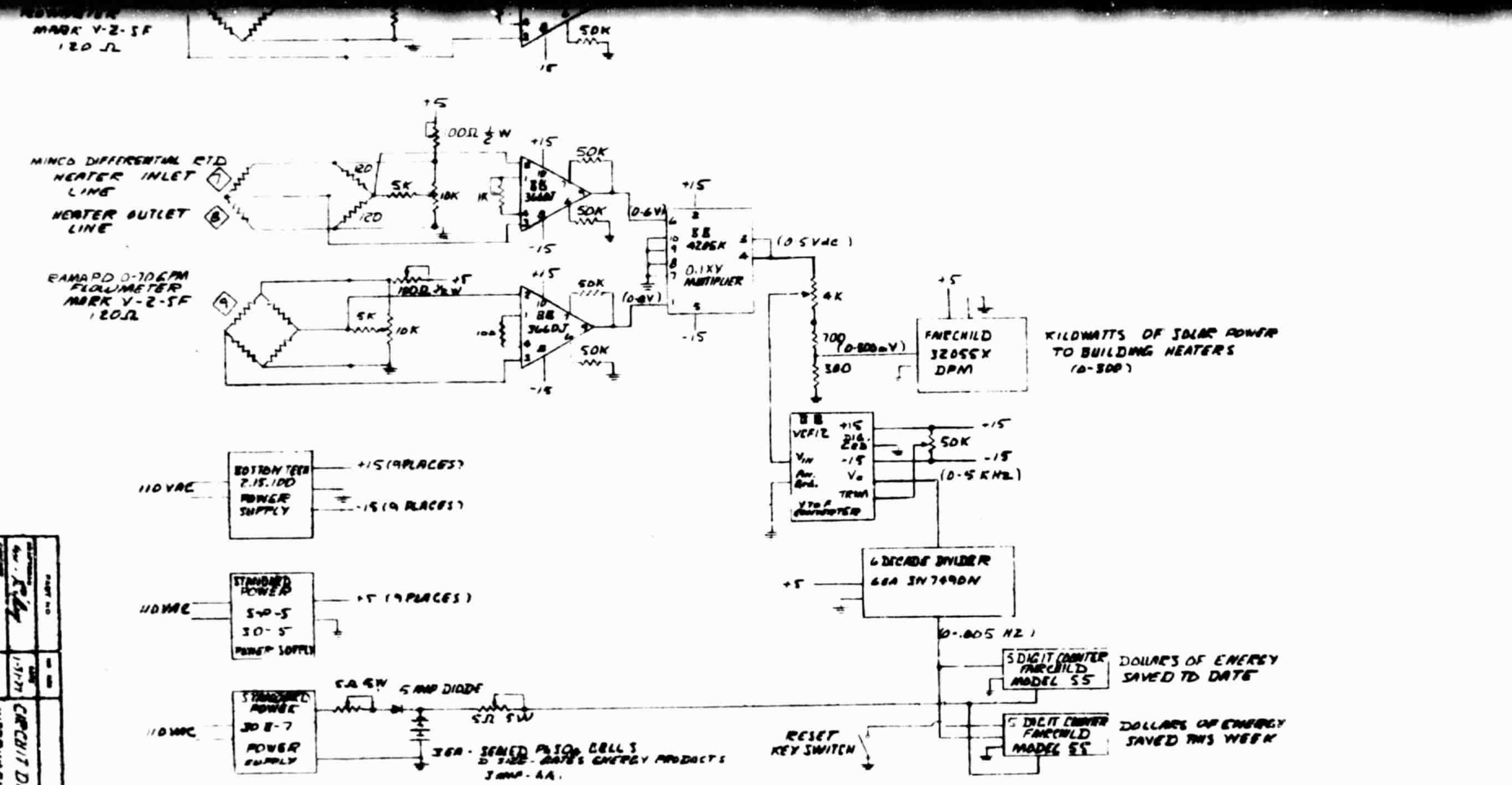
S3

FOLDOUT FRAME





FOLDOUT FRAME

Note:

1. ½ WATT OR GREATER RESISTORS & POTS SATISFACTORY EXCEPT AS NOTED.
2. ① TO ⑨ INDICATES UD TRANSDUCER NUMBER CODE

PART NO.	NO. REQ.	DESCRIPTION	MATERIAL
DRAFTSMAN	DATE 1-31-77	CIRCUIT DIAGRAM, DISPLAY INSTRUMENTATION, TROY LIB. SOLAR HEATING SYSTEM	UNIVERSITY OF DAYTON RESEARCH INSTITUTE DAYTON OHIO
SCALE NONE		41683	D77D02

TROY · MIAMI COUNTY PUBLIC LIBRARY
SOLAR HEATING DEMONSTRATION PROJECT
ERDA CONTRACT NUMBER E(49-18)2375

RICHARD LEVIN ASSOCIATES INC. ARCHITECTS
24 NORTH JEFFERSON STREET DAYTON, OHIO 45402 513 224 1931

printing

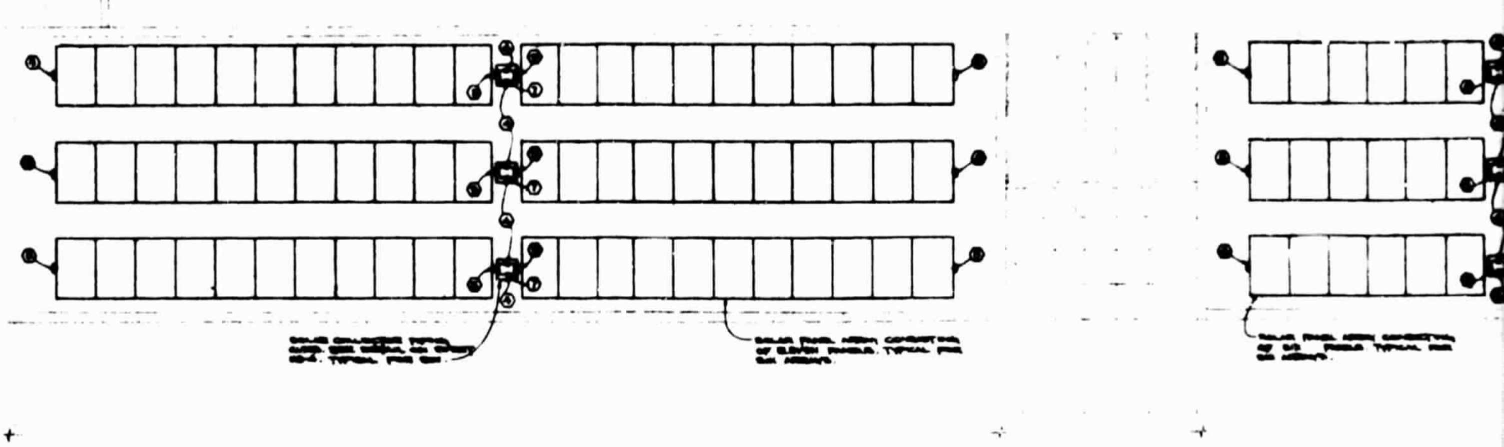
revisions

project no. 7244

drawn

checked

approved



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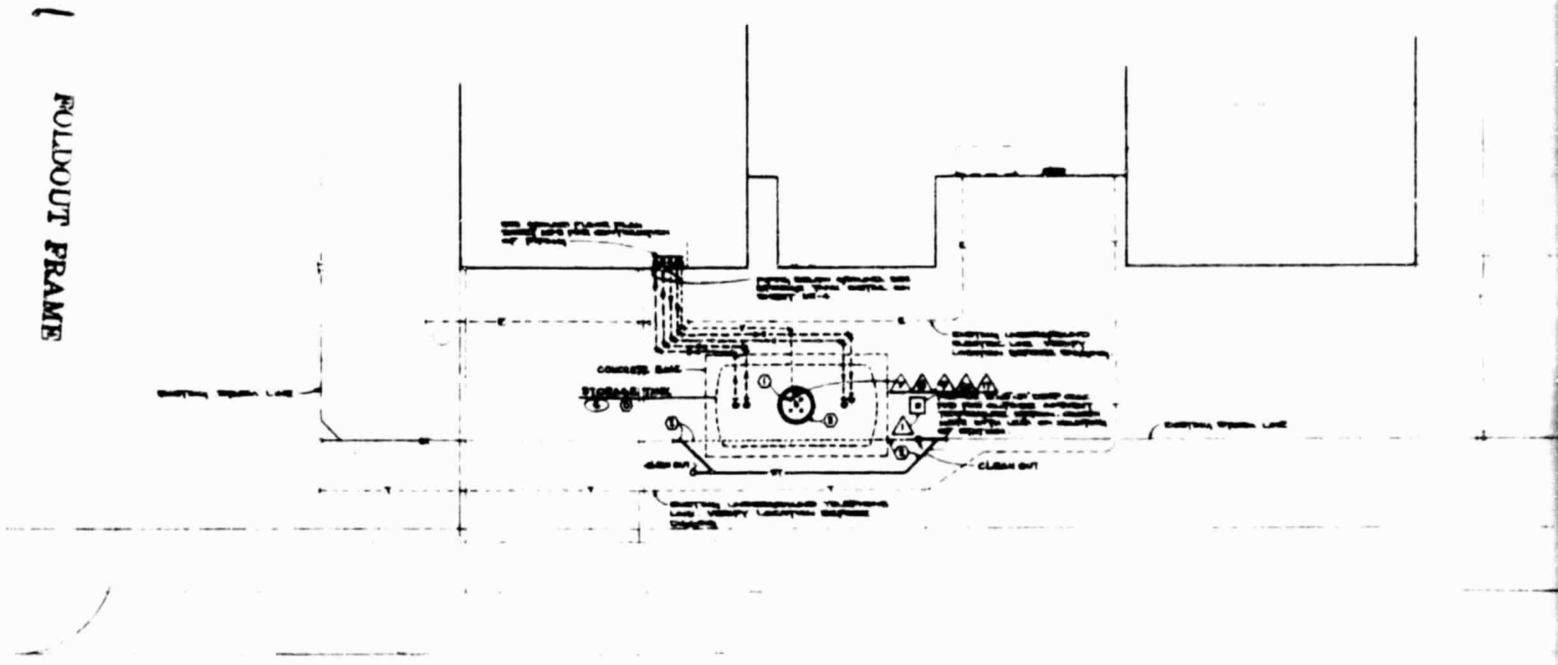

PARTIAL SITE PLAN

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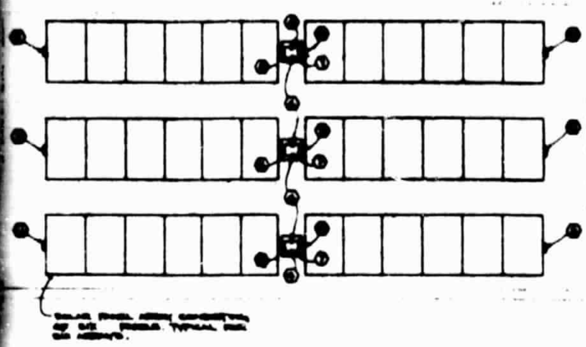

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project no. 7244.1
drawn G.W. / D.E.
checked R.J.P.
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NOTES

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LEGEND—ELECTRICAL

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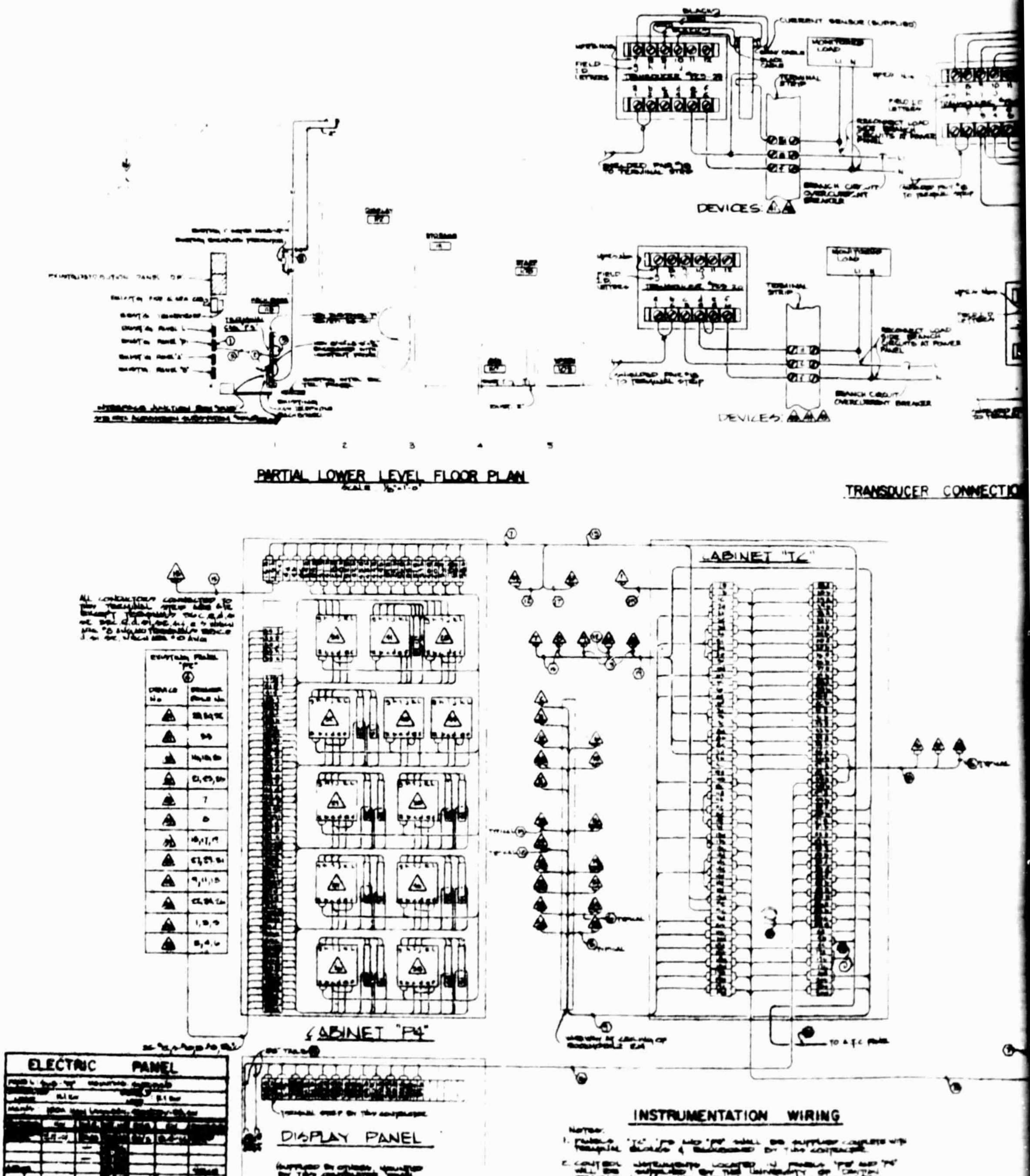
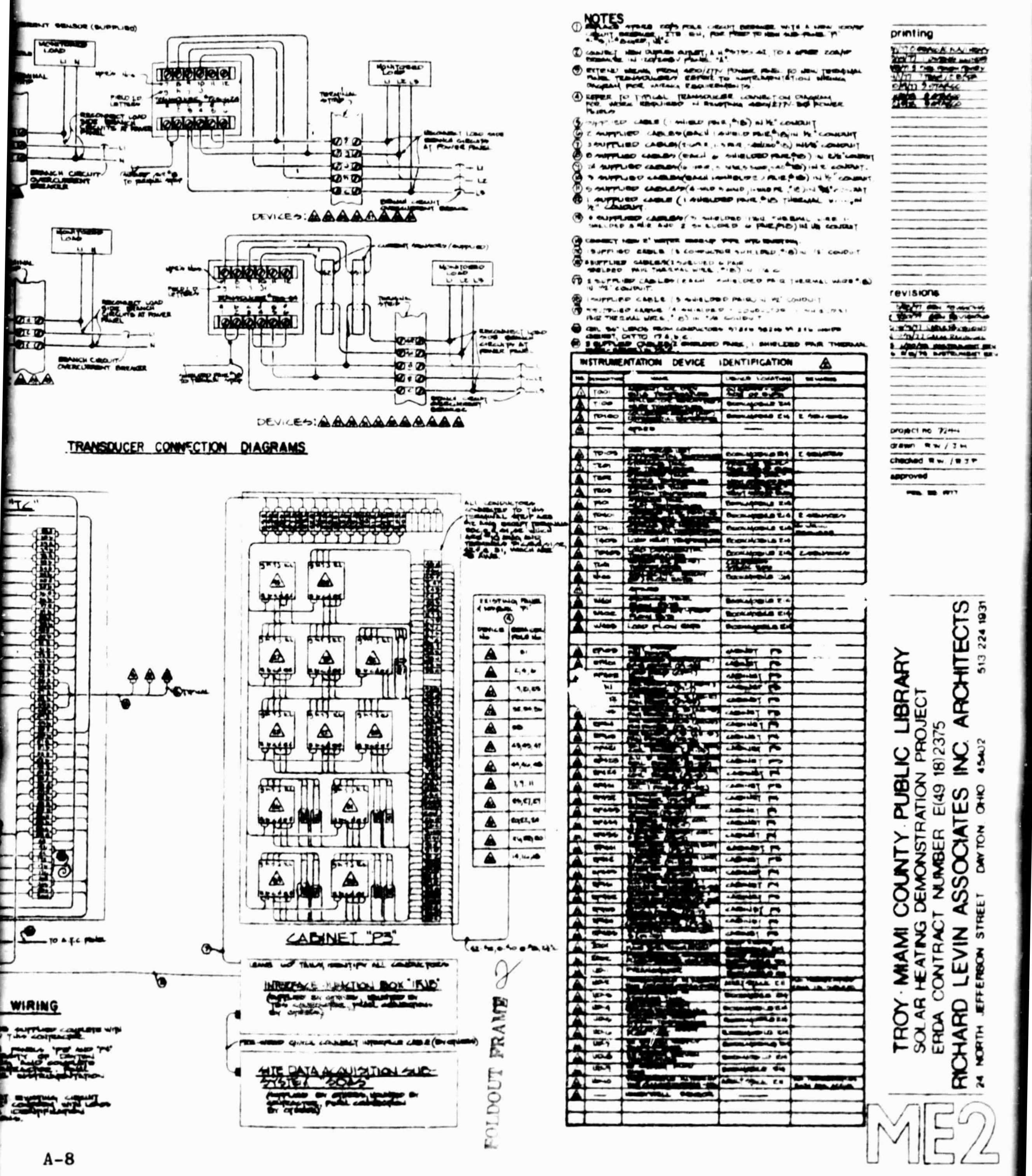
ME1

FOLDOUT FRAME

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TRANSDUCER CONNECTION DIAGRAMS
DEVICES:
INSTRUMENTATION DEVICE IDENTIFICATION
CABINET "P3"
INTERFACE JUNCTION BOX "IJB"
SITE DATA ACQUISITION SUB-SYSTEM "SDAS"
WIRING
FOLDOUT FRAME
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ERDA CONTRACT NUMBER E(49 18)2375
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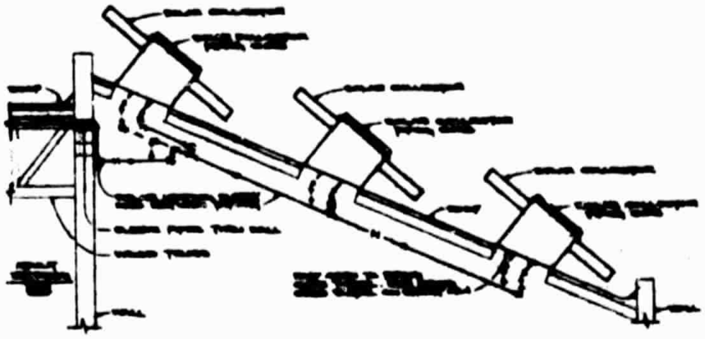
513 224 1931
ME2



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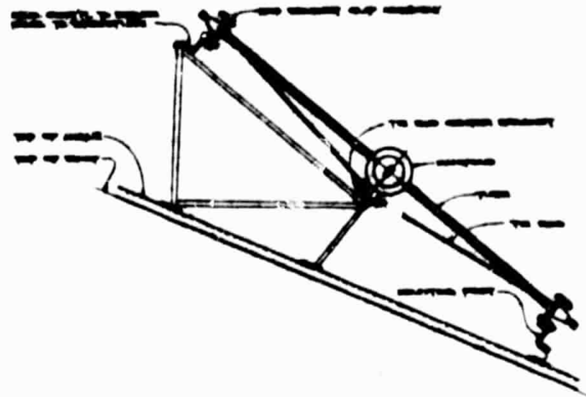

SOLAR COLLECTOR

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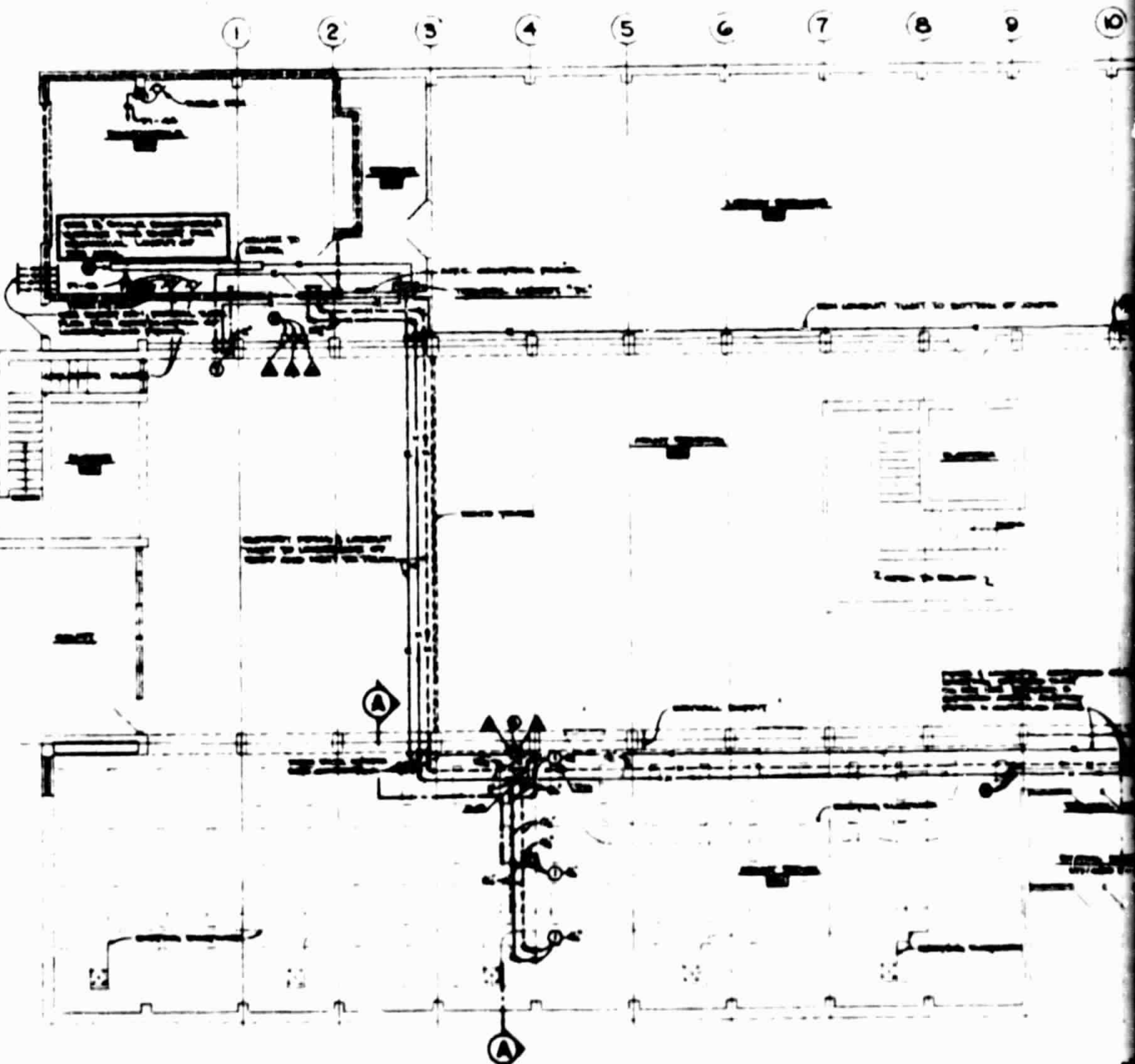

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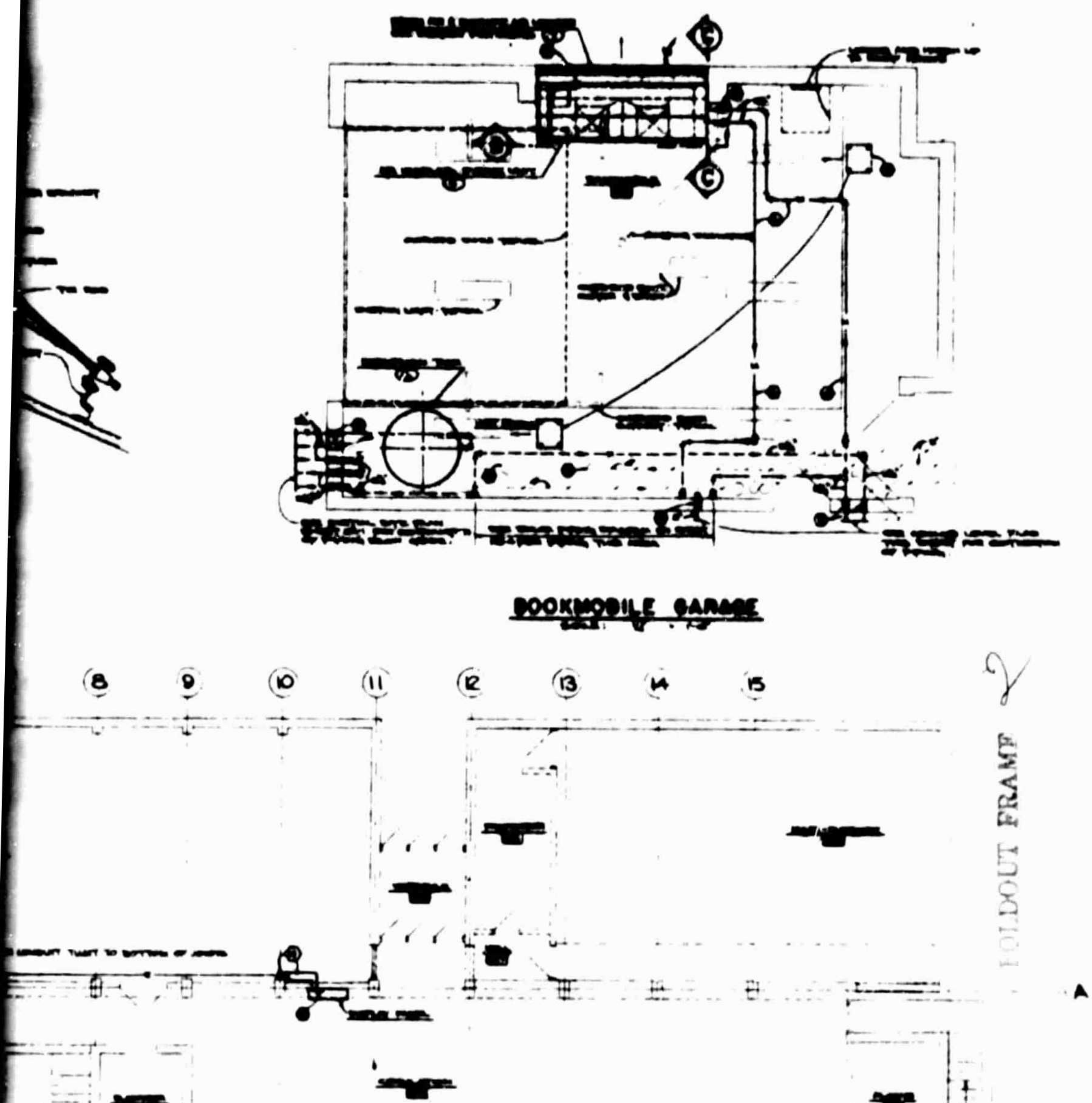

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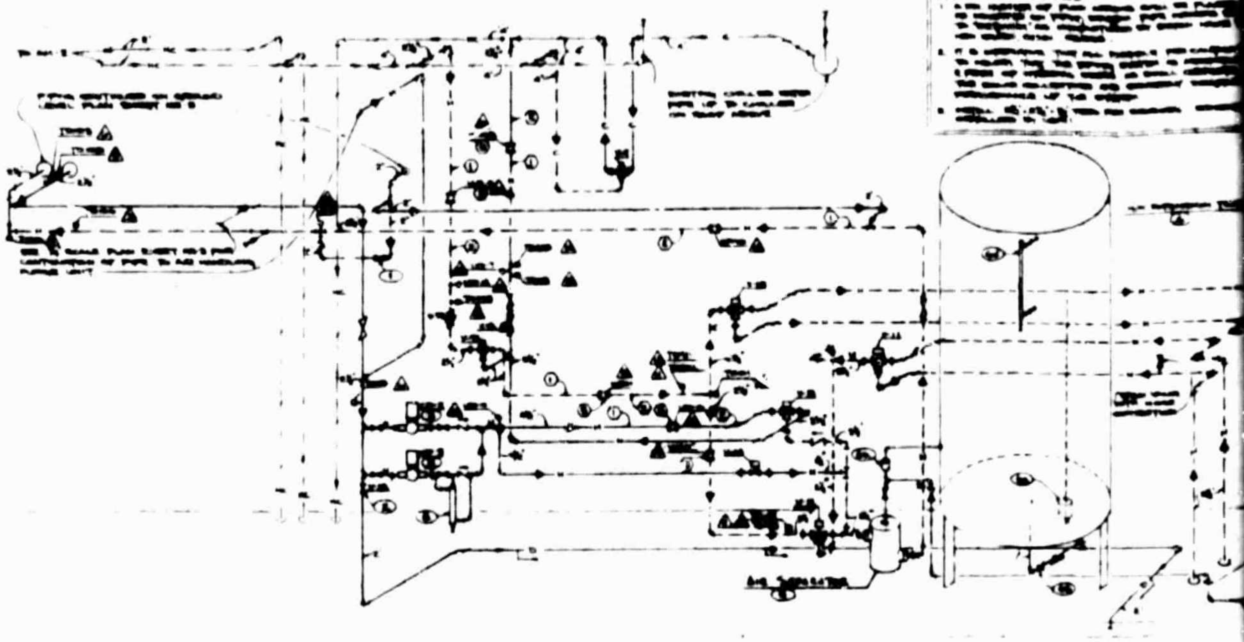
ME3

GENERAL NOTES



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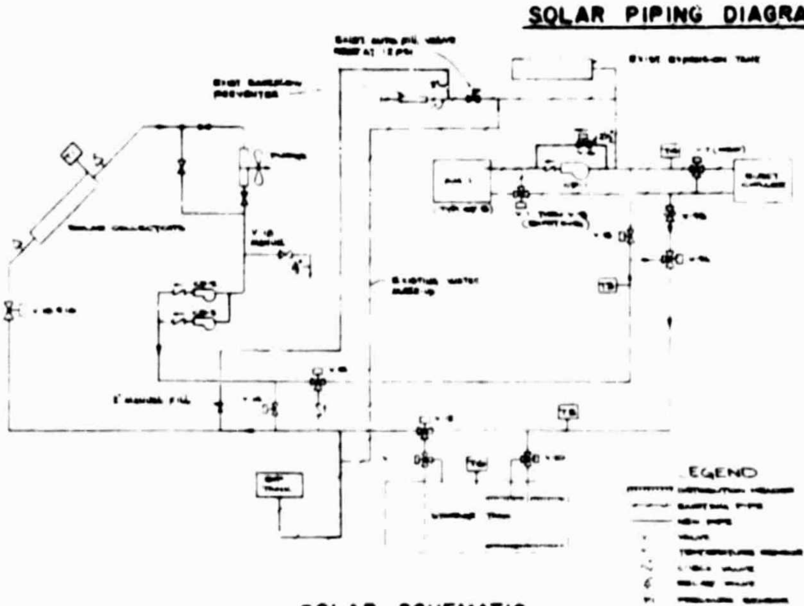

SOLAR SCHEMATIC

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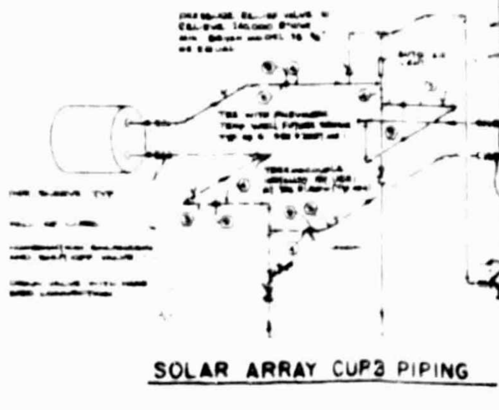
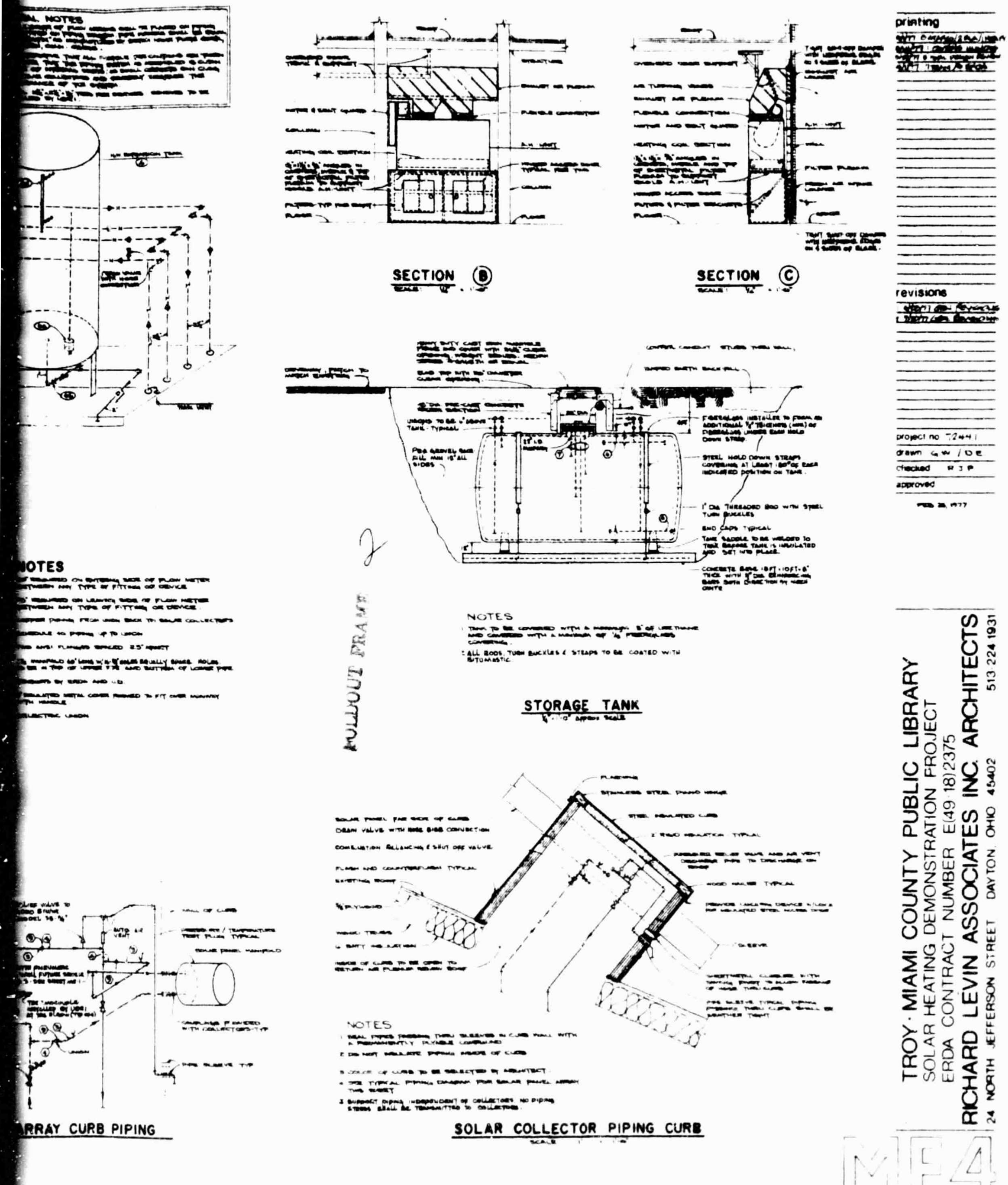
EQUIPMENT DATA



SOLAR ARRAY CUP3 PIPING

FOLDOUT FRAME



NOTES
SECTION (B)
SECTION (C)
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NOTES
STORAGE TANK
FOLDOUT FRAME
NOTES
ARRAY CURB PIPING
SOLAR COLLECTOR PIPING CURB
TROY-MIAMI COUNTY PUBLIC LIBRARY
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ERDA CONTRACT NUMBER E(49-18)2375
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ME4

APPENDIX B

SUNPAK^{TM} SOLAR COLLECTOR
INSTALLATION, SERVICE, AND OPERATING MANUAL

OWENS-ILLINOIS

SUNPAK™ SOLAR COLLECTOR

INSTALLATION, SERVICE AND OPERATING MANUAL

SOLAR ENERGY PRODUCTS GROUP

FOREWORD

This manual is intended to serve both as a guide to installation procedures and as a means of understanding the basis of solar-collector operation and maintenance.

Those persons charged with understanding and operating the collector system should read and understand the entire manual.

Those persons concerned only with installation of hardware will find essentially all the necessary information in Section 2, Installation Procedure, and in the accompanying Figures and Drawings.

Each specific SUNPAK™ application will be somewhat unique as a result of small differences in circumstances of installation and use. The manual is valid for the majority of these circumstances. The manufacturer should be contacted for recommendations if the customer feels his installation may be atypical in any way.

TABLE OF CONTENTS

IMPORTANT

Please see pages 7, 12, and 14 for safety information

1.0 General Description

1.1 Physical Dimensions

The standard SUNPAK™ module consists of 24 individual collector tubes manifolded together as shown in Figure 5.1. A nominal gross area of 4'x 8' is occupied by the assembled module. The effective collection area of the standard SUNPAK™ module is 27.4 square feet. It is the latter area (27.4 ft^2) that is used as the basis for describing collector performance and in quoting collector array prices.

A typical module weighs about 110 pounds (dry) and will contain about 9 gallons of fluid (water preferred) when filled. The resulting collector load is approximately 4 lb/ft^2 dry and 7 lb/ft^2 water filled.

1.2 Materials and Parts

The glass components are made with Owens-Illinois KG-33 (KIMAX®) borosilicate glass to provide strength, optical clarity, and thermal shock resistance. The fluid passageways inside the manifold are copper. All internal copper connections are hard soldered. High temperature silicone rubber "O"-rings and grommets are used for seals. The copper cup assemblies and internal headers are encased in a molded urethane foam which serves as an insulating support structure. The urethane foam is sheathed in a rigid shell of fiberglass reinforced polyester resin. The materials have been chosen to resist damage to the collector by stagnation temperatures which may rise as high as 650° F in an unfilled collector exposed to the sun.

A complete parts list appears in Table 1.

1.3 Fluid Flow

1.3.1 Collector Fluid Type

Water is the preferred heat transfer fluid due to its low cost and good thermal performance. The low loss property of the SUNPAK™ collector makes use of water practical even in cold climates. The use of other fluids such as glycol solutions is also possible, but rarely necessary. Questions regarding fluid selection should be reviewed with the manufacturer in light of the specific application.

1.3.2 Fluid Flow Path

The SUNPAK™ manifold is designed to deliver water in a serpentine series flow pattern to its 24 tubes. This is accomplished with the use of the standard 8 mm O.D. or optional 11 mm O.D. feeder tubes which channel water to and from the closed end of each collector tube. Figures 5.2A, 5.2B, and 5.2C illustrate the flow pattern. In a multi-module collector array, the individual modules are interconnected in parallel flow arrangement.

1.3.3 Collector Fill Flow Rates

Fluid flow rate during filling must be above a certain minimum value in order to prevent two phase flow in the feeder tubes and the resulting possibility of air entrapment. For the 8 mm standard feeder tubes, a minimum fill rate of 0.3 gpm/module is recommended with the optimum rate being 0.4-0.5 gpm/module. The 11 mm optional feeder tubes require a minimum fill rate of 0.6 gpm/module with 0.7-0.8 gpm/module being optimum. See Section 3.1 for details.

1.3.4 Collector Operating Flow Rates

Efficiency of energy transfer to the collector fluid will be affected by fluid flow rate. For the 8 mm standard feeder tubes, a minimum operating flow rate of 0.25 gpm/module is recommended and a flow rate of 0.3 gpm/module is considered to be near optimum. The 11 mm optional feeder tubes require a minimum operating flow rate of about 0.5 gpm/module with 0.6 gpm/module being optimum.

1.4 Installation Overview

1.4.1 General Description

The collector has been designed to allow easy installation. Heavy lifting equipment is not necessary as long as there is sufficient access to allow components to be carried to the mounting surface. Each component can be easily lifted by one man. After manifolds and brackets are mounted, collector tubes are simply inserted into their "O"-ring seals at the manifolds. Plastic end caps with adjusting screws are used at the closed ends of the tubes to hold them in place against hydraulic pressure in the operating system (see Figure 5.7). If a tube replacement is necessary, the plastic end cap is removed by loosening the adjusting screw and giving a quick twist. The tube can then be removed from its seal and a new one inserted.

1.4.2 Installation Manpower

The installation procedure is quite simple and requires a minimum of tools (see Table II). Although specific systems differ somewhat, a typical 100 ft^2 array, not including SUNPAK™ reflectors (see Section 1.4.6), could be installed with about one man-day of effort. Inclusion of the reflector elements in the installation of a new system would increase the installation time for the 100 ft^2 array to about two man-days of effort. Provision of proper tools, carpenters' aprons for carrying small parts, and efficient layout of the parts inventories to avoid long carrying distances will all serve to minimize installation time. A five-man crew seems to be optimum with three men on the collector hardware installation and two helpers to maintain an uninterrupted flow of parts.

1.4.3 Collector Manifold Arrangement

The manifold is designed with internal nominal 1-inch I.D. copper header pipes. Adjacent manifolds are coupled by a specially designed mechanical coupling included with the factory-supplied hardware. Additional couplings are available for connection of external piping to the manifold inlets and outlets. As many as 15 manifolds can be joined in a single row by interconnecting the internal headers. Longer arrays can be fabricated, but careful attention to flow arrangement and header pressure drops is necessary to assure balanced flow distribution to individual modules. Best flow distribution will result when the inlet and outlet of a given row of modules are at opposite ends of the array. Header pipe thermal expansion is taken up by the mechanical header couplings.

1.4.4 Mounting Surface

The collector is designed to mount on a tilted support surface provided by the customer. This can be a sloping roof or a sawtooth structure on a flat roof. The plane in which manifold and end brackets are mounted should not deviate from flatness by more than 1/4" along any 4' length. More pronounced irregularities, especially along the length of a manifold, will require the use of shims to provide a flat surface to assure proper tube and manifold alignment.

When the collector is mounted on a watertight surface, a commonly employed technique to minimize roof penetrations is the mounting of horizontal members on the roof exterior to which the collector brackets can be attached. The horizontal members may be treated 2" x 6" lumber or galvanized metal channels which are blocked up to allow water drainage. Roof penetrations at the blocking should be flashed or caulked for watertightness.

1.4.5 Diffuse Reflector Surface

Collector modules can be mounted over one of two types of background reflectors; a flat diffuse reflector, or a shaped (cylindrical) non-imaging specular reflector. For best results with the diffuse reflector, the surface should have a non-glossy, reflective nature such as flat white paint. A surface which tends to be self-cleaning with rain water would be most desirable.

Several diffuse reflector materials have been tested for reflectance. Those showing satisfactory reflectance included white vertical aluminum siding, white aluminum shingles, and white roof paint applied over asphalt rolled roofing. White exterior paint over plywood gives satisfactory reflectance for up to a year which might be acceptable for a small test stand, but this approach does not offer a long-life background needed for a permanent installation.

1.4.6 SUNPAK™ Shaped Specular Reflector

The SUNPAK™ Shaped Specular Reflector (SSR) is shipped ready-for-mounting by the customer using the spring tube clips and interlocking tabs on the reflector elements (see Drawing ED-1). This mounting system assures proper reflector alignment and structural integrity to withstand wind and snow loading.

1.4.7 Mounting Surface Tilt Angle

The angle of tilt of the support surface depends upon several factors which influence the matching of collector output with load requirements over the duration of the operating year. In general, a winter heating load is best satisfied with a south-facing array tilted at an angle of the latitude plus 10-20 degrees. A constant annual load such as domestic hot water would use a tilt approximately equal to the latitude. A load which peaks in the summertime would use a tilt equal to the latitude minus 10-20 degrees. Collector output is not very sensitive to deviations of a few degrees from the optumum tilt angle.

1.4.8 Special Considerations for Low Tilt Angle

Generally, the collector will be mounted at a tilt ranging from 30 to 70 degrees from horizontal. Tilt angles of less than 30 degrees will require special consideration of air clearing during collector filling. Information can be obtained from the manufacturer.

1.4.9 Mounting Surface Structural Integrity

The SUNPAK™ collector module and shaped reflector attachment are designed to withstand wind, snow, and ice loadings normally encountered in service. It is the responsibility of the customer to insure that the mounting surface to which the collector is attached has the required structural integrity to support the filled collector array under normally anticipated conditions. It should be noted that at recommended collector operating pressures of 30 psi or less, hydraulic pressure in the tubes will yield a resultant force at each mounting bracket attached to the surface. Maximum forces on the mounting surface are on the order of 30 lb. (downward) at each end bracket and 40 lb. (upward) at each center bracket. In long collector array designs, careful attention should be paid to the deflection characteristics of the support structure under wind loading. Further information can be obtained from the manufacturer.

2.0 Installation Procedure

2.1 Installation Sequence and Layout

2.1.1 Sequence

The general sequence of collector installation is as follows:

a. chalkline layout of mounting surface reference lines;
b. layout and mount manifold center brackets;
c. square and mount manifolds and mechanical header couplings;
d. square and mount tube end supports;
e. tighten support tie rods between manifolds and end supports;
f. install feeder and collector tubes;
g. connect external piping and leak check;
h. install manifold connector covers;
i. secure manifold connector covers and end caps.

The details of each installation will be somewhat different. The manufacturer's field service personnel have accumulated a good deal of experience and can be relied upon to prepare local installation crews and provide time-saving hints. The customer should not hesitate to call upon this experience either in the field or by phone or mail to the manufacturer's office directed to the responsible Project Manager.

2.1.2 Layout (Figures 5.1 and 5.4 and Drawings ED-1 and ED-2)

A single module will occupy a space of 4 feet wide and 8 feet tall. Provision should be made for minimum length runs of external piping at the end of an array of modules and for the manifold end caps which project about six inches beyond the ends of the array. Provision should also be made for removal of tubes during servicing which will require a minimum of 3" of clearance at the ends of the 8' module dimension. If the total array consists of several parallel rows of modules, then access must be provided between rows for servicing any point in the array.

A chalkline is first made to fix the centerline of the manifolds. Two additional chalklines are then laid out parallel to the first and lying 46' +1/8", -0" above and below the manifold centerline. These lines mark the centerlines of the tube end support mounting spacer holes. A perpendicular chalkline is made at the starting end of the array to mark the end of the first module. Additional perpendicular lines may be made at 4' intervals down the row to mark the space occupied by each module. Intervals should be measured along a stationary steel tape to avoid accumulated measurement error.

2.2 Manifold Center Brackets, Part SK-2852, Figs. 5.4, 5.5, and Drawing ED-1

Manifolds are mounted with 3 center brackets per module which are fastened to the mounting surface on the manifold centerline chalkline. The first bracket of the first module is located 8" inboard from the first perpendicular reference chalkline marking the end of the first module. Remaining center brackets in the row are secured at 16" intervals. The 16" tolerance is approximately equal to ± 1/16" and should be done with a stationary steel tape to prevent accumulated measurement error. The center brackets are fastened to the mounting surface with appropriate customer-supplied fasteners.

2.3 Squaring and Mounting Manifolds, Part SK-5155, Figs. 5.5, 5.6, and Drawing ED-1

Field experience has shown that careful alignment of the manifolds at this point can result in optimum alignment of all components in the array. It should be noted that manifolds must be positioned on the center brackets with the "T" marking on the bottom mounting brackets facing the upslope side of the mounting surface. The manifold nameplate should be on the downslope side of the surface.

At this point, both the first and last manifold of each row of modules should be lowered onto the center brackets and made hand tight using the threaded end of the support rod (SK-2851) and the locknut/washer assembly. Use of two washers in this assembly may help to avoid deformation of the brackets due to inadvertent over tightening. Both manifolds should be made perfectly square and level in all directions using a steel square, steel scale, and level. Support rods are then tightened to hold manifolds firmly.

Mounting of the intermediate manifolds is made easier by temporarily locating a taut steel wire (use a turnbuckle) about 1" above the two end manifolds and extending the full length of the collector array between these manifolds. After making sure that this wire is perfectly straight and level, all intermediate manifolds should have the same relationship to the wire as the two end manifolds already mounted.

The remaining manifolds can now be lowered into place one at a time being sure to attach the floating mechanical coupling (SK-3047) at each header connection. When manifolds are properly aligned and secured by the support rods, a gap of 1/8" should exist between ends of adjoining header pipes. This gap and the coupling are used to take up thermal expansion of the headers. No soldering is necessary within the array. Mechanical couplings can be tightened at this time.

2.4 Tube End Supports, Part SK-2848, Figs. 5.4, 5.5, and Drawings ED-1 and ED-2

The aluminum tube end supports are now mounted using the "Z" shaped mounting spacers (SK-2880). The horizontal chalklines at 46" +1/8, -0 serve as the centerlines for the mounting holes of the "Z" brackets. The first pair of brackets will be located opposite one another at a point 2" inboard from the first perpendicular reference chalkline marking the end of the first module. The second pair of brackets will be located 46" inboard from the first pair. Intermediate brackets will be mounted at 48" intervals. Brackets for the last module in a row will again have a 46" separation as did those for the first module. A stationary steel tape should be used to lay out these mounting holes since accumulated measurement error will result in collector tubes not being perpendicular to the manifolds. This could lead to sealing problems.

If not already done, the tube end supports and "Z" mounting spacers should be fastened together. Working at the first module of the row, these assemblies should be placed onto the support rods and held in position at the mounting holes to check the squareness of the support rods to the manifolds and the end supports. If square, the rubber pads (SK-2875) can be placed beneath the feet of the mounting spacers and the spacer/end support assemblies can be mounted for all modules in the row. A spot check of the squareness of the support rods in the row is advisable.

The butt joints between successive tube end support channels are made with a simple clamp arrangement using the clips (SK-2870) and a bolt (SK-5318) and nut (SK-5316). Since no clips are used on the first and last brackets of a row (no butt joints at these locations), a small shim spacer (SK-2[illegible]89) is provided to maintain constant collector tube height. The shim is inserted between the tube end support and mounting spacer. Larger shims under the feet of the "Z" mounting spacers may be needed if the mounting surface is very irregular. Wherever penetrations are made directly into a roof structure, care should be taken to maintain the integrity of the roof.

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The nuts holding the threaded support rods to the tube end support channels may now be made tight enough to adjust the distance between the inner face of the support channel and the flat side of the manifold to equal 41-1/2" - 41-5/8".

Manifold connector covers (SK-5419) should be fastened into place with the special fasteners (SK-5407).

2.5 Feeder Tube (SK-4920) and Collector Tube (SK-3092) Installation, Fig. 5.7 and Drawing ED-1

!!SAFETY GLASSES AND GLOVES SHOULD BE WORN!!

The feeder tubes form a continuous fluid channel when the flared ends are snapped into place in the manifold grommets (SK-4921). Installation procedures are identical for the standard 8 mm feeder tubes and the optional 11 mm feeder tubes. Care should be exercised in properly sealing the tubes in the grommets. Do not use any petroleum-based lubricants on the silicone rubber parts. If some lubrication is required during installation, only a common soap solution in water or ethylene glycol should be used. Silicone rubber can become brittle and crack in a short time after contact with petroleum compounds.

Before actually inserting the feeder tubes, a check should be made of every collector tube opening in every manifold in the array to be certain that grommets, end seals, and "O"-rings are in place and passageways are clear. It should also be confirmed that the protective carbon material is present on the non-flared ends of the feeder tubes. This assures that the collector tubes will not be damaged when slipped over the feeder tubes.

Do not walk on installed manifolds or tube end supports at any time. Supporting brackets were not designed to withstand such loading and improper collector tube and manifold alignment may result.

Ideally, sufficient access should exist between rows of modules to allow the feeder tubes and collector tubes to be installed separately as in Figure 5.7. If this is the case, all feeder tubes can be installed at this time. If insufficient access exists to insert the tubes from the ends of the tube end supports, then feeder and collector tubes must be installed together. Basically this involves placing the feeder tube into the collector tube and lowering both into the space between the manifold and tube end supports. The closed end of the collector tube is extended through the tube end support and the feeder tube is withdrawn slightly from the open end of the collector tube to allow seating of the flared end into the grommet.

Proper tube and manifold alignment will be assured if the following sequence of tube insertion is observed. This sequence is valid regardless of which method is used to place the feeder and collector tubes. Tubes 1 and 2 of the first manifold in the row of modules should be inserted and the support cup assemblies (SK-3048) put in place and made finger tight fixing the space between the flat side of the manifold and the end support channels at 41-1/2" - 41-5/8". (See Figure 5.2C for details of tube numbering sequence.) Nuts on the support rod outboard ends may have to be loosened. Tubes number 23 and 24 of the first module should then be installed in the same manner followed by the four tubes at the center of the manifold. By "playing" the adjusting screws of the support cups against the support rod nuts, the proper 41-1/2" - 41-5/8" dimension can be fixed and the nuts on the support rods given a final tightening. At no time should support cup adjusting screws be more than finger tight.

Remaining tubes in the first module can now be installed. Tubes for other modules in the row should be installed in the same sequence. It should be noted here that the optional shaped specular reflector element (SK-2988) should be installed as each tube is installed. Spring clips (SK-2987) and the interlocking reflector tabs are much easier to work with at this point.

2.6 External Piping To and From the Solar Collector

The piping connections to the collector may be made at either end of a bank. The top header, i.e., the pipe located furthest from the mounting surface, is the outlet header. The bottom pipe is the inlet header.

The connecting piping to each row of manifolds should be properly supported to prevent undue stress on the collector system. Expansion of external piping from the collector should be considered in this area. The headers within the collector manifold are compensated for expansion by the mechanical coupling. Support to the manifolds is not designed to cover the stresses that may be introduced by the connecting piping.

External piping may be joined to the manifold header pipes by a soldered connection, but extreme caution should be exercised to prevent damage to any of the soldered connections inside the manifold or the manifold insulation. An electrical resistance soldering tool is recommended, but a torch can be used if heat shields are employed to protect manifold insulation. A solder of 95% tin and 5% antimony is recommended.

A preferred alternative is the connection of external piping using the positive restraint coupling (SK-4253) as shown in Drawing ED-2. This avoids all soldering and can also be used in conjunction with the termination adaptor (SK-5319) for header pipe termination.

Vent valves near the inlet and outlet connections are recommended for several purposes. These parts can be used as air vents when the system is filled or drained. These valves may be manual or automatic depending on desired operation conditions. In an emergency no flow condition, the steam may be vented through these valves to protect the system from undue thermal and pressure conditions.

The maximum recommended operating pressure of the solar collector row is 30 psig. The recommended design is to provide for a pressure relief valve of 30 psig or less in the outlet header line to vent the collector in an emergency condition. It is absolutely essential that no type of shutoff valve be located between the collector and the relief valve. Such a valve could be accidentally closed and eliminate over-pressure protection. The inlet of the collector should be maintained below 30 psig and can be accomplished with a pressure regulator in the system. Each pressure relief valve should be vented properly to insure that steam and water are diverted safely. A pressure relief valve should be provided to each row of manifolds. For multi-manifolded rows, each row which can be isolated from the system must have a safety relief valve.

2.7 Leak Detection

The collector row should be checked for leaks at the coupling between modules and at the connecting piping. Next, the "O"-ring seal area should be checked for leakage. Leak testing can be with either air or water. Water is the preferred method and can be used by pressurization of the system not to exceed 30 psig. In some systems or situations, it may be desirable to use air to check for leaks. In these cases, pressurization with low pressure air (~5 psi) and a soap solution is a convenient way to find leaks before a system is water filled. The collector should not be pressurized over 10 psi with air due to the potential hazard of flying glass if a tube would be broken. Note that air testing is not recommended during a bright, clear day. Evenings or nights are suggested to reduce pressure-volume changes of air as it is heated in a closed system.

2.8 End Cap Attachment, Part SK-5153, Drawing ED-2

After leak testing, the insulating end caps can be cut as necessary to make provision for the connecting piping. The caps should fit as closely as possible to the piping to minimize heat losses. The caps are held in place by the special fasteners (SK-5407) which permit access to this location for system servicing.

2.9 SUNPAK™ Test Module Package - Special Note

Purchasers of the two-module test array package will also receive this Installation and Operation Manual, and should become thoroughly familiar with all information presented even though the test array is of small size. All installation procedures and modes of operation are identical for large arrays and the small test array. Some time might be saved, however, by taking note of the following facts about the test array:

a. Depending on the nature of the mounting surface and physical access, the entire array could be assembled in the shop and carried to the final location.

b. Wherever assembly is done, use of reference chalklines is still recommended, but the use of a taut steel wire is not necessary in aligning the two manifolds (see Section 2.3).

c. Since both manifolds are the "ends" of a row, the spacing between the mounting holes of the "Z" shaped mounting spacers will be 46" for both modules (see Section 2.4).

d. If more convenient, external piping connections for the inlet and outlet header pipes may be at the same end of the two module array. Any flow maldistribution should be negligible for such a short array (see Section 1.4.3).

e. The mounting surface need not necessarily be constructed for long term durability. Exterior grade plywood with a suitable finish is acceptable (see Section 1.4.5).

f. Since many test modules may be run without energy storage facilities and without sophisticated control logic, it may be advisable to make special provisions to drain the solar loop when necessary due to severely cold weather. This must be accomplished manually in the test module array by removing the first inlet tube of each module (tube #1) and all the even numbered tubes in the module (see Figure 5.2C for tube numbering sequence).

g. During periods of high insolation and no collector fluid flow, the possibility of collector boilout can be easily avoided by temporarily shading the test module with a suitable opaque cover. The collector modules need not be drained if this step is taken.

h. The structural integrity of the mounting surface is equally important for test modules and large sized arrays. Even though the test installation may be temporary, the mounting surface must be sound (see Sections 1.4.4-1.4.9).

3.0 Recommended Operating Procedures

3.1 Filling

The internal parts of the SUNPAK™ solar collector will approach temperatures in excess of 600° F while standing in bright sunlight. While the SUNPAK™ collector has been constructed with low expansion glass, filling the collector during midday portions of a bright day are not recommended. Filling a collector in a bright sun could cause damage due to thermal shock. Introduction of a fluid into a hot tube could also result in the initial slug of fluid leaving the collector to be a mixture of hot water and steam. The outlet from the collector on initial fill should be properly vented. The recommended procedure to avoid steam generation and potential thermal shock of the equipment is to fill in the early morning so that a high stagnation temperature is not reached. Filling should not be attempted after 9:00 A.M., and is best carried out less than one hour after sunrise.

The invidivual modules of a collector array are connected in a parallel fluid flow pattern. The fluid flow rate during filling must be sufficient to cause all modules in the array to fill uniformly and to prevent two-phase flow in the feeder tubes which could lead to air entrapment. Air entrapment can cause one or more modules to cease flowing if the back pressure of the air lock is greater than the pressure drop offered by neighboring modules. Air locks may also be encountered when a partially filled array is refilled or whenever air is introduced into a filled array such as when the piping is drained for repairs. The piping system should be designed to minimize the introduction of air into the array during normal operation.

Air entrapment during collector filling can be avoided through the use of the following flow rate guidelines. For the standard 8 mm feeder tubes, a minimum fill rate of 0.3 gpm/module is recommended with optimum fill rates lying in the 0.4-0.5 gpm/module range. For the optional 11 mm feeder tubes, a minimum fill rate of 0.6 gpm/module should be used with 0.7-0.8 gpm/module being optimum.

IMPORTANT

The boiling out of a collector as a means of emptying the collector for shut-down is not recommended. Under extreme insolation conditions, the collector could be damaged by thermal shock.

3.2 Operating Flow Rates

The operating flow rates recommended for the SUNPAK™ collector module are a compromise between desired fluid temperature gain, energy requirements of the load, adequate flow distribution in the collector array, and fluid pumping costs. For most applications, the standard 8 mm O.D. feeder tubes provide adequate energy delivery with good fluid distribution and acceptable pressure drops across the array. Some load requirements, however, have demanded higher fluid flow rates. Larger feeder tubes of 11 mm O.D. have been added as an option to give higher flow rates at pressure drops across the array which are comparable to the smaller, standard feeder tubes at lower flow rates.

Figure 5.3 shows the pressure drop across a module as a function of fluid flow rate for both 8 mm and 11 mm feeder tubes. The flow characteristics of the collector are such that a pressure drop of 5 psi or more across the array will assure that distribution of flow to all modules in the array is uniform. As flow rates rise above the minimum needed for good fluid distribution, collector residence time is shortened and fluid temperature gain is reduced. It has been found that the optimum compromise flow rates for the SUNPAK™ collector are 0.3 gpm/module for 8 mm feeder tubes and 0.6 gpm/module for 11 mm feeder tubes.

3.3 Freeze Protection

The very low loss coefficient of the SUNPAK™ collector affords it excellent freeze protection. The collector will gain enough energy on even the cloudiest days to prevent freezing of the collector modules during daylight hours or through a below freezing night. Piping to and from the collector modules is, however, more vulnerable to freezing, especially under no-flow conditions. The length of such external piping runs should be minimized. It is recommended that all piping systems external to the collector be properly insulated to avoid the problem of freezing a line to the collector resulting in isolation of that element.

Temperature monitoring of the collector fluid is suggested and heat may be added at night to keep the solar loop from freezing. Where below freezing temperatures are particularly severe or prolonged, exposed piping to and from the array should be electrically traced and insulated. Under conditions of no fluid flow, it may be advisable to charge a sustained pulse of fluid to the array at about 4-hour intervals. This pulse can be drawn from storage and should be of sufficient duration to totally displace all fluid contained in the tubes, manifolds, and system piping (each module contains about 9 gallons of fluid).

The collector's tubular design tends to shed snow easily. Experience in Toledo has shown that even a nine-inch snow storm did not cover the array. However, if an array should become completely snow-covered such that no insolation could reach the collector, there could be a danger of freezing the array. To prevent this, the entire volume of water in the exposed solar loop should be exchanged with warm water at least once a day.

IMPORTANT

3.4 Maintenance and Safety

Extreme caution should be exercised when performing maintenance on the collector. Accidental breakage of a tube in a system operating under pressure at temperatures above 140° F could result in serious burns to personnel. Tubes should not be removed from an array during periods of bright sunlight if there is a possibility that the module being serviced could be air locked. This could lead to the release of pressurized steam, even though the inlet and outlet headers may be at atmospheric pressure.

Care should be exercised in handling partially filled tubes which may have reached elevated stagnation temperatures in the unfilled portion of the tube. Pouring water from the tube could cause flashing of the water as it contacts the high temperature region of the tube and in some cases this may result in breakage of the tube.

Personnel handling the evacuated collector tubes should wear gloves and safety glasses. This is standard procedure for any routine glass handling work. Failure of a tube due to rough handling results in an implosion and does not generate a serious problem due to flying glass.

The collector support structure should be designed to prevent harm to people or property from falling glass or hot heat transfer fluid in the event of failure of a glass tube or other collector part. If corrosive or toxic heat transfer fluids are used, provision should be made to conduct these fluids to a safe area in the event of collector failure. Safety relief valves protecting the collector against pressures greater than 30 psig should be vented to a safe area.

The collector tubes tend to be self cleaning in normal rainfall. However, if extended dry periods or other abnormal conditions cause an excessive covering of dirt on the collector, occasional hosing off is recommended. If performance is being measured with the aid of a pyranometer, the cover of the pyranometer should be kept clean at all times.

Under conditions of no fluid flow, high levels of insolation on a filled collector can rapidly lead to a boilout condition in the collector. The system should not be shut down for maintenance during bright sunlight hours unless absolutely necessary. If such a daylight shutdown is unavoidable, that portion of the system requiring service should be isolated from the remainder of the system and shut down. That portion of the system must then be drained down or adequately shaded from insolation. It is better to schedule no-flow types of maintenance for night hours or periods of low insolation when no draining or shading is needed.

Recommended spare parts should include 2% extra collector and feeder tubes. Required quantities of other expendable parts (gaskets, seals, etc.) will vary with the installation and can be recommended once the system characteristics are defined.

3.5 Monitoring Performance

Performance of the SUNPAK™ collector can be monitored by comparing the useful energy being gained by the collector to the insolation entering the plane of the collector. Consideration must be given to the residence time of the collector when determining heat gained. For example, a module operating with a 0.3 gpm flow rate will have a 30 minute residence time. To calculate the heat being gained, one would determine a ΔT by subtracting an inlet temperature from the outlet temperature which occurs 30 minutes later. This residence time would, of course, be different for other flow rates. Residence time can be estimated assuming plug flow and a 9 gal/module fluid capacity.

3.6 Technical Assistance

If additional information is desired, please contact the responsible manufacturer's Project Manager at the following address:

OWENS-ILLINOIS, INC.
Solar Energy Products Group
SUNPAK™ Program
P. O. Box 1035
Toledo, OH 43666

4.1 TABLE I

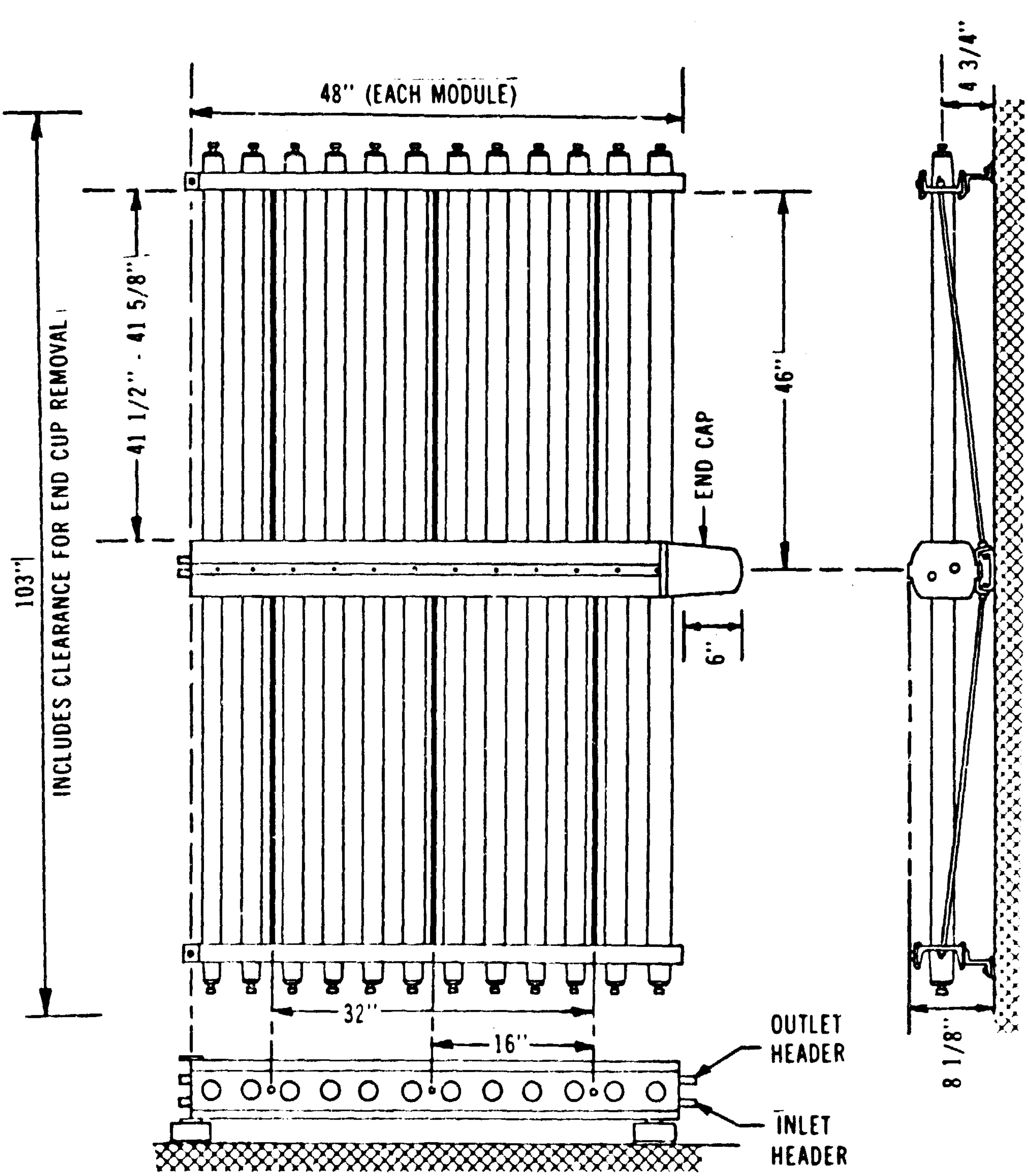
SUNPAK™ PARTS LIST

Number Required Per Module	Part Number	Part Identification
1	SK-5155-2	Standard Manifold (8 mm Feeder Tubes)
1	SK-5155-1	Optional Manifold (11 mm Feeder Tubes)
12	SK-4921-2	Standard Grommets (8 mm Feeder Tubes)
12	SK-4921-1	Optional Grommets (11 mm Feeder Tubes)
24	SK-4920-2	Standard Feeder Tubes (8 mm)
24	SK-4920-1	Optional Feeder Tubes (11 mm)
6	SK-2851	Support Rods
3	SK-2852	Manifold Center Brackets
2	SK-2848	Tube End Supports
4	SK-2870	Clips
2-4	SK-2875	Mounting Pads
2-4	SK-2880	Mounting Spacers
0-2	SK-2989	Shim Spacers
24	SK-3048	Support Cup Assemblies
24	SK-3092	Collector Tube Assemblies
2	SK-3047	Floating Tube Couplers
As Required	SK-4253	Positive Restraint Tube Couplers
As Required	SK-5319	Termination Adaptors
2 Per Junction	SK-5419	Manifold Connector Covers
4 Per Junction	SK-5407	Manifold Connector Cover Fasteners
1 Per End	SK-5153	End Caps
2 Per End	SK-5407	End Cap Fasteners
24	SK-2988	Optional Shaped Specular Reflectors

4.2 TABLE II

SUGGESTED INSTALLATION TOOL LIST

1. "Holster"-type tool pouch
2. Carpenter's apron for small parts
3. 1/4" ratchet socket drive
4. 1/4" x 6" drive extension
5. 5/16" deep well socket (1/4" drive)
6. 5/16" nut driver



48" (EACH MODULE)
103"
INCLUDES CLEARANCE FOR END CUP REMOVAL
41 1/2" - 41 5/8"
46"
END CAP
6"
32"
16"
OUTLET HEADER
INLET HEADER
4 3/4"
8 1/8"

Figure 5.1

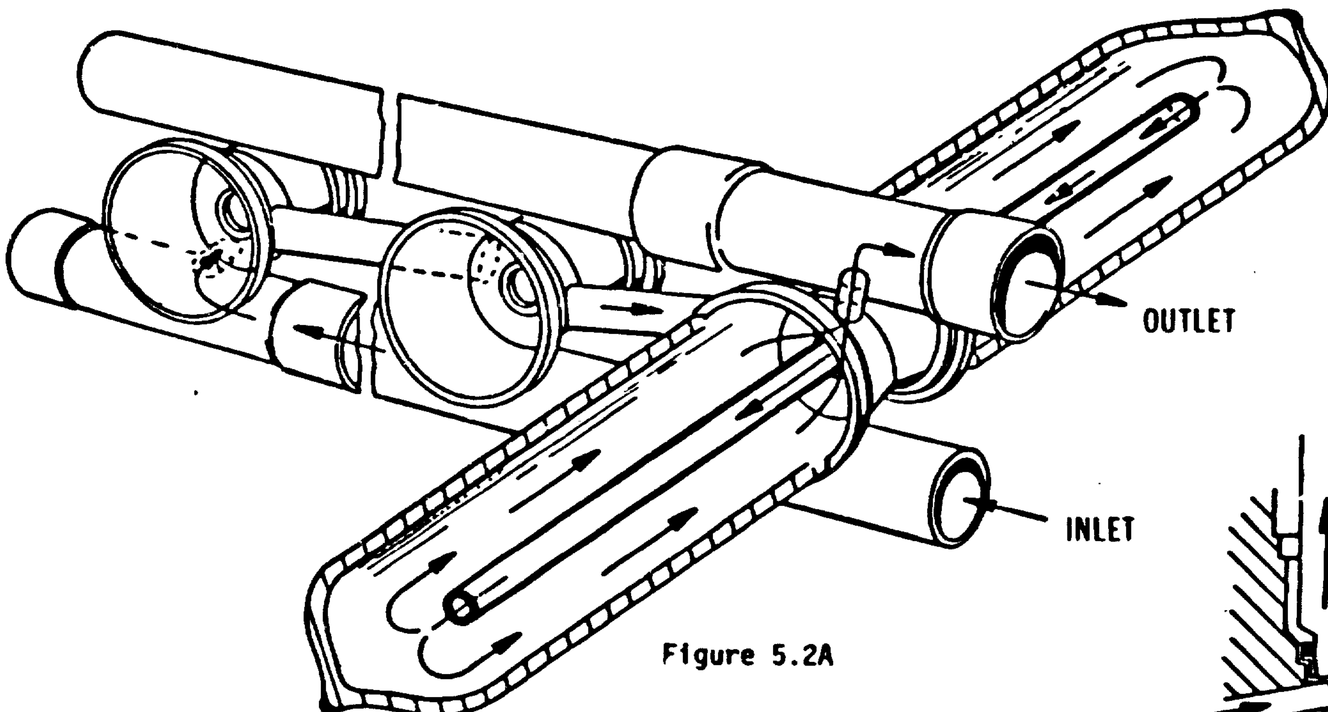


Figure 5.2A

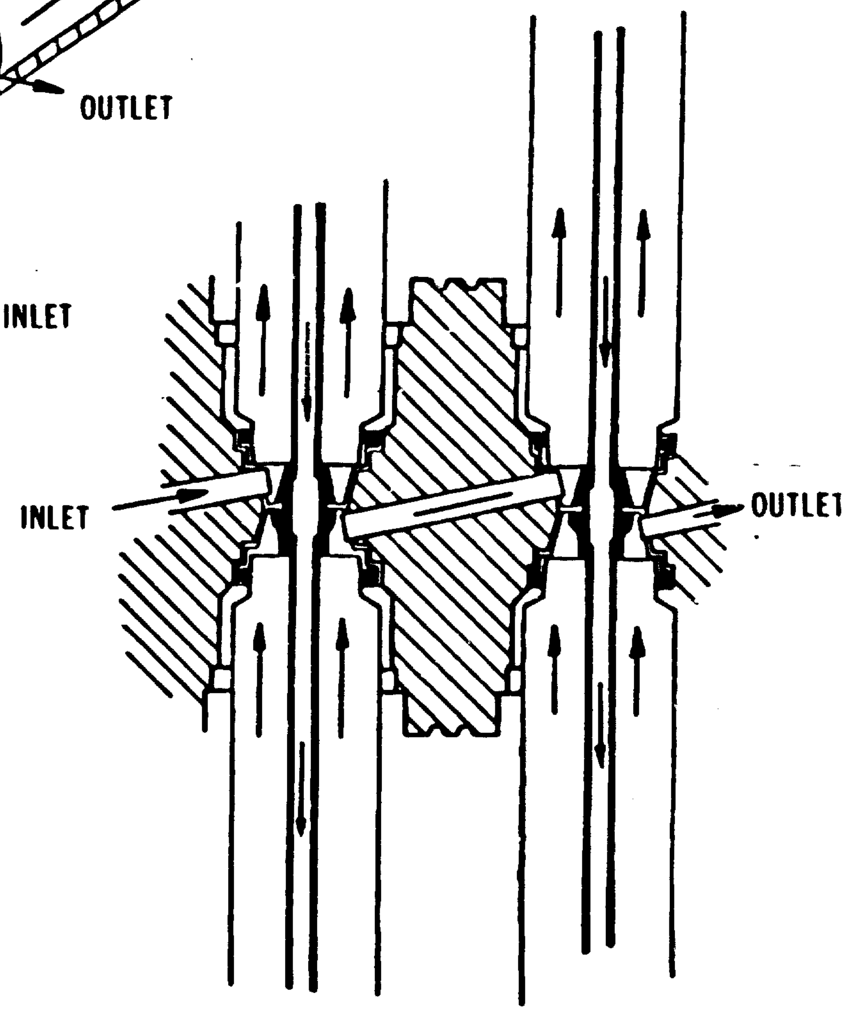


Figure 5.2B

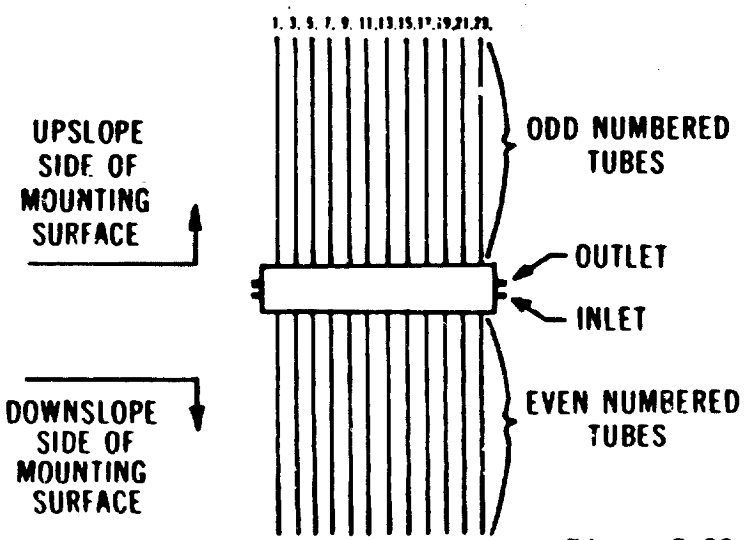
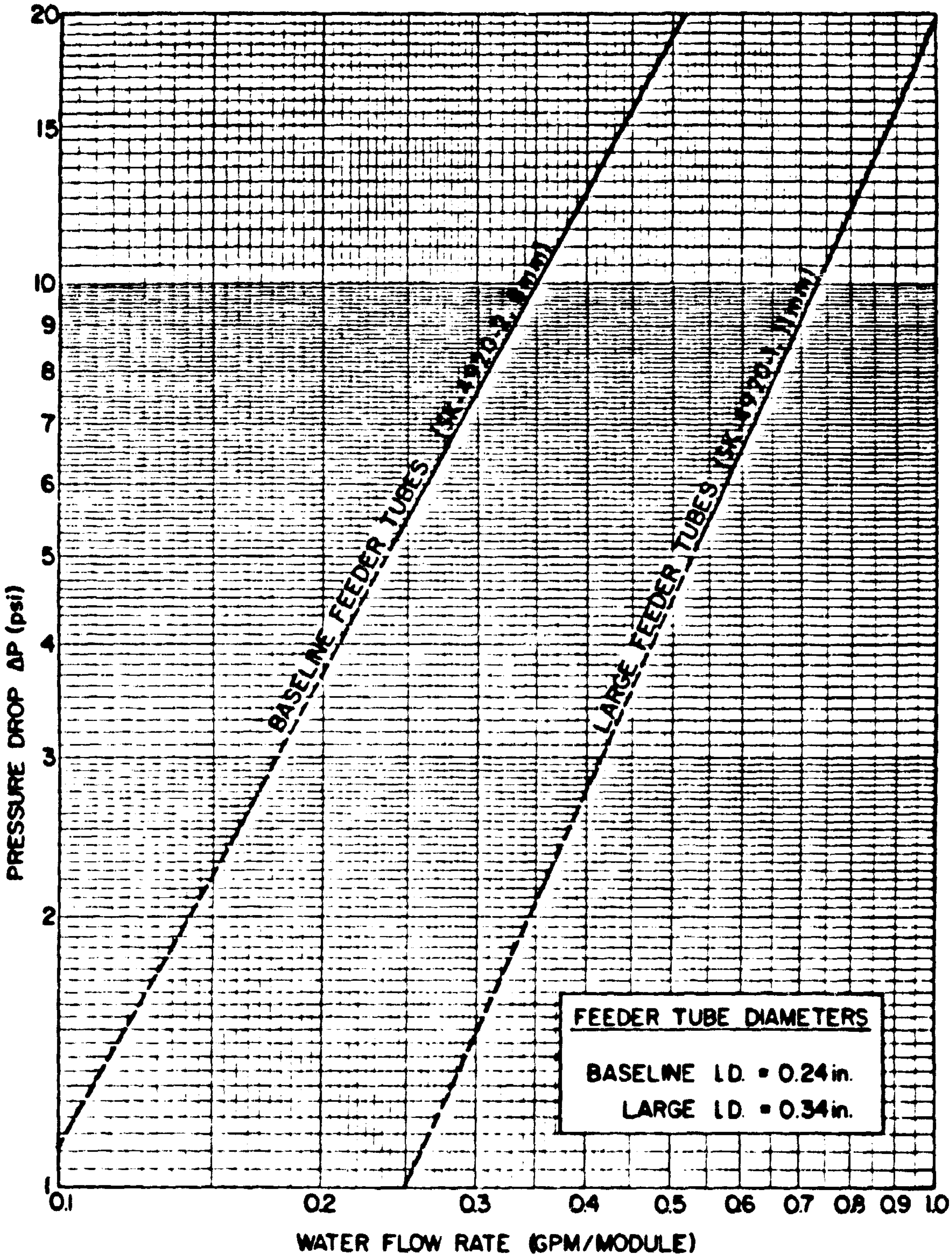


Figure 5.2C



PRESSURE DROP ΔP (psi)
20
15
10
9
8
7
6
5
4
3
2
1
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
WATER FLOW RATE (GPM/MODULE)
BASELINE FEEDER TUBES
LARGE FEEDER TUBES
FEEDER TUBE DIAMETERS
BASELINE I.D. = 0.24 in.
LARGE I.D. = 0.34 in.

Figure 5.3

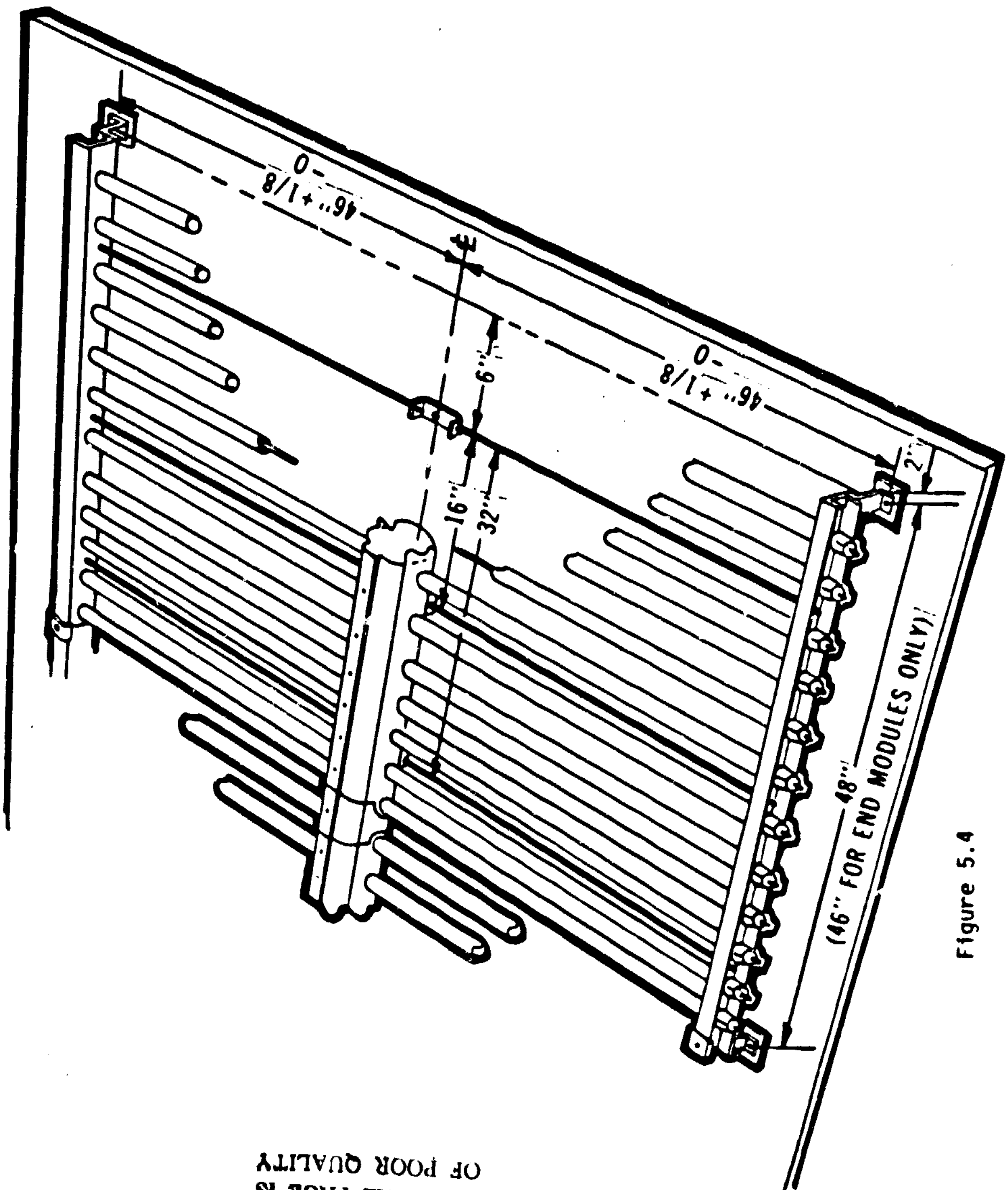
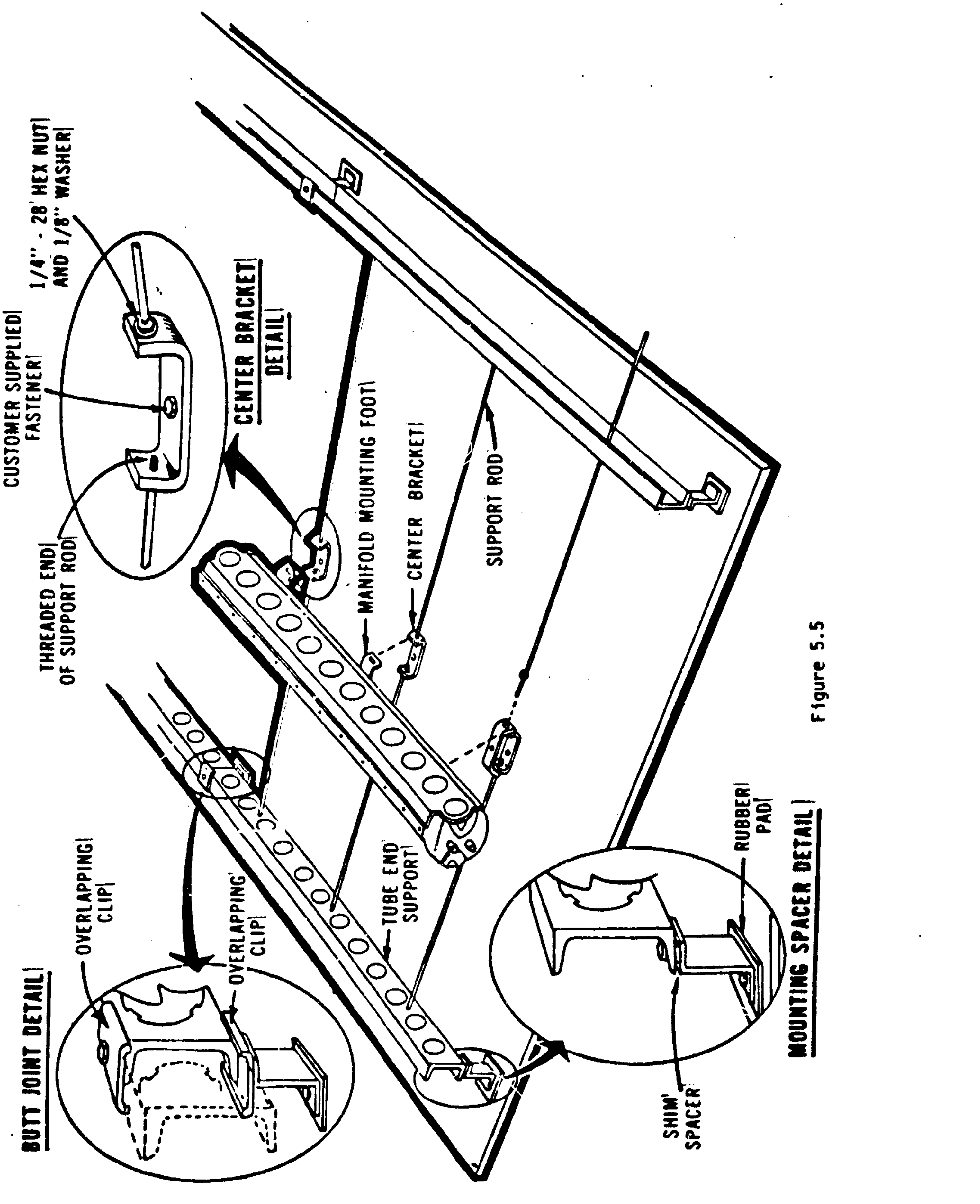


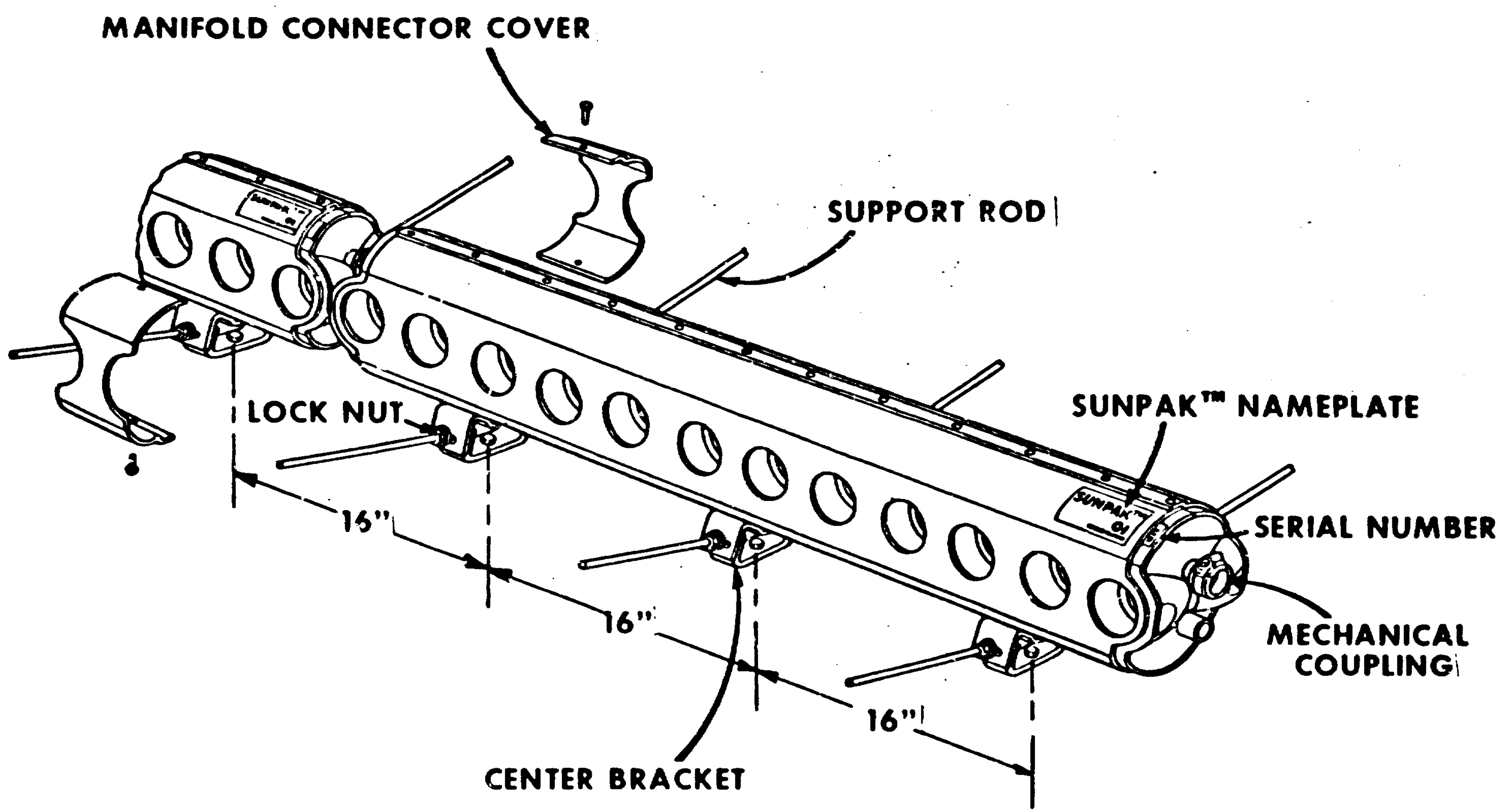
Figure 5.4

ORIGINAL PAGE IS



CENTER BRACKET DETAIL
CUSTOMER SUPPLIED FASTENER
1/4" - 28 HEX NUT AND 1/8" WASHER
THREADED END OF SUPPORT ROD
MANIFOLD MOUNTING FOOT
CENTER BRACKET
SUPPORT ROD
BUTT JOINT DETAIL
OVERLAPPING CLIP
OVERLAPPING CLIP
TUBE END SUPPORT
MOUNTING SPACER DETAIL
RUBBER PAD
SHIM SPACER

Figure 5.5



MANIFOLD ASSEMBLY

Figure 5.6

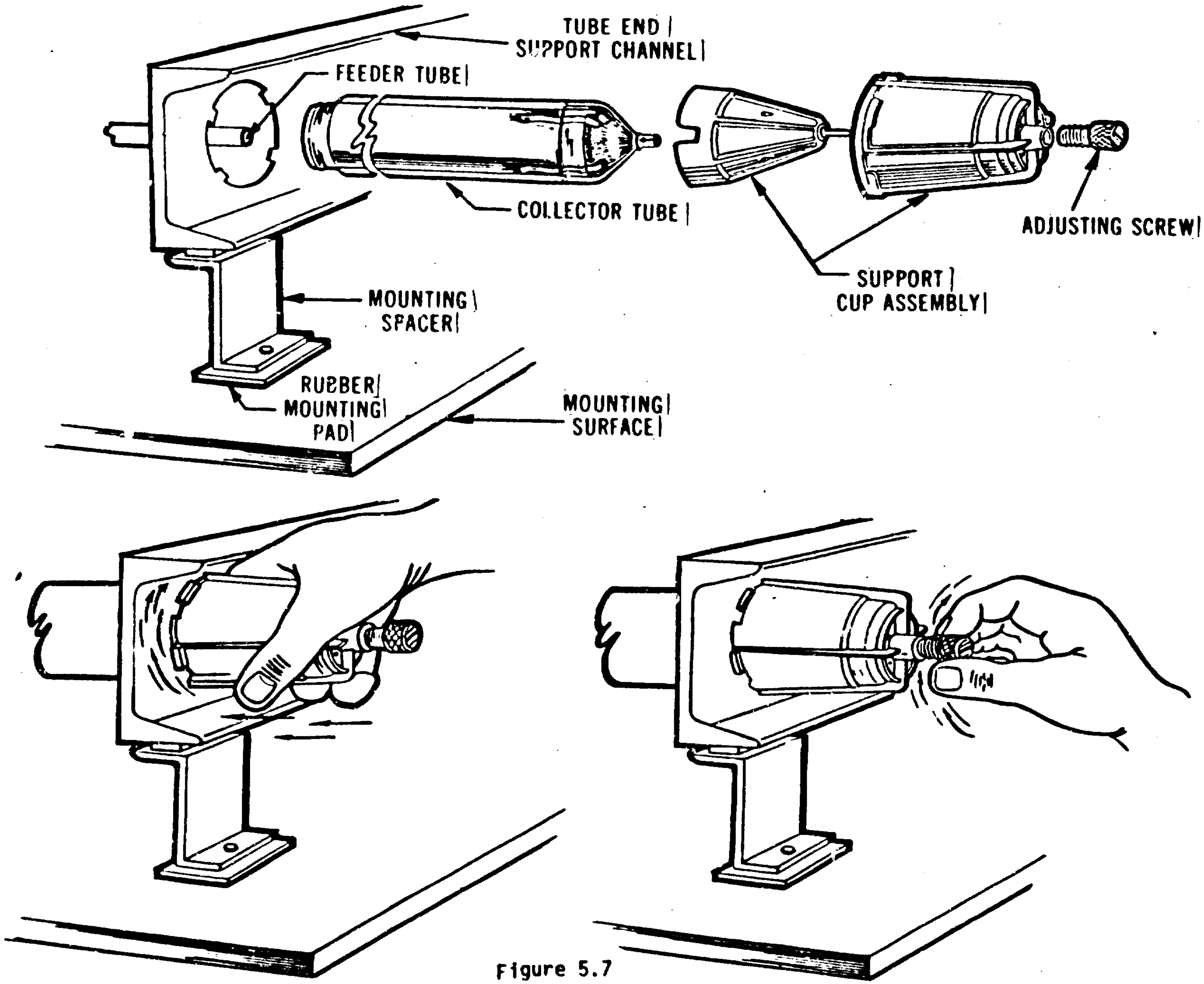
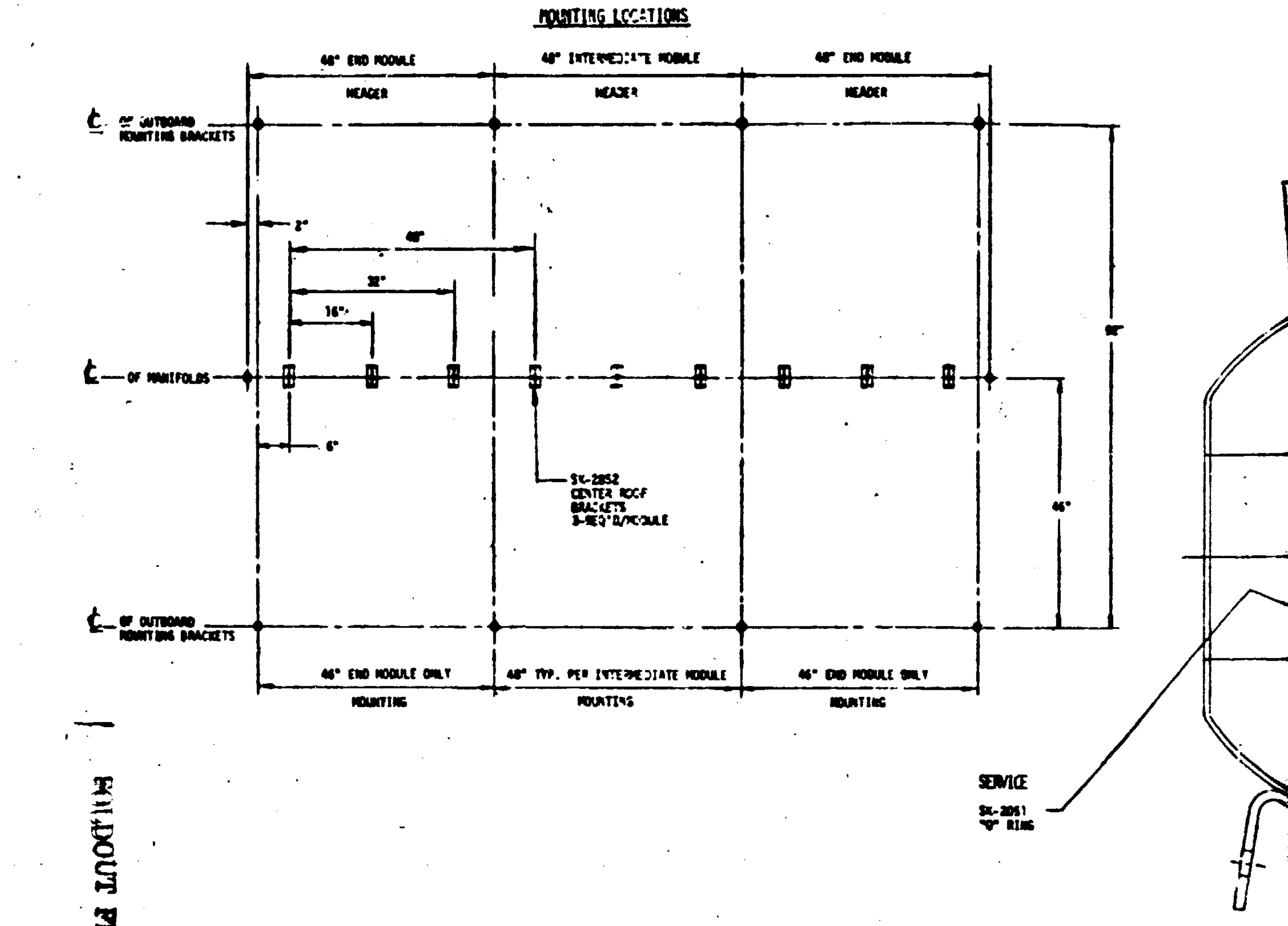
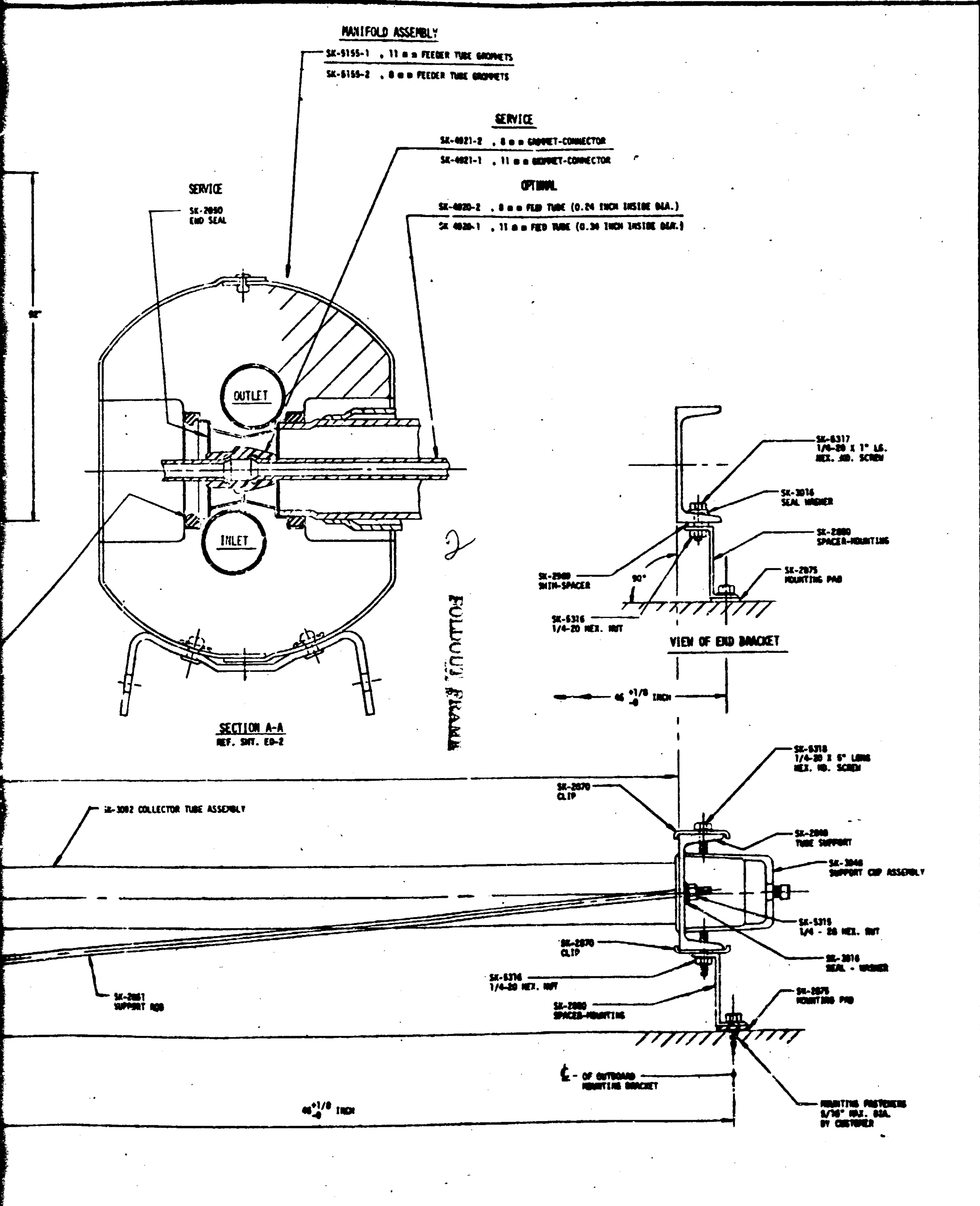

TUBE END
SUPPORT CHANNEL
FEEDER TUBE
COLLECTOR TUBE
ADJUSTING SCREW
SUPPORT
CUP ASSEMBLY
MOUNTING
SPACER
RUBBER
MOUNTING
PAD
MOUNTING
SURFACE

Figure 5.7

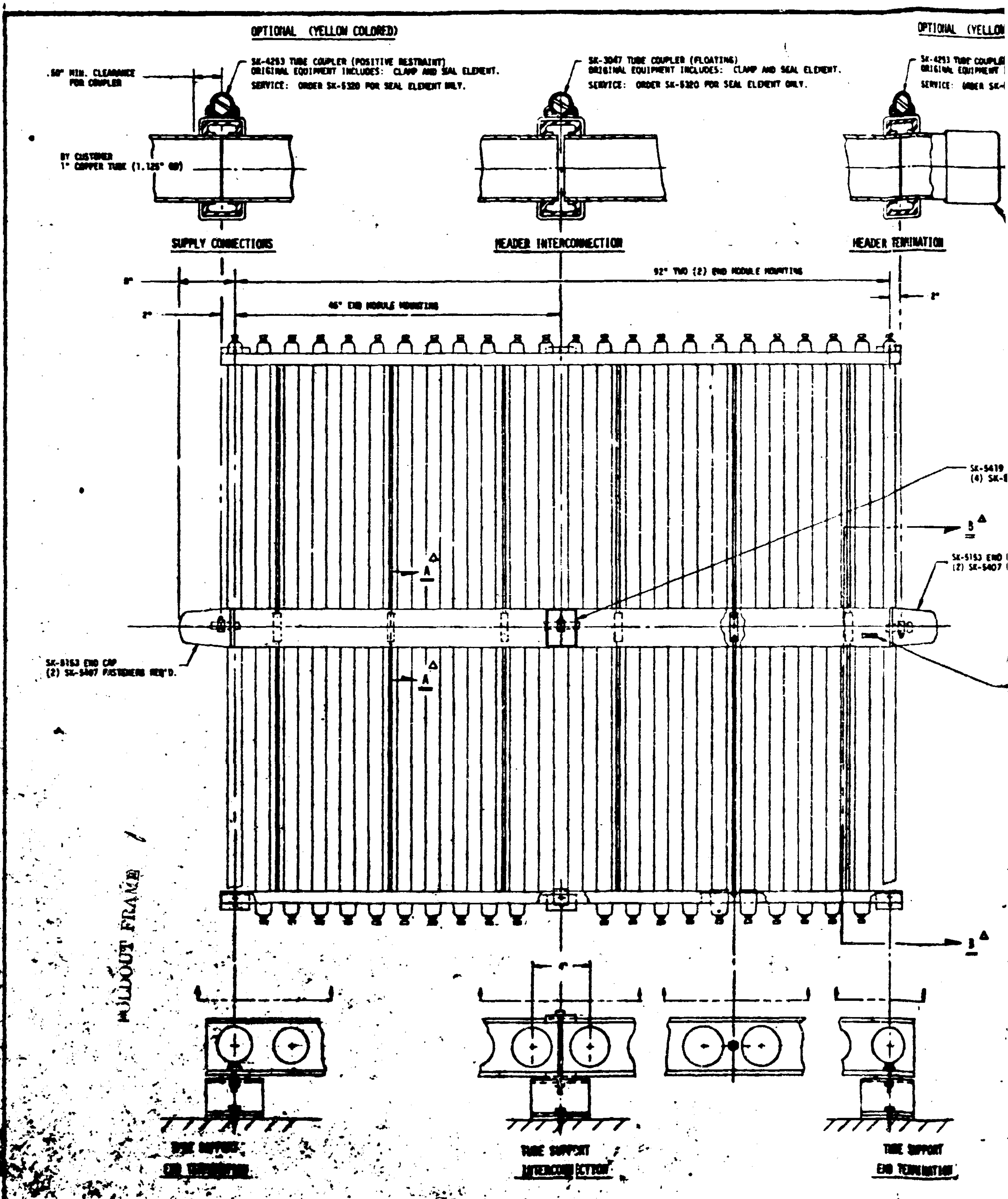
FOLDOUT FRAME



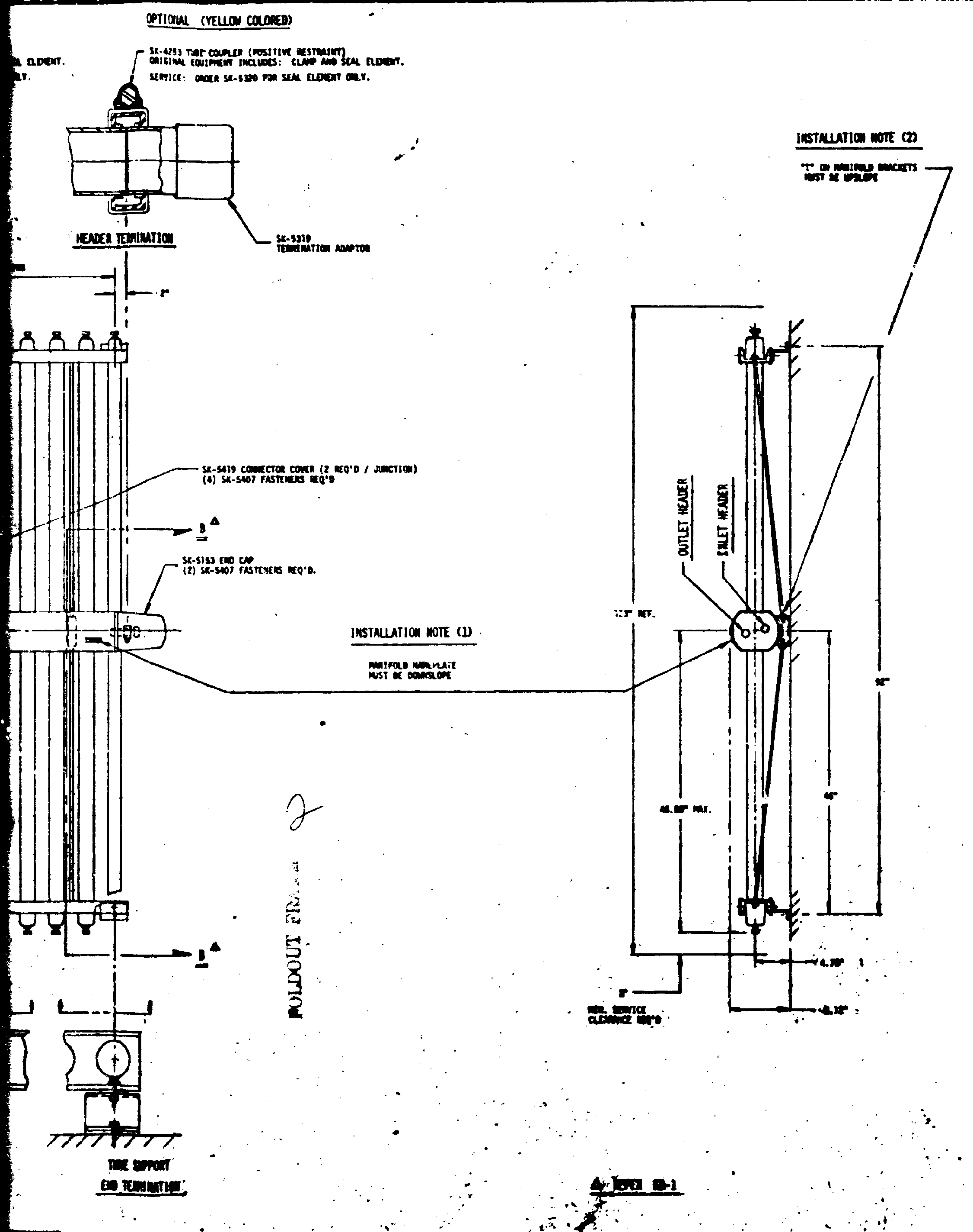
SUNPAK TM SOLAR COLLECTOR ASSEMBLY DRAWING ED-1



REVISED 1-3-78



SUNPAK SOLAR COLLECTOR TWO (2) MODULE LAYOUT DRAWING ED-2


OPTIONAL (YELLOW COLORED)
SK-4253 TUBE COUPLER (POSITIVE RESTRAINT)
ORIGINAL EQUIPMENT INCLUDES: CLAMP AND SEAL ELEMENT.
SERVICE: ORDER SK-5320 FOR SEAL ELEMENT ONLY.
HEADER TERMINATION
SK-5319
TERMINATION ADAPTOR
2"
SK-5419 CONNECTOR COVER (2 REQ'D / JUNCTION)
(4) SK-5407 FASTENERS REQ'D
SK-5153 END CAP
(2) SK-5407 FASTENERS REQ'D.
INSTALLATION NOTE (1)
MANIFOLD NAMEPLATE
MUST BE DOWNSLOPE
INSTALLATION NOTE (2)
"T" ON MANIFOLD BRACKETS
MUST BE UPSLOPE
OUTLET HEADER
INLET HEADER
REF.
92"
46"
MAX.
3"
MIN. SERVICE
CLEARANCE REQ'D
TUBE SUPPORT
END TERMINATION
FOLDOUT FRAME

APPENDIX C

ENGINEERING DATA FOR TROY LIBRARY

HONEYWELL, INC.

VALVE NUMBER	VALVE NUMBER	VALVE SIZE	CONTROLLER NUMBER	STR. THRU	3-WAY	ANGLE	SCREWED	FLANGED	UNIT CAPACITY	#HR.	G.P.M.	REQ'D CV.	VALVE CV.	INSET PRESS	PRESS DROP
V-6	V5011A1734	2½"	MP953C1000	X				X	36		X		63		.32#
V-7	V5013B1029	4"	MP953C1489		X			X	154		X		160		.92#
V-8	V5011A1734	2½"	MP953C1000	X				X	36		X		63		
V-9	V5013B1003	2½"	MP953D1107		X			X	36		X		63		
V-10 (DIVERTING)	V5013C1001	2½"	MP953D1107		X			X	36		X		63		
V-11	V5013B1003	2½"	MP953C1000		X			X	36		X		63		
V-12	V5013B1003	2½"	MP953C1000		X			X	36		X		63		
V-13	V5013B1003	2½"	MP953D1107		X			X	36		X		63		
V-14	V5011A1734	2½"	MP953D1107	X				X	36		X		63		
V-15	V5011A1734	2½"	MP953C1000	X				X	36		X		63		
V-16	V5011A1734	2½"	MP953C1000	X				X	36		X		63		

BILL OF MATERIAL

SOLAR SYSTEM DEVICES

KEY	QTY.	O.S. N.R.	DESCRIPTION
VP-6 THRU VP-16	11	SEE VALVE SCHEDULE	SEE VALVE SCHEDULE
TP-1	1	LP914A1052	DA SENSOR 40°-240°
	1	315046B	WELL
T-2	1	LP914A1011	DA SENSOR 40°-160°
	1	311085-00107	SHIELD
T-3 & T-4	2	LP914A1045	DA SENSOR 40°-160°
	2	315046B	WELL
T-5	2	C773A1006	SENSOR
T-6	2	121371A	WELL
FS-1	1	MAMFS43	FLOW SW
P-1	1	PP97A1076	PRESSURE CONTROLLER 10# - 300#
A-1	1	FAR3430C	ALARM BELL
	1	FAR3004A	GONG

BILL OF MATERIAL

SOLAR HEAT SYSTEM

PANEL DEVICES

KEY	QTY.	O.S. N.R.	DESCRIPTION
PE-1 THRU PE-12	12	15750097-001	PRECISION P.E. SW. SPDT
TD-1	1	803842EAKXA	T.D.R. 2-60 MIN. DELAY ON DROP OUT
TD-2	1	803842AADXA	T.D.R. 2.5-50 SEC. DELAY ON PULL IN
TD-3	1	803842AAHXA	T.D.R. 3-30 MIN. DELAY ON PULL IN
TD-4	1	804132EAA	T.D.R. .2-5 HR. DELAY ON PULL IN
R-1 *THRU R-11 & R-14, R-15, R-16	17	R4222D1005	RELAY DPDT 120V COIL
EP-1 2,6, 7-9 10 THRU 14	9	RP417B1007	E.P. RELAY 3 PORT 120V COIL
*PE-13, 14 & 15	3	P658B1012	P.E. RELAY S.P.D.T.
C-1	1	R7412A1004	DIFFERENTIAL TEMP. CONTROLLER
C 2&3	2	RP908A1021	SINGLE INPUT CONTROLLER
RP-1&2	2	RP471A1002	PNEU. RELAY 3 PORT
PL-1&2	2	165364DAA	PILOT LIGHT RED 120V
S-1	1	30017296-2	SWITCH, TOGGLE
S-2	1	12TS115-1	TOGGLE SW. D.P.D.T. MAINTAINED 3 POS.
S-5	1	11TS115-3	TOGGLE SW. S.P.D.T. MAINTAINED 2 POS.
*SP-1&2&3	3	802550	TOGGLE SW. PNEW. 3 WAY 2 POSITION
XD-1	1	SC-2306W/77	TYPE 'J' T.C. INPUT. 3#-15# OUTPUT 0° - 240° SPAN MFG. BY R.I.S.
*	2	K1121	PHOTO ELECTRIC CELL MFD. BY INTERMATIC, INC.

*CHANGES TO ORIGINAL JOB

SEQUENCE OF OPERATION

ALARM AND SYSTEM PROTECTION SEQUENCE

IF OUTDOOR AIR TEMPERATURE FALLS BELOW 40°F. AND V-13 IS BYPASSING THE COLLECTORS, VALVE V-14 WILL OPEN AND PUMPS CP-2 AND CP-3 WILL RUN FOR 10 MINUTES OUT OF EVERY 4 HOURS ONLY IF COLLECTOR DISCHARGE TEMPERATURE IS ABOVE 40°F. SHOULD THE COLLECTOR DISCHARGE TEMPERATURE FALL TO 40°F, V-13 WILL SHIFT TO ALLOW COLLECTOR FLOW, PUMPS CP-2 AND CP-3 WILL RUN, FLOW WILL BE DIVERTED THROUGH THE STORAGE TANK, VALVE V-8 WILL CLOSE AND VALVE V-9 WILL BYPASS THE BUILDING HEATING SYSTEM. THIS SEQUENCE WILL REMAIN IN EFFECT UNTIL COLLECTOR DISCHARGE TEMPERATURE RISES TO 70°F, AT WHICH TIME THE SYSTEM WILL RETURN TO NORMAL OPERATING SEQUENCE.

IF COLLECTOR DISCHARGE TEMPERATURE RISES TO 220°F, THE PURGE UNIT O. A. AND EXHAUST DAMPERS WILL OPEN AND THE FAN WILL START.

FS-1, UPON SENSING FLOW IN THE AUTO FILL LINE, OR P-1, UPON SENSING A SYSTEM PRESSURE OF 11#, WILL SOUND AN ALARM AND LIGHT THE COLLECTOR LEAK PILOT LIGHT.

IF COLLECTOR DISCHARGE TEMPERATURE FALLS TO 38°F, AN ALARM WILL BE SOUNDED AND THE COLLECTOR LOW TEMPERATURE PILOT LIGHT WILL BE LIGHTED.

IT SHOULD BE NOTED THAT NO SILENCE SWITCH HAS BEEN PROVIDED FOR THE ALARM, AS THE TAKING OF PROMPT CORRECTIVE ACTION IS CONSIDERED ESSENTIAL UNDER BOTH ALARM CONDITIONS. WHEN THE FAULT HAS BEEN CORRECTED THE ALARM SYSTEM WILL RESET ITSELF.

SEQUENCE OF OPERATION

NORMAL OPERATING SEQUENCE

THE FOLLOWING SEQUENCE OF OPERATION WILL PREVAIL WITH THE SOLAR HEAT/OFF/ELECTRIC CHILLING SWITCH IN THE SOLAR HEAT POSITION AND THE FILLED/DRAINED SWITCH IN THE FILLED POSITION.

WHEN COLLECTOR DISCHARGE TEMPERATURE RISES TO 120° AS SENSED BY T-1, VALVE V-13 WILL ALLOW FLOW THROUGH THE COLLECTORS, PUMPS CP-2 AND CP-3 WILL RUN, CP-1 WILL STOP, VALVE V-6 WILL BE OPEN, V-7 WILL BYPASS THE CHILLER, V-8 WILL BE OPEN AND V-9 WILL ALLOW FLOW THROUGH THE BUILDING HEATING SYSTEM.

WHEN V-13 SHIFTS TO ALLOW FLOW THROUGH THE COLLECTORS A 20 MIN. TIMING PERIOD WILL BE INITIATED. AT THE END OF THIS PERIOD IF THE DISCHARGE TEMPERATURE HAS FALLEN BELOW 80°F, V-13 WILL BYPASS THE COLLECTORS, PUMPS CP-2 AND CP-3 WILL STOP AND CP-1 WILL START.

ANYTIME V-13 IS BYPASSING THE COLLECTORS, V-12 WILL ALLOW FLOW THROUGH THE STORAGE TANK, FLOW BEING IN THE BOTTOM AND OUT THE TOP OF THE TANK. IF V-13 IS ALLOWING COLLECTOR FLOW AND TANK RETURN WATER TEMPERATURE IS 5° OR MORE ABOVE THE TANK TEMPERATURE, V-12 WILL ALLOW FLOW THROUGH THE TANK, FLOW BEING IN THE TOP AND OUT THE BOTTOM. IF TANK RETURN WATER TEMPERATURE IS LESS THAN 2°F ABOVE TANK TEMPERATURE THE TANK WILL BE BYPASSED.

IF AT ANY TIME SUPPLY WATER TEMPERATURE TO THE BUILDING HEATING SYSTEM DROPS TO 75°F AS SENSED BY T-4 VALVE V-8 WILL CLOSE AND VALVE V-9 WILL BYPASS THE BUILDING HEATING SYSTEM.

WITH THE SOLAR HEAT/OFF/ELEC. CHILLING SWITCH IN THE ELECT. CHILLING POSITION, VALVE V-6 WILL BE CLOSED, V-7 WILL BYPASS THE CHILLER UNTIL CHILLER RETURN TEMPERATURE FALLS BELOW 90°F, V-8 WILL BE CLOSED, V-9 WILL BYPASS THE BUILDING COOLING SYSTEM, AND PUMP CP-1 WILL RUN CONTINUOUSLY.

WITH THE SOLAR HEAT/OFF/ELECT. CHILLING SWITCH IN THE OFF POSITION, ALL PUMPS WILL STOP.

WITH THE FILLED/DRAINED SWITCH IN THE DRAINED POSITION, V-13 WILL BYPASS THE COLLECTORS.

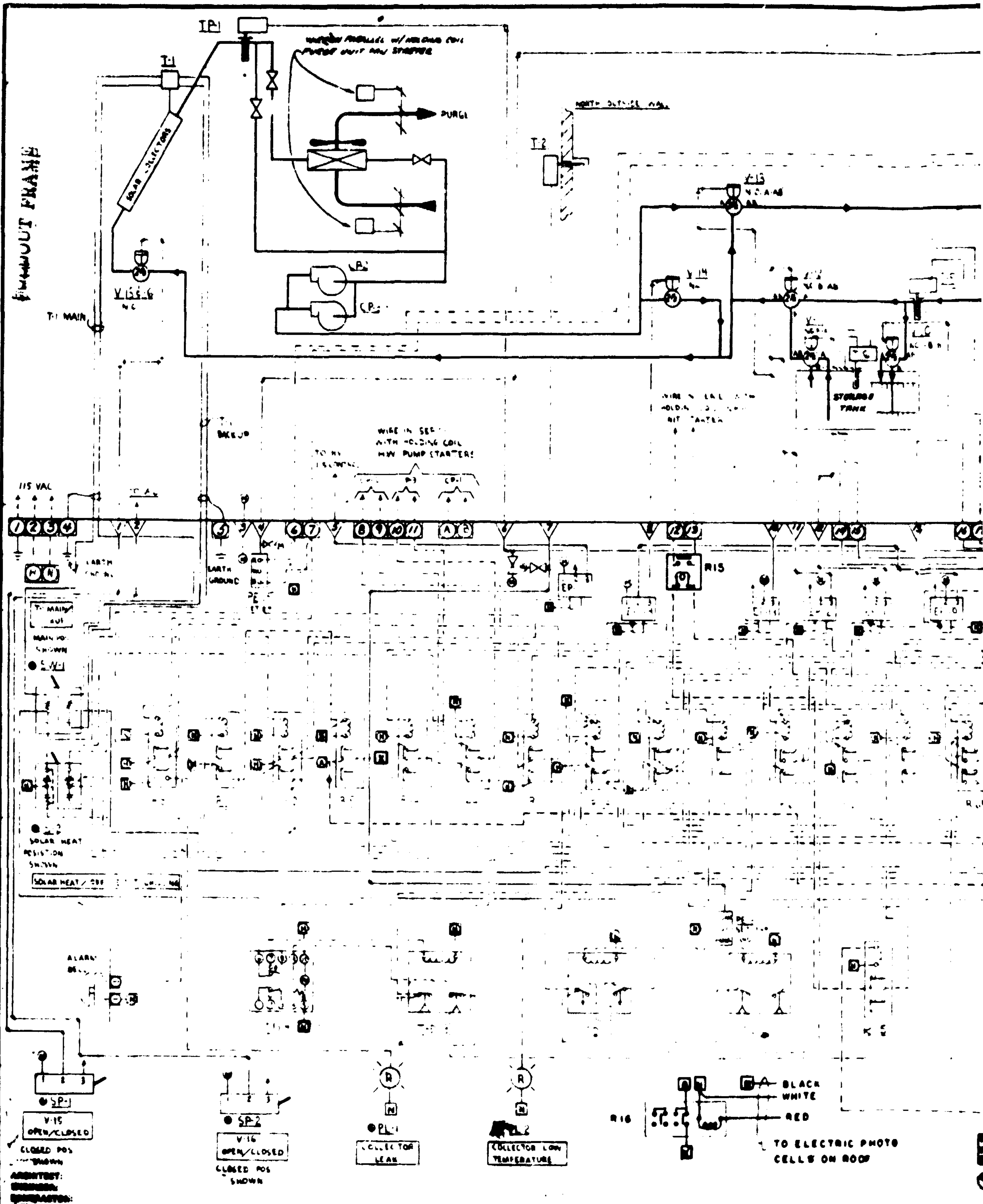
VALVES V-15 AND V-16 ARE MANUALLY CONTROLLED BY SWITCHES MOUNTED ON THE TC PANEL.

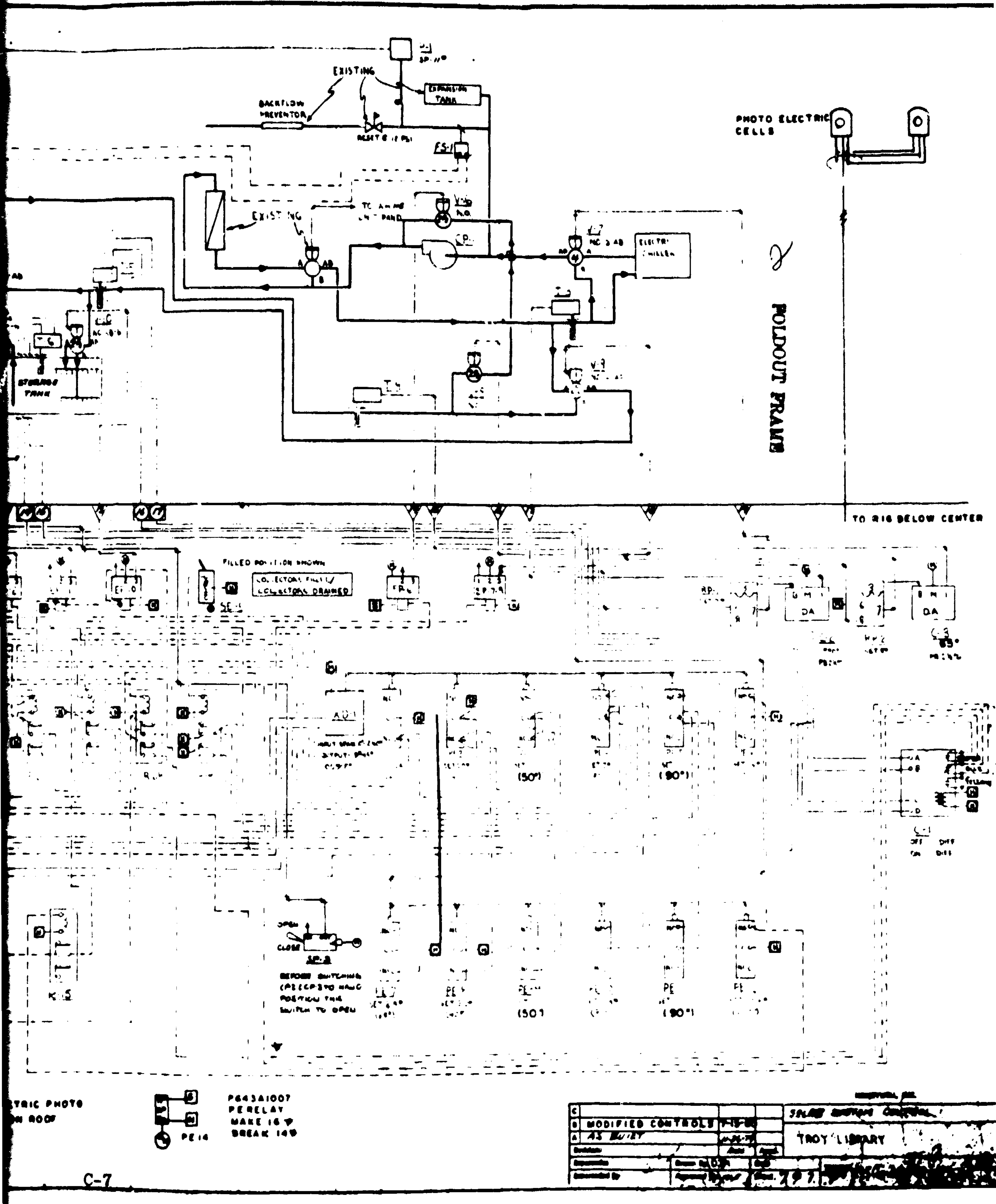
PNEUMATIC TOGGLE SWITCH SP-3 CAN OVERRIDE THE CONTROL OF V-14 AND OPEN THE VALVE MANUALLY.

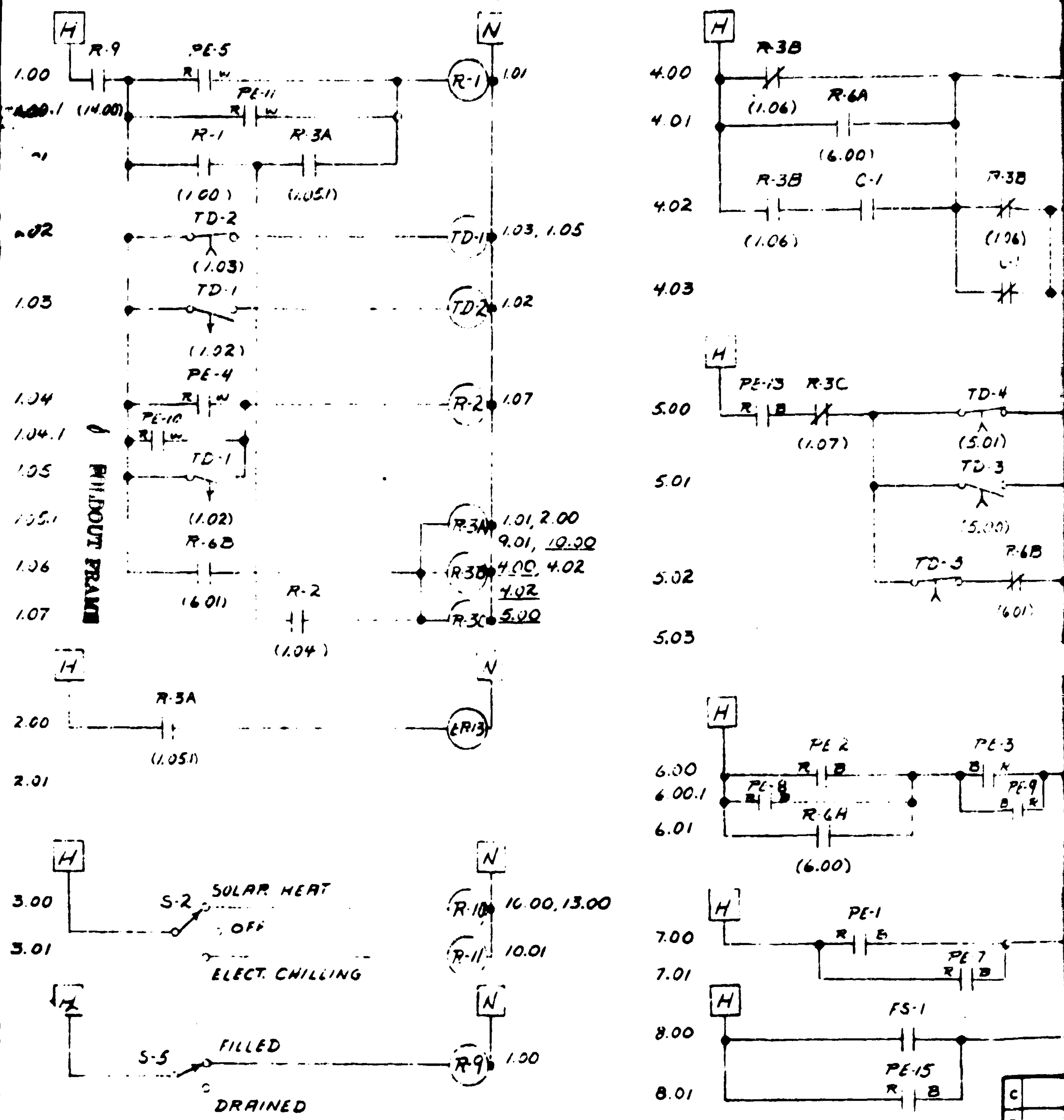
THE CONTROL OF CP-1 IS DE-ENERGIZED AT NIGHT THROUGH THE PE RELAY PE-14, PILOTED FROM THE DAY-NITE AIR MAIN.

TWO PHOTO-ELECTRIC CELLS, WIRED IN PARALLED FOR BACK-UP OPERATION, IS WIRED THROUGH RELAY R-16 TO ENERGIZE PUMP CP-1 DURING DAYLIGHT HOURS REGARDLESS OF TEMPERATURE.

FOLDOUT FRAME




EXISTING
BACKFLOW PREVENTOR
EXPANSION TANK
FS-1
EXISTING
CP-1
ELECTRIC CHILLER
STORAGE TANK
PHOTO ELECTRIC CELLS
FOLDOUT FRAME
TO R16 BELOW CENTER
FILLED POSITION SHOWN
COLLECTORS FILLED
COLLECTORS DRAINED
DA
DA
(50°)
(90°)
OPEN
CLOSE
SP-2
BEFORE SWITCHING CP2 & CP3 TO HAND POSITION THIS SWITCH TO OPEN
PE
(50)
PE
(90°)
TRIC PHOTO
ON ROOF
P643A1007
PE RELAY
MAKE 16
BREAK 14
PE14
B MODIFIED CONTROLS
A AS BUILT
TROY LIBRARY

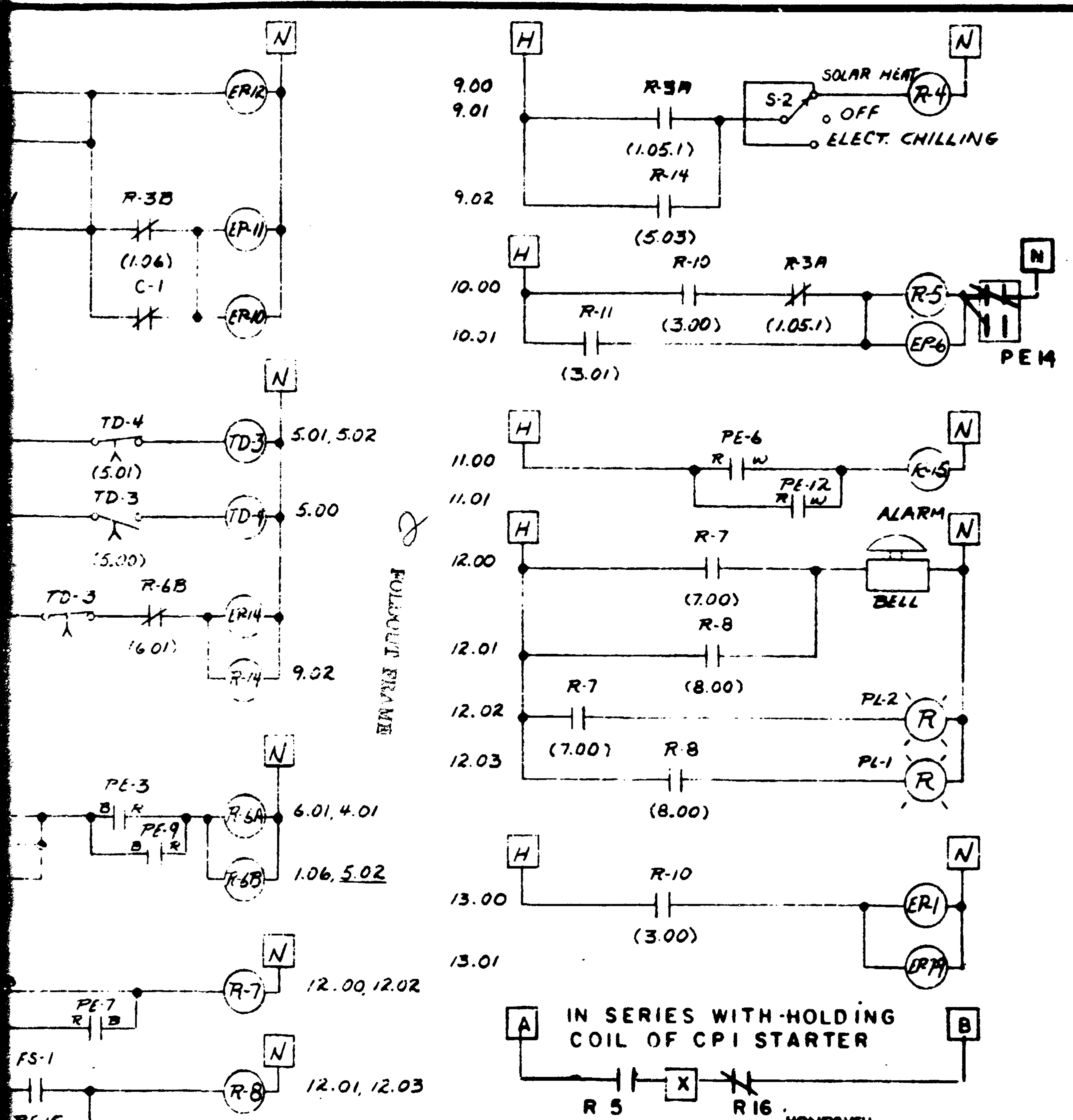


N.C. DELAY OPEN (ENER)

N.O. DELAY CLOSE (ENER)

N.O. DELAY OPEN (DE ENER)

ARCHITECT:
ENGINEER:
CONTRACTOR:
APPLICATION ENGINEER:



HONEYWELL

C			
B			
A	ADDED PE14, R16	7-15-80	
REVISIONS		DATE	APPD.

LADDER DIAGRAM - SOLAR PANEL

TROY LIBRARY

SUPERCEDES	DRAWN BY: MLE	DATE 9/20/77	DRAWING NUMBER 950-77567-2	REV
SUPERSEDED BY	APPROVED BY:	SHEET 7A OF 7		

BILL OF MATERIAL

AH-1

FIELD MOUNTED DEVICES

CODE	QTY.	PART NO.	DESCRIPTION
D-1, D-2	2	D641A	DAMPER
HL-1	1	LA419D1075	FIRESTAT
LL-1	1	L480G1002	FREEZESTAT
LP-1, LP-5	2	LP914A1003	SENSOR (-40 160)
LP-2, LP-4	2	LP914A1144	SENSOR (25 125)
LP-3	1	LP914A1060	SENSOR (-40 160)
		315046B	WELL (½")
MP-1, MP-2	2	MP909B1007	DAMPER MOTOR
TP-1, TP-2 TP-3	7	TP970A1004	THERMOSTAT
	7	14002132-101	COVER
	7	14001608-001	RING
	7	14001615-002	FITTING
VP-1	1	VALVE SCHEDULE	
*	7	RP670A1001	SWITCHING RELAY
*	7	RP972A1006	REVERSING RELAY

DEVICES MOUNTED IN ELECT. HT. PANEL

PE-1, PE-2	2	P658A1005	P.E. SWITCH

PANEL MOUNTED DEVICES

C-1, C-3	2	RP908B1029	RESET CONTROLLER
C-2, C-4	2	RP908A1062	LIMIT CONTROLLER
G-1, G-3	2	804071A	3½" GAGE (-40 160)
G-2, G-4	2	804071AP	3½" GAGE (25 125)
*PE-3	1	P643A1007	P.E. SWITCH
RP-10	1	RP471A1002	PNEUMATIC RELAY
RP-5	1	RP972A1006	REVERSING RELAY
RP-11	1	RP971A1015	RATIO RELAY
*RP-2,8	2	RP670A1019	SWITCHING RELAY DAY-NITE
*RP-3,4,7,9	4	RP670A1001	SWITCHING RELAY
*RP-12	2	RP670B1009	SWITCHING RELAY

*Changes to original job

HONEYWELL

C				
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REVISIONS		DATE	APPD.	

SUPERSEDES	DRAWN BY:	DATE	DRAWING	REV
SUPERSEDED BY	APPROVED BY:	SHEET OF	NUMBER	

01-3212-020 5-00 5000

SEQUENCE OF OPERATION

AH-1 UNIT OPERATION

When the system is indexed to solar heating (air pressure on line 5 from the solar panel) the outside air damper is closed, the return air damper is open and the control of the three-way valve is controlled by the space thermostat. The complete sequence is determined whether solar water of adequate temperature is available or not. If adequate temperature is available, according to the reset schedule, i.e., 70° F. outside air temperature, 70° F. water temperature being supplied to the coil, 0° F. outside air temperature, 90° F. water temperature being supplied to the coil, then the space thermostat operates through reversing relay RP5 and Solar Heat - Electric Chiller Selector Switch (SH-EC) RP-4 and Selector Relays RP-7, RP-3, and RP-12 to operate the three-way valve, opening port A to AB for flow through the coil for heating. The electric reheat is locked out.

If water temperature supplied to the coil is less than the above reset schedule then the space thermostat operates through relays RP-5, RP-4, RP-7, RP-3 and RP-12 to cycle the electric reheat to maintain space temperature. The three-way valve is positioned to the by-pass position (B-AB) to prevent carrying the heat away through flowing water.

The space thermostat also is piped through another SH-EC selector relay RP-9 to cycle the fan during the day at one temperature and cycle the fan at nite at a lowered nite temperature. With the system indexed to "Electric Chiller" at the Main Solar Panel, air pressure on 5 is bled off and all selector relays pass on 6-7. With the space temperature below the set point of the master space thermostat the outside air damper running closed. The three-way valve on the chilled water coil remains in the by-pass position. When the space temperature exceeds the thermostat setting (8# branch pressure) the outside air and return air damper modulates to maintain 60° mixed air temperature until the outside air temperature exceeds 68° F. At 68° F. outside air temperature the outside air damper is closed, the return air damper opens. The mixed air temperature will be over 60° F. so the three-way valve on the chilled water coil will be in the full flow position.

Space temperature at the Master Space Thermostat is maintained during the DAY by the space thermostat cycling the fan. During the NITE mode the fan does not run.

Zone temperature is maintained by the zone thermostat operating a pneumatic damper motor to modulate the discharge dampers of the mixing box. The action of the thermostat is reversed depending upon the temperature of the air leaving the unit, i.e., heating or cooling.

HONEYWELL

C			
B			
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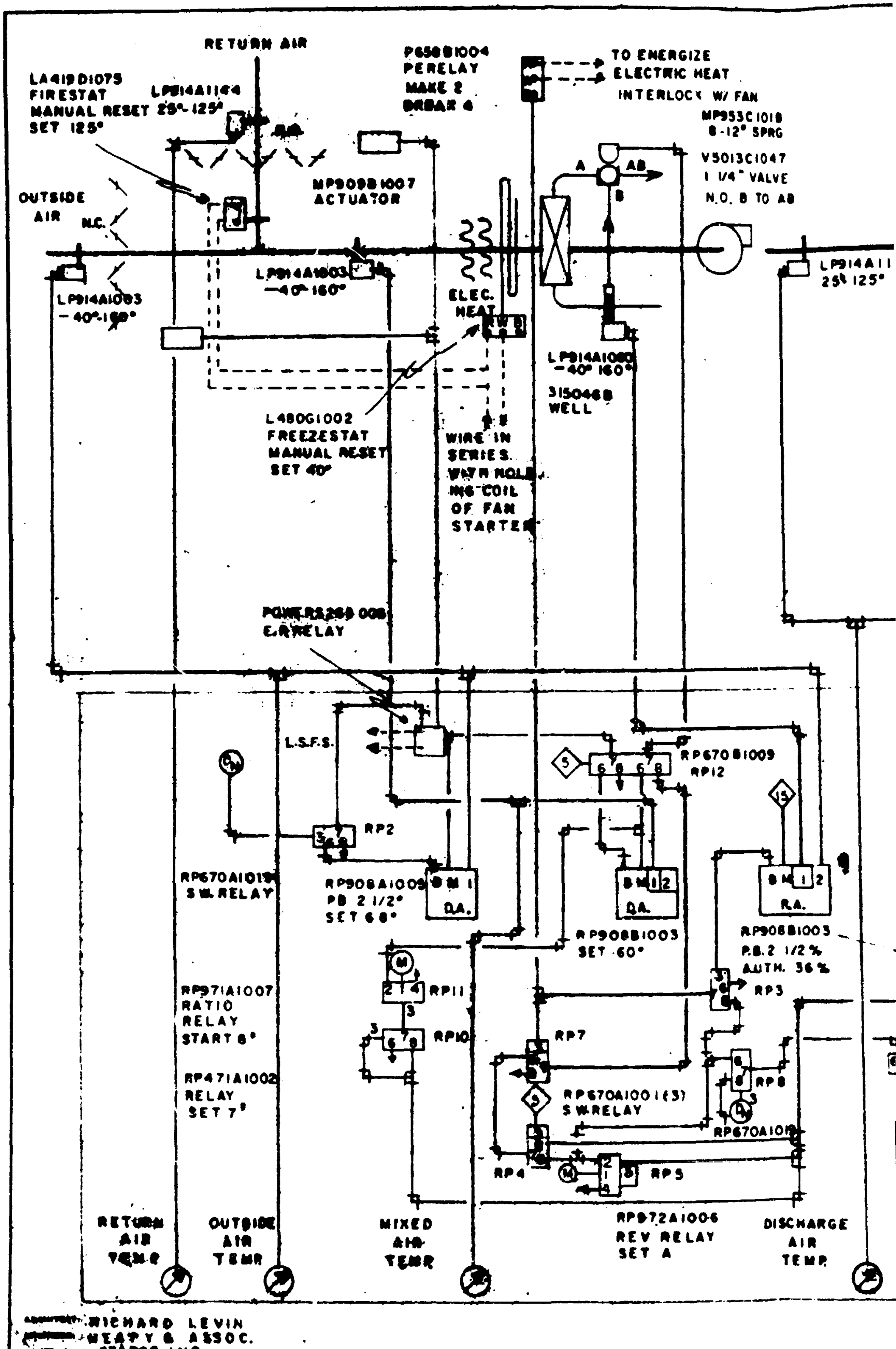
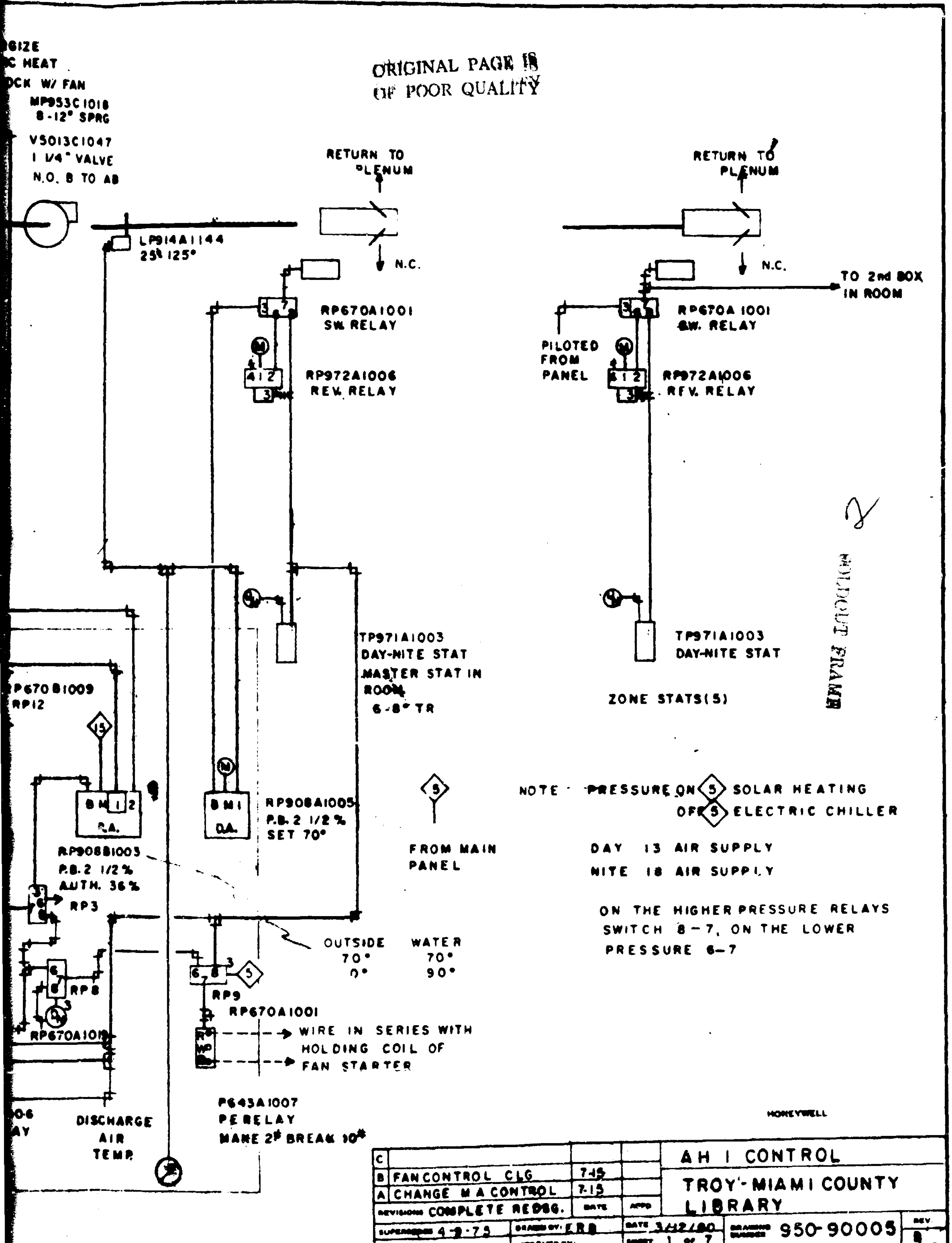
REVISIONS		DATE	APPD.

SUPERSEDES	DRAWN BY:	DATE	DRAWING NUMBER	REV.
SUPERSEDED BY	APPROVED BY:	SHEET OF		

01-0013-000 5-00 0000



FOLDOUT FRAME



FOLDOUT FRAME

BILL OF MATERIAL

AH-3 & 4 CONTROL

FIELD MOUNTED DEVICES

CODE	QTY.	PART NO.	DESCRIPTION
D-1, D-2	4	D641A	DAMPER
HL-1	2	LA419D1075	FIRESTAT
LL-1	2	L480G1002	FREEZESTAT
LP-1, LP-5	4	LP914A1003	SENSOR (-40 160)
LP-2, LP-4	4	LP914A1144	SENSOR (25 125)
LP-3	2	LP914A1060	SENSOR (-40 160)
	2	315046B	WELL ($\frac{1}{2}$")
MP-1, MP-2	4	MP909C1054	DAMPER MOTOR
TP-1, TP-2	3	TP970A1004	THERMOSTAT
	3	14002132-101	COVER
	3	14001608-001	RING
	3	14001615-002	FITTING
V-1	2	VALVE SCHEDULE	

DEVICES MOUNTED IN ELEC. HT. PANEL

CODE	QTY.	PART NO.	DESCRIPTION
PE-1, PE-2	4	P658A1005	P.E. SWITCH

PANEL MOUNTED DEVICES

CODE	QTY.	PART NO.	DESCRIPTION
C-1, C-3	4	RP908B1029	RESET CONTROLLER
C-2, C-4	2	RP908A1062	LIMIT CONTROLLER
G-1, G-3	4	804071A	$3\frac{1}{2}$" GAGE (-40 160)
G-2, G-4	4	804071AP	$3\frac{1}{2}$" GAGE (25 125)
*PE-3	2	P643A1007	P.E. SWITCH
RP-10	2	RP471A1002	PNEUMATIC RELAY
RP-5	2	RP972A1006	REVERSING RELAY
RP-11	2	RP971A1015	RATIO RELAY
*RP-2,8	4	RP670A1019	SWITCHING RELAY DAY-NITE
*RP-3,4,7,9	8	RP670A1001	SWITCHING RELAY
*RP-12	2	RP670B1009	SWITCHING RELAY

*Changes to original job

HONEYWELL

		DATE	APPD.
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REVISIONS			

SUPERSEDES	DRAWN BY:	DATE	DRAWING NUMBER	REV
SUPERSEDED BY	APPROVED BY:	SHEET OF		

91-3213-020 3-69 5000

SEQUENCE OF OPERATION

AH3 & 4 UNIT VENTILATORS

When the system is indexed to solar heating (air pressure on line 5 from the solar panel) the outside air damper is closed, the return air damper is open and the control of the three-way valve is controlled by the space thermostat. The complete sequence is determined whether solar water of adequate temperature is available or not. If adequate temperature is available, according to the reset schedule, i.e., 70° F. outside air temperature, 70° F. water temperature being supplied to the coil, 0° F. outside air temperature, 90° F. water temperature being supplied to the coil, then the space thermostat operates through reversing relay RP5 and Solar Heat - Electric Chiller Selector Switch (SH-EC) RP-4 and Selector Relays RP-7, RP-3, and RP-12 to operate the three-way valve, opening port A to AB for flow through the coil for heating. The electric reheat is locked out.

If water temperature supplied to the coil is less than the above reset schedule then the space thermostat operates through relays RP-5, RP-4, RP-7, RP-3 and RP-12 to cycle the electric reheat to maintain space temperature. The three-way valve is positioned to the by-pass position (B-AB) to prevent carrying the heat away through flowing water.

The space thermostat also is piped through another SH-EC selector relay RP-9 to cycle the fan during the day at one temperature and cycle the fan at nite at a lowered nite temperature. With the system indexed to "Electric Chiller" at the Main Solar Panel, air pressure on 5 is bled off and all selector relays pass on 6-7. With the space temperature below the set point of the master space thermostat the outside air damper running closed. The three-way valve on the chilled water coil remains in the by-pass position. When the space temperature exceeds the thermostat setting (8# branch pressure) the outside air and return air damper modulates to maintain 60° mixed air temperature until the outside air temperature exceeds 68° F. At 68° F. outside air temperature the outside air damper is closed, the return air damper opens. The mixed air temperature will be over 60° F. so the three-way valve on the chilled water coil will be in the full flow position.

Space temperature at the Master Space Thermostat is maintained during the DAY by the space thermostat cycling the fan. During the NITE mode the fan does not run.

HONEYWELL

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B			
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REVISION		DATE	APPD.
SUPERSEDES	DRAWN BY:	DATE	DRAWING NUMBER	REV
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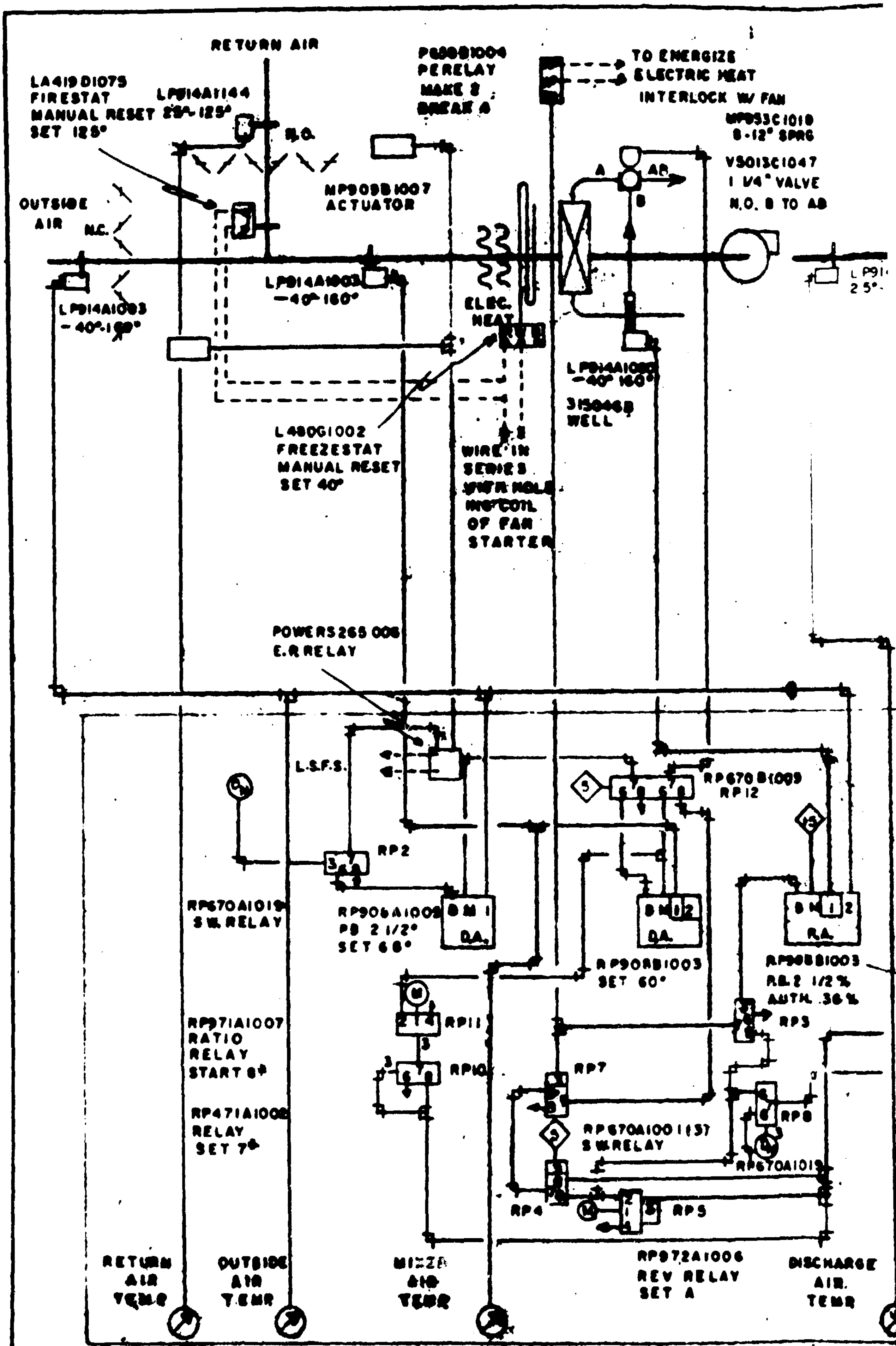
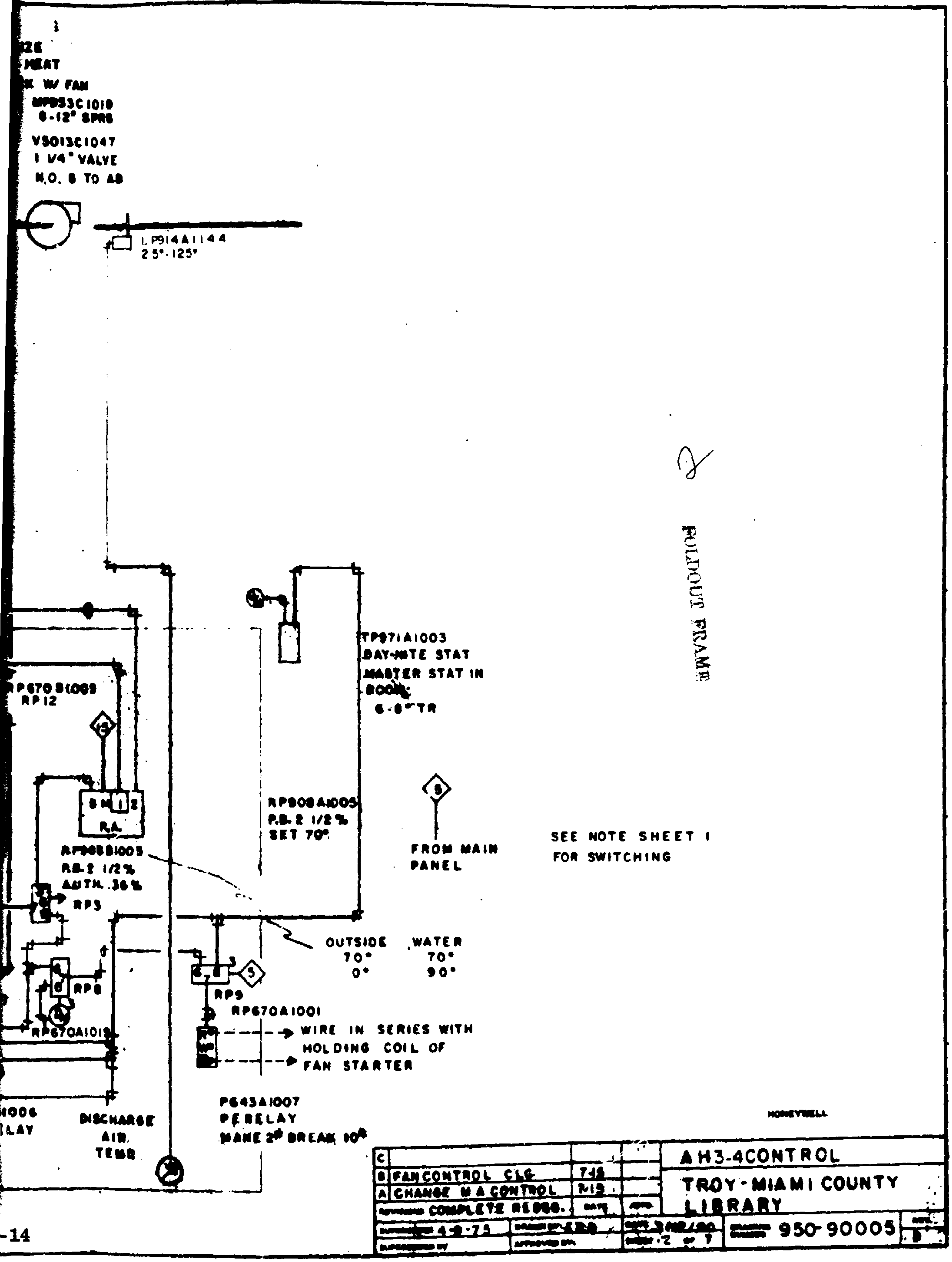
FOLDOUT FRAME



RICHARD LEVIN
HEAPY & ASSOC.
STARCO, INC.



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SEQUENCE OF OPERATION

AH-2 & 5 CONTROL

WHEN THE FAN IS RUNNING, THE MASTER THERMOSTAT WILL CYCLE THE THREE STAGES OF ELECTRIC REHEAT THROUGH PE SWITCHES TO MAINTAIN SPACE TEMPERATURE. THE MASTER THERMOSTAT WILL ALSO MODULATE THE CHILLED WATER VALVE FOR COOLING.

THE ADDITIONAL SPACE THERMOSTATS WILL CYCLE THEIR RESPECTIVE ELECTRIC REHEATS THROUGH PE SWITCHES.

UPON RECEIVING A SIGNAL FROM THE SOLAR PANEL, THE ACTION OF VP-1 WILL BE REVERSED. VP-1 WILL THEN BE SEQUENCED TO MAINTAIN REQUIRED DISCHARGE TEMPERATURE.

BILL OF MATERIAL

CODE	QTY.	PART NO.	DESCRIPTION
PE-1 THRU PE-7	17	P658A1005	P.E. SWITCH
RP-1	2	RP411A1005	AIR MOTION RELAY
TP-1-TP-3	6	TP970A1004	THERMOSTAT
	6	14002132-101	COVER
	6	14001608-001	RING
	6	14001615-002	FITTING
VP-1	2	VALVE SCHEDULE	
RP-4,RP-7	4	RP471A1002	PNEUMATIC RELAY
RP-5	2	RP972A1006	REVERSING RELAY
RP-6	2	RP971A1015	RATIO RELAY

950-74091-3

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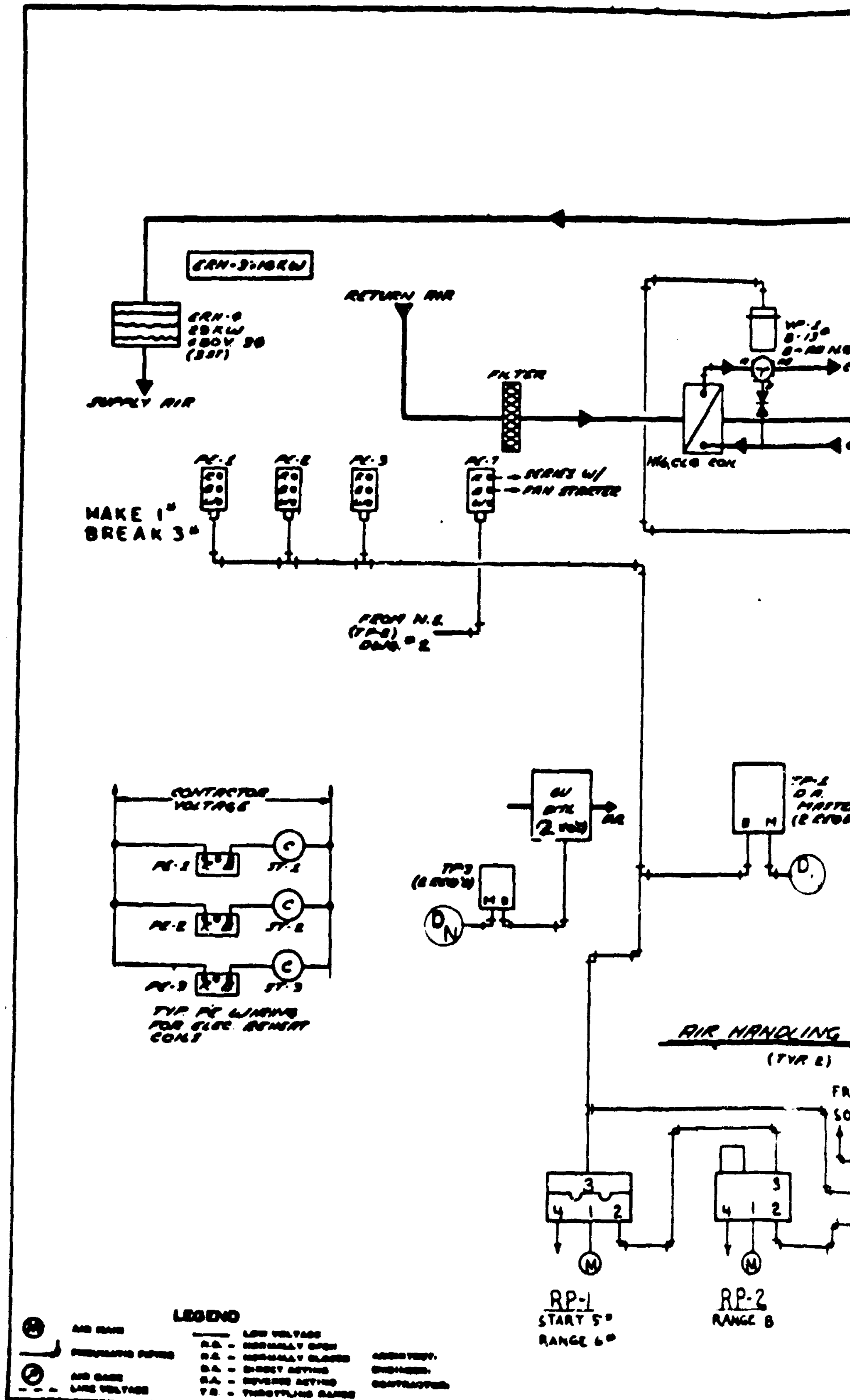
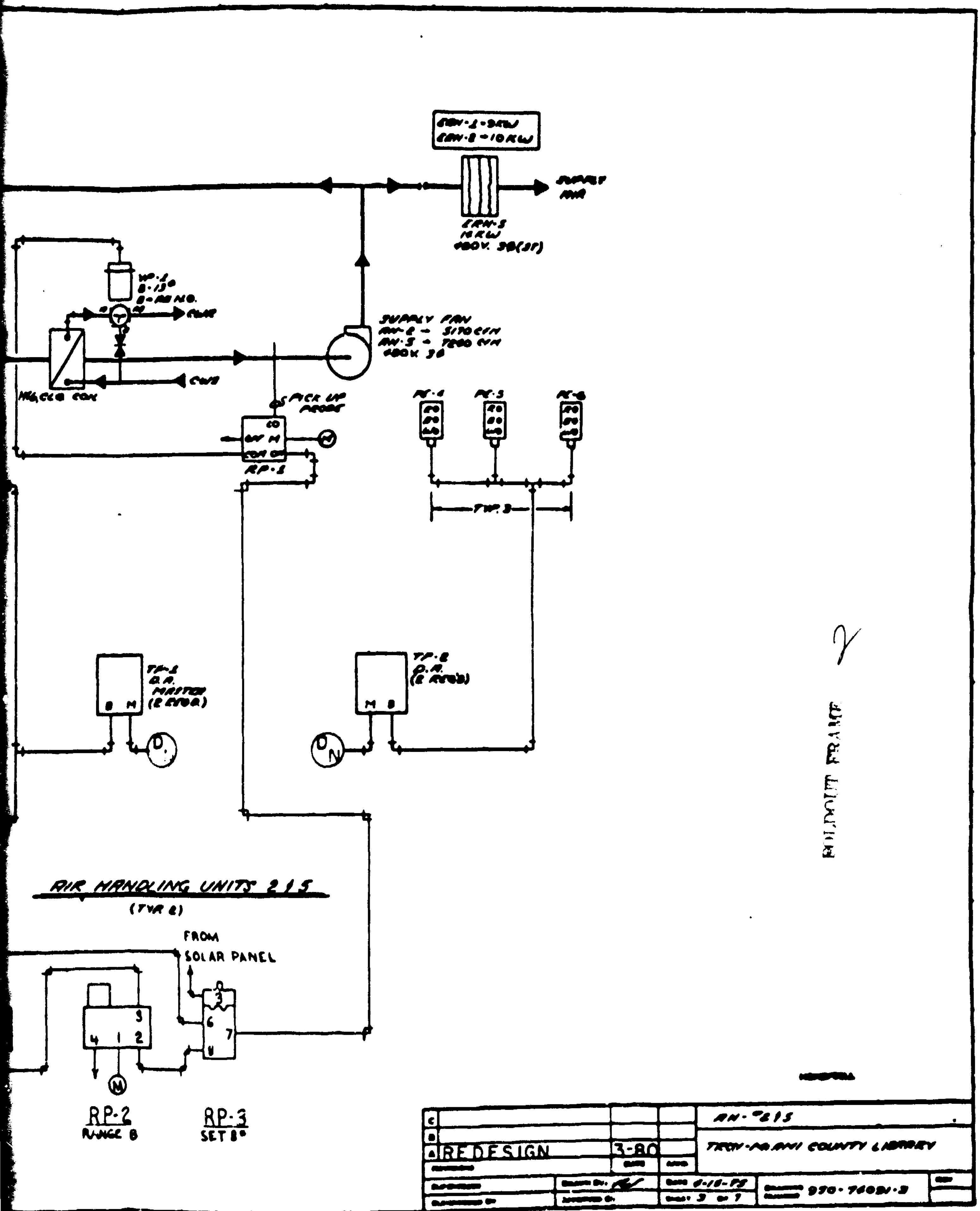
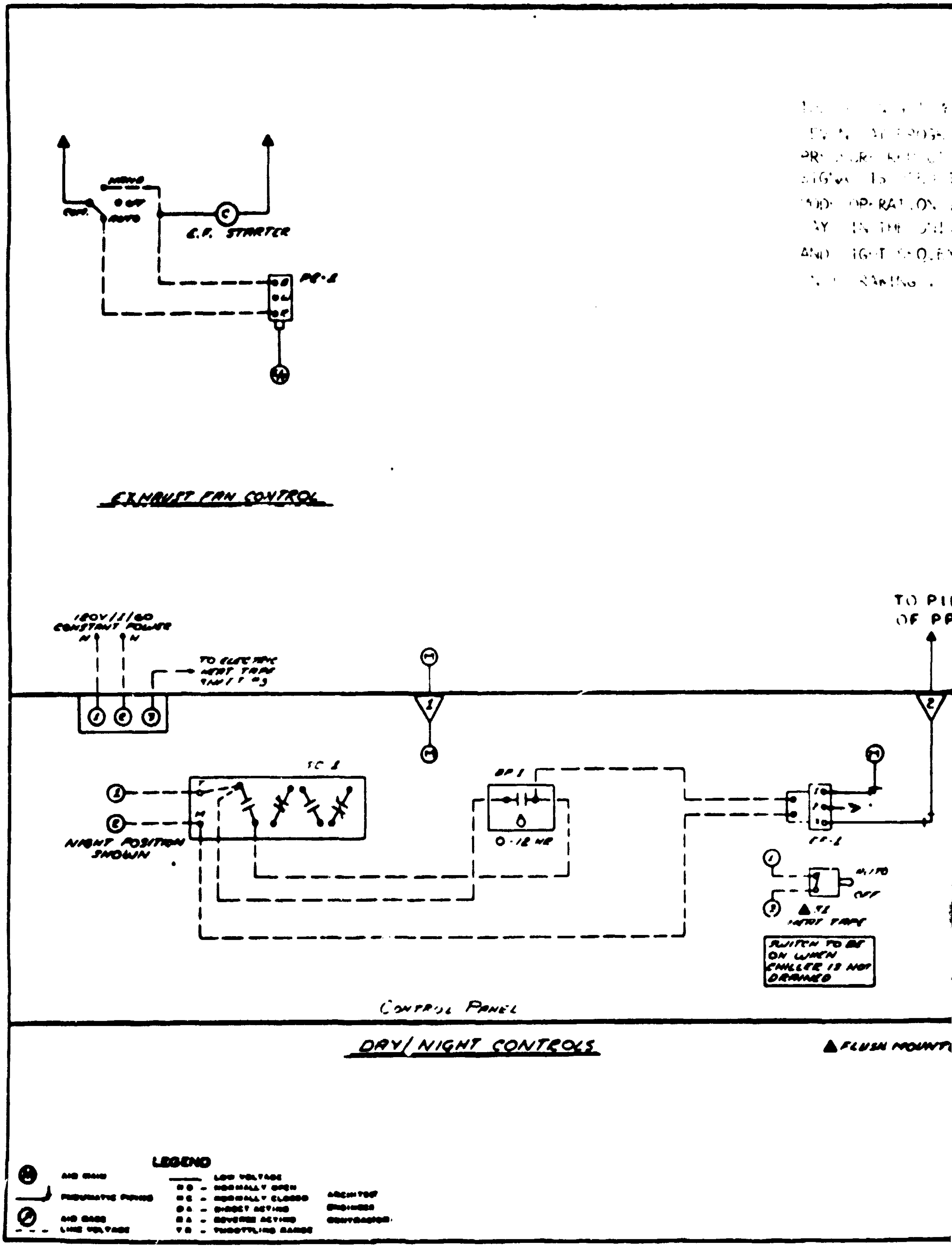



SUPPLY FAN
PICK UP PROBE
RP-1
M
FROM
SOLAR PANEL
3
6
7
4 1 2
3
M
RP-2
RP-3
REDESIGN
3-80
FOLDOUT FRAME

FOLDOUT FRAME



[illegible] OPERATION IS [illegible] PROGRAM TIMER TO PILOT THE [illegible] OVER PRESSURE [illegible] VALVE. FOR DAY OPERATION [illegible] SIGNAL IS [illegible] PNEUMATIC PIPING. [illegible] NIGHT MODE OPERATION [illegible] SIGNAL TRIGGERS [illegible] VARIOUS RELAY IN THE [illegible] TO ACHIEVE [illegible] DIFFERENT DAY AND NIGHT SEQUENCE [illegible] CHART DESCRIBING [illegible] DRAWINGS.

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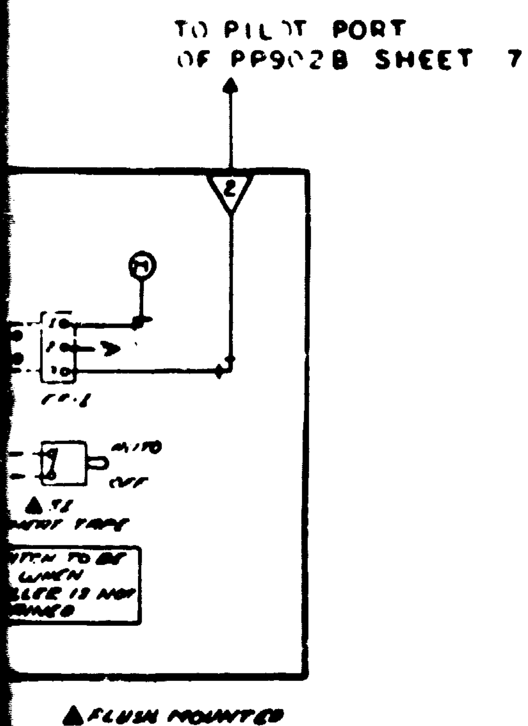

FOLDOUT FRAME

C				DAY/NIGHT CONTROLS
B				
A	REDESIGN	3-80		TROY-MIAMI COUNTY LIBRARY
REVISIONS		DATE	APPD	

SUPERVISOR	DRAWN BY	DATE	DRAWING NUMBER 930-7F09-4	
SUPERVISED BY	APPROVED BY	SHEET 4 OF 7		

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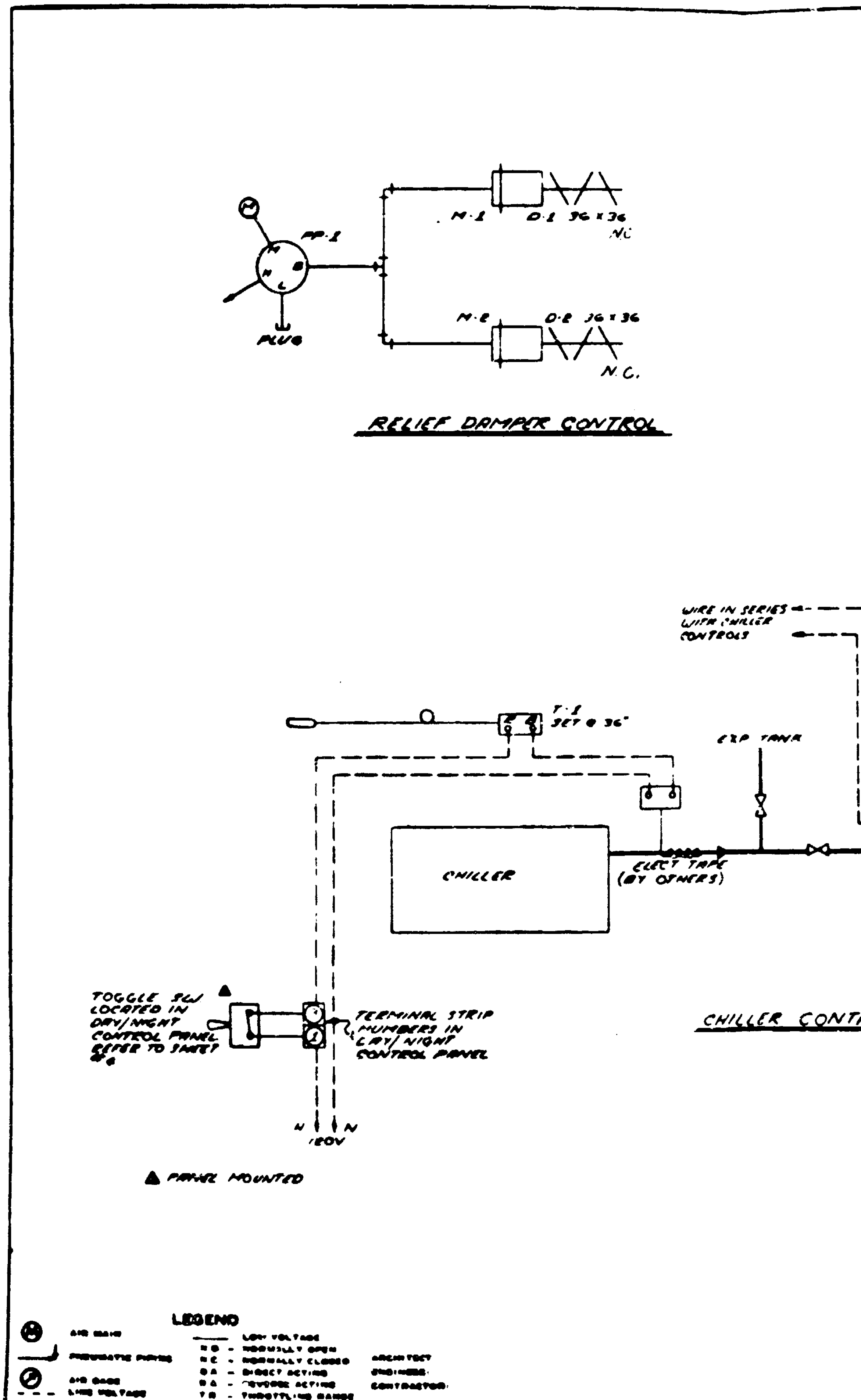


SEQUENCE OF OPERATION

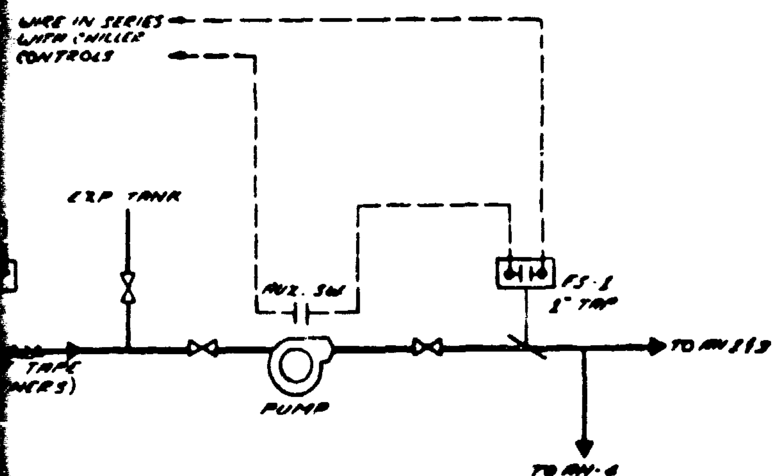
RELIEF DAMPER CONTROL

THE RELIEF DAMPERS WILL MODULATE OPEN WHEN THE STATIC PRESSURE IN THE RETURN AIR PLENUM ABOVE THE CEILING INCREASES.

CHILLER CONTROLS

THE CHILLER WILL BE OPERATIVE IF THE PUMP IS OPERATING. PROVING PUMP OPERATION IS THE AUX. SWITCH ON THE PUMP AND A FLOW SWITCH IN THE PUMP DISCHARGE.

THE ELECTRIC HEAT TAPE WILL BE ENERGIZED WHEN THE OUTSIDE AIR REACHES 36°. WHEN THE CHILLER IS DRAINED, A SWITCH IN THE AH-1 CONTROL PANEL SHOULD BE TURNED 'OFF', NOT ALLOWING THE HEAT TAPE TO OPERATE.



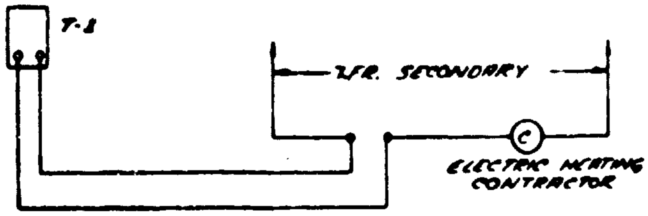
CHILLER CONTROL

BILL OF MATERIAL

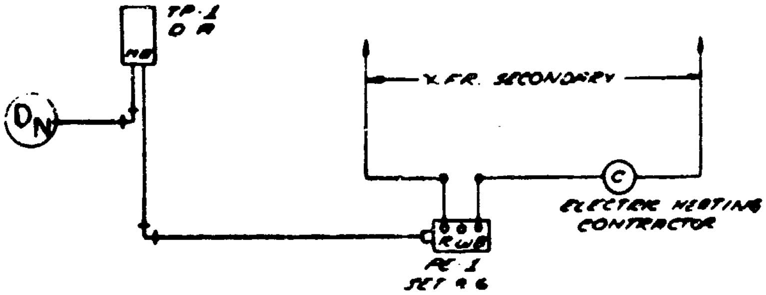
CODE	QTY.	PART NO.	DESCRIPTION
D-1, D-2	2	D 641	DAMPER
FS-1	1	FS4-3	FLOW SWITCH
MP-1 MP-2	2	MP909B1007	MOTOR
PP-1	1	PP905A1000	STATIC PRESSURE CONTROLLER
T-1	1	T675A1508	TEMPERATURE CONTROLLER
	1	34886 A	SHIELD

HONEYWELL

Title	RELIEF DAMPER / CHILLER CONTROLS
	TROY-MIAMI COUNTY LIBRARY
Drawn by	RW
Date	6-17-75
Sheet	5 of 7
Drawing number	330-7608I-S



PROPELLER / C.U.H. CONTROL
(TYP 3)



CC (FIN TUBE) CONTROL
(TYP 2)

LEGEND

Sequence of Operation

Propeller and Fan Control
On a call for heat, the electric space thermostat will cycle the heaters as required to maintain space temperature.

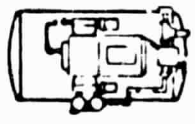
Convection (Fin Tube) Control
TheDay-Nite Thermostat will control the P.E. Switch which will cycle the heaters to maintain the space temperature.

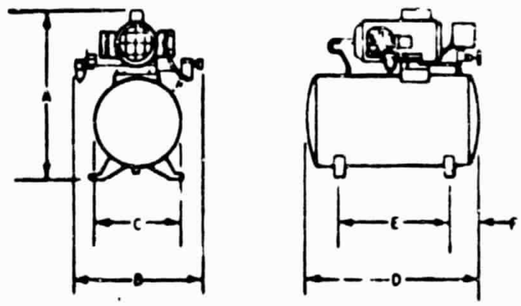
FOLDOUT FRAME

PE-1	2	P658A1005	PE Relay
T-1	3	T4051D1007	Thermostat
TP-1	2	TP971A1003	Day-Nite Thermost[illegible]
	2	14002132-101	Cover
	2	14001608-001	Ring
	2	14001615-002	Fitting

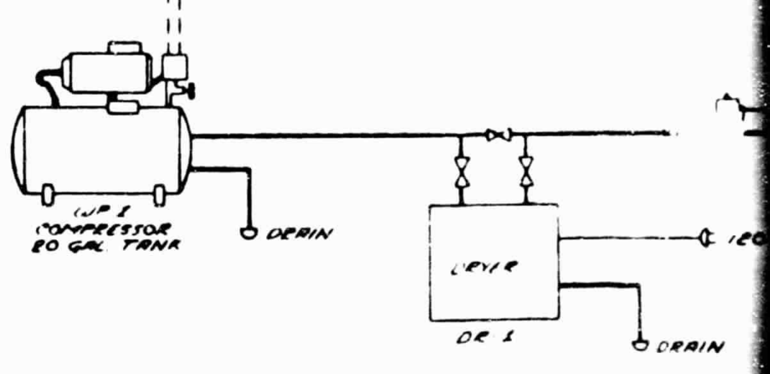
C			CU.H. & C.C. CONTROLS
B			
A	REDESIGN	3-80	TROY-MIAMI COUNTY LIBRARY
	6-19-78	6 of 7	93C-7409-7

FOLDOUT FRAME





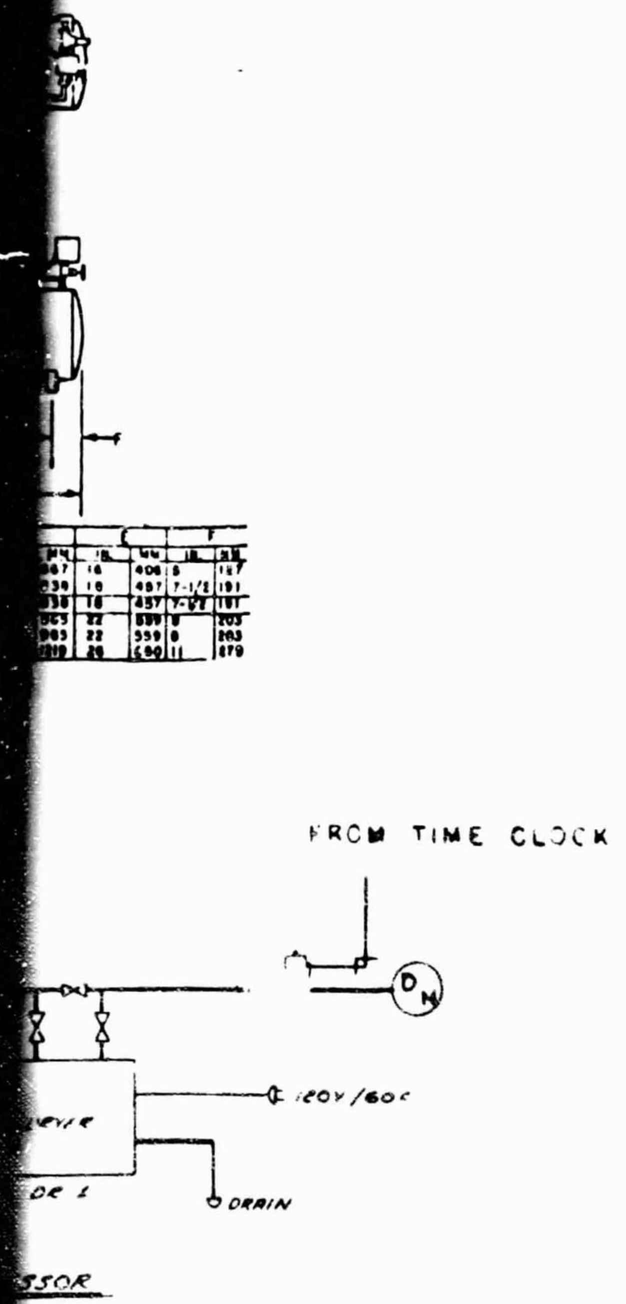
MODEL	A		B		C		D		E		F	
	IN	MM	IN	MM	IN	MM	IN	MM	IN	MM	IN	MM
WP260T (1/6 HP) 12 GAL	23-3/4	603	18	457	11-1/2	[illegible]	26-1/4	667	16	406	5	127
WP260A (1/4 HP) 20 GAL	24-3/8	619	19-1/2	495	14	356	33	839	18	457	7-1/2	191
WP260B (1/2 HP) 20 GAL	26-7/8	683	19-1/2	495	14	356	33	838	18	457	7-1/2	191
WP260C (3/4 HP) 30 GAL	30	762	19	483	18	381	38	965	22	559	8	203
WP260D (1 HP) 30 GAL	29-1/4	743	19	483	18	[illegible]	38	965	22	559	8	203
WP260E (1-1/2 HP) 60 GAL	34-1/4	870	20-3/4	527	18-1/2	470	48	1219	26	660	11	279



COMPRESSOR

LEGEND

AIR MAIN	——— LOW VOLTAGE		
PNEUMATIC PIPING	N O - NORMALLY OPEN		
AIR GAGE	N C - NORMALLY CLOSED	ARCHITECT	
- - - LINE VOLTAGE	D A - DIRECT ACTING	ENGINEER	
	R A - REVERSE ACTING	CONTRACTOR	
	T R - THROTTLING RANGE		



SEQUENCE OF OPERATION

COMPRESSOR CONTROLS

THE COMPRESSOR WILL PROVIDE CLEAN, DRY AIR FOR THE TEMPERATURE CONTROL SYSTEM.

FOLDOUT FRAME 2

BILL OF MATERIAL

CODE	QTY.	PART NO.	DESCRIPTION
DR-1	1	AK3480	DRYER
		AK3485D	DRAIN KIT
WP-1	1	WP160B3B0A1B	COMPRESSOR.
	1	PP902B10C1	Pressure Reducing Valve & Filter (2- Pressure)

HONEYWELL

C				COMPRESSOR
B				TROY-MIAMI COUNTY LIBRARY
A	CHGD PRV	3-80		
REVISIONS		DATE	APPD.	
SUPERSEDES	DRAWN BY: RJ	DATE 6-17-75	DRAWING NUMBER 950-76091-7	
SUPERSEDED BY	APPROVED BY:	SHEET 7 OF 7		

APPENDIX D
VENDOR ITEMS

LIST OF ITEMS INCLUDED

Water Storage Tank

Expansion Tank

By-Pass Chemical Feeder

Air Separator

Circulating Pumps

Purge Unit

Purge Unit Control Dampers

Single Seated Valves

Single Seated, Normally Open, Pneumatic Valve Assemblies

Single Seated, Normally Closed, Pneumatic Valve Assemblies

Three-Way Mixing and Diverting Valves

Three-Way Pneumatic Valve Assemblies

Pneumatic Valve Assemblies, Three-Way Mixing or Diverting

Tank Fittings

Relief Valves

Water Vent Valves

Swing Check Valves

Gate Valves

Combination Starters

Circuit Breaker Panel

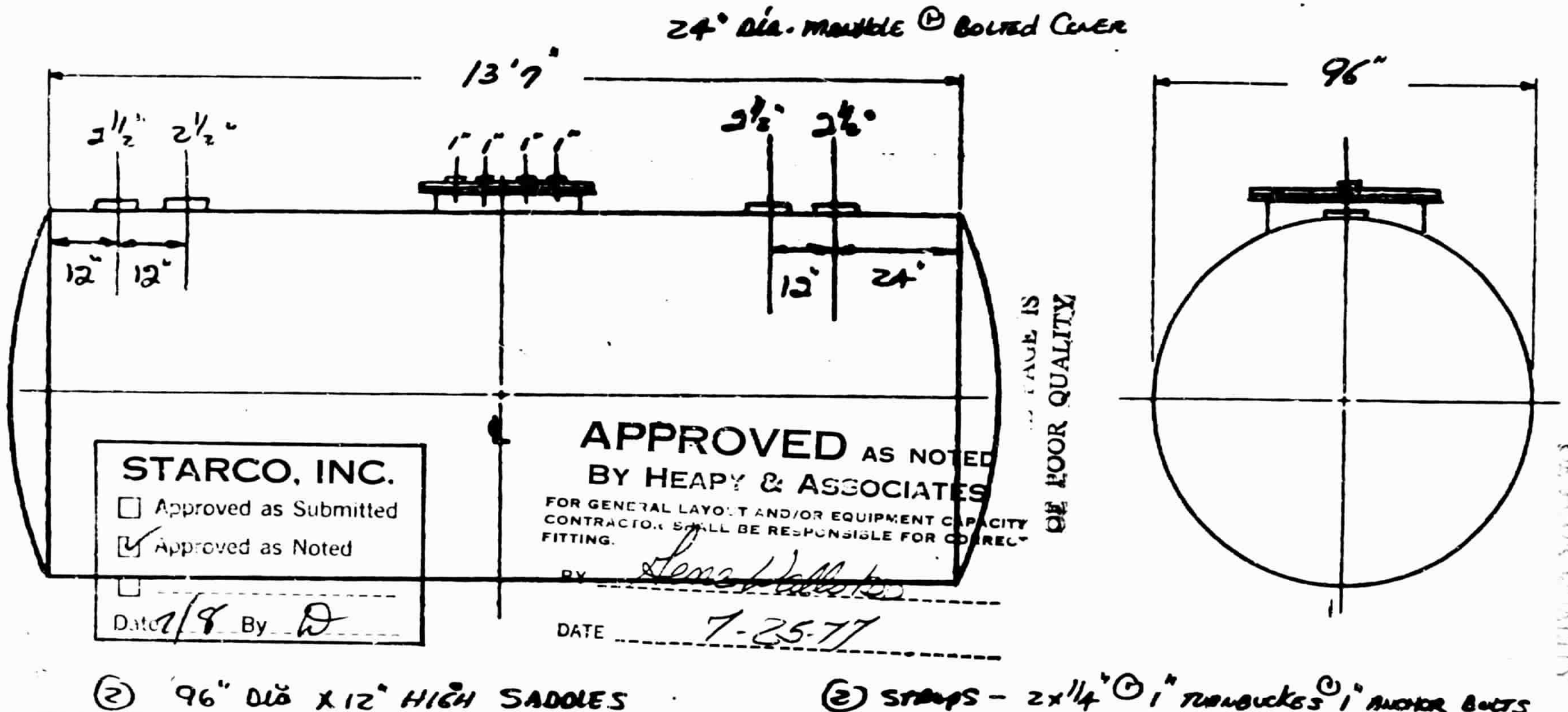
NEMA Enclosures

Differential Pressuretrol Controllers

Solar Temperature Control

Watt Transducers

Insulation Material



STARCO, INC.
- [ ] Approved as Submitted
- [x] Approved as Noted
- [ ]

Date 1/8 By D

APPROVED AS NOTED
BY HEAPY & ASSOCIATES
FOR GENERAL LAYOUT AND/OR EQUIPMENT CAPACITY
CONTRACTOR SHALL BE RESPONSIBLE FOR CORRECT
FITTING.
BY [signature]
DATE 7-25-77

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OF POOR QUALITY

SPECIFICATION: 5,000 GALLON SHELL THICKNESS ¼"
Nº REQUIRED ____ HEAD THICKNESS 13/32" (DISHED)
MATERIAL: STEEL-COMMERCIAL GRADE OPEN-HEARTH

CONSTRUCTION - IN ACCORDANCE WITH THE NATIONAL BOARD OF FIRE UNDERWRITERS.

STAMPING: ( ) UNDERWRITERS LABEL FOR ABOVE GROUND
(X) NOT LABELED

PAINT: ~~Black Asphaltum~~ Zinc Chromate ~~Primer~~

NOTES: Tank to be constructed for 30# working press.

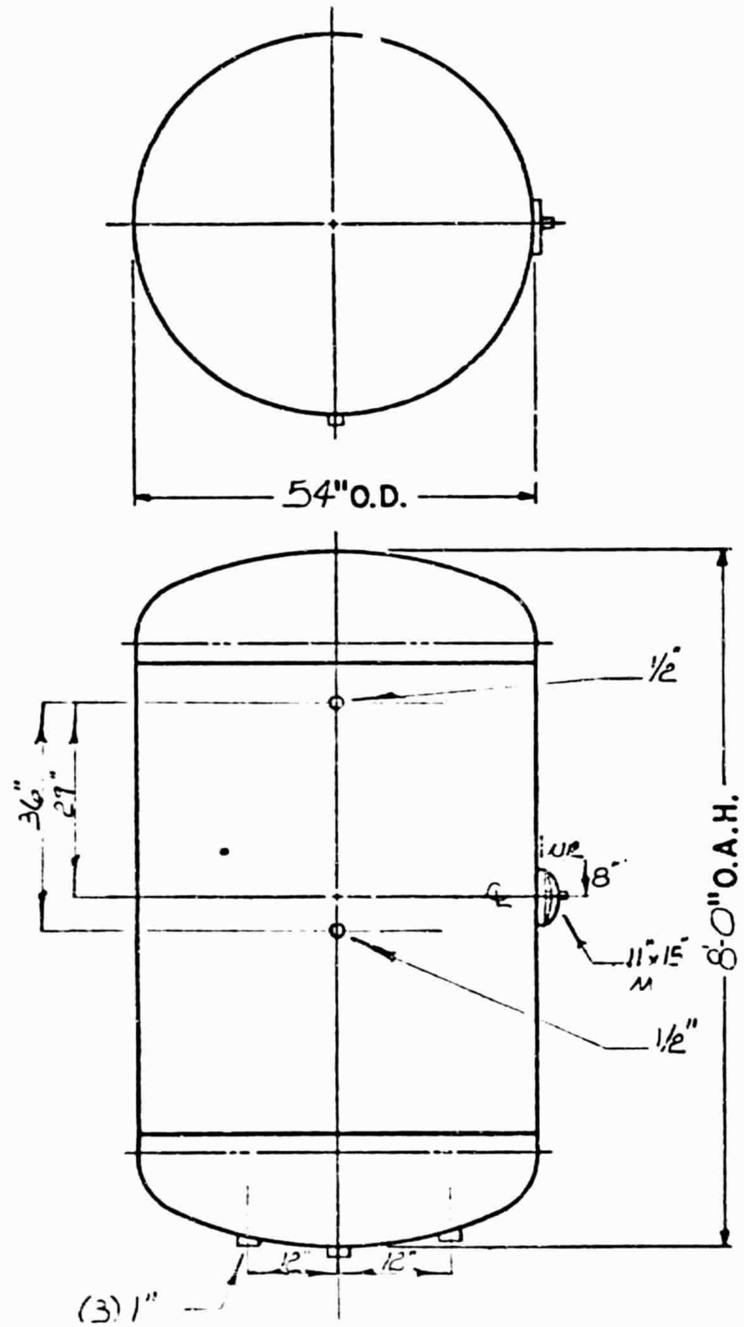
CUSTOMER: STARCO, INC.
DAYTON, OHIO
P.O. Nº 3542
PROJECT: TROY - MIAMI LIBRARY
TROY - OHIO
ARCHITECT:
ENGINEER:
AGENT: JORDAN EQUIP. Co.

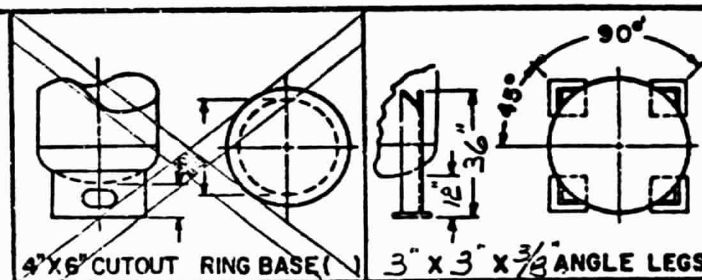
WATER STORAGE TANK

ADAMSON

ADAMSON CO. INC. EAST PALESTINE, OHIO

SCALE	CHECKED	DRAWN BY	DATE	JOB №
NONE	✓	[initials]	6/20/77	





TANK SPECIFICATIONS:

Nº. OF UNITS REQUIRED: ONE (1)

DESIGN PRESSURE 100 P.S.I.

TEST PRESSURE 150 P.S.I.

CONSTRUCTION: (X) A.S.M.E. INSPECTED & STAMPED

( ) MFG. STANDARD

MATERIAL: CARBON STEEL

SHELL - SA 455

HEADS - SA 515 GR 70

PAINT OR LINING:

EXTERIOR - RED OXIDE

INTERIOR - NONE

NOTES:

REVISION	1	2	3	4	5
DATE					

CUSTOMER: STAMCO, INC

DAYTON, OHIO

P.O. Nº. 3542

PROJECT: TROY [illegible] LIBRARY

TROY, OHIO

ARCHITECT:

ENGINEER:

AGENT: NORMAN EQUIPMENT CO

EXPANSION TANK

ADAMSON

ADAMSON CO. INC.

SCALE	CHECKED	DRAWN BY	DATE	JOB Nº.
NONE	[illegible]	[illegible]	11 AUG 77	1675-P

DEARBORN

EQUIPMENT BULLETIN 80770

chemical feeding equipment

STARCO, INC.
☑ Approved as Submitted
☐ Approved as Noted
☐ ____________
Date 9/21 By D

MODEL HV AND AV BY-PASS CHEMICAL FEEDERS

APPROVED BY
HEAPY & ASSOCIATES
FOR GENERAL LAYOUT AND/OR EQUIPMENT CAPACITY
CONTRACTOR SHALL BE RESPONSIBLE FOR CORRECT FITTING.
BY ____________
DATE 10-3-77

ADVANTAGES:

- **Easy to install**
- **Safe and easy to use**
- **Economical**

Dearborn offers two sizes of by-pass feeders for introducing powdered or liquid water treatment chemicals. The feeders are of steel construction and suitable for working pressures up to 300 psi.

The Type HV (2 gallon) and AV (5 gallon) feeders each have a 3½" fill opening. The closure requires just a ¼" turn by hand to open or close the feeder for a perfect seal. The closure actually tightens with pressure. The greater the pressure the tighter the seal. The floating seal is positively self-aligning; cannot cock or distort. The cover is removable in its entirety, including gasket. No loose parts to assemble. "O" ring seals can be replaced quickly in the field. Safety feature will **not** allow removal of cap with pressure on the feeder. Pressure **must** be released to open.

INSTALLATION

Dearborn By-Pass Feeders may be installed in any of the following manners:

- **Between the suction and discharge of a pump.**
- **On horizontal or vertical piping using a valve or orifice to create flow through the feeder.**
- **Direct to system piping or pump suction using water from a source at higher pressure.**

NOTE: Feeders are furnished without valves and fittings. See reverse side for valve and fitting requirements and typical drawings for each of the above installations.

TYPE OF FEEDER	CAPACITY IN GALLONS	MAXIMUM WORKING PRESSURE	SIZE OF VALVES AND FITTINGS	A	B	SHIPPING WEIGHT
HV	2	300 P.S.I.	3/4"	7	18-3/4	23 lbs.
AV	5	300 P.S.I.	3/4"	10 1/4	20-1/2	39 lbs.

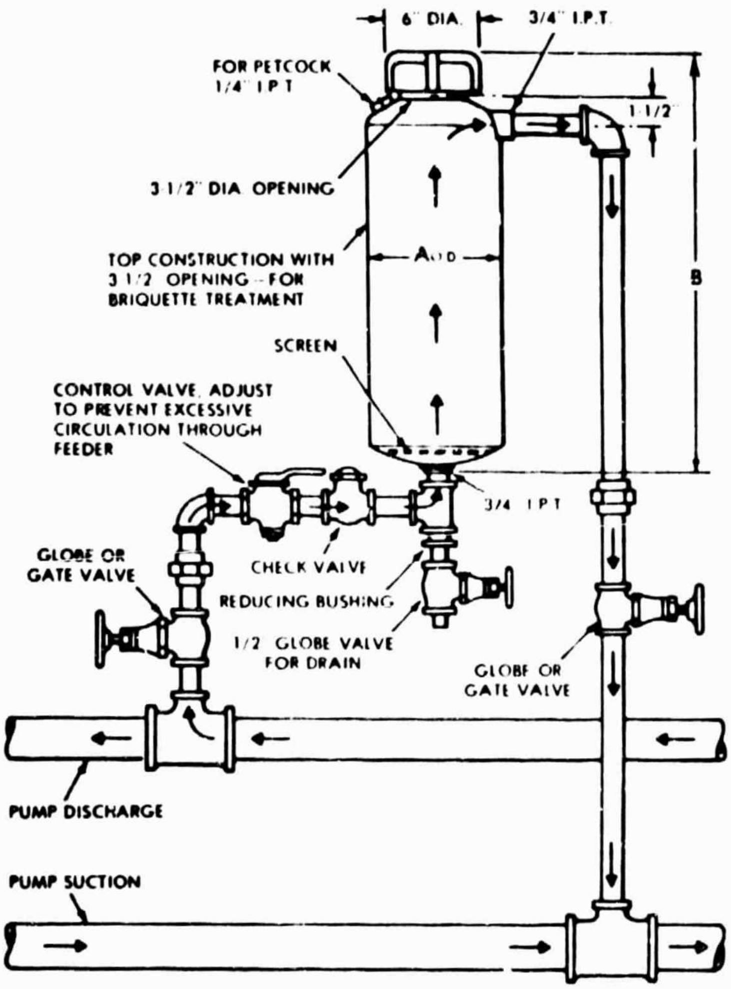
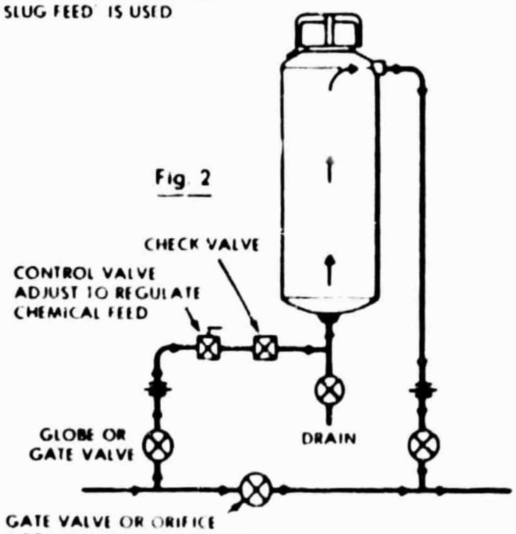


Fig. 1

NOTE: CONTROL VALVE NOT REQUIRED WHEN "SLUG FEED" IS USED

Fig. 2



BELL & GOSSETT ITT
Fluid Handling Division

The Rolairtrol Air Separator

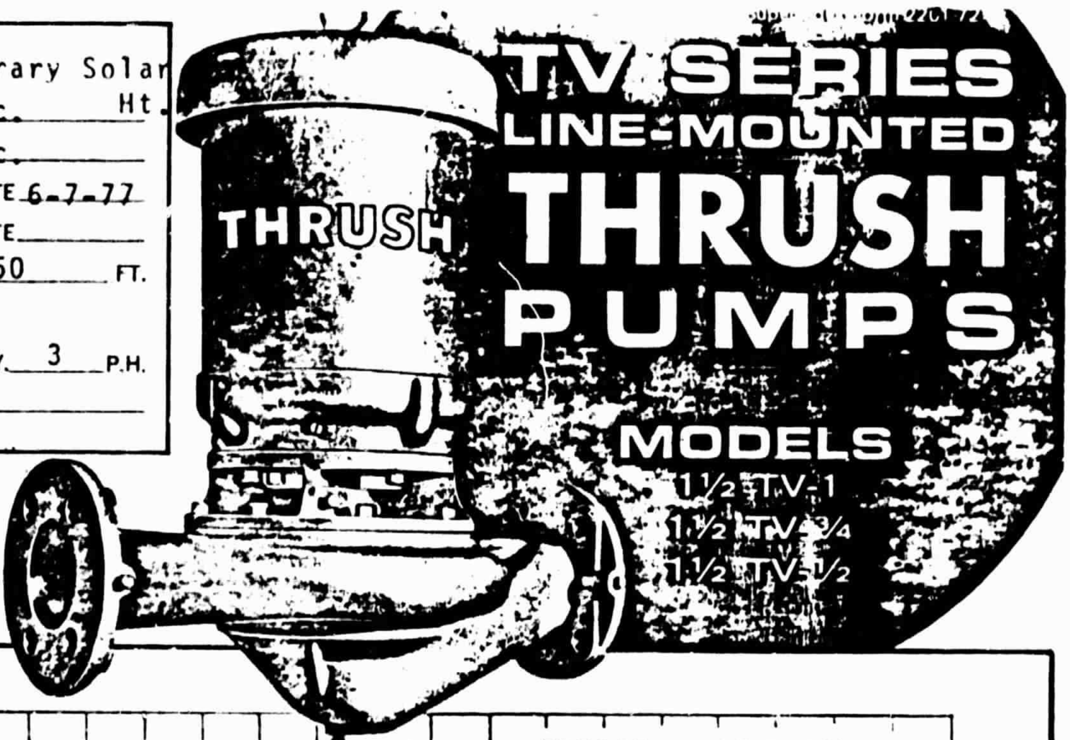
Model No. RL-2-1/2

Less Straines

Capacity: 90 GPM

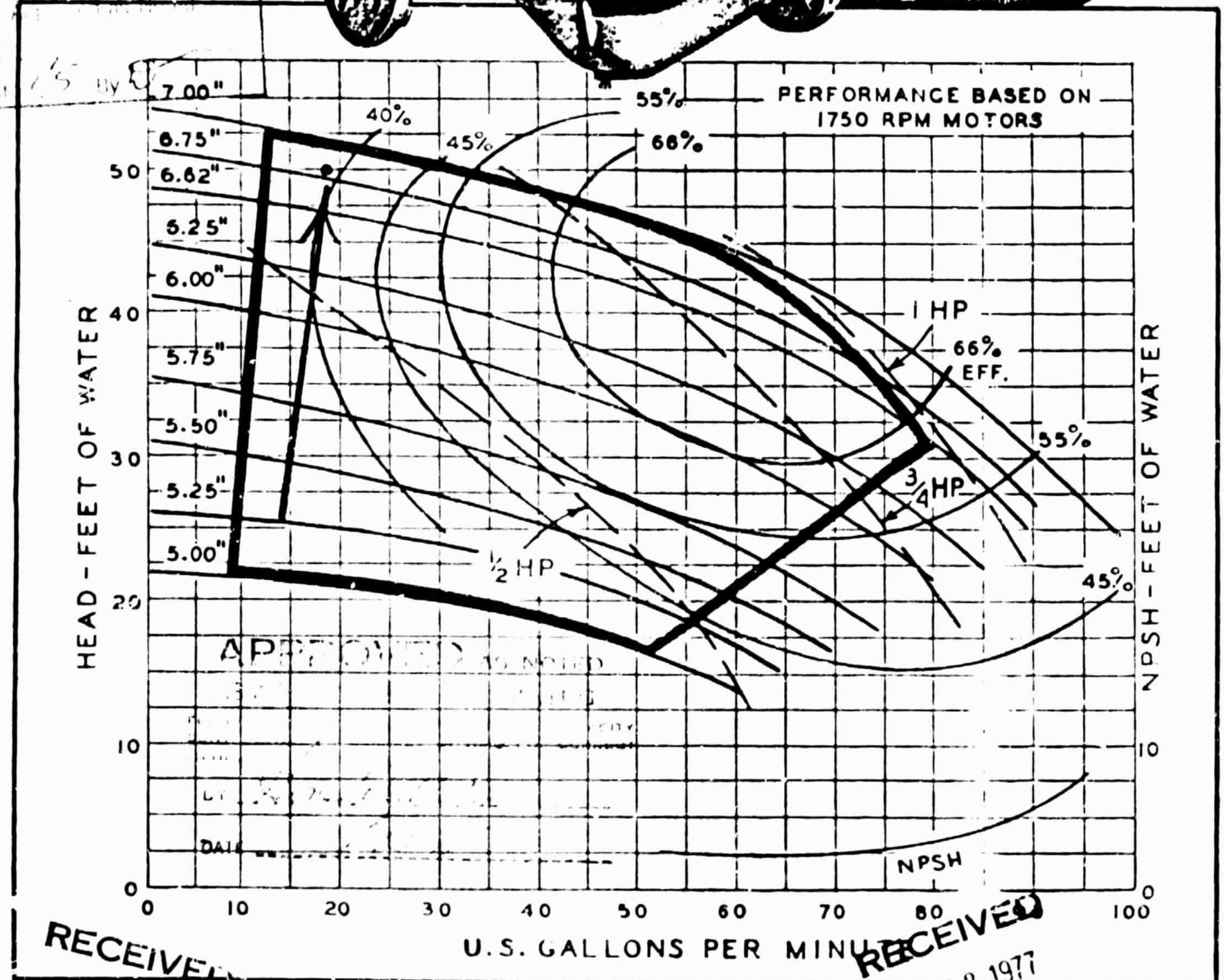
JOB Troy- Miami Library Solar Ht.
ENGINEER Heapy & Assoc.
CONTRACTOR Starco, Inc.
SUBMITTED BY WeberHuff DATE 6-7-77
APPROVED BY ____ DATE ____
18 GPM 50 FT.

ELECTRICAL DATA:
480 VOLTS 60 CY. 3 P.H.
MODEL 1½ TV 1



TV SERIES LINE-MOUNTED THRUSH PUMPS

MODELS
1 1/2 TV-1
1 1/2 TV-3/4
1 1/2 TV-1/2

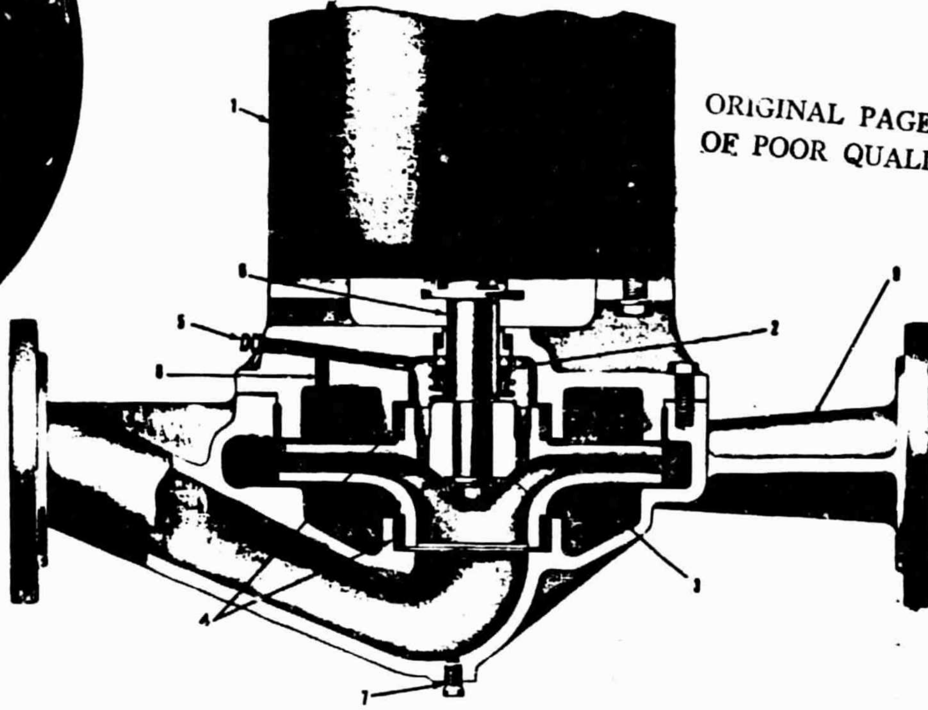


THRUSH Products, Inc.

MODELS

1½ TV-1
1½ TV-¾
1½ TV-½

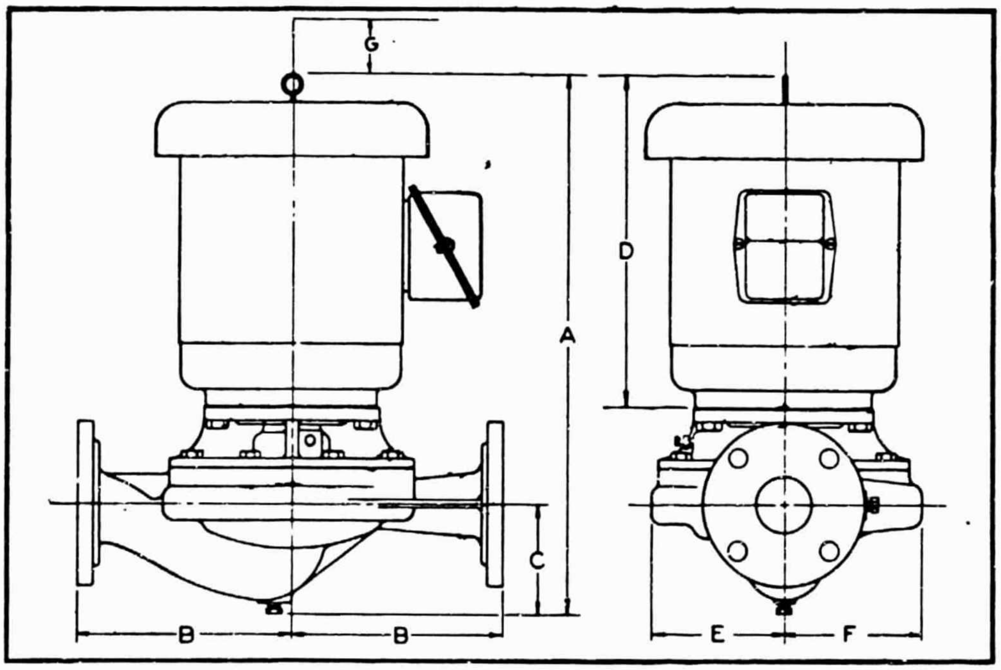
ORIGINAL PAGE IS
OF POOR QUALITY



Specifications

1. Extra quiet, 1750 rpm motor. Standard construction is drip-proof. (Special construction and special electrical characteristics are available at extra cost.)
2. Mechanical seals have high temperature faces and E.P.T. elastomer as standard. Maximum recommended operating temperature - 250° F. Maximum recommended operating pressure - 175 PSIG
3. Bronze impeller — dynamically balanced.
4. Double bronze wear rings — optional.
5. Manual vent plug.
6. Bronze motor shaft sleeve.
7. Drain Plug.
8. Built-in bypass automatically purges air from mechanical seal chamber as well as carrying off frictional heat developed at seal faces.
9. Diffuser section, designed as a part of the casing, allows discharge connection to be same size as the suction connection to simplify piping.
10. Pressure gauge tappings on suction and discharge flanges of casing are provided as standard.
11. Casing flanges are built for companion A.S.A. 125 pound flanges. (Companion flanges not furnished.)

TV SERIES, LINE-MOUNTED **THRUSH PUMPS**



TV Series Thrush Pumps are single-suction, close-coupled, closed impeller, designed for efficient, quiet operation in heating and air conditioning systems. Extra quiet motor, shell molding and coring of impeller and pump volute assure quiet, vibration-free service. Center line suction and discharge divides pump weight evenly. No foundation, floor space or vibration dampeners are required. Pipe and fittings are saved with these line-supported Thrush Pumps. Complete rotating unit may be removed for inspection or maintenance without breaking flanged pipe connections. A diffuser section, designed as a part of the Pump casing, allows the discharge connection to be the same size as the suction connection. TV Series Thrush Pumps are built to time-tested principles by the oldest manufacturer of line-mounted Centrifugal Pumps and Circulators.

MODEL NO.	SUCTION AND DISCHARGE	MOTOR H.P.	SHIPPING WT. LBS.	A	B	C	D	E	F	G
1½ TV-1	1½″	1	108	20⅞″	8″	2½″	13⅛″	4¾″	5″	3″
1½ TV-¾	1½″	¾	86	17⅛″	8″	2½″	9⅜″	4¾″	5″	3″
1½ TV-½	1½″	½	76	16¾″	8″	2½″	9″	4¾″	5″	3″

THRUSH

THRUSH Products, Inc.
P. O. Box 228 • Peru, Indiana 46970

C-3

Litho In U.S.A.

THE [illegible] COMPANY - LA CROSSE, WISCONSIN 54601

SUBMITTAL DATA

ARCHITECT	**APPROVAL STAMP**
ENGINEER: [illegible]	A[illegible] AS NOTED
PROJECT: [illegible]	[illegible] MATES
ORDER DATE / CUSTOMER ORDER NUMBER: [illegible] / CUSTOMER ACCOUNT NO: [illegible] 66-1399-6	FO[illegible] ENT CAPACITY C[illegible] FOR CORRECT F[illegible]
SOLD TO: [illegible], Inc. P.O. Box 158 [illegible] Station [illegible], Ohio 45417 (INCLUDE ZIP CODE)	B: Gene Walls [illegible] DATE: 7-13-77

TAG: [ ] CLIMATE CH. [X] TORRIVENT [ ] CAB FAN [ ] CENT. A.C. CONDENSER

UNIT

QUAN OF UNITS	SIZE	MODEL (1)	Submittal Drawing
2	17	Arr. 6. Vertical Floor; DISCHARGE: Vert. Discharge; ZONES	— adjust RPM to match data

SCFM	ESP	TSP	BHP	RPM	DIAMETER	TYPE	NUMBER OF FANS
[illegible]		1.12 (.75)	3.79	708	15	TC	2

COILS

QTY PER UNIT	COILS	COIL TYPE (2)	SIZE WIDE	SIZE LONG	SERIES	TUBES Rows	TUBES Mat (3)	SUPPLY	TURBS CIRC (4)	KW / MBH	EAT DB WB	LAT DB WB	FLUID TYPE (5)	GPM OR PRESS	TEMP IN OUT	WATER ΔP FEET OF H2O	COIL NO. 812
	PREHEAT SECTION																
2	FIRST IN CASING	W	[illegible]	72	18	2	A	R	8	713.7	90	149.8	HW	149.8	220/ 180	.92	16
	SECOND IN CASING																
	MULTI ZONE																

Air pressure drop = .50

ACCESSORIES

1" 3/4 lb. neoprene insulation

STARCO, INC.
[✓] Approved as Submitted
[ ] Approved as Noted
[ ] ____
Date 7/5 By ____

RECEIVED JUL 13 1977 Richard Levin Assoc., Inc.

RECEIVED JUL 14 1977 Richard Levin Assoc., Inc.

INLET VANES [ ] AUTOMATIC (by others) [ ] MANUAL

ISOLATORS: [ ] FLOOR [ ] CEILING [ ] RIS [ ] SPRING

2 DRIVE [illegible] RPM [ ] FIXED [X] VARIABLE [ ] 1.2 MHP [X] 1.5 MHP [X] ENCL. BELT GD.

MOTOR

2 MOTOR 7.5 HP 480 V 60 CY 3 PH 1730 RPM MOUNT [ ] RIGHT [X] LEFT [ ] OPEN [ ] SPECIAL

MAGNETIC STARTER: By Others

MECHANICAL SPECIFICATIONS – STANDARD CLIMATE CHANGERS

CASINGS – Removable Panels Phosphatized and Painted

COILS – Plate Fins – Seamless copper tubes with galvanized steel casings. All coils are pitched in the unit.

FANS – Forwardly Curved – in LP and MP units in Size 31 and smaller. Backwardly Inclined in HP units Size 25 and smaller. Air Foil in LP and MP Sizes 35 and larger and HP Sizes 31 and larger.

BEARINGS 200,000 hour average life – Greasable

DRAIN PANS – Extended under both Fan and Coil Section on all cooling units. Pan is covered with 1/2" foam in place insulation.

MODEL (1)
LP Low Pressure
MP Med. Pressure
HP High Pressure
DT Draw Thru
MZ Multi-Zone
DD Double Duct
SC Spray Coil
T Torrivent or Cabinet Fan
TC Condenser

COOLING COILS (2)
W Standard Water
D Drainable
DD Double Circuit Drainable
K Cleanable
F 1 – Refrigerant - 12
F 2 – Refrigerant - 22

HOT WATER COILS (2)
AW Single Pass Opposite End Connections
WS Two Pass Same End Connections

STEAM COILS (2)
A Single Pass Opposite End Connections
N Non Freeze Opposite End Connections

TUBE MATERIAL (3)
[illegible] Standard Copper
C .016 Red Brass
D .049 Red Brass

TURBULATORS (4)
O Without
T With

CIRCUITS
Tubes Fed

FLUID TYPE (5)
12 Refrigerant 12
22 Refrigerant 22
CW Chilled Water
HW Hot Water
ST Steam
SP Special

SALES ORDER NUMBER
Rewrite #1
K-[illegible]-K394

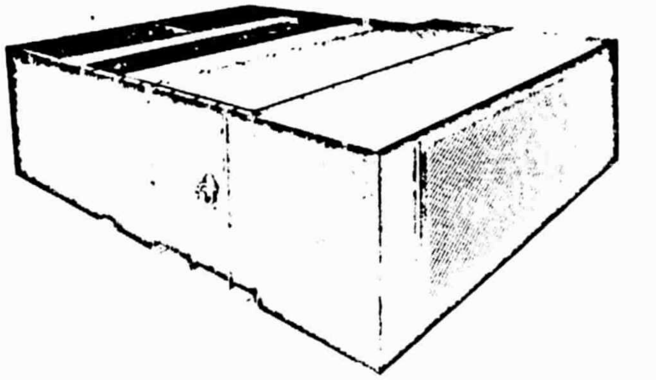
SHEET 1 OF 1

SUBMITTAL DATA

T-30 338 (9/75)

HORIZONTAL, VERTICAL AND VERTICAL INVERTED TORRIVENTS®

SIZES NO. T7, T9, T17, T21, T24, T25, T31 AND T31V



MECHANICAL SPECIFICATIONS

UNIT CASING — Constructed of high grade steel reinforced and braced with steel angle framework. Removable panels provide access to all internal parts. Sectionalized construction consisting of fan section and coil section.

UNIT INSULATION — (Optional) — Panels insulated with one of the following:
1" blanket fiber glass, 1/8" sprayed undercoat or 1/2" blanket fiber glass.

CENTRIFUGAL FANS — Double width, double inlet, forward curved, multi-blade type. Shaft operated below its first critical speed. Bearings grease lubricated. Bearings have 200,000 hour average life. Fan housing die-formed and air tight. Fans dynamically balanced and run tested after installation in unit casing.

COILS — Continuous copper plate fin or Sigma-Flo® aluminum fins and copper tube type. Fin collars drawn and belled; fins bonded to tubes by mechanical expansion. No soldering or tinning used in bonding process. Coils removable through access panels.

UNIT AND ACCESSORY FINISH — Casing and all accessories, except coil, chemically cleaned, phosphatized, and coated with baked on enamel.

FILTER AND MIXING BOXES — Filter and combination filter-mixing boxes designed to hold low or high velocity, 2 inch permanent or throwaway type filters. Flat filter boxes with access doors on both sides, all others with large, single access door. Mixing box damper blades are the parallel type, set for merging of air stream inside the box. Blades locked to slotted rods which rotate in nylon bushings.

DISCHARGE PLENUMS — Straight-thru discharge plenums internally insulated with neoprene faced 1/2" fiber glass. As specified, plenum provided with 1" duct collar, discharge grille with adjustable horizontal louvers, discharge grille with adjustable horizontal and vertical louvers or insulated sound baffles.

FACE AND BYPASS DAMPERS — Opposed blade type dampers locked to slotted damper rods. Damper rods rotate in rust-proof nylon bushings.

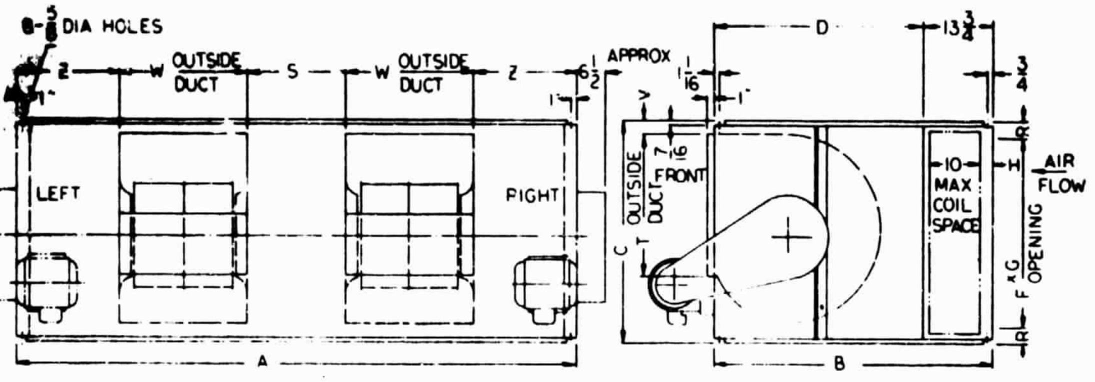
TABLE 1—Metal Gauges

	ITEM	T7	T9	T17	T21	T24	T25	T31	T31V
FAN SECTION	DISCHARGE PANEL	16	16	[illegible]	[illegible]	14	14	14	14
	END PANELS	16	16	14	14	12	12	12	12
	REMAINING PANEL	18	18	18	18	18	18	18	18
COIL SECTION	TOP AND BOTTOM PANELS	18	18	18	[illegible]	[illegible]	18	18	18
	SIDE PANELS	16	16	14	[illegible]	12	12	12	12
	COIL SUPPORT CHANNELS	12	12	12	10	10	10	10	10

TABLE 2—Fan Sizes

UNIT SIZE	NO FANS	FAN SIZES
T7	2	[illegible]
T9	2	[illegible]
T17	2	[illegible]
T21	2	[illegible]
T24	3	[illegible]
T25	2	[illegible]
T31	2	[illegible]
T31V	2	[illegible]

BASIC HORIZONTAL FAN AND COIL SECTION

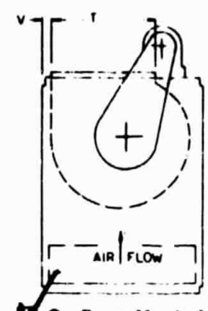


T 24 HAS 3 FANS ADD S AND W FOR EXTRA FAN

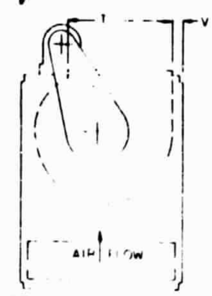
TABLE 3

	UNIT SIZE	COIL SIZE FULL COIL	COIL SIZE MOD. COIL	A	B	C	D	F	G	H	K	[illegible]	[illegible]	V	W	Z
	T[illegible]	18 × 48	[illegible] × 48	6[illegible]	[illegible]	[illegible]	21[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2[illegible]	12[illegible]	12[illegible]
	T9	[illegible]	[illegible]	85	[illegible]	23[illegible]	23[illegible]	[illegible]	[illegible]	3[illegible]	3[illegible]	[illegible]	[illegible]	[illegible]	16[illegible]	8[illegible]
✓	[illegible]	32 × [illegible]	24 × [illegible]	91	[illegible]	33[illegible]	[illegible]	[illegible]	[illegible]	3[illegible]	2[illegible]	8[illegible]	12[illegible]	$2\frac{1}{2}$	$20\frac{1}{4}$	16
	T[illegible]	[illegible] × 96	24 × [illegible]	109	[illegible]	33[illegible]	[illegible]	[illegible]	[illegible]	$3\frac{3}{4}$	2[illegible]	[illegible]	22[illegible]	[illegible]	22[illegible]	[illegible]
	T24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	T[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	$50\frac{13}{16}$	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	26[illegible]	16[illegible]

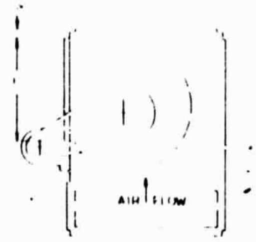
VERTICAL UNITS



☑ G Front Vertical

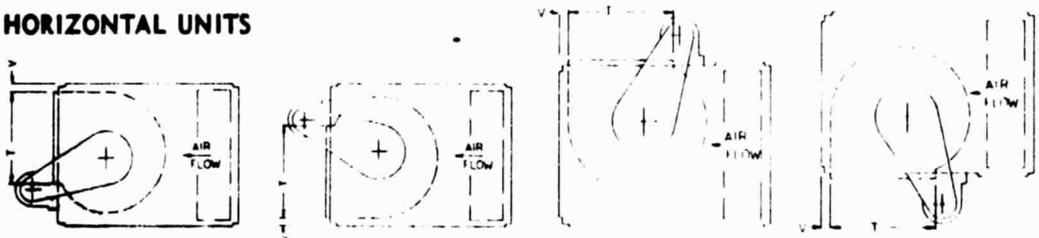


☐ H Back Vertical



☐ K Front Horizontal

HORIZONTAL UNITS



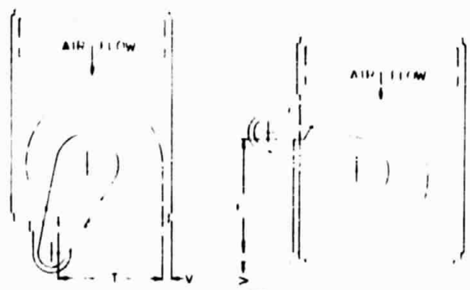
TOP HORIZONTAL
☐ A Floor Mounted
☐ D Ceiling Mounted

BOTTOM HORIZONTAL
☐ B Floor Mounted
☐ E Ceiling Mounted

TOP VERTICAL
☐ C Floor Mounted

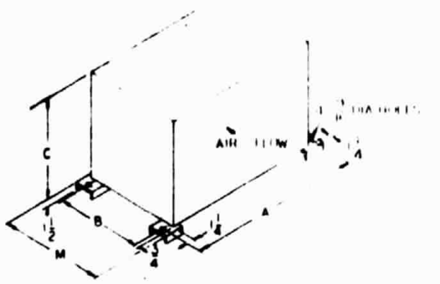
BOTTOM VERTICAL
☐ F Ceiling Mounted

VERTICAL INVERTED UNITS



☐ M Back Vertical
☐ N Bottom Horizontal

MOUNTING DIMENSIONS—Horizontal Floor, Vertical Wall and Vertical Inverted Wall



MOUNTING DIMENSIONS— Vertical Inverted Ceiling

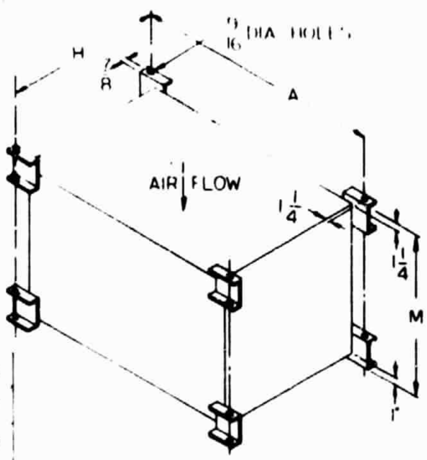
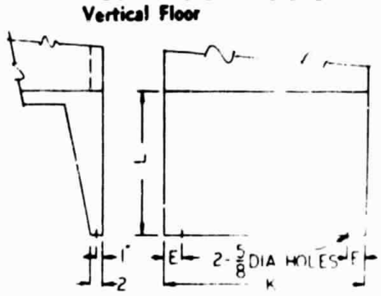


TABLE 4

	UNIT SIZE	A	B	C	E	H	K	L	M
	T7	$63\frac{1}{2}$	33	$21\frac{9}{16}$	[illegible]	[illegible]	[illegible]	14	[illegible]
	T9	$87\frac{1}{2}$	[illegible]5	$23\frac{9}{16}$	2	25	[illegible]	14	39
	T17	[illegible]	45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	T[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	T24 T25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	T31 T31V	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

MOUNTING DIMENSIONS— Vertical Floor



STRAIGHT-THRU DISCHARGE PLENUM

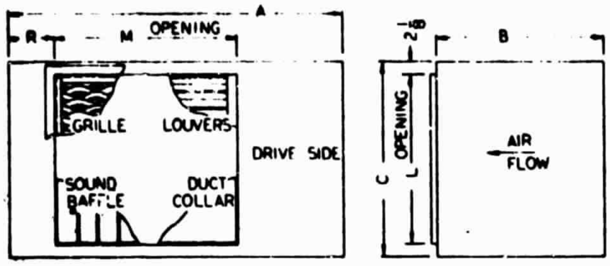
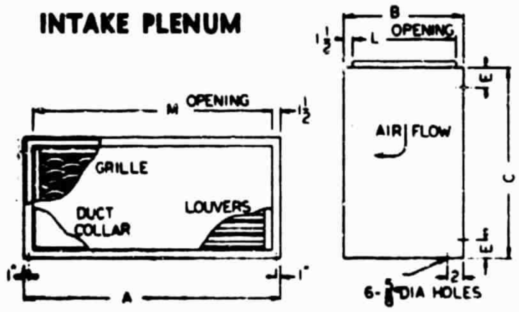


TABLE 5

	UNIT SIZE	A	B	C	L	M	R
☐	T7	66	20	21 1/4	17	36	12 1/2
☐	T9	90	25	23 1/4	19	60	11 1/16
☐	T17	98	30	33 1/4	29	60	15 1/4
☐	T21	116	30	33 1/4	29	75	16 11/16
☐	T24 T25	122	35	37 1/4	33	80	17 7/16
☐	T31	122	35	47 1/4	43	80	16 1/16

INTAKE PLENUM

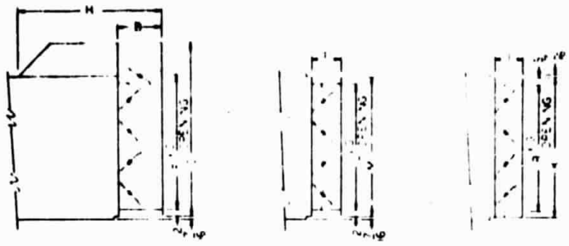


TOP VIEW

TABLE 8

	UNIT SIZE	A	B	C	E	L	M
☐	T7	61	14 3/8	21	2	11 3/8	58
☐	T9	85	14 3/8	23	2	11 3/8	82
☐	T17	91	22 1/2	33	3	19 1/2	88
☐	T21	109	22 1/2	33	3	19 1/2	106
☐	T24 & T25	115	25	37	3	22	112
☐	T31 & T31V	115	30 7/8	47	3	21 1/8	112

FACE AND BYPASS DAMPERS



☐ **EXTERNAL FACE AND BYPASS DAMPER WITH DUCT**

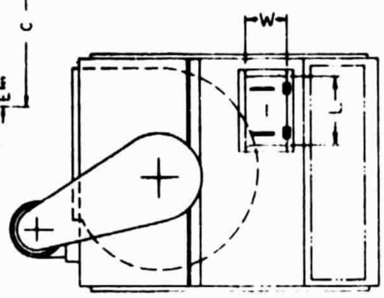
☐ **FACE DAMPER**

☐ **INTERNAL FACE AND BYPASS DAMPER**

TABLE 6

	UNIT SIZE	B	C	F	[illegible]	[illegible]	J	[illegible]	[illegible]	M	[illegible]	S	T
☐	T7	8 1/16	26 1/4	17 1/4	[illegible]	[illegible]	[illegible]	21	17	[illegible]	17 1/4	1 7/8	7
☐	T9	7 9/16	28 9/16	19 1/4	[illegible]	[illegible]	5 3/4	[illegible]	[illegible]	[illegible]	19	2	[illegible]
☐	T17	11 1/16	41 9/16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	9
☐	T21	11 1/16	41 9/16	29 1/4	102 1/4	[illegible]	9 1/2	33 1/8	[illegible]	[illegible]	[illegible]	2	9
☐	T24 T25	12 9/16	46 1/2	33 1/4	108 1/4	41 1/8	12 1/4	37	33	37	33	2	9 3/4
☐	T31 T31V	14 9/16	58 9/16	43 1/4	108 1/4	43 1/8	8	47 1/16	43	47	43 1/4	2	9 3/4

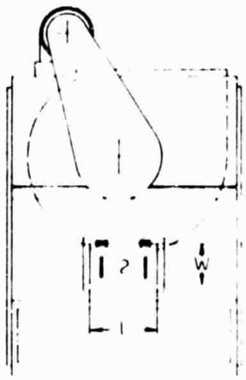
ACCESS DOORS



☐ **ACCESS DOOR 1**

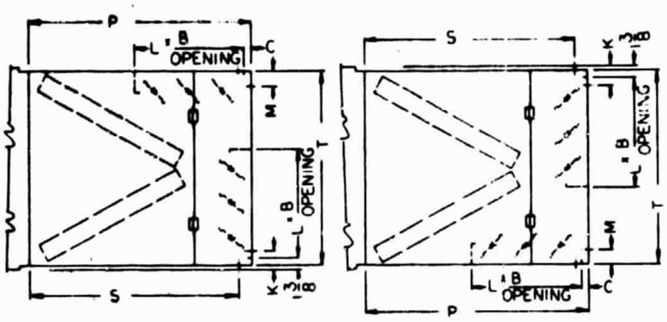
TABLE 7

	UNIT SIZE	ACCESS DOOR 1 OR 2 L	W
☐	T7	12	6
☐	T9	12	6
☐	T17	18	10
☐	T21	18	10
☐	T24 T25	18	10
☐	T31 T31V	18	10



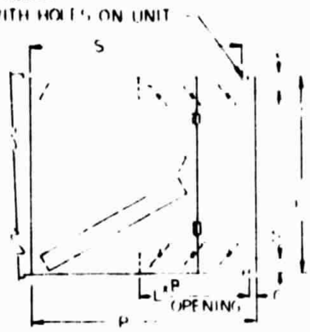
☐ **ACCESS DOOR 2**

DELUXE COMBINATION FILTER-MIXING BOXES



☐ **HORIZONTAL—Top and Back**
☐ **VERTICAL—Back and Bottom**
☐ **VERTICAL INVERTED Top and Front**

☐ **HORIZONTAL—Back and Bottom**
☐ **VERTICAL—Front and Bottom**
☐ **VERTICAL INVERTED Top and Back**

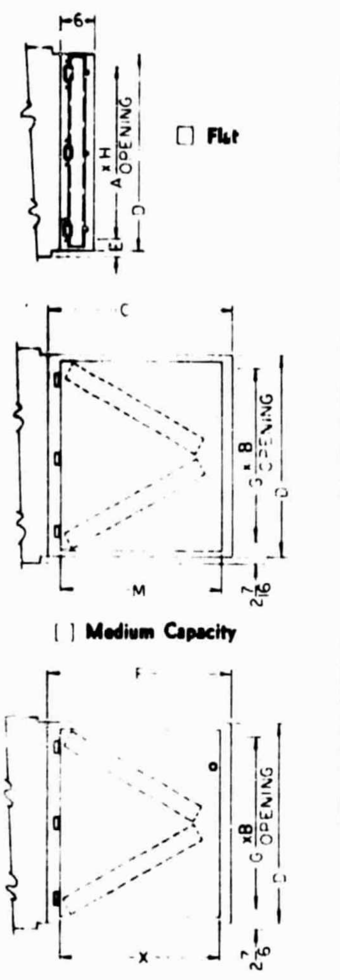


☐ **HORIZONTAL—Top and Bottom**
☐ **VERTICAL—Front and Back**
☐ **VERTICAL INVERTED Front and Back**

TABLE 9

	UNIT SIZE	FILTERS COMB. BOX NO.	SIZE	B	C	K	L	[illegible]				
☐	T7	4	16 x [illegible]	[illegible]	2	2 1/16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
☐	T9	[illegible]	16 x [illegible]	[illegible]	[illegible]	2 1/16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
☐	T17	8	20 x [illegible]	[illegible]	1	3 1/16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
☐	T21	10	20 x [illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
☐	T24 T25	6 / 6	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
☐												
☐	T31	[illegible] / 8	[illegible]	[illegible]	1	3 1/16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

FILTER BOXES

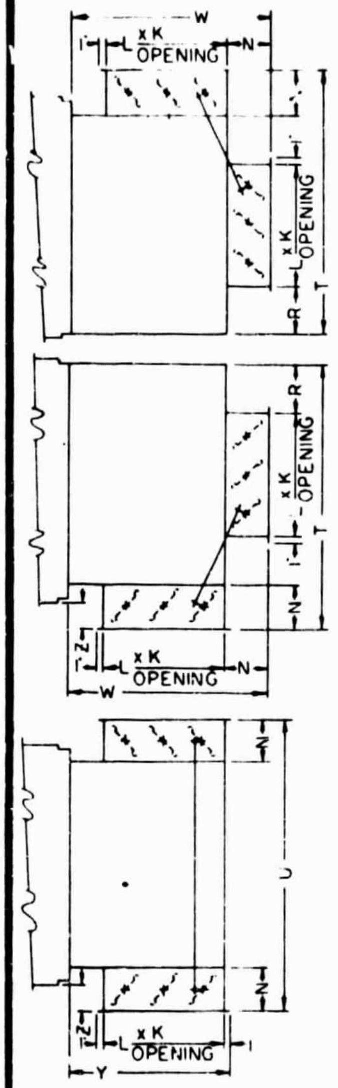


☐ Flat

[ ] Medium Capacity

☐ High Capacity

MIXING BOXES*

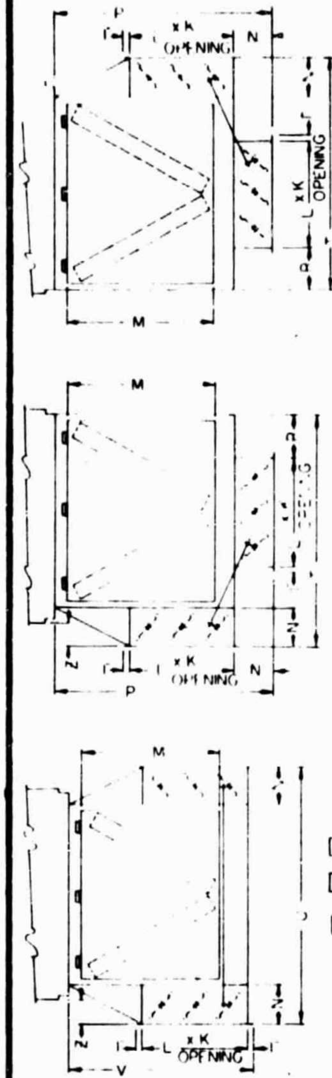


☐ HORIZONTAL– Top & Back
☐ VERTICAL– Back & Bottom
☐ VERTICAL INVERTED– Top & Front

[ ] HORIZONTAL– Back & Bottom
[ ] VERTICAL– Front & Bottom
☐ VERTICAL INVERTED– Top & Back

[ ] HORIZONTAL– Top & Bottom
☐ VERTICAL– Front & Back
[ ] VERTICAL INVERTED– Front & Back

COMBINATION FILTER-MIXING BOXES*



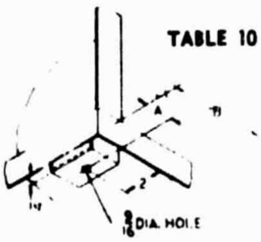
☐ HORIZONTAL– Top & Back
☐ VERTICAL– Back & Bottom
☐ VERTICAL INVERTED– Top & Front

[ ] HORIZONTAL– Back & Bottom
[ ] VERTICAL– Front & Bottom
[ ] VERTICAL INVERTED– Top & Back

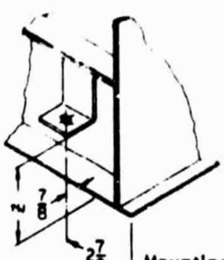
[ ] HORIZONTAL– Top & Bottom
☐ VERTICAL– Front & Back
☐ VERTICAL INVERTED– Front & Back

TABLE 10

UNIT SIZE	A
T7	[illegible]
T9	[illegible]
T17	[illegible]
T21	[illegible]
T24 T25	[illegible]
T31	[illegible]

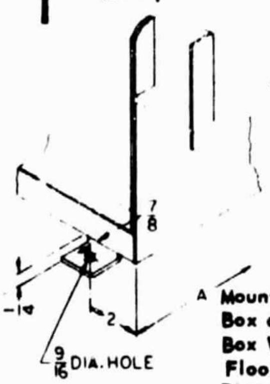


Mounting Dimensions-Medium and High Capacity Filter Boxes. See General Note 5.



UNIT SIZE	A	Z
[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]
17	[illegible]	4 3/16
21	108	4 3/16
25	114	3 3/16
31	115	4 3/16

Mounting Dimensions-Mixing Box or Combination Filter-Mixing Box With Inlet on Bottom, Floor Mounting, or Inlet Top, Ceiling Mounting. See General Note 5.



Mounting Dimensions-Mixing Box or Combination Filter-Mixing Box With Inlets on Back and Top, Floor Mounting, or Back and Bottom, Ceiling Mounting. See General Note 5.

TABLE 10

UNIT SIZE	FILTERS FLAT NO	FLAT SIZE	MED CAP NO	MED CAP SIZE	HIGH CAP NO	HIGH CAP SIZE	COMB BOX NO	COMB BOX SIZE	A	B	C	D	E	F	G	H	K	L	M	N	P	R	T	U	V	W	X	Y	Z
T7	1 2	16 × 20 20 × 20	4	16 × 25	2 4	16 × 20 20 × 20	4	16 × 25	17	51	19 3/4	21*	2 7/16	23 3/4	17	57	54 5/8	12 1/2	17 3/8	5 3/4	28 3/4	4 1/4	24 3/4	28 1/2	24	21 1/4	21 3/8	17	5 3/8
T9	4	20 × 20	8	16 × 20	8	20 × 20	8	16 × 20	18 5/8	81	19 3/8	23	2 3/8	23 1/2	19	81	75 5/8	12 1/2	17	5 3/4	28 3/4	5 1/4	26 3/4	30 1/2	24	21 1/4	21 [illegible]	17	5 3/8
T17	6 2	16 × 20 16 × 25	8	20 × 25	9 3	20 × 20 20 × 25	8	20 × 25	29 1/4	87	27	33	2 5/16	23 1/2	29	87	84 3/8	20 1/2	24 5/8	6 3/4	39 3/4	6 1/4	37 3/4	42 1/2	34	30 3/4	21 1/8	25	4 5/16
T21	8 2	16 × 20 16 × 25	10	20 × 25	12 3	20 × 20 20 × 25	10	20 × 25	29 1/4	105	27	33	2 5/16	23 1/2	29	105	102 1/4	20 1/2	24 3/8	6 3/4	39 3/4	6 1/4	37 3/4	42 1/2	34	30 3/4	21 1/8	25	4 5/16
T24 & T25	12	16 × 20	6 6	16 × 25 20 × 25	9 6	20 × 20 20 × 25	6 6	16 × 25 20 × 25	33 1/2	111	25 3/4	37	2 5/16	23	33	111 1/2	108 1/4	22 1/2	23 3/8	5 3/4	37 1/2	7 1/4	40 3/4	44 1/2	32 3/4	31 3/4	20 3/8	27	3 5/16
T31 & T31V	7 7	16 × 20 16 × 25	12 8	16 × 20 16 × 25	12 8	20 × 20 20 × 25	12 8	16 × 20 16 × 25	42 1/4	111	18 3/4	47	2 13/16	23 1/8	43	111 1/2	108 1/4	26 1/2	16 3/8	6 3/4	38 1/4	10 1/4	51 3/4	56 1/2	32 1/2	38 1/4	20 1/4	32 1/2	4 3/16

* D DIM ON 7 FLAT FILTER BOX IS 20 1/2

TABLE 11 -- APPROXIMATE OPERATING WTS. (LBS.)

	UNIT MODEL NUMBER																		
	3	6	7	8	9	10	12	14	17	21	24	25	31	35	41	50	63	73	86
TORRIVENT																			
CASING ONLY	155	215	255	330	400	360	390	490	515	600	765	900	970	1725	2210	2450	2850		
1 ROW LARGE	213	307	351	451	529	489	555	675	730	852	1050	1185	1355	2153	2699	3012	3628		
2 ROW LARGE	235	352	417	485	615	537	647	776	843	983	1206	1441	1587	2610	2986	3360	4063		
ACCESSORIES																			
FLAT FILTER BOX																			
THROWAWAY	28	38	42	45	54	68	73	76	92	113	120	120	135	170	180	210	335		
LOW VELOCITY PERMANENT	33	47	52	56	67	84	91	97	117	145	155	155	183	222	234	284	426		
HIGH VELOCITY PERMANENT	51	63	69	75	91	108	120	131	156	193	207	207	257	306	338	365	582		
MEDIUM FILTER BOX																			
THROWAWAY	78	101	131	144	167	171	178	228	247	303	324	324	355	370	456	520	565	655	775
LOW VELOCITY PERMANENT	84	117	149	162	191	195	204	260	284	348	373	373	413	429	546	631	695	805	950
HIGH VELOCITY PERMANENT	96	141	181	190	227	231	248	312	347	428	456	456	513	557	706	799	935	1085	1275
HIGH CAPACITY BOX																			
THROWAWAY	111	148	155	170	180	192	229	260	278	330	398	398	425	470	535	590	680		
LOW VELOCITY PERMANENT	120	166	184	194	208	223	261	305	324	393	468	468	512	574	660	735	865		
HIGH VELOCITY PERMANENT	136	198	217	230	257	271	317	360	396	489	576	576	648	742	852	950	1160		
ROLL FILTER	80	114		142		158	187	204	219	250		290	363	430	475	500	750	870	1025
COMB. FILT-MIX BOX																			
THROWAWAY	115	168	200	248	255	286	300	315	358	400	490	490	620	710	790	885	1113	1310	1550
LOW VELOCITY PERMANENT	122	184	217	266	279	310	324	345	393	441	540	540	686	780	874	997	1265	1485	1730
HIGH VELOCITY PERMANENT	134	208	249	298	315	346	368	397	456	521	625	625	786	906	1035	1165	1505	1740	2060
DELUXE COMB. FILTER MIX BOX																			
THROWAWAY	193	240	263	352	369	376	407	474	501	586	604	604	732	986					
LOW VELOCITY PERMANENT	200	256	280	370	393	400	431	504	536	627	654	654	798	1056					
HIGH VELOCITY PERMANENT	212	280	312	402	429	436	475	556	600	707	739	739	858	1182					
MIXING BOX	82	118	122	160	175	182	256	270	319	340	380	380	437	519	623	750	869	1010	1185
EXTERNAL FACE AND BYPASS	40	58	79	96	100	112	154	161	170	216	241	292	417	457	470	618	925	1070	1265
INTERNAL FACE AND BYPASS	30	53	74	77	92	100	109	113	124	184	211	223	327	334	363	441	535		
FACE DAMPERS	36	55	65	91	102	106	111	115	142	225	232	232	297	312	370	446	545		
STRAIGHT THRU DISCHARGE PLENUM	50	65	90	100	130	110	130	150	170	180	200	200	300	400	400				
WALL INTAKE BOX																			
STEEL	90	110	110	150	220	240	270	330	310	480	600	600	725	800	930	1140	1450		
ALUMINUM	40	50	50	75	105	170	115	15	115	255	380	380	460	525	605	745	940		

GENERAL NOTES

1. Discharge plenums are not available for units with 90 degree rotated fans or "X" units.
2. Connection sides for coils and damper rods and motor drive positions are determined by facing front of unit. The arrangement drawings shown above indicate right side of unit.
3. Drives, coil and damper rods may be furnished either right or left hand as specified on the order.
4. Damper drive rods are 7/16" diameter with a 1/2" adapter.
5. For ceiling suspension accessory mounting legs must be bolted to tops of accessories similar to bolting shown on Page 4. Legs will project above Torrivent unit 1/4". No other change in leg dimensions.

TABLE 12 – WATER AND STEAM COILS

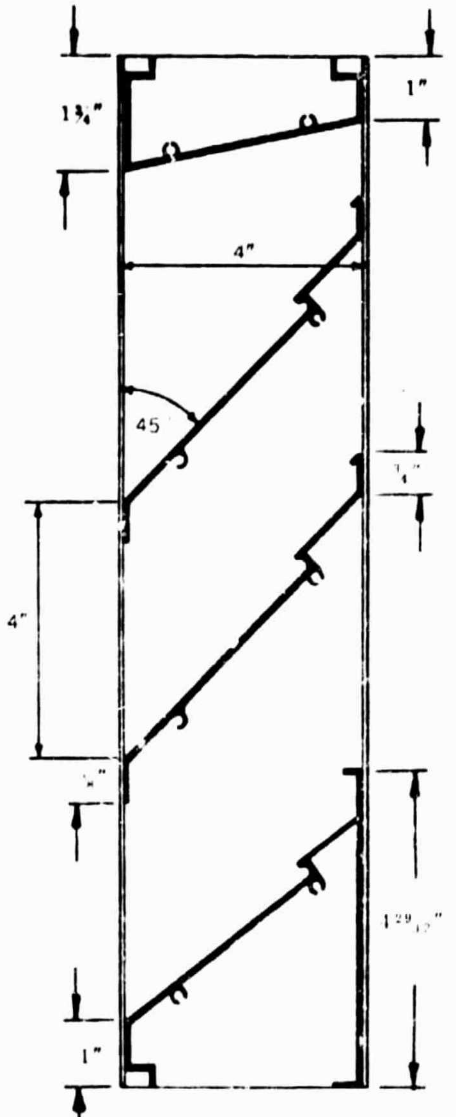
COIL TYPE	HEADER HEIGHT	CONNECTION SIZE SUPPLY	RETURN	DRAIN & VENT
W - WATER	18, 24, 30, 33	2½ N.P.T.	2½ N.P.T.	
D - DRAINABLE	18, 24, 30, 33	2½ N.P.T.	2½ N.P.T.	½ N.P.T. (EXT)
DD - DRAINABLE	18, 24, 30, 33	2½ N.P.T.	2½ N.P.T.	½ N.P.T. (EXT)
K - CLEANABLE	18, 24, 30, 33	2½ N.P.T.	2½ N.P.T.	
P2 - WATER	12, 18, 24, 30	3/4 N.P.T.	3/4 N.P.T.	–
P4 - WATER	12, 18, 24, 30	1 N.P.T.	1 N.P.T.	–
P8 - WATER	18, 24, 30	1¼ N.P.T.	1¼ N.P.T.	–
A - STEAM	18, 24, 30, 33	2½ N.P.T.	1 N.P.T.	
AW - HOT WATER	18, 24, 30, 33	2½ N.P.T.	2½ N.P.T.	
WC - HOT WATER	12, 16	1 N.P.T.	1 N.P.T.	
WC - HOT WATER	24	1½ N.P.T.	1½ N.P.T.	
WC - HOT WATER	30, 33	2½ N.P.T.	2½ N.P.T.	
N, NS	12	1½ N.P.T.	1 N.P.T.	
N, NS	18	2 N.P.T.	1 N.P.T.	
N, NS	24	2½ N.P.T.	1¼ N.P.T.	
N, NS	30, 33	3 N.P.T.	1¼ N.P.T.	

All 12" header height coils, Types A, AW, D, K, and W, supply 1¼ N.P.T., return 1¼ N.P.T.
Above connections internal except drain and vent.

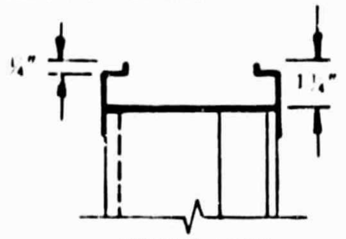
AIRLINE PRODUCTS COMPANY

STATIONARY EXTRUDED WEATHER-RESISTANT LOUVER

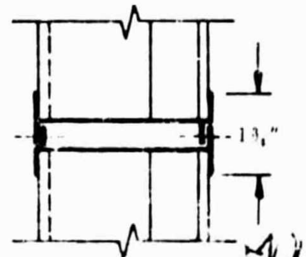
XB 4



VERTICAL SECTION

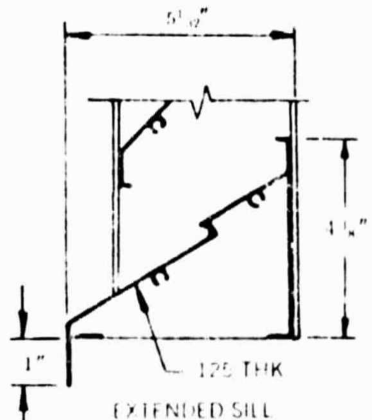


TYPICAL JAMB



TYPICAL VERTICAL MULLION

MULLION TO BE @ CENTER OF LOUVER, IF REQ'D



EXTENDED SILL

2 pcs. - 108 x 32

SCREEN

SCREEN MOUNTED IN EXTRUDED REMOVABLE FRAME IS ATTACHED TO LOUVER WITH S/S SCREWS SPECIFY MATERIAL AND SIZE OF MESH

½" Galv.

SCREEN MOUNTED INTERIOR SIDE ☒
EXTERIOR ☐

GENERAL NOTES

1. STANDARD CONSTRUCTION .081 ALUMINUM, ALLOY 6063 T5, [redacted] FINISH. **Dark Bronze**
2. LOUVER SIZE = OPENING SIZE LESS 1/4".
3. THE MAXIMUM LOUVER WIDTH = 96". LARGER SIZES ARE MADE IN SECTIONS WITH VERTICAL MULLIONS.

(SEE REVERSE SIDE FOR SCHEDULE OF SIZES)

DWG. NO.	JOB NAME **Solar Heat**
JOB NO.	ARCHITECT
DATE	ENGINEER
	CUSTOMER **Enterprise Roofing & Sht.Mtl.**

AIRLINE PRODUCTS COMPANY
Hagerstown, Md.
THIS DRAWING SUPERSEDES ALL PREVIOUS ISSUES

APPROVED AS NOTED
DATE 7-13-77

STARCO, INC.
☒ Approved as Submitted
☐ Approved as Noted
☐
Date ___ By ___

RECEIVED
JUL 14 1977
Richard Levin Assoc., Inc.

RECEIVED
JUL 13 1977
Richard Levin Assoc., Inc.

RUSKIN MANUFACTURING COMPANY

Control Dampers

Type CD35-0BC
Variations 1-2-5

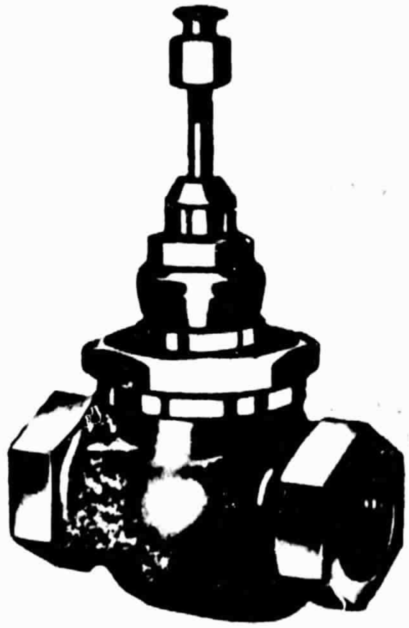
Honeywell

Single Seated Valves

MODEL NUMBER V5011A-E

General

These single-seated, two-way, straight through valves provide proportional control of steam, liquids, air, or other non-combustible gases in HVAC systems requiring tight shut-off. They are available in bronze bodies with screwed NPT end connections or cast iron bodies with flanged end connections.



Features

- Direct or reverse acting.
- Stainless steel stem with removable composition disc and self-adjusting, spring loaded Teflon packing.
- Bronze, brass, or stainless steel plugs provide equal percentage or linear flow characteristics.
- High pressure models available (V5011D or E).
- Stainless steel, metal-to-metal seating available in smaller valve sizes.
- Suitable for pneumatic (1/2 to 6 in.) or electric (1/2 to 4 in.) actuation with proper linkage.
- Repack and rebuild kits available for field servicing.

Specifications

MODELS

V5011A: Direct acting (stem down to close) single-seated valve. Equal percentage flow. Screwed (1/2 to 3 in.) or flanged (2-1/2 to 6 in.) end connections. 125 and 150 psi (860 and 1035 kPa) body pressure rating.

V5011B: Same as V5011A except reverse acting (stem down to open). Flanged end connections only, 4 to 6 in.

V5011C: Direct acting single-seated valve. Linear flow characteristics for modulating low or intermediate pressure steam. Screwed end connections only, 1/2 to 3 in. Metal-to-metal seating (1/2 to 1-1/2 in. valves).

V5011D: Same as V5011A except 250 psi (1725 kPa) body pressure rating. Flanged end connections only, 2-1/2 to 6 in.

V5011E: Same as V5011B except 250 psi (1725 kPa) body pressure rating, 4 to 6 in.

Rev. 10-76
R.F.L.

Form Number 77-5315
Commercial Div

CLOSE-OFF RATINGS

Refer to Figs. 1A through 1G and Table 1.

VALVE RATINGS

Refer to Table 2.

CONTROL AGENTS AND DISCS

Refer to Table 3.

END CONNECTIONS, PLUGS, SIZES, AND CAPACITIES (Cv's)

Refer to Table 4.

STEM TRAVEL

1/2 to 3 in. valves: 3/4 in. (19 mm).
4, 5, and 6 in. valves: 1-1/2 in. (38 mm).

TRIM MATERIALS

Packing: Teflon Cone for 125 psi (860 kPa) flanged and 150 psi (1035 kPa) screwed valves, all sizes. Teflon "V" Ring for 250 psi (1725 kPa) valves, 1-1/2 to 6 in. size.

Disc: Removable composition.

Disc Holder: Screwed Bodies - Brass, Flanged Bodies - Cast Iron.

Plug: Screwed Bodies - Contoured. For Cv's of 4.0 and below - Stainless Steel. For Cv's above 4.0 - Brass. Flanged Bodies - V-Ported, skirt guided bronze for all sizes.

Seat: (Replaceable, screwed into body) Screwed Bodies - Brass. Flanged Bodies - Bronze.

DIMENSIONS

Refer to Figs. 8, 9 and 10 and Tables 5 and 6.

ACCESSORIES

Packing Conversion Kits (for converting to high pressure applications):
14002920-001 – Rubber "V" Ring for 1/2 to 1-1/4 in. valves.
14002920-002 – Teflon "V" Ring for 1-1/2 to 3 in. valves.

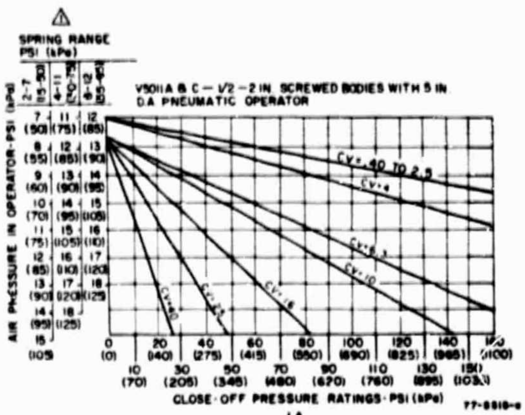
WHEN SPECIFYING, INDICATE

1. Model Number
2. Accessories
3. Actuator (Refer to Valve/Operator Selection Table 7)

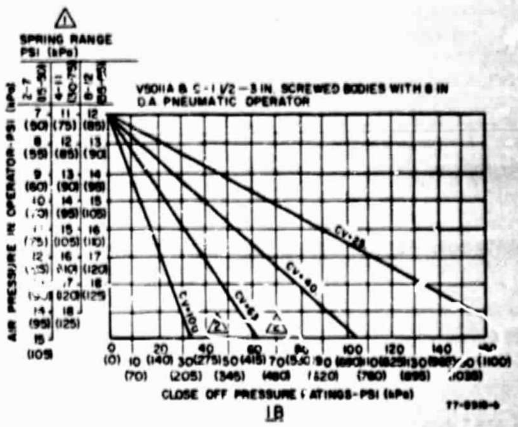
Repack and Rebuild Kits

SERVICELINE Kit No.	Pipe Size (Inches)	Cv	Stem Size	Disc Size
14002694-001	1/2, 3/4, 1	4.0 or less	1/4 in.	1/2 in.
14002695-001	3/4, 1, 1-1/4	6.3 or 10.0	1/4 in.	3/4 in.
14003109-001	1-1/4	16.0	1/4 in.	1 in.
14003110-001	1-1/2, 2, 2-1/2	25.0	3/8 in.	1-1/4 in.
14003111-001	2, 2-1/2, 3	40.0	3/8 in.	1-1/2 in.
14003294-001	1/2, 3/4, 1, 1-3/4		1/4 in.	
14003295-001	1-1/2, 2, 2-1/2, 3		3/8 in.	
14003296-001	4, 5, 6		1/2 in.	

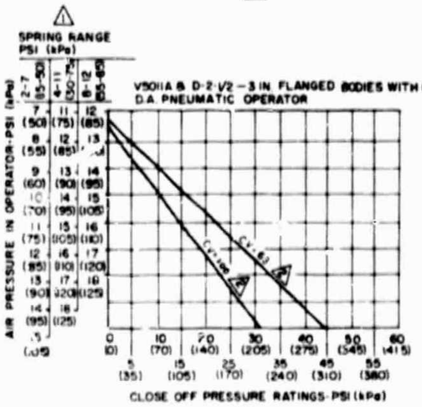
NOTE: No kits are available for 1-1/2, 2, and 2-1/2 in. valves having a Cv of less than 25.0



1A



1B



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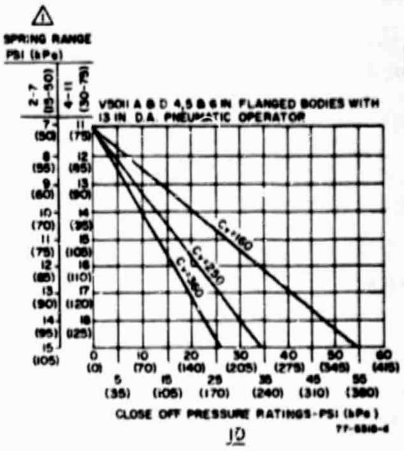

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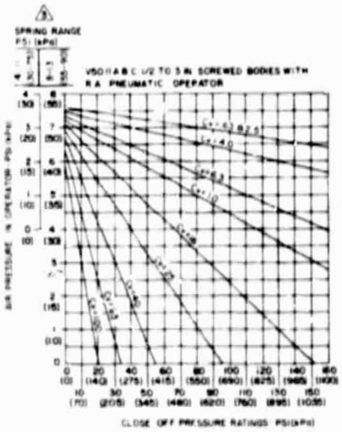
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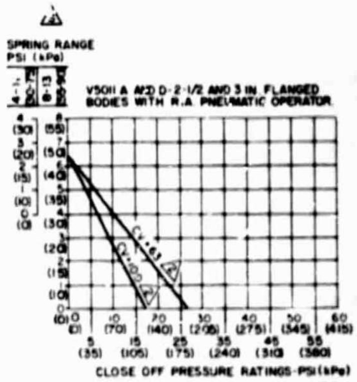

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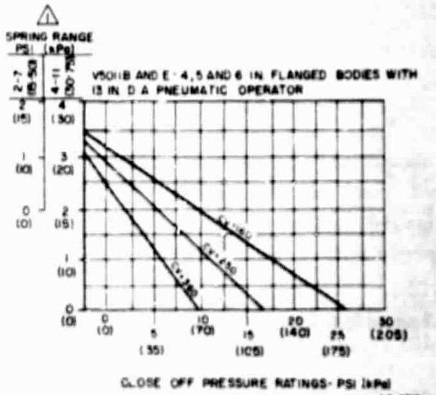

1G

⚠1 **USE 4-11 PSI (30-75 kPa) RANGE FOR DETERMINING CLOSE OFF OF VALVES USED WITH MP953A.**

⚠2 **DUE TO DIFFERENCES IN VALVE BODY CONSTRUCTION, SCREWED AND FLANGED PATTERNS HAVE DIFFERENT CLOSE-OFF RATINGS. THIS APPLIES TO VALVES IN THE 2-1/2 AND 3 IN. SIZES. SEE 1A AND 1B.**

⚠3 **USE 8-13 PSI (55-90 kPa) RANGE FOR DETERMINING CLOSE OFF OF VALVES USED WITH MP953B.**

FIG. 1–CLOSE-OFF PRESSURES AT VARIOUS CONTROL AIR PRESSURES FOR V5011A-E SINGLE-SEATED VALVES AND MP953 PNEUMATIC OPERATORS

77-5315

TABLE 1—CLOSE-OFF RATINGS FOR V5011A-E WITH ELECTRIC ACTUATORS

Model Number	Close-Off Pressure Ratings psi (kPa) — Linkage Seal-Off Force[a] 160 lb	80 lb	Cv
V5011A & C Screwed Connections	150 (1035)	150 (1035)	.40
			.63
			1.0
			1.6
			2.5
			4.0
	150 (1035)	122 (840)	6.3
	150 (1035)	106 (730)	10
	141 (970)	60 (415)	16
	91 (630)	39 (270)	25
	55 (380)	22 (150)	40
	32 (220)	12 (80)	63
	20 (140)	8 (55)	100
V5011A & D Flanged Connections	26 (175)	10 (70)	63
	20 (140)	7 (50)	100
	10 (70)		160
	6 (40)		250
	4 (30)		360
V5011B & E Flanged Connections	10 (70)		160
	6 (40)		250
	4 (30)		360

[a]Maximum linkage seal-off force on valve stem is either 160 or 80 pounds, depending upon the valve linkage used, as follows:

160 lb — Q618A (160 lb model), Q601D, E, J, K, Q455B, C, D.

80 lb — Q618A (80 lb model), Q601F, G, H, L, M, Q455A, E, F, G.

TABLE 2–VALVE RATINGS[a]

<table>
<tr><td>Body</td><td colspan="3">Screwed, cast-bronze
150 psi at 250F max. steam (1035 kPa at 121C)
250 psi at 250F max. water (1725 kPa at 121C)
Flanged, cast-iron
125 and 250 psi at 250F max.
(860 and 1725 kPa at 121C)</td></tr>
<tr><td rowspan="5">Maximum Pressure Differential for Normal Life of Trim</td><td rowspan="4">Composition discs</td><td rowspan="2">Water</td><td>Proportional, 25 psi (170 kPa)</td></tr>
<tr><td>2-Position, 50 psi (345 kPa)</td></tr>
<tr><td rowspan="2">Steam (A, B & C only)</td><td>Proportional, 35 psi (240 kPa)</td></tr>
<tr><td>2-Position, 70 psi (480 kPa)</td></tr>
<tr><td>Metal-to-metal seats</td><td>Steam only</td><td>100 psi (690 kPa)</td></tr>
<tr><td>Maximum Pressure Differential for Quiet-Water Service</td><td colspan="3">20 psi (140 kPa)</td></tr>
<tr><td>Maximum Pressure Differential for Close off</td><td colspan="3">Refer to Fig. 1</td></tr>
<tr><td rowspan="2">Teflon-Cone Packing (V5011A and C)</td><td>Water[b]</td><td colspan="2">150 psi max. at 250F max. (1035 kPa at 121C); 40F min (4C)</td></tr>
<tr><td>Steam</td><td colspan="2">100 psi max. at 337F max. (680 kPa at 169 kPa)</td></tr>
<tr><td>Teflon-"V" Ring Packing (V5011 D & E and 14002920-002 Kit)</td><td>Water[b]</td><td colspan="2" rowspan="2">250 psi max. at 250F max (1725 kPa at 121C); 40F min (4C)</td></tr>
<tr><td>Rubber-"V" Ring Packing (14002920-001 Kit)</td><td>Water</td></tr>
</table>

[a]For high fluid temperatures, the valve and/or piping should be insulated to prevent ambient temperatures from exceeding ratings at the actuator location.

[b]Maximum-temperature differential in alternate hot-cold water use, 140F.

TABLE 3–RECOMMENDED CONTROL AGENTS AND DISCS AVAILABLE

Model	Body Pattern	Recommended Control Agents	Discs Available (Composition except as noted)
V5011A & D	Screwed	Water	35 to 200F
		Water	115 to 275F
	Flanged	Water	35 to 275F
V5011B	Flanged	Water	35 to 275F
V5011C	Screwed	Steam	115 to 275F
		Steam	275 to 425F
		Steam	Metal-to-metal seats[a]
V5011D	Flanged	Water	35 to 275F
V5011E	Flanged	Water	35 to 275F

[a]Composition disc available in all valve sizes. Metal-to-metal seats available in 1/2 through 1-1/2 in sizes only.

NOTE: 35 to 200F = 2 to 93C
35 to 275F = 2 to 135C
115 to 275F = 46 to 135C
275 to 425F = 135 to 216C

TABLE 4–PLUG CHARACTERISTICS, END CONNECTIONS, SIZES, AND CAPACITY INDEXES (Cv's) AVAILABLE

Model No. and Plug Characteristics	End Connections	Body Size (in.)	Capacity Index (Cv)
V5011A Equal Percentage & V5011C Modified Linear (1/2 to 1-1/2 in. valves only)	Screwed	1/2	0.4, 0.63, 1.0, 1.6, 2.5, 4.0
		3/4	6.3
		1	10.0
		1-1/4	16
		1-1/2	25
		2	40
		2-1/2	63
		3	100
V5011A & D Equal Percentage	Flanged	2-1/2	63
		3	100
V5011A, B, D & E Equal Percentage	Flanged	4	160
		5	250
		6	360

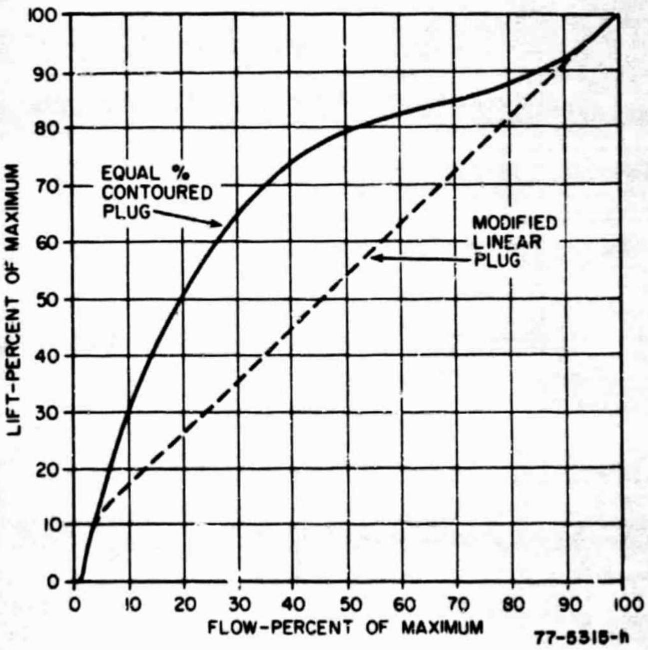

FIG. 2–V5011 AVERAGE FLOW CHARACTERISTICS

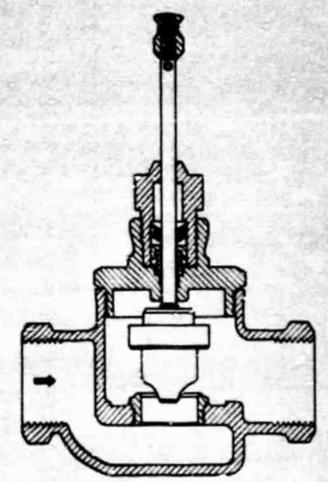

FIG. 3–V5011A & C SCREWED 1/2 TO 3 IN. BRONZE BODY VALVE – 150 PSI (1035 kPa). PACKING SHOWN

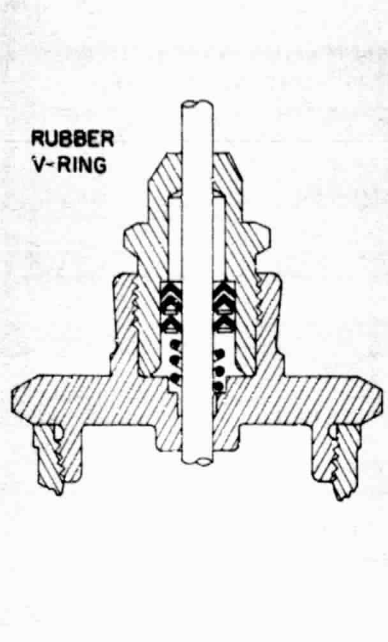

FIG. 4–ACCESSORY 250 PSI (1725 kPa) PACKING FOR 1/2 TO 1-1/4 IN. SCREWED BRONZE BODY VALVES

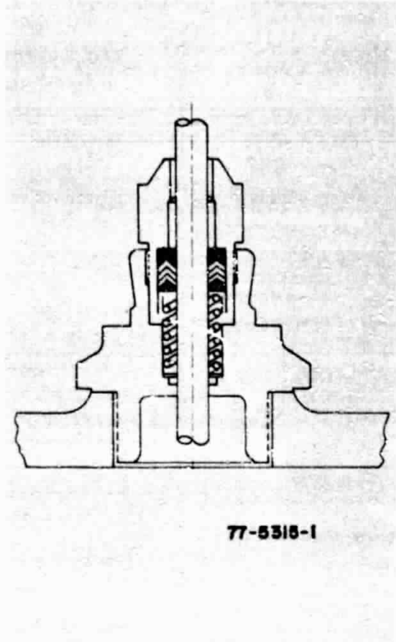

FIG. 5–250 PSI (1725 kPa) PACKING FOR 1-1/2 TO 3 IN. SCREWED BRONZE VALVE BODIES

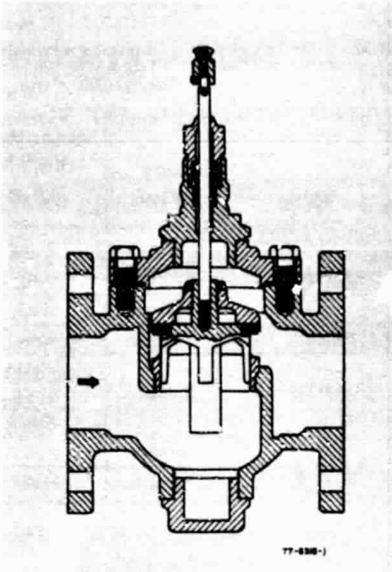

FIG. 6–FLANGED, CAST IRON, DIRECT ACTING, 125 PSI (1035 kPa) VALVE BODY 2-1/2 THRU 6 IN. (THE 250 PSI [1725 kPa] VALVES HAVE RAISED FACE RING)

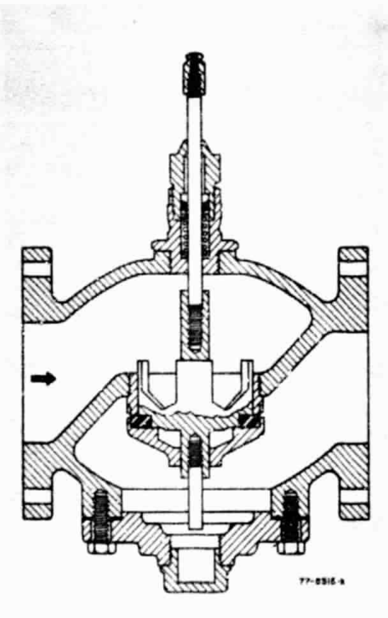

FIG. 7–FLANGED, CAST IRON, REVERSE ACTING, 125 PSI (1035 kPa) VALVE BODY 4 THRU 6 IN. (THE 250 PSI [1725 kPa] VALVES HAVE RAISED FACE RING)

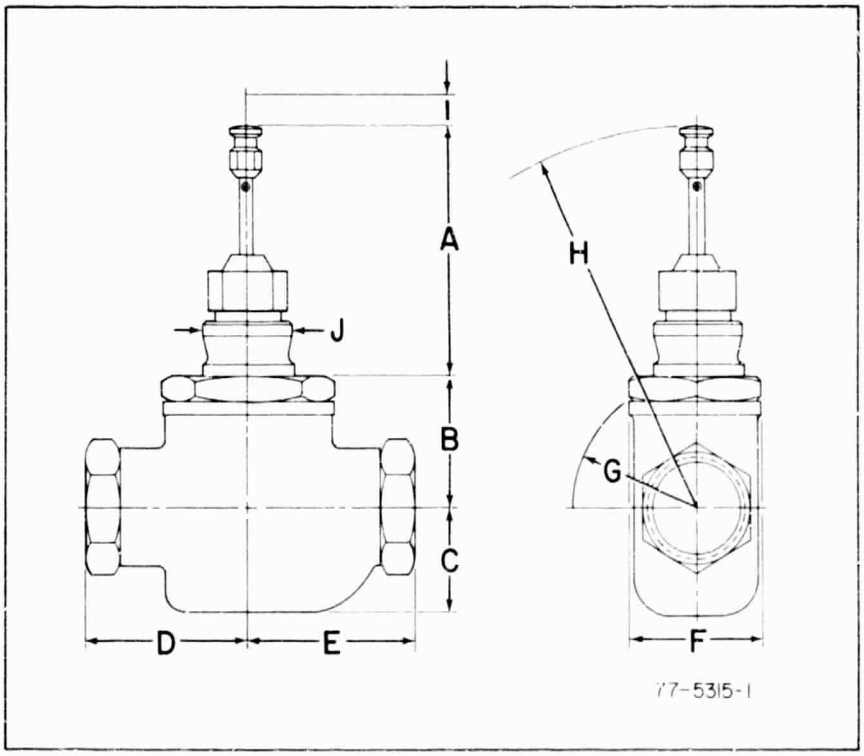

FIG. 8–V5011A & C SCREWED, DIRECT ACTING BODY DIMENSIONS (REFER TO TABLES 5 AND 6)

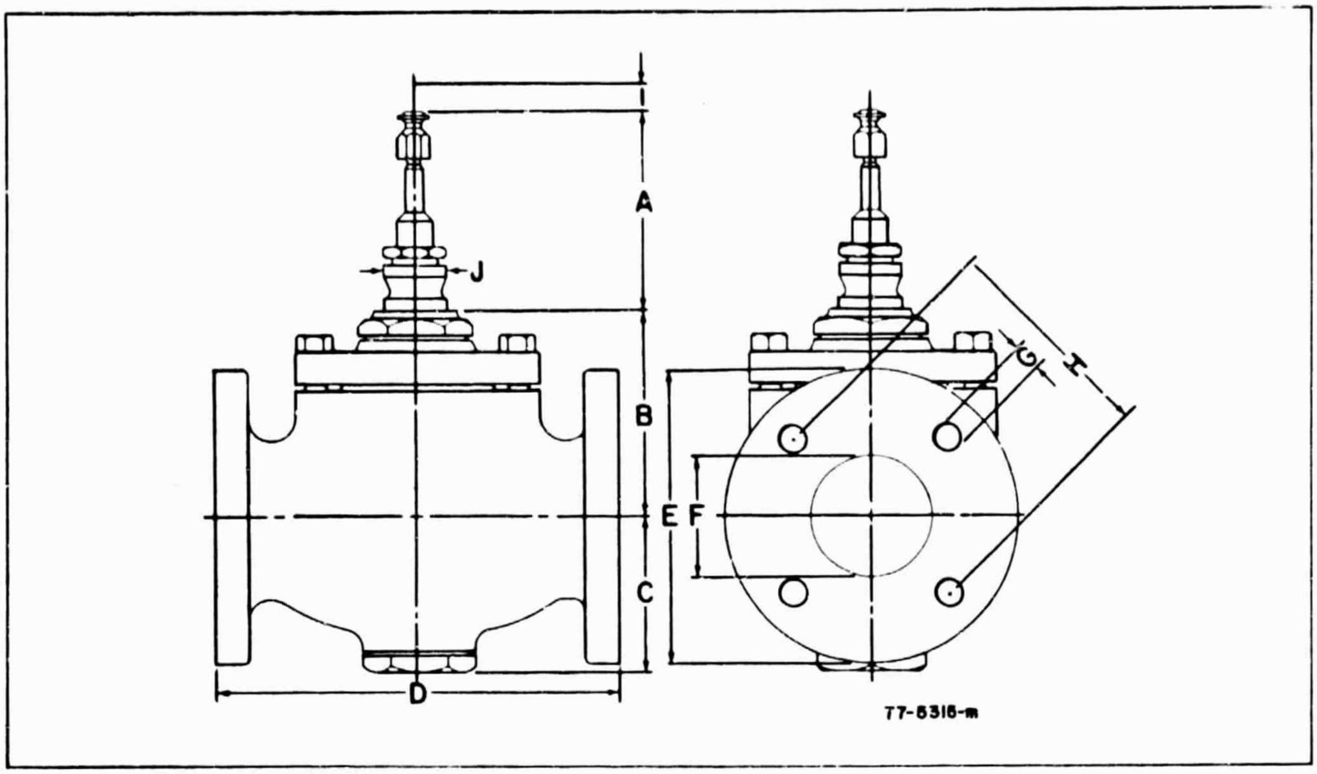

FIG. 9—V5011A & D FLANGED BODY DIMENSIONS (REFER TO TABLES 5 AND 6)

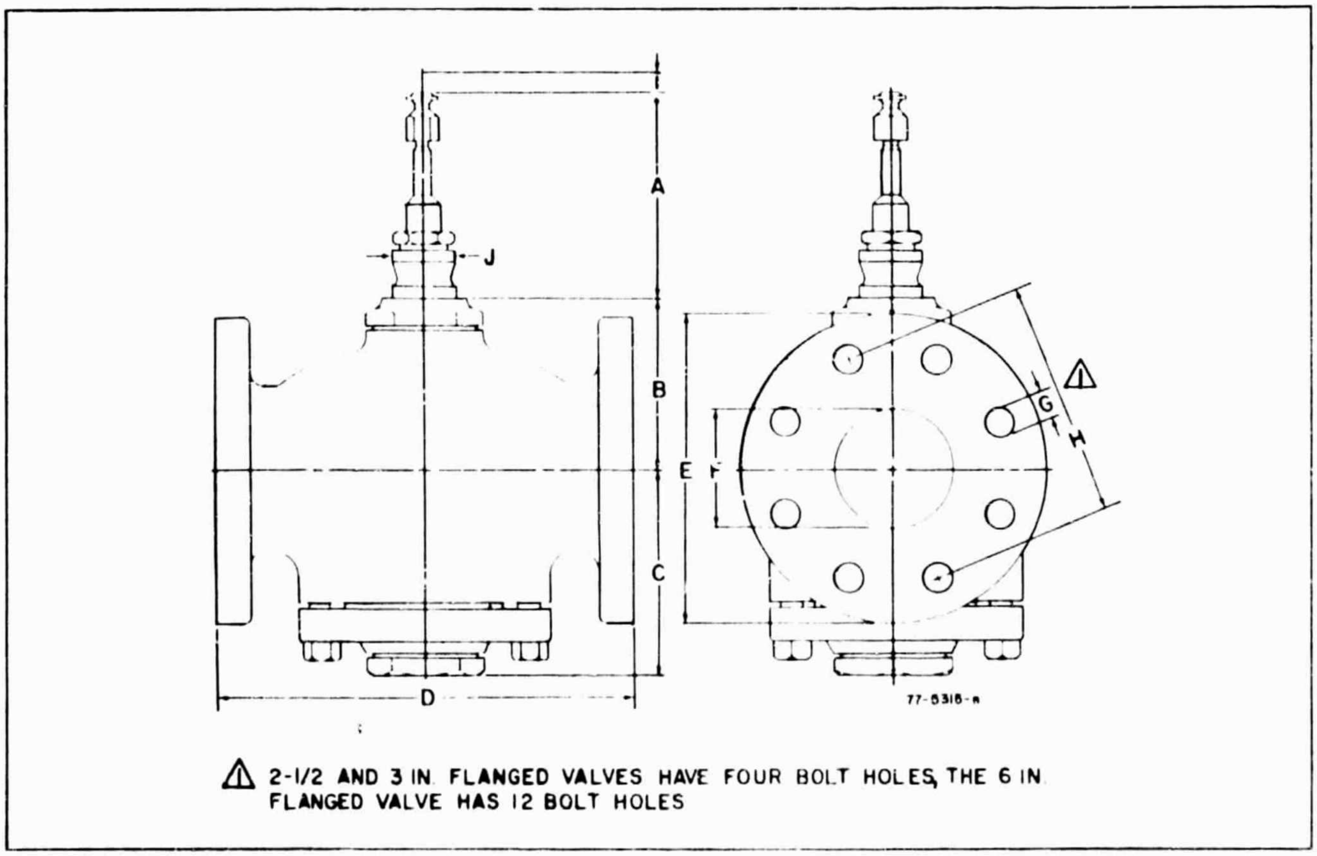

FIG. 10—V5011B & E FLANGED BODY DIMENSIONS (REFER TO TABLES 5 AND 6)

TABLE 5–V5011A-E DIMENSIONS IN INCHES
REFERENCED IN FIGURES 8, 9, & 10

Body Style & Figure Reference	Valve Size (In.)	A[a]	B	C	D	E	F	G	H	I (Travel)	J (Dia.)	No. of Flange Bolt Holes
	1/2	3-1/2	1-1/4	1-3/4	1-1/2	1-7/8	1-13/16	1-5/8	3	3/4	1-3/8	--
	3/4	|	1-1/4	1-3/4	1-1/2	2	1-13/16	1-5/8	3	|	|	--
V5011A & C	1	|	1-3/8	1-5/8	2-1/8	2-1/4	1-15/16	1-3/4	3	|	|	--
Screwed,	1-1/4	|	1-9/16	1-1/2	2-1/2	2-1/2	2-9/16	1-15/16	3-1/16	|	|	--
Direct Body	1-1/2	|	1-11/16	1-3/8	2-7/8	2-7/8	3-9/16	2-11/16	3-1/16	|	|	--
(Fig. 8)	2	|	1-15/16	2	2-7/8	2-7/8	3-5/16	2-5/16	3-15/16	|	|	--
	2-1/2	|	2-3/16	2-3/8	3-3/4	3-3/4	3-3/16	3-1/16	4-9/16	|	|	--
	3	3-1/2	2-5/8	2-3/8	4-7/16	4-7/16	4-15/16	3-5/8	5	3/4	1-3/8	--
V5011A	2-1/2	3-1/2	4-13/16	4	9-1/2	7	2-1/2	3/4	5-1/2	3/4	1-3/8	4
Flanged,	3	3-1/2	5-3/8	4-5/8	11	7-1/2	3	3/4	6	3/4	1-3/8	4
Direct Body	4	5-1/4	7-9/16	5-3/16	13	9	4	3/4	7-1/2	1-1/2	1-7/8	8
(Fig. 9)	5	|	7	6-1/8	15	10	5	7/8	8-1/2	|	|	8
	6	5-1/4	8	7-1/16	16-1/2	11	6	7/8	9-1/2	1-1/2	1-7/8	8
V5011B Flanged,	4	6-3/4	4-11/16	8-1/16	13	9	4	3/4	7-1/2	1-1/2	1-7/8	8
Reverse Body	5	|	5-5/8	7-1/2	15	10	5	7/8	8-1/2	|	|	8
(Fig. 10)	6	6-3/4	6-9/16	8-1/2	16-1/2	11	6	7/8	9-1/2	1-1/2	1-7/8	8
V5011D	2-1/2	3-1/2	4-13/16	3-3/4	11-1/2	7-1/2	2-1/2	7/8	5-7/8	3/4	1-3/8	4
Flanged,	3	3-1/2	5-3/8	4-1/4	12-1/2	8-1/4	3	|	6-5/8	3/4	1-3/8	4
Direct Body	4	5-1/4	7-9/16	5	14-1/2	10	4	|	7-7/8	1-1/2	1-7/8	8
(Fig. 9)	5	|	7	5-1/2	16-3/4	11	5	|	9-1/4	|	|	8
	6	5-1/4	8	6-1/4	18-5/8	12-1/2	6	7/8	10-5/8	1-1/2	1-7/8	12
V5011E Flanged,	4	6-3/4	4-3/4	7-5/16	14-1/2	10	4	7/8	7-7/8	1-1/2	1-7/8	8
Reverse Body	5	|	5-3/4	6-3/4	16-3/4	11	5	|	9-1/4	|	|	8
(Fig. 10)	6	6-3/4	6-11/16	7-7/8	18-5/8	12-1/2	6	7/8	10-5/8	1-1/2	1-7/8	12

[a]Dimension "A" is with Valve closed (stem down for V5011A, C, & D, stem up for V5011B & E)

TABLE 6–V5011A-E DIMENSIONS IN MILLIMETERS REFERENCED IN FIGURES 8, 9, & 10

Body Style & Figure Reference	Valve Size (In.)	A[a]	B	C	D	E	F	G	H	I (Travel)	J (Dia.)	No. of Flange Bolt Holes
	1/2	89	32	44	38	48	46	41	76	19	35	--
	3/4		32	44	38	51	46	41	76			--
V5011A & C	1		35	41	54	57	49	44	76			--
Screwed,	1-1/4		40	38	63	63	65	49	77			--
Direct Body	1-1/2		43	35	73	73	90	68	77			--
(Fig. 8)	2		48	51	73	73	84	58	100			--
	2-1/2		55	60	95	99	182	77	116			--
	3	89	67	60	113	113	125	92	127	19	35	--
V5011A	2-1/2	89	122	102	241	178	63	19	140	19	35	4
Flanged,	3	89	136	117	279	190	76	19	152	19	35	4
Direct Body	4	133	192	132	330	229	102	19	190	38	48	8
(Fig. 9)	5		178	155	381	254	127	22	215			8
	6	133	203	179	419	279	152	22	241	38	48	8
V5011B Flanged,	4	171	119	205	330	229	102	19	190	38	48	8
Reverse Body	5		143	190	381	254	127	22	215			8
(Fig. 10)	6	171	167	216	419	279	152	22	241	38	48	8
V5011D	2-1/2	89	122	95	292	178	63	22	149	19	35	4
Flanged,	3	89	136	108	317	209	76		168	19	35	4
Direct Body	4	133	192	127	368	254	102		200	38	48	8
(Fig. 9)	5		178	140	425	279	127		235			8
	6	133	203	159	473	318	152	22	270	38	48	12
V5011E Flanged,	4	171	120	186	368	254	102	22	200	38	48	8
Reverse Body	5		146	171	425	279	127		235			8
(Fig. 10)	6	171	170	200	473	318	152	22	270	38	48	12

[a]Dimension "A" is with Valve closed (stem down for V5011A, C, & D, stem up for V5011B & E)

Typical Operation

In a normally open application an increase in temperature at the sensor or controller moves the valve stem toward the closed position. In a normally closed application a decrease in temperature moves the valve stem toward the open position.

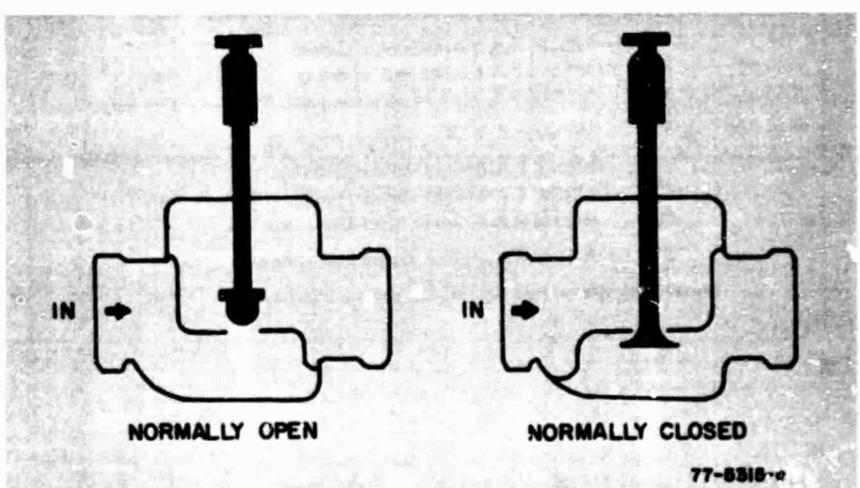

FIG. 11–TYPICAL OPERATION

TABLE 7—VALVE/OPERATOR SELECTION

Valve	Size (Inches)	Cv	⚠1 Pneumatic Operator	⚠2 Electric Actuators				Electronic Actuators
				2-Position or Floating Non-Spring Return	2-Position Spring Return	Proportional Non-Spring Return	Proportional Spring Return	
V5011A	1/2 NPT	.63, 1.0, 1.6, 2.5, 4.0	A1,C1 A2,C2 B1,D1	E or G	H or I	J or L	M or N	O or P
	3/4	6.3						
	1	10						
	1-1/4	16						
	1-1/2	25						
	2	40	A1,C1					
	2-1/2	63						
	3 NPT	100	A2,C2 B1,D1	E or G	H or I	J or L	M or N	O or P
	2-1/2 Flg.	63	A2,C2 B1,D1	E or G	H or I	J or L	M or N	O or P
	3	100	A2,C2 B1,D1	E or G	H or I	J or L	M or N	O or P
	4	160	A3,C3	F	•	K	•	•
	5	250		F	•	K	•	•
	6 Flg.	360	A3,C3	F	•	K	•	•
V5011B	4 Flg.	160	A3,C3	F	•	K	•	•
	5	250		F	•	K	•	•
	6 Flg.	360	A3,C3	F	•	K	•	•
V5011C	1/2 NPT	.40, .63, 1.0, 1.6, 2.5, 4.0	A1,C1 A2,C2 B1,D1	E or G	H or I	J or L	M or N	O or P
	3/4	6.3						
	1	10						
	1-1/4	16						
	1-1/2	25						
	2	40	A1,C1					
	2-1/2	63						
	3 NPT	100	A2,C2 B1,D1	E or G	H or I	J or L	M or N	O or P
V5011D	2-1/2 Flg.	63	A2,C2 B1,D1	E or G	H or I	J or L	M or N	O or P
	3	100	A2,C2 B1,D1	E or G	H or I	J or L	M or N	O or P
	4	160	A3,C3	F	•	K	•	•
	5	250		F	•	K	•	•
	6 Flg.	360	A3,C3	F	•	K	•	•
V5011E	4 Flg.	160	A3,C3	F	•	K	•	•
	5	250		F	•	K	•	•
	6 Flg.	360	A3,C3	F	•	K	•	•

NOTES:

⚠1 The MP953A-D are rolling type diaphragm actuators which provide proportional control of V5011 valves.

- **A1** – MP953A D.A. 5 in. dia. with positioner.
- **A2** – MP953A D.A. 8 in. dia. with positioner.
- **A3** – MP953A D.A. 13 in. dia. with positioner.
- **B1** – MP953B R.A. 7-1/8 in. dia. with positioner.
- **C1** MP953C D.A. 5 in. dia. without positioner.
- **C2** – MP953C D.A. 8 in. dia. without positioner.
- **C3** – MP953C D.A. 13 in. dia. without positioner.
- **D1** – MP953D R.A. 7-1/8 in. dia. without positioner.

*Not recommended for tight close-off. Use pneumatic operator.

⚠2 Example Linkages

Q601E1000 160 lb. seal-off force.
Q618A1024 80 lb. seal-off force.
Q618A1032 160 lb. seal-off force.

Letter Designation	Use Motor Similar to:	with	Linkage Similar to:
E	M644A		Q618A1024
F	M644C		Q601E1000
G	M634B		Q618A1032
H	M845A		Q618A1032
I	M845E		Q618A1032
J	M944A		Q618A1024
K	M944C		Q601E1000
L	M934A		Q618A1032
M	M945A		Q618A1032
N	M945F		Q618A1032
O	M7644B		Q618A1024
P	M7045		Q618A1032

Honeywell

Temperature Controls

VP514A & C SINGLE-SEATED, NORMALLY OPEN, PNEUMATIC VALVE ASSEMBLIES

Specification Data

ORIGINAL PAGE IS
OF POOR QUALITY

APPLICATION

Used for normally open, proportional control of steam, liquids, air, or other non-combustible gases in heating, air-conditioning, and heat-exchanger systems where tight shutoff is required.

Rated for steam or water service. However, for throttling-service on steam coils, the modifier-linear characteristic is preferred; for throttling-service on hot-water coils, the equal-percentage characteristic is preferred. See Table 4 for availability.

NOTE: 1/2 to 3 in. screwed valve bodies can be field converted to 250 psi high pressure service with special kits.
ORDER: 14002920-001 for 1/2 to 1-1/4 in. V5011 bodies.
14002920-002 for 1-1/2 to 3 in. V5011 bodies.

CONSTRUCTION

Single-seated, straight-through, globe body with high-lift plug. Available with American Standard Taper Pipe Threads (NPT) in bronze bodies or American Standard Flanged Ends in cast-iron bodies. Spring-loaded rubber or Teflon packings provide self-adjusting, tight seal-off characteristics for all common control agents in heating and air conditioning systems; however, due to the packing construction, this valve is not suitable for use with combustible gases, particularly liquid-petroleum gas. Supplied in all sizes with a composition disc suitable for pressure drops listed in Table 3. For high pressure service: 250 psig-rated valves are available and stainless-steel, metal-to-metal seating is available in smaller valve sizes.

The MP953A operator used in the VP514A valve assembly is furnished with a Gradutrol* positive-positioning relay. Start point and operating range are adjustable on the positioner to provide sequence operation with other controlled devices. The VP514C assembly is without relay. The operators have a tough, wear-resistant replaceable, neoprene diaphragm. The small operator is also available with a silicone diaphragm for high-temperature applications.

*Trademark
Rev. 1-74
R.F.L.

VP514A With Gradutrol* Relay

ASSEMBLY SPECIFICATIONS

ASSEMBLY COMPONENTS:

Assembly No.	A[illegible]	Valve Body	Positioner
VP514A (N.O.)	MP953A (D.A.)	V5011A, C or D (D.A.)	With
VP514C (N.O.)	MP953C (D.A.)	V5011A, C or D (D.A.)	Without

DIMENSIONS: See Table 1 and Figure 1.

CLOSE-OFF RATINGS: See Figure 2.

VALVE BODY SPECIFICATIONS

ACTION: Direct. Push down to close.

RECOMMENDED CONTROL AGENTS AND DISCS AVAILABLE: Refer to Table 2.

RATINGS: Refer to Table 3.

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END CONNECTIONS, PLUG CHARACTERISTICS, SIZES, AND CAPACITIES: Refer to Table 4.

TRAVEL:
1/2 through 3 in. sizes–3/4 in.
4, 5, and 6 in. sizes–1-1/2 in.

TRIM MATERIALS:
Stem: Stainless-steel.
Packing:
Teflon cone for 125 psi flanged, 150 psi screwed bodies all sizes.
Teflon "V" Ring for 250 psi rating 1-1/2 to 6 in. valve bodies
Rubber "V" Ring for 250 psi rating 1/2 to 1-1/4 in. valve bodies.
Disc Holder:
Screwed bodies–brass.
Flanged bodies–bronze.
Disc: Removable-composition for all bodies and all sizes.
Plug:
Screwed bodies contoured.
Cv's of 4.0 and below–stainless-steel.
Cv's above 4.0–brass.
Flanged Bodies V-Ported.
All Sizes–skirt-guided bronze.
Seat: Screwed into body. Replaceable.
Screwed bodies–brass.
Flanged bodies–bronze.

OPTIONAL MODELS:
V5011C is available in 1/2 through 1-1/2 in. sizes with metal to metal seats, integral disc and stainless-steel trim. For higher pressure limits and steam service, see limitations in Tables 2, 3, and 4.

V5011D Flanged for high-pressure service in 2-1/2 to 6 inch bodies.

OPERATOR SPECIFICATIONS

POSITIONER: On MP953A only.
Start point–adjustable between 3 and 10 psi.
Operating range–3, 5, or 10 psi.

SPRING RANGES: MP953C only. See Figure 2.

OPERATING TEMPERATURE: 160 F maximum ambient at neoprene diaphragm. 250 F maximum ambient at silicone diaphragm.

CONTROL AIR PRESSURE: 25 psi maximum.

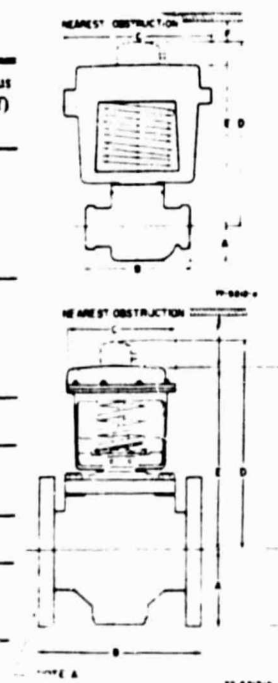
AIR CONNECTIONS: 1/8 in. NPT female.

FINISH: Gray

Table 1–Dimensions and Stroke, VP514A & C.

Connections	Body Size (in.)	Operator	Stroke (in.)	Dimensions (Inches) A[a]	B	C	D VP514A	E VP514C	F	Swing Radius (Bonnet off) (in.)
Screwed[b] V5011A, C & D	1/2	Small	3/4	1-3/4	3-3/8	5-1/8	8-1/8	5-7/8	4-3/8	1-5/8
	3/4	Small	3/4	1-3/4	3-1/2	5-1/8	8-1/8	5-7/8	4-3/8	1-5/8
	1	Small	3/4	1-5/8	4-3/8	5-1/8	8-1/4	6	4-3/8	1-3/4
	1-1/4	Small	3/4	1-1/2	5	5-1/8	8-7/16	6-3/16	4-3/8	2
	1-1/2	Small	3/4	1-3/8	5-3/4	5-1/8	8-9/16	6-5/16	4-3/8	2-1/8
	1-1/2	Medium	3/4	1-3/8	5-3/4	8-1/4	10-7/16	8-3/16	5-3/8	2-1/8
	2	Small	3/4	2	5-3/4	5-1/8	8-13/16	6-9/16	4-3/8	2-3/8
	2	Medium	3/4	2	5-3/4	8-1/4	10-11/16	8-7/16	5-3/8	2-3/8
	2-1/2	Medium	3/4	2-3/8	7-1/2	8-1/4	10-15/16	8-11/16	5-3/8	3-1/8
	3	Medium	3/4	2-3/8	8-7/8	8-1/4	11-3/8	9-1/8	5-3/8	3-5/8
Flanged V5011A	2-1/2	Medium	3/4	4	9-1/2	8-1/4	13-9/16	11-5/16	5-3/8	
	3	Medium	3/4	4-5/8	11	8-1/4	14-1/8	11-7/8	5-3/8	
	4	Large	1-1/2	5-3/16	13	13-1/2	19-13/16	17-9/16	7-11/16	
	5	Large	1-1/2	6-1/8	15	13-1/2	19-1/4	17	7-11/16	
	6	Large	1-1/2	7-1/16	16-1/2	13-1/2	20-1/4	18	7-11/16	
Flanged V5011D (250 psig)	2-1/2	Medium	3/4	3-3/4	11-1/2	8-1/4	13-9/16	11-5/16	5-3/8	
	3	Medium	3/4	4-1/4	12-1/2	8-1/4	14-1/8	11-7/8	5-3/8	
	4	Large	1-1/2	5	14-1/2	13-1/2	19-13/16	17-9/16	7-11/16	
	5	Large	1-1/2	5-1/2	16-3/4	13-1/2	19-1/4	17	7-11/16	
	6	Large	1-1/2	6-1/4	18-5/8	13-1/2	20-1/4	18	7-11/16	

[a] 250 psig flanged valves have raised face ring.
[b] 250 psi service available by ordering special kits.



1A

1B

Fig. 1–Dimensions.

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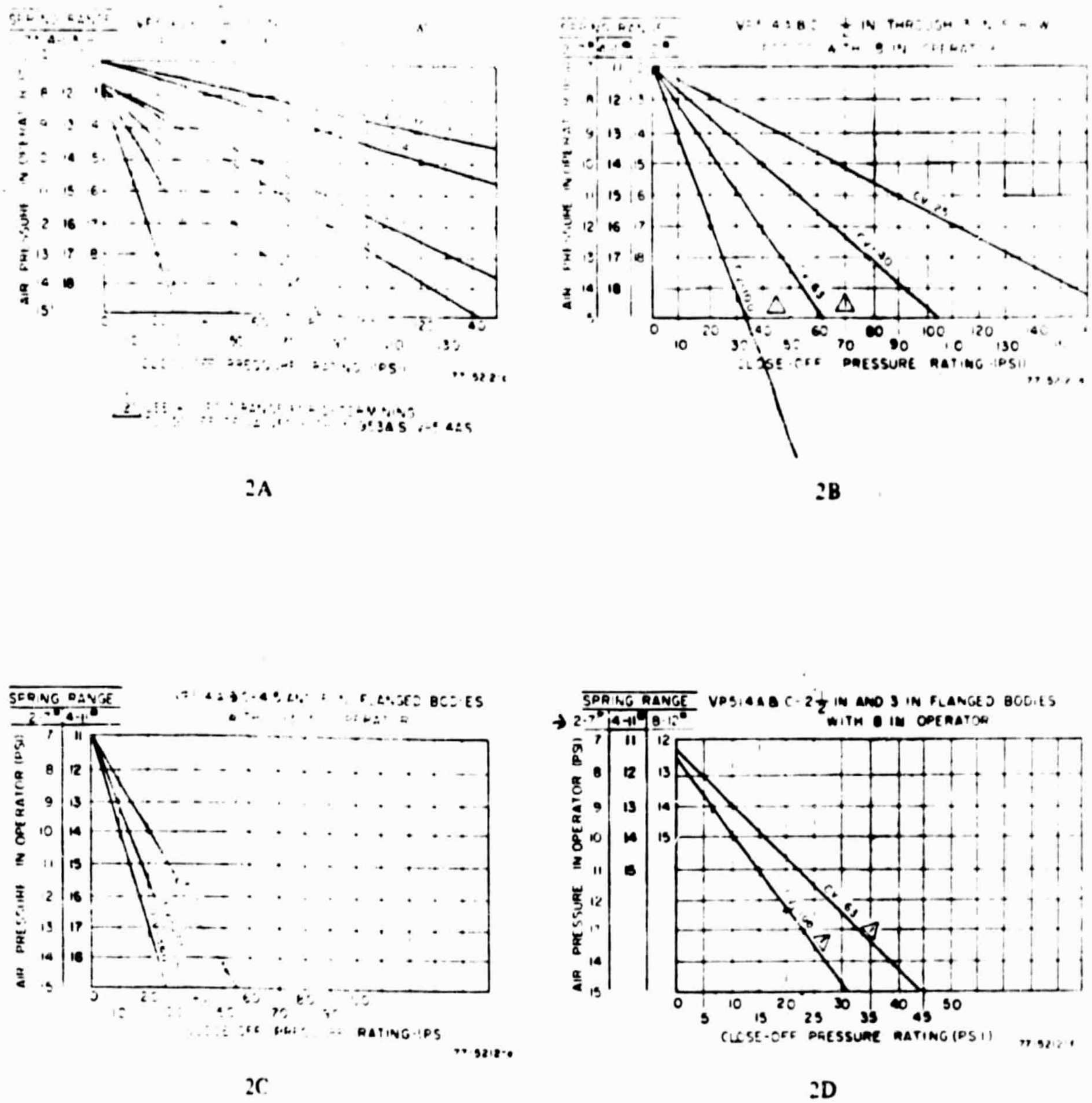

⚠1 Due to differences in valve body construction, screwed and flanged patterns have different close-off ratings. This applies to valves in the 2-1/2 in and 3 in sizes.

Fig. 2 Close-off Ratings, VP514A & C.

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Table 2 – Recommended Control Agents and Discs Available.

Model	Body Pattern	Recommended Control Agents	Discs Available (Composition except as noted)
V5011A	Screwed	Water	35 to 200 F
		Water	115 to 275 F
	Flanged	Water	35 to 275 F
V5011C	Screwed	Steam	115 to 275 F
		Steam	275 to 425 F
		Steam	Metal-to-metal seats[a]
V5011D	Flanged	Water	35 to 275 F

[a]Composition disc available in all valve sizes. Metal-to-metal seats available in 1/2 through 1-1/2 in. sizes only. See Table 4.

Table 3 – Valve Ratings.[a]

Body	Screwed, cast-bronze, 150 psig at 366 F max. steam 250 psig at 250 F max. water Flanged, cast-iron, 125 and 250[d] psig at 353 F max.		
Maximum-Pressure Differential for Normal Life of Trim	Composition discs	Water	Proportional, 25 psig
			2-position, 50 psig
		Steam[d]	Proportional, 35 psig
			2-position, 70 psig
	Metal-to-metal seats[c]	Steam	100 psig
Maximum-Pressure Differential for Quiet-Water Service	20 psig		
Maximum-Pressure Differential for Close off	Refer to Fig. 2.		
Teflon-Cone Packing (V5011A & C)	Water[b]	150 psig max. at 250 F max.; 40 F min.	
	Steam	100 psig max. at 337 F min.	
Teflon-"V" Ring Packing (V5011D 1-1/2 to 6 in. valves)	Water[b]	250 psig max. at 250 F max.; 40 F min.	
Rubber "V" Ring Packing (V5011D 1/2 to 1-1/4 in. Valves	Water		

[a]For high fluid temperatures, the valve and/or piping should be insulated to prevent ambient temperatures from exceeding operator ratings at the motor location.

[b]Maximum-temperature differential in alternate hot-cold water use, 140 F.

[c]Not recommended for use on water.

[d]250 psig rating on V5011D flanged valves applies to water; these valves are not recommended for steam.

Table 4 – Plug Characteristics, End Connections, Sizes, and Capacity Indexes (Cv's) Available.

Model No. and Plug Characteristics	End Connections	Body Size (in.)	Capacity Index (Cv)
V5011A Equal Percentage & V5011C Modified Linear	Screwed	1/2	0.4, 0.63, 1.0, 1.6, 2.5, 4.0
		3/4	6.3
		1	10.0
		1-1/4	16
		1-1/2	25
		2	40
		2-1/2	63
		3	100
V5011A & D Equal Percentage	Flanged	2-1/2	63
		3	100
V5011A & D Equal Percentage	Flanged	4	160
		5	250
		6	360

FLOW CHARACTERISTICS

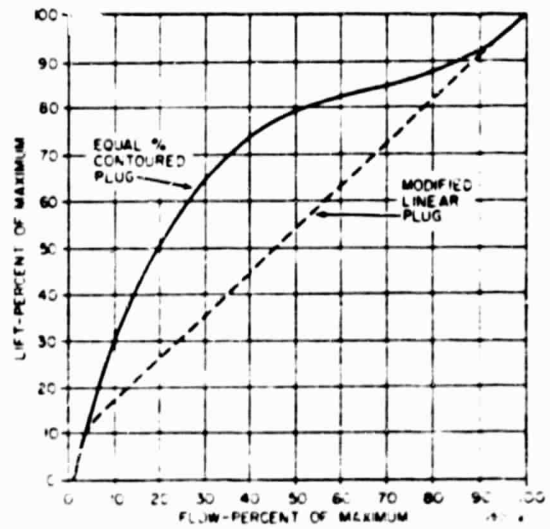

Fig. 3 – V5011 Average Flow Characteristics

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VALVE CONSTRUCTION

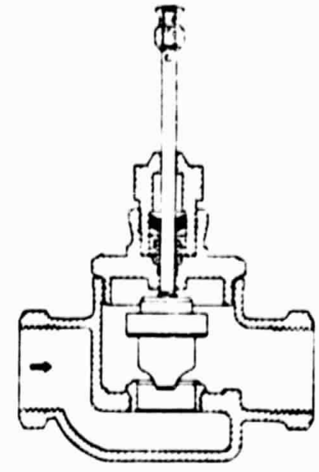

Fig. 4–V5011A & C Screwed Pattern - 150 psi. Packing Shown.

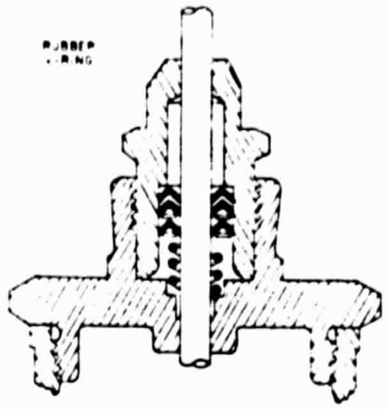

Fig. 5–250 psi Packing for 1/2 to 1-1/4 in. Screwed Valve Bodies.

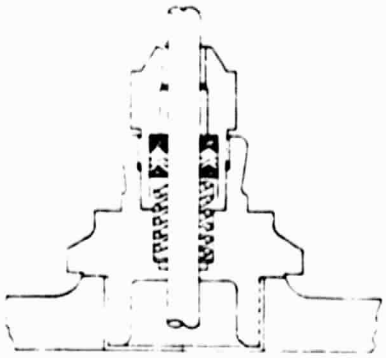

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Fig. 6–250 psi Packing for 1-1/2 to 3 in. Screwed Valve Bodies.

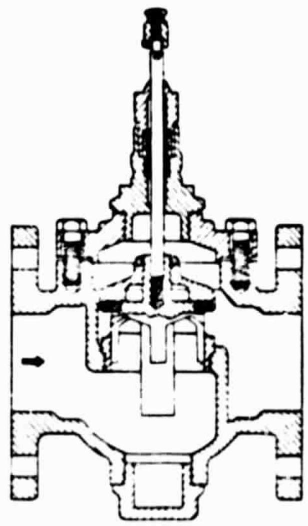


Fig. 7–V5011A Flanged Pattern - 125 psi.

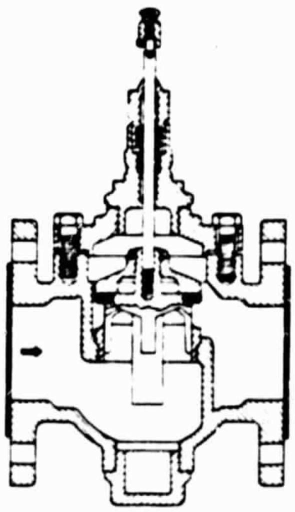


Fig. 8–250 psi Flanged Valve Body.

77-5212

TYPICAL OPERATION

VP514A (Fig. 9)–Normally open. An increase in control air pressure moves the valve toward closed. Full main pressure available through the positioner provides positive valve positioning for all load conditions.

VP514C (Fig. 10) Same as VP514A except less positioner.

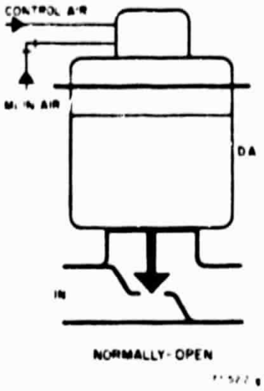


Fig. 9–VP514A Operation.

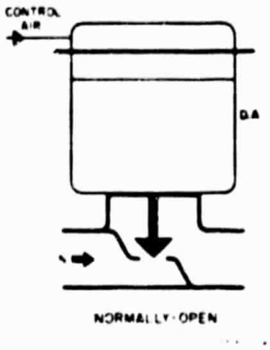


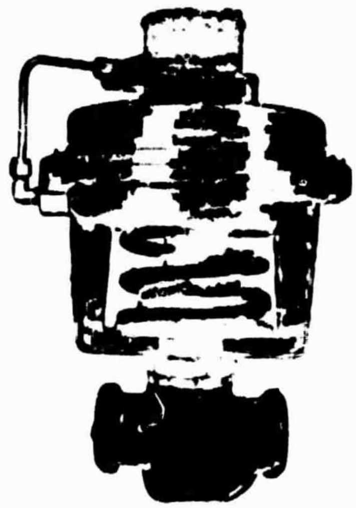
Fig. 10–VP514C Operation.

Honeywell

Temperature Controls

VP514B, D, E & F SINGLE-SEATED, NORMALLY CLOSED, PNEUMATIC VALVE ASSEMBLIES

Spec[illegible]



APPLICATION

Used for normally closed, proportional control of steam, liquids, air, or other non-combustible gases in heating, air-conditioning, and heat exchanger systems where tight shutoff is required.

Rated for steam or water service. However, for throttling-service on steam coils, the modified-linear characteristic is preferred; for throttling-service on hot-water coils, the equal-percentage characteristic is preferred. See Table 4 for availability.

NOTE: 1/2 to 3 in. screwed body valves can be field converted to 250 psi high pressure service with special kits.

ORDER: 14002920-001 for 1/2 to 1-1/4 in. V5011 bodies
14002920-002 for 1-1/2 to 3 in. V5011 bodies

CONSTRUCTION

Single-seated, straight-through, globe body with high-lift plug. Available with American Standard Taper Pipe Threads (NPT) in bronze bodies or American Standard Flanged Ends in cast-iron bodies. Spring-loaded rubber or Teflon packings provide self-adjusting, tight seal-off characteristics for all common control agents in heating and air conditioning systems; however, due to the packing construction, this valve is not suitable for use with combustible gases, particularly liquid-petroleum gas. Supplied in all sizes with a composition disc suitable for pressure drops listed in Table 3. For high pressure service: 250 pound rated valves are available, and stainless steel, metal-to-metal seating is available in smaller valve sizes.

The MP953A and MP953B operators used in the VP514E and VP514B valve assemblies respectively are furnished with a Gradutrol* positive-positioning relay. Start point and operating range are adjustable on the positioner to provide sequence operation with other controlled devices. The MP953C and MP953D operators furnished with the VP514F and VP514D assemblies respectively are furnished without the relay. The operators have a tough, wear-resistant replaceable, neoprene diaphragm. (Silicone diaphragm models are also available.)

*Trademark

Rev. 1-74

R.F.L.

ASSEMBLY

ASSEMBLY COMPONENTS:

Assembly No.	Actuator	Valve Body	Positioner
VP514B (N.C.)	MP953B (R.A.)	V5011A, C or D (D.A.)	With
VP514D (N.C.)	MP953D (R.A.)	V5011A, C or D (D.A.)	Without
VP514E (N.C.)	MP953A (D.A.)	V5011B & E (R.A.)	With
VP514F (N.C.)	MP953C (D.A.)	V5011B & E (R.A.)	Without

DIMENSIONS: See Table 1 and Figure 1.

CLOSE-OFF RATINGS: See Figures 2 and 3.

VALVE BODY SPECIFICATIONS

MODEL AND ACTION:
V5011A, C & D–Direct. Push down to close.
V5011B & E–Reverse. Push down to open.

RECOMMENDED CONTROL AGENTS AND DISCS AVAILABLE: Refer to Table 2.

RATINGS: Refer to Table 3.

END CONNECTIONS, PLUG CHARACTERISTICS, SIZES, AND CAPACITIES: Refer to Table 4.

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Commercial Div

TRAVEL:
1/2 through 3 in. sizes–3/4 in.
4, 5, and 6 in. sizes–1-1/2 in.

TRIM MATERIALS:
Stem: Stainless steel.
Packing:
Teflon-cone for 125 psi flanged, 150 psi screwed, all sizes.
Teflon "V" Rings for 250 psi rating 1-1/2 to 6 in. valves.
Rubber "V" Rings for 250 psi rating 1/2 to 1-1/4 in. valves.
Disc Holder:
Screwed bodies–brass.
Flanged bodies–cast iron.
Disc: Removable-composition for all bodies and all sizes.
Plug:
Screwed bodies contoured.
Cv's of 4.0 and below–stainless steel.
Cv's above 4.0–brass
Flanged Bodies V-Ported.
All sizes–skirt-guided bronze.
Seat: Screwed into body. Replaceable.
Screwed bodies–brass.
Flanged bodies–bronze.

OPTIONAL MODELS: V5011C is available in 1/2 through 1-1/2 in. sizes with metal-to-metal seats, integral disc and stainless steel trim. For higher pressure limits and steam service, see limitations in Tables 2, 3, and 4. V5011D or E valves for high pressure service in 2-1/2 to 6 in. bodies.

OPERATOR

POSITIONER (On MP953A & B only):
Start point–adjustable between 3 and 10 psig.
Operating range–3, 5, or 10 psig.

SPRING RANGES: MP953C & D only (see Figs. 2A & 2B).

OPERATING TEMPERATURE: 160 F maximum (neoprene diaphragm).

CONTROL AIR PRESSURE: 25 psi maximum.

AIR CONNECTIONS: 1/8 in. NPT female.

FINISH: Gray

Table 1–Dimensions & Stroke, VP514B, D, E, & F.[b]

Connections[a]	Body Size (in.)	Operator	Stroke (in.)	Dimensions (Inches) A	B	C	D VP514B & E	E VP514D & F	F	Swing Radius (Bonnet off) (in.)
Screwed[b] V5011A & D.A. Body (150/250 psi)	1/2	Medium	3/4	1-3/4	3-3/8	7-1/8	10	6-7/8	4-3/8	1-5/8
	3/4	Medium	3/4	1-3/4	3-1/2	7-1/8	10	6-7/8	4-3/8	1-5/8
	1	Medium	3/4	1-5/8	4-3/8	7-1/8	10-1/8	7	4-3/8	1-3/4
	1-1/4	Medium	3/4	1-1/2	5	7-1/8	10-1/4	7-3/16	4-3/8	2
	1-1/2	Medium	3/4	1-3/8	5-3/4	7-1/8	10-3/8	7-5/16	4-3/8	2-1/8
	2	Medium	3/4	2	5-3/4	7-1/8	10-5/8	7-9/16	4-3/8	2-3/8
	2-1/2	Medium	3/4	2-3/8	7-1/2	7-1/8	10-15/16	7-13/16	4-3/8	3-1/8
	3	Medium	3/4	2-3/8	8-7/8	7-1/8	11-3/8	8-1/4	4-3/8	3-5/8
Flanged V5011A D.A. Body (125 psi)	2-1/2	Medium	3/4	4	9-1/2	7-1/8	13-1/2	10-7/16	5-3/8	
	3	Medium	3/4	4-5/8	11	7-1/8	14-1/8	11	5-3/8	
	4	Large	1-1/2	5-3/16	13	13-1/2	16-5/16	13-3/16	7-11/16	
	5	Large	1-1/2	6-1/8	15	13-1/2	15-3/4	12-5/8	7-11/16	
	6	Large	1-1/2	7-1/16	16-1/2	13-1/2	16-3/4	13-5/8	7-11/16	
Flanged V5011B R.A. Body (125 psi)	4	Large	1-1/2	8-1/16	13	13-1/2	16-15/16	14-11/16	7-11/16	
	5	Large	1-1/2	7-1/2	15	13-1/2	17-7/8	15-5/8	7-11/16	
	6	Large	1-1/2	8-1/2	16-1/2	13-1/2	18-13/16	16-9/16	7-11/16	
Flanged V5011D (250 psig) D.A. Body	2-1/2	Medium	3/4	3-3/4	11-1/2	8-1/4	[illegible]	11-5/16	5-3/8	
	3	Medium	3/4	4-1/4	12-1/2	8-1/4	[illegible]	11-7/8	5-3/8	
	4	Large	1-1/2	5	14-1/2	13-1/2	19-13/16	17-9/16	7-11/16	
	5	Large	1-1/2	5-1/2	16-3/4	13-1/2	19-1/4	17	7-11/16	
	6	Large	1-1/2	6-1/4	18-5/8	13-1/2	20-1/4	18	7-11/16	
Flanged V5011E (250 psig) R.A. Body	4	Large	1-1/2	7-5/16	14-1/2	13-1/2	17	14-3/4	7-11/16	
	5	Large	1-1/2	6-3/4	16-3/4	13-1/2	18	15-3/4	7-11/16	
	6	Large	1-1/2	7-7/8	18-5/8	13-1/2	18-15/16	16-11/16	7-11/16	

[a] V5011D's are 250 psig valves.
[b] 250 psi service available by ordering special kits.
[c] 250 psi flanged valves have a raised face ring.

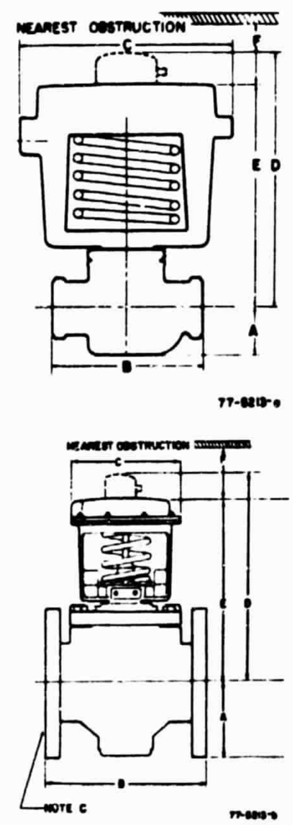

Fig. 1–Dimensions.

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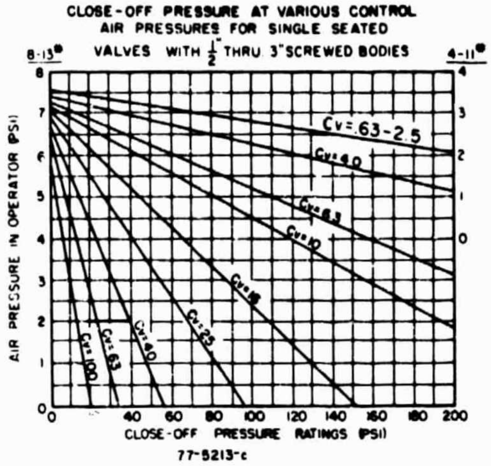
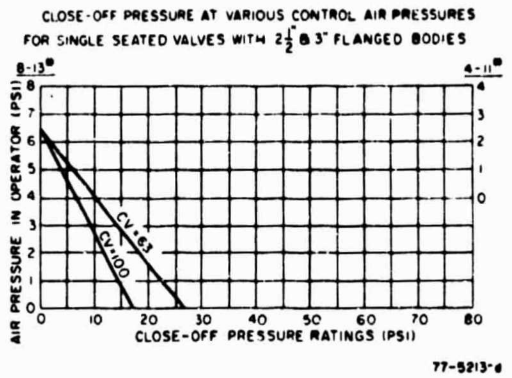


2A



2B

Fig. 2–Close-Off Ratings, VP514B & D. (Valves with Positioners use 8 to 13 pound spring for close off.)

NOTE: Due to differences in valve body configuration, screwed and flanged patterns have different close-off ratings. This applies to valves in the 2-1/2 in. and 3 in. sizes. See Fig. 2A and 2B.

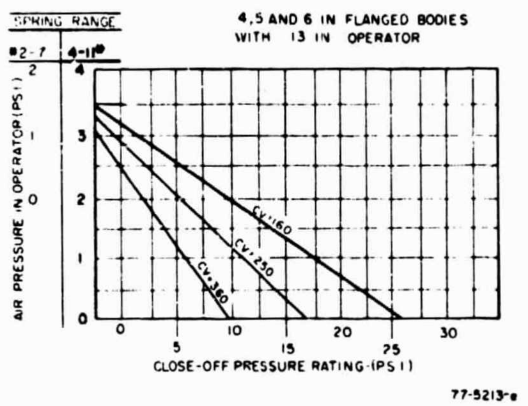


Fig. 3–Close-Off Ratings, VP514E & F.

Table 2–Recommended Control Agents and Discs Available.

Model	Body Pattern	Recommended Control Agents	Discs Available (Composition except as noted)
V5011A & D	Screwed	Water	35 to 200 F
		Water	115 to 275 F
	Flanged	Water	35 to 275 F
V5011B	Flanged	Water	35 to 275 F
V5011C	Screwed	Steam	115 to 275 F
		Steam	275 to 425 F
		Steam	Metal-to-metal seats[a]
V5011D	Flanged	Water	35 to 275 F
V5011E	Flanged	Water	35 to 275 F

[a]Composition disc available in all valve sizes. Metal-to-metal seats available in 1/2 through 1-1/2 in. sizes only. See Table 4.

Table 3–Valve Ratings[a].

Body	Screwed, cast-bronze. 150 psig at 366 F max. steam; 250 psig at 250 F max. water. Flanged, cast-iron, 125 and 250[d] psig at 353 F max.		
Maximum-Pressure Differential for Normal Life of Trim	Composition discs	Water	Proportional, 25 psig
			2-position, 50 psig
		Steam[e]	Proportional, 35 psig
			2-position, 70 psig
	Metal-to-metal seats[c]	Steam	100 psig
Maximum-Pressure Differential for Quiet-Water Service	20 psig		
Maximum-Pressure Differential for Close off	Refer to Fig. 3		
Teflon-Cone Packing (V5011A and C).	Water[b]	150 psig max. at 250 F max.; 40 F min.	
	Steam	100 psig max. at 337 F max.	
Teflon-"V" Ring Packing 1-1/2 to 6 in. valves	Water[b]	250 psig max. at 250 F max.; 40 F min.	
Rubber-"V" Ring Packing 1/2 to 1-1/4 in. valves	Water		

[a]For high fluid temperatures, the valve and/or piping should be insulated to prevent ambient temperatures from exceeding ratings at the actuator location.

[b]Maximum-temperature differential in alternate hot-cold water use, 140 F.

[c]Not recommended for use on water.

[d]250 psig maximum rating applies to V5011D & E flanged valves.

[e]250 psig V5011D and E are not recommended for steam.

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Table 4—Plug Characteristics, End Connections, Sizes, and Capacity Indexes (Cv's) Available.

Model No. and Plug Characteristics	End Connections	Body Size (in.)	Capacity Index (Cv)
V5011A Equal Percentage & V5011C Modified Linear (1/2 to 1-1/2 in. valves only)	Screwed	1/2	0.4, 0.63, 1.0, 1.6, 2.5, 4.0
		3/4	6.3
		1	10.0
		1-1/4	16
		1-1/2	25
		2	40
		2-1/2	63
		3	100
V5011A & D Equal Percentage	Flanged	2-1/2	63
		3	100
V5011A, B, D & E Equal Percentage	Flanged	4	160
		5	250
		6	360

FLOW CHARACTERISTICS

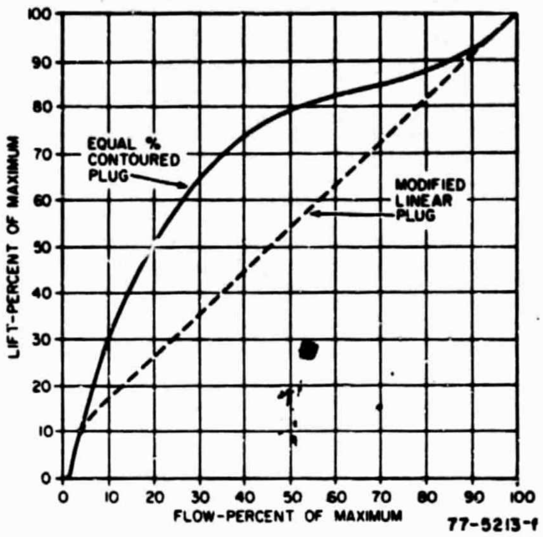


Fig. 4—V5011 Average Flow Characteristics.

VALVE CONSTRUCTION

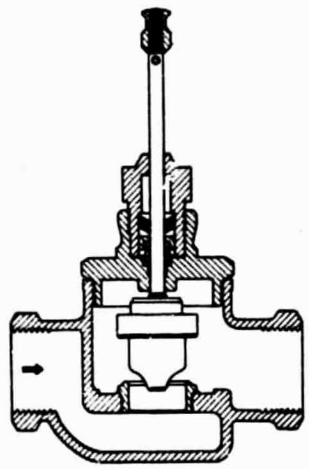


Fig. 5—Screwed Bronze Body Valves 1/2 thru 3 in. Packing Shown is for 150 psi Service.

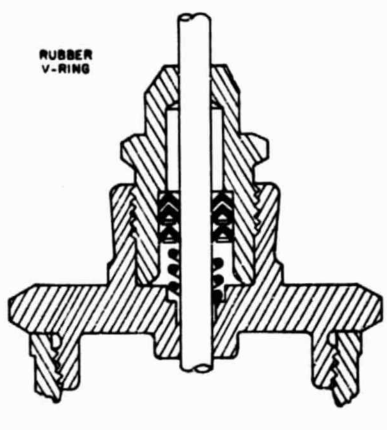


Fig. 6—Packing for 1/2 thru 1-1/4 in. Bronze Body Valves for 250 psi Service.

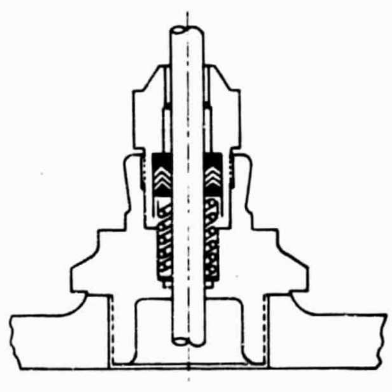


Fig. 7—Packing for 1-1/2 thru 3 in. Bronze Body Valves for 250 psi Service.

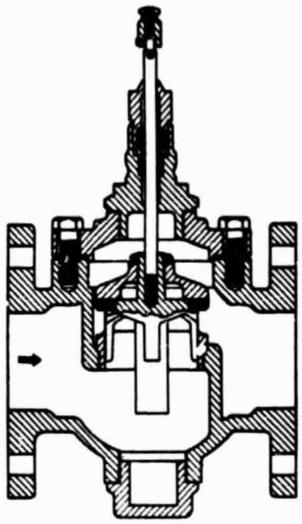


Fig. 8–Flanged, Cast Iron, Direct Acting, 125 psi Valve Body 2-1/2 thru 6 Inches.

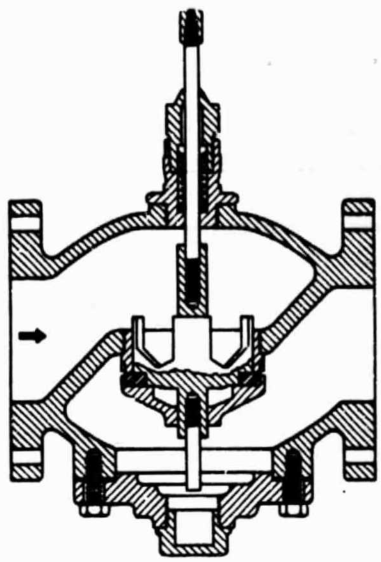


Fig. 9–Flanged, Cast Iron, Reverse Acting, 125 psi Valve Body 4 thru 6 Inches.

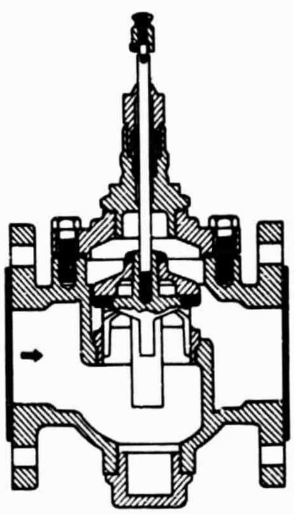


Fig. 10–Flanged, Cast Iron, Direct Acting, 250 psi Valve Body 2-1/2 thru 6 Inches.

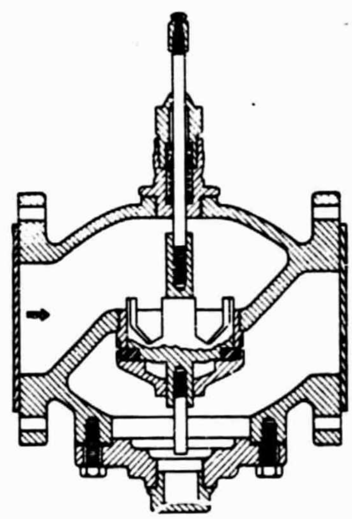


Fig. 11–Flanged, Cast Iron, Reverse Acting, 250 psi Valve Body 4 thru 6 Inches.

77-5213

TYPICAL OPERATION

VP514B (Fig. 12) and VP514E (Fig. 14)–normally closed. An increase in control air pressure moves the valve toward open. Full main pressure available through the positioner to provide positive valve positioning for all load conditions.

VP514D (Fig. 13) and VP514F (Fig. 15)–same as VP514B and VP514E respectively except less positioner.

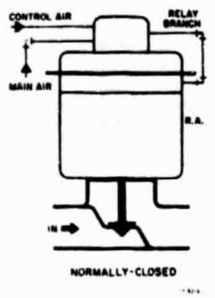


Fig. 12–VP514B Operation (1/2 to 3 in. Sc. Valve Sizes).

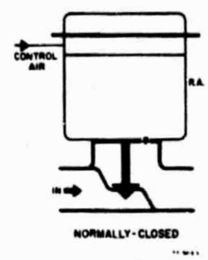


Fig. 13–VP514 Operation (1/2 to 3 in. Sc. Valve Sizes).

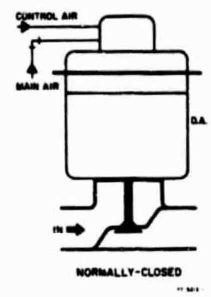


Fig. 14–VP514E Operation (4, 5 & 6 in. Fl. Valve Sizes).

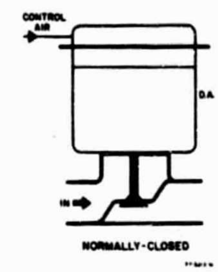
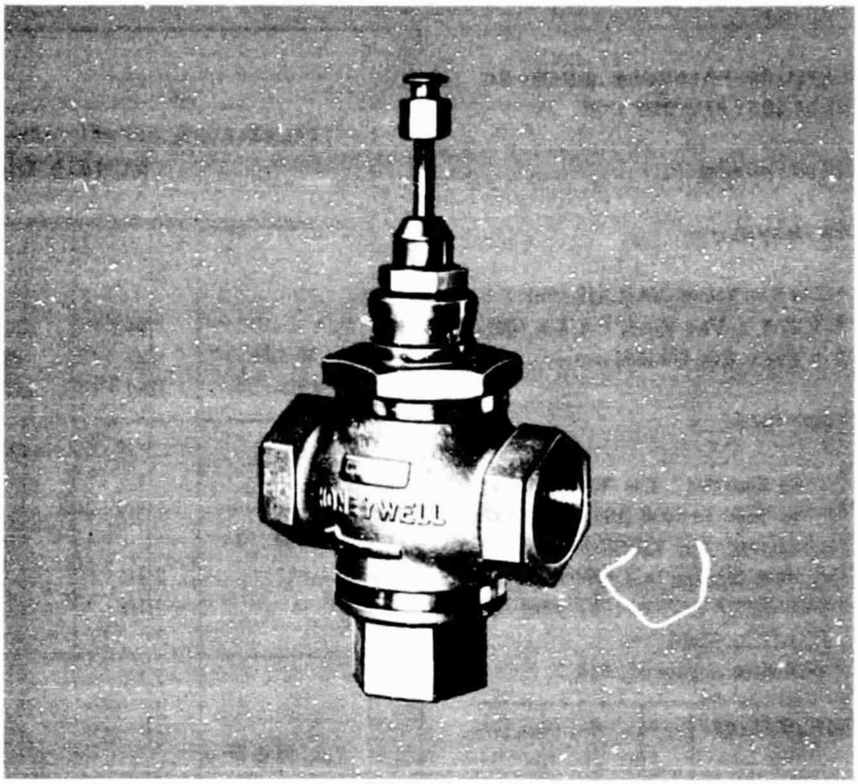


Fig. 15–VP514F Operation (4, 5 & 6 in. Fl. Valve Sizes).

Honeywell

Three-Way Mixing & Diverting Valves

MODEL NUMBER V5013A–E



General

These valves provide proportional or two-position control of hot or cold water in heating or cooling systems. They can be used for mixing service (V5013A, B & D) to direct flow from one of two inlets to a common outlet or for diverting service (V5013C & E) to direct flow from a common inlet to one of two outlets. NOTE: *Mixing and diverting valves cannot be interchanged.*

Features

- Direct or reverse acting.
- Bronze body with screwed end connections or cast iron body with flanged end connections.
- Stainless steel stem, bronze plug, and replaceable bronze seats.
- Spring loaded, self-adjusting Teflon packing.
- High pressure models available (V5013D & E).
- Constant total flow throughout full plug travel.
- Linear flow characteristic for each port.
- Suitable for pneumatic or electric actuation (with proper linkage).
- Repack kits available for field servicing.

Specifications

MODELS

V5013A: Three-way mixing valve, 1/2 to 2 in. screwed body; 2-1/2 to 6 in. flanged body. Straight through flow with stem down.

V5013B: Three-way mixing valve, 2-1/2 to 8 in. flanged body. Straight through flow with stem down.

V5013C: Three-way diverting valve, 2-1/2 to 8 in. flanged body. Straight through flow with stem up.

V5013D: Same as the V5013B but with 250 psi (1725 kPa) body pressure rating.
V5013E: Same as the V5013C but with 250 psi (1725 kPa) body pressure rating.

MAXIMUM BODY PRESSURE

V5013A-C: 150 psi (1035 kPa).
V5013D & E: 250 psi (1725 kPa).

END CONNECTIONS, SIZES, AND CAPACITIES (Cv)

Valve	Size (Inches)	Cv
V5013A Screwed	1/2	2.5, 4.0
	3/4	6.3
	1	10
	1-1/4	16
	1-1/2	25
	2	40
V5013B-E Flanged	2-1/2	63
	3	100
	4	160
	5	250
	6	360
	8	600

Rev. 10-76
R.F.L.

Form Number 77-5316
Commercial Div.

MAXIMUM TEMPERATURE

250F (121C)

PACKING LIMITS

Temperature: 40 to 240F (4 to 129C). Pressure: V5013A-C – 150 psi (1035 kPa) max. V5013D & E – 250 psi (1725 kPa) max.

MAXIMUM PRESSURE DROP TO ENSURE SEAT AND DISC LIFE

20 psi (140 kPa)

STEM TRAVEL

1/2 to 3 in. Valves: 3/4 in. (19 mm).
4, 5, & 6 in. Valves: 1-1/2 in. (38 mm).
8 in. Valves: 2 in. (51 mm).

ACCESSORIES

Packing Conversion Kits (for converting to high pressure (250 psi [1725 kPa] applications): 14002920-001 - Rubber "V" Ring for 1/2 to 1-1/4 in. valves. 14002920-002. - Teflon "V" Ring for 1-1/2 to 3 in. valves.
Repack Kits for V5013A, B, & C:

SERVICELINE Kit No.	Pipe Size (Inches)	Stem Dia. (In. [mm])
14003294-001	1/2, 3/4, 1, 1-3/4	1/4 (6)
14003295-001	1-1/2, 2, 2-1/2, 3	3/8 (9)
14003296-001	4, 5, 6, 8	1/2 (13)

CLOSE-OFF PRESSURE RATINGS

Refer to Figs. 1A-1F and Table 1.

DIMENSIONS

Refer to Figs. 2, 3, & 4.

WHEN SPECIFYING, INDICATE

1. Model Number (Service Desired).
2. Accessories.
3. Operator (Refer to Valve/Operator Selection Table 4).

TABLE 1—CLOSE-OFF PRESSURE RATINGS FOR V5013A-E VALVES WITH ELECTRIC OPERATORS

Model No.	Pipe Size (In.)	Close-Off Ratings[a] PSI (kPa) When Used with Linkages: Q618A 80 lb Linkage	Q618A 160 lb Linkage	Q601E
V5013A	1/2	140 (965)	150 (1035)	-----
	1/2	130 (895)	150 (1035)	-----
	3/4	120 (830)	150 (1035)	-----
	1	70 (485)	150 (1035)	-----
	1-1/4	--------	146 (1005)	-----
	1-1/2	35 (240)	98 (675)	-----
	2	20 (140)	67 (460)	-----
V5013B & D	2-1/2	--------	32 (220)	-----
	3	--------	22 (150)	-----
	4	--------	--------	9 (60)
	5	Not recommended for tight close-off		
	6	Not recommended for tight close-off		
	8	Not recommended for tight close-off		
V5013C & E	2-1/2	--------	32 (220)	-----
	3	--------	22 (150)	-----
	4	--------	--------	9 (60)
	5	Not recommended for tight close-off		
	6	Not recommended for tight close-off		
	8	Not recommended for tight close-off		

[a] Represents maximum pressure difference between the outlet and either of the two inlets (or between the inlet and either of two outlets).

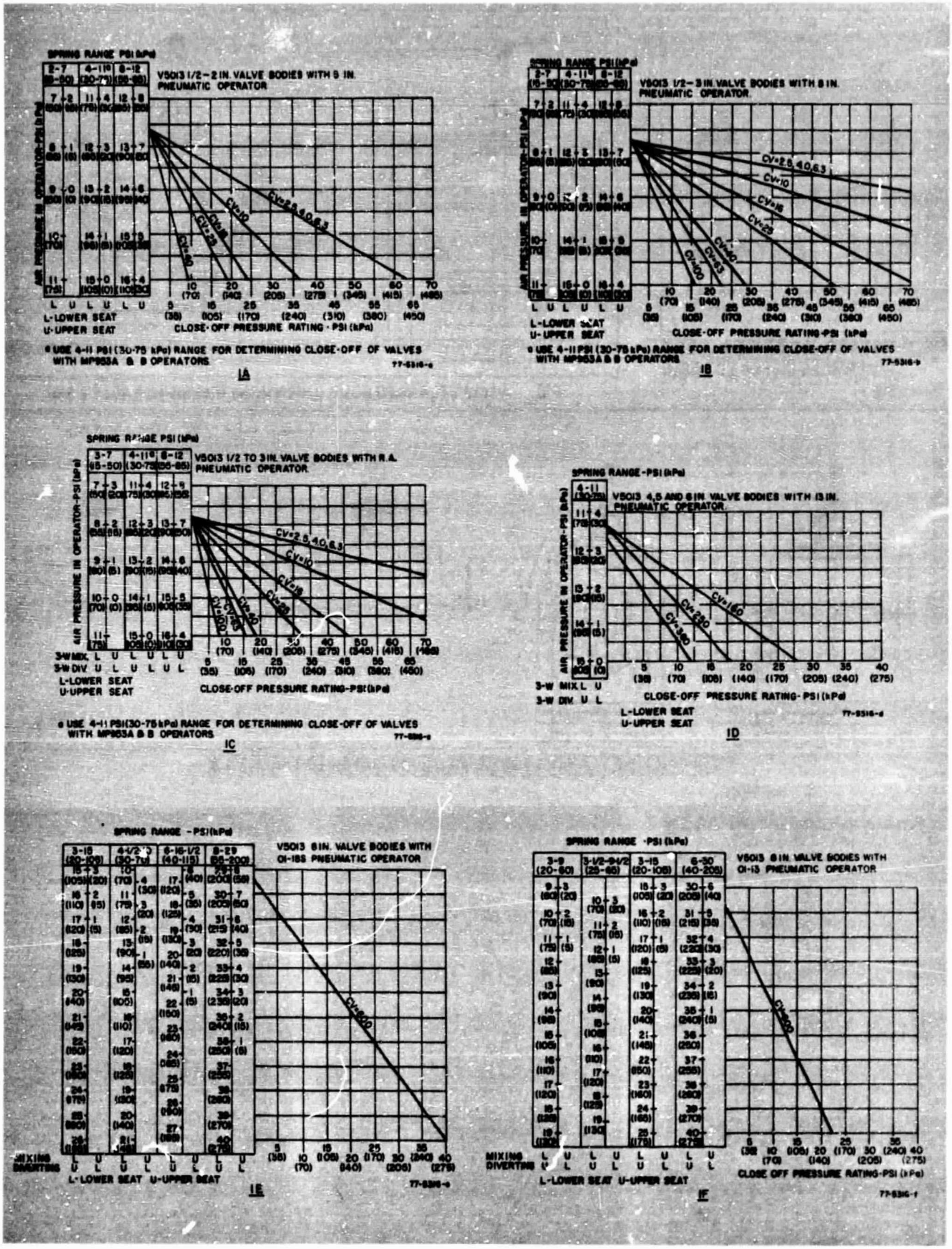


FIG. 1—CLOSE-OFF RATINGS OF V5013 VALVES AT VARIOUS CONTROL AIR PRESSURES WHEN USING MP953 OPERATORS (OR TYPE 01 OPERATORS ON 8 IN. VALVE BODIES)

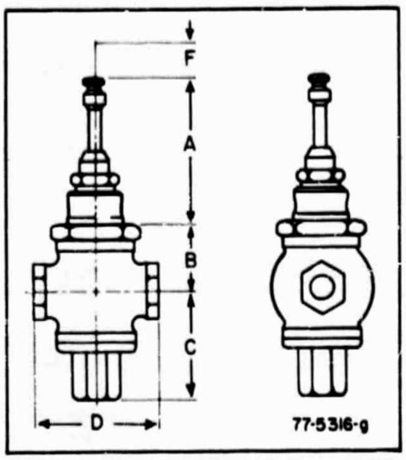


FIG. 2—V5013A SCREWED BODY DIMENSIONS (REFER TO TABLE 2 & 3)

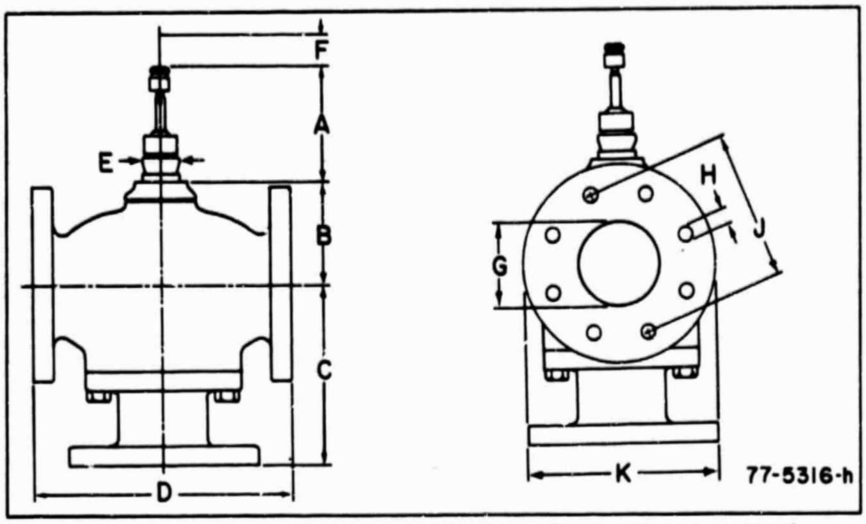


FIG. 3—V5013A FLANGED BODY DIMENSIONS (REFER TO TABLE 2 & 3)

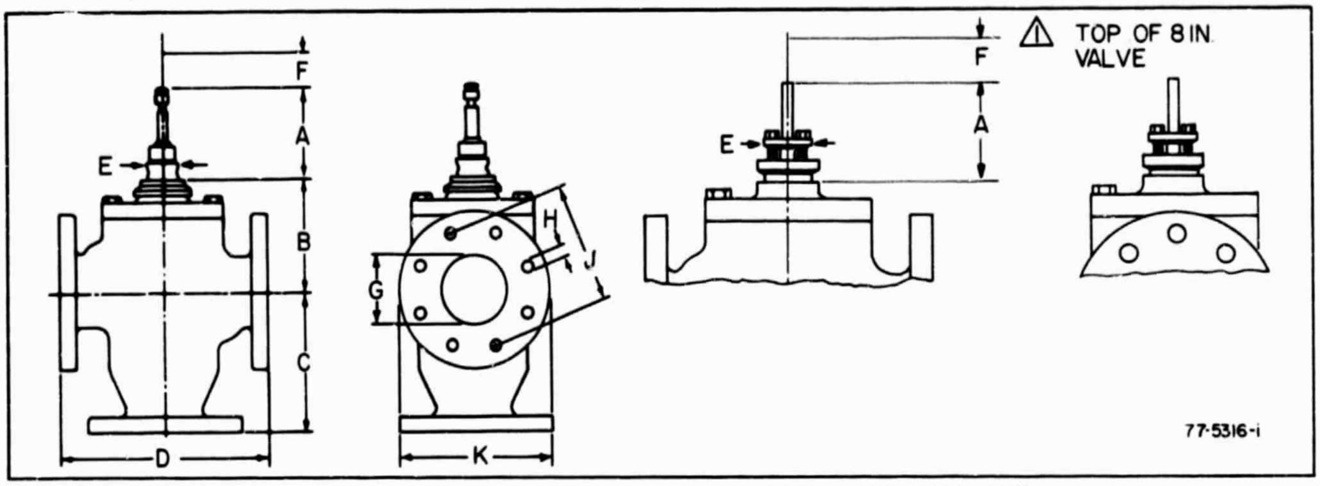


FIG. 4—V5013B-E FLANGED BODY DIMENSIONS (REFER TO TABLE 2 & 3)

INNER VALVE CONSTRUCTION

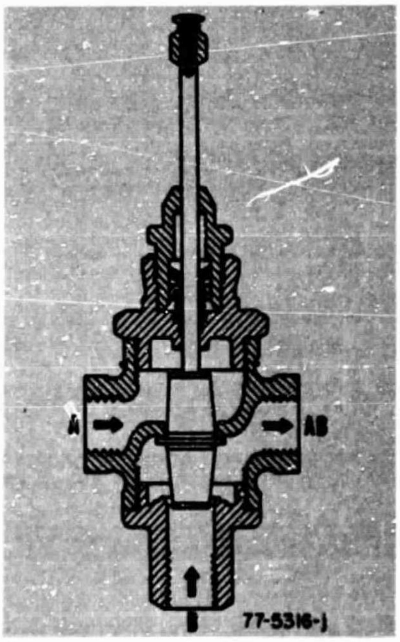


FIG. 5—V5013A THREE-WAY MIXING VALVE

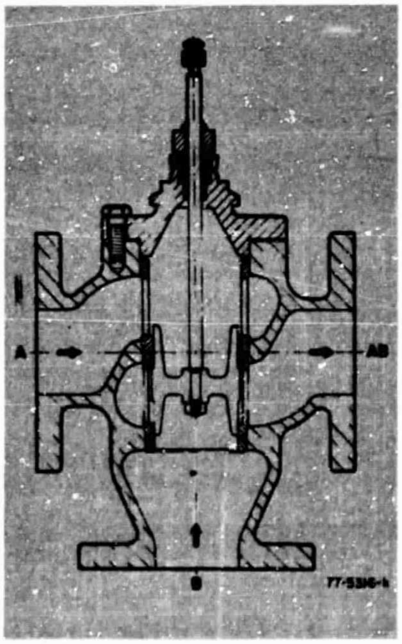


FIG. 6—V5013B & D THREE-WAY MIXING VALVE

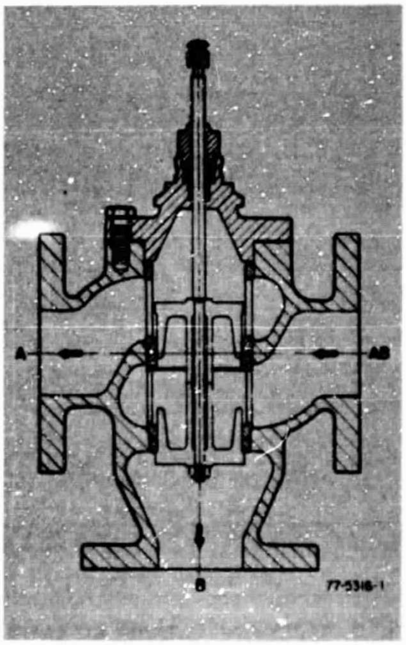


FIG. 7—V5013C & E THREE-WAY DIVERTING VALVE

TABLE 2–V5013A-E DIMENSIONS IN INCHES
REFERENCED IN FIGURES 2, 3 & 4

Valve and Figure Reference	Valve Size	A	B	C	D	F	F	G	H	J	K	No. of Bolt Holes
V5013A Fig. 2 & 3	1/2 NPT	3-1/2	1-9/16	2-3/4	3-1/8	1-3/8	3/4					
	3/4		1-9/16	2-9/16	3-3/8							
	1		1-3/4	2-13/16	3-7/8							
	1-1/4		1-15/16	2-11/16	4-1/4							
	1-1/2		2-3/16	2-7/8	4-3/4							
	2 NPT		2-7/16	3-1/4	5-7/8							
	2-1/2 Flg.		3-3/4	6-7/16	9-1/2			2-1/2	3/4	5-1/2	7	4
	3	3-1/2	4-7/16	6-5/8	11	1-3/8	3/4	3	3/4	6	7-1/2	4
	4	5-1/4	4-11/16	8-11/16	13	1-7/8	1-1/2	4	3/4	7-1/2	9	8
	5	5-1/4	5-5/8	9-5/8	15	1-7/8	1-1/2	5	7/8	8-1/2	10	8
	6 Flg.	5-1/4	6-9/16	10-11/16	16-1/2	1-7/8	1-1/2	6	7/8	9-1/2	11	8
V5013B & C Fig. 4	2-1/2 Flg.	3-1/2	4-1/2	6-7/16	9-1/2	1-3/8	3/4	2-1/2	3/4	5-1/2	7	4
	3	3-1/2	5-1/4	6-5/8	11	1-3/8	3/4	3	3/4	6	7-1/2	4
	4	5-1/4	5-7/8	8-11/16	13	1-7/8	1-1/2	4	3/4	7-1/2	9	8
	5	5-1/4	6-1/4	9-5/8	15	1-7/8	1-1/2	5	7/8	8-1/2	10	8
	6	5-1/4	7-1/4	10-11/16	16-1/2	1-7/8	1-1/2	6		9-1/2	11	8
	8 Flg.	5-1/8	9-1/4	14	21-3/8	3-1/4	2	8	7/8	11-3/4	13-1/2	12
V5013D & E Fig. 4	2-1/2 Flg.	3-1/2	4-5/8	7	11-1/2	1-3/8	3/4	2-1/2	7/8	5-7/8	7-1/2	4
	3	3-1/2	5-1/4	7-1/2	12-1/2	1-3/8	3/4	3		6-5/8	8-1/4	4
	4	5-1/4	7-1/2	9-1/2	14-1/2	1-7/8	1-1/2	4		7-7/8	10	8
	5	5-1/4	8	10-3/16	16-3/4	1-7/8	1-1/2	5		9-1/4	11	8
	6	5-1/4	8	11-3/16	18-5/8	1-7/8	1-1/2	6	7/8	10-5/8	12-1/2	12
	8 Flg.	5-1/8	9-1/4	14-5/8	22-3/8	3-1/4	2	8	1	13	15	12

TABLE 3--V013A-E DIMENSIONS IN MILLIMETERS
REFERENCED IN FIGURES 2, 3 & 4

Valve and Figure Reference	Valve Size	A	B	C	D	E	F	G	H	J	K	No. of Bolt Holes
V5013A Fig. 2 & 3	1/2 NPT	90	40	70	79	35	19					
	3/4		40	65	82							
	1		44	71	98							
	1-1/4		49	68	108							
	1-1/2		55	73	121							
	2 NPT		62	82	149							
	2-1/2 Flg.		95	163	241			63	19	140	178	4
	3	90	113	168	279	35	19	76	19	152	190	4
	4	133	119	221	330	48	38	102	19	190	229	8
	5	133	143	244	381	48	38	127	22	216	254	8
	6 Flg.	133	167	271	419	48	38	152	22	241	279	8
V5013B & C Fig. 4	2-1/2 Flg.	90	114	163	241	35	19	63	19	140	178	4
	3	90	133	168	279	35	19	76	19	152	190	4
	4	133	149	221	330	48	38	102	19	190	229	8
	5	133	159	244	381	48	38	127	22	216	254	8
	6	133	184	271	419	48	38	152		241	279	8
	8 Flg.	130	235	356	543	82	51	203	22	298	343	12
V5013D & E Fig. 4	2-1/2 Flg.	90	117	178	292	35	19	63	22	149	190	4
	3	90	133	190	317	35	19	76		168	209	4
	4	133	190	241	368	48	38	102		200	254	8
	5	133	203	259	425	48	38	127		235	279	8
	6	133	224	284	473	48	38	152	22	270	317	12
	8 Flg.	130	235	371	568	82	51	203	25	330	381	12

Typical Operation

MIXING SERVICE

When a mixing valve is used in a modulating heating application with Port B connected to a hot water boiler, Port A to a boiler bypass, and Port AB to a load, a fall in temperature at the controller lifts the stem to proportionally open Port B and close Port A increasing temperature of the water leaving the valve.

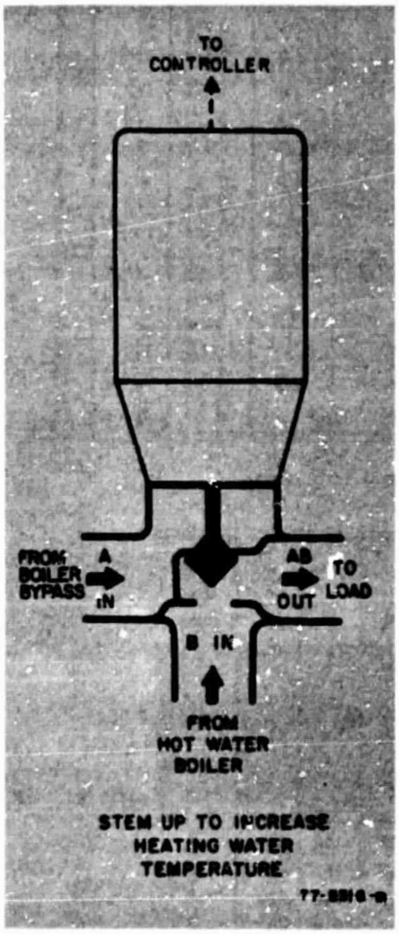


FIG. 8–V5013A, B, & D MIXING VALVE OPERATION

DIVERTING SERVICE

When a diverting valve is used in a heating application, with Port A connected to a coil, Port B connected to a coil bypass, and Port AB connected to the supply, a fall in temperature at the controller moves the valve stem up, opening to Port A and closing to Port B, increasing the flow of hot water through the coil.

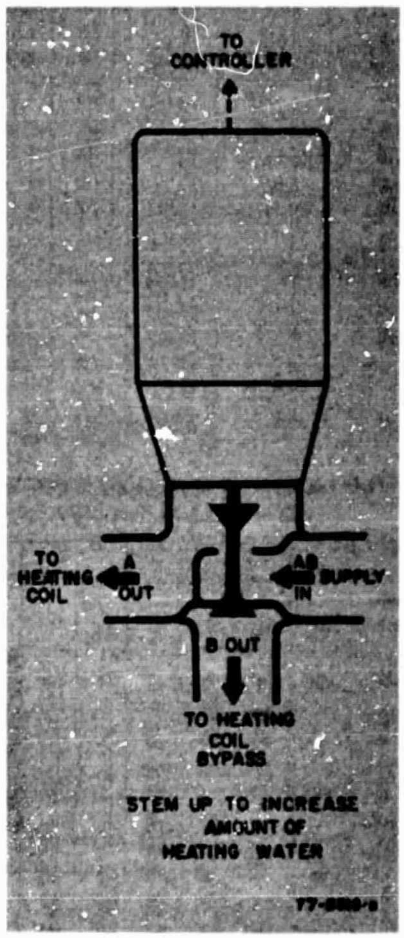


FIG. 9–V5013C & E DIVERTING VALVE OPERATION

TABLE 4—VALVE/OPERATOR SELECTION MATRIX

Basic Valve	Size (Inches)	Cv	⚠1 Pneumatic Operator	⚠2 Electric Actuators: Two-Position or Floating Non-Spring Return	Two-Position Spring Return	Proportional Non-Spring Return	Proportional Spring Return	Electronic Actuators	Notes
V5013A	1/2	2.5, 4.0	A1,C1 A2,C2 B1,D1	E or G	H or I	J or L	M or N	O or P	
Three-way	3/4	6.3							
Mixing Valve	1	10							
with Screwed	1-1/4	16							
End Connections	1-1/2	25							
	2	40	A1,C1 A2,C2 B1,D1	E or G	H or I	J or L	M or N	O or P	
V5013B & D	2-1/2	63	A2,C2 B1,D1	E		J or L			
Three-Way	3	100	A2,C2 B1,D1	E		J or L			
Mixing Valve	4	160	A3,C3	F		K			
Flanged	5	250							
End Connections	6	360	A3,C3	F		K			
(D Model for	8	600	Industrial Type: 01-15	Not recommended for tight close-off. Use pneumatic opener.					
High Pressure			or 01-18S						
Applications).									
V5013C & E	2-1/2	63	A2,C2 B1,D1	E		J or L			
Three-Way	3	100	A2,C2 B1,D1	E		J or L			
Diverting Valve	4	160	A3,C3	F		K			
Flanged	5	250	A3,C3						
End Connections	6	360	A3,C3	F		K			
(E Model for	8	600	Industrial Type: 01-15	Not recommended for tight close-off. Use pneumatic operator.					
High Pressure			or 01-18S						
Applications).									

NOTES:

⚠1 The MP953A-D are rolling type diaphragm actuators which provide proportional control of V5011 valves.

- A1 – MP953A D.A. 5 in. dia. with positioner.
- A2 – MP953A D.A. 8 in. dia. with positioner.
- A3 – MP953A D.A. 13 in. dia. with positioner.
- B1 – MP953B R.A. 7-1/8 in. dia. with positioner.
- C1 – MP953C D.A. 5 in. dia. without positioner.
- C2 – MP953C D.A. 8 in. dia. without positioner.
- C3 – MP953C D.A. 13 in. dia. without positioner.
- D1 – MP953D R.A. 7-1/8 in. dia. without positioner.

*Not recommended for tight close-off. Use pneumatic operator.

⚠2 Example Linkages:

Q601E1000 – 160 lb. seal-off force.
Q618A1024 – 80 lb. seal-off force.
Q618A1032 – 160 lb. seal-off force.

Letter Designation	Use Motor Similar to:	with	Linkage Similar to:
E	M644A		Q618A1024
F	M644C		Q601E1000
G	M634B		Q618A1032
H	M845A		Q618A1032
I	M845E		Q618A1032
J	M944A		Q618A1024
K	M944C		Q601E1000
L	M934A		Q618A1032
M	M945A		Q618A1032
N	M945F		Q618A1032
O	M7044B		Q618A1024
P	M7045		Q618A1032

77-5316

Honeywell

VP516A & C THREE-WAY PNEUMATIC VALVE ASSEMBLIES

APPLICATION

For proportional or two-position control of hot or cold water in coils of heating or cooling systems. Used for mixing service to direct flow from two inlets to a common outlet; for general purpose mixing applications. Not for diverting flow from a common inlet to one of two outlets.

CONSTRUCTION

Three-way mixing, normally open to bottom inlet. Constant total flow throughout full plug travel. Spring-loaded, self-adjusting, Teflon or rubber "V" ring packing. Operator can be rotated to align air connection with control air piping and can be removed without disturbing adjustments. Operator furnished with tough wear-resistant Neoprene diaphragm. Small operator available with silicone diaphragm for high temperature applications. Diaphragms replaceable. The MP953A Operator used in the VP516A Valve Assembly is furnished with a Gradutrol positive positioning relay. The start point and operating range are adjustable on the positioner to provide sequence operation with other controlled devices. The VP516C assembly is furnished without the relay.

ASSEMBLY

ASSEMBLY	BODY	OPERATOR (DIRECT)	
		MODEL	POSITIONER
VP516A	V5013A	MP953A	With
VP516C	V5013A	MP953C	Without

Valve assemblies shipped assembled.

BODY

SIZES: 1/2 in. through 2 in., screwed.

NOMINAL BODY RATING: 250 psi bronze.

FLOW CHARACTERISTICS: Constant total flow throughout full plug travel.

SEAT: Top seat in valve body, lower seat in lower inlet. Integral brass.

VP516A with Gradutrol* Relay

PLUG: Contoured to provide linear characteristics. Brass. Metal-to-metal seating.

CAPACITY: See Table 2 for Cv.

PACKING: Teflon "V" ring on 1-1/2 and 2 in. Valves - Rubber "V" ring on 1/2 to 1-1/4 in. Valves, spring-loaded, self-adjusting.

LIFT: All sizes, 3/4 in.

OPERATOR

CONTROL AIR PRESSURE: 25 psi maximum.

POSITIONER: On VP516A only.
Start point—adjustable between 3 and 10 psi.
Operating range—3, 5, or 10 psi.

SPRING RANGES AVAILABLE (VP516C, less positioner): 2 to 7, 4 to 11, or 8 to 12 psi.

*Trademark

Rev. 11-73
R.F.L.

Form Number 77-5214
Commercial Div

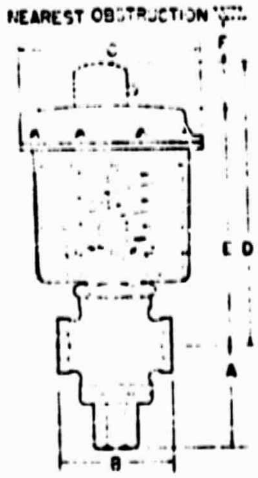


Fig. 1 - Dimensions.

Body Size (in.)	Operator	A	B	C	[illegible]	[illegible]	[illegible]
[illegible]	Small	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Small	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	Small	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Small	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Small	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Small	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Medium	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Medium	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ORIGINAL PAGE IS OF POOR QUALITY

OPERATING TEMPERATURE: 160F maximum ambient at Neoprene diaphragm; 250F maximum ambient at silicone diaphragm.

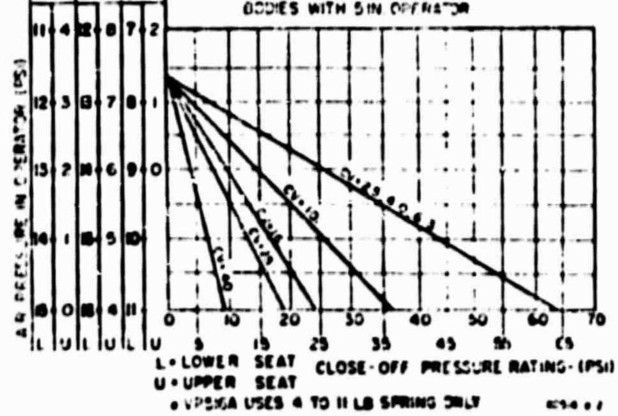
FINISH: Gray.

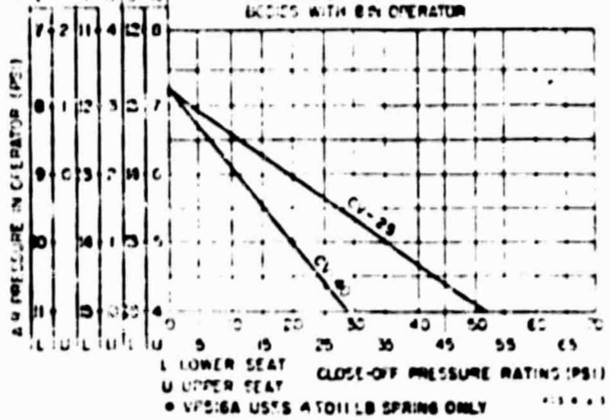
CLOSE-OFF RATINGS: The air pressure available and spring range determine the VP516 close-off rating. With a three-way valve, the close-off rating against the upper seat may be different than that against the lower seat. Both should be checked on the graphs. The close-off rating for the upper seat is determined by the lowest air pressure available in the operator. The lower seat close-off is determined by the highest air pressure available.

TABLE 2 - VALVE RATINGS

VALVE ASSEMBLY	SIZE (INCHES)	Cv*	RECOMMENDED MAXIMUM PRESSURE DIFFERENTIAL	MAX PRESS DIFFERENTIAL (FOR CLOSE-OFF)	PACKING OR OPERATOR LIMITATION: MAXIMUM TEMPERATURE OF AGENT**	MAXIMUM PRESSURE OF AGENT	NORMAL LIMITING FACTOR
VP516A & VP516C	½ ½ ¾ 1 1¼ 1½ 2	2.5 4.0 6.3 10.0 16.0 25.0 40.0	20 psi	See Graphs	240F	250 psi screwed 125 psi flanged	Maximum Pressure Differential

*For determing required Cv, see page J-6 in Automatic Controls Catalog
**Minimum water temperature, 40 F.
Maximum temperature differential when used for alternating hot and cold water, 140 F.





77-5214

INNER VALVE CONSTRUCTION

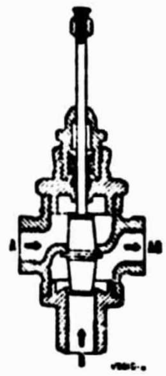


Fig. 2–V5013A (Mixing Valve).

TYPICAL OPERATION

Normally open to Port B. An increase in control air pressure moves the plug away from Port A. Maximum control air pressure closes Port B and opens Port A. Full main pressure available through the positioner to provide positive valve positioning for all load conditions.

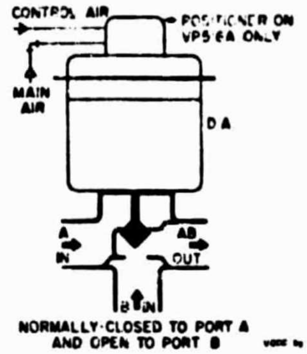


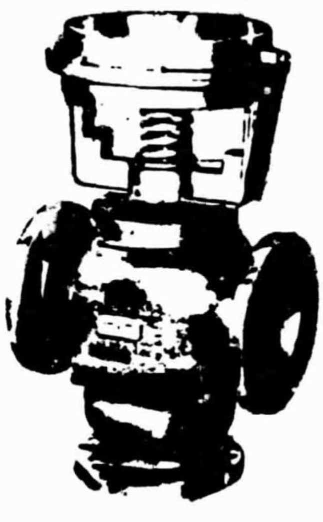
Fig. 3–VP516A and C Operation.

Honeywell

[illegible]

VP516E-H PNEUMATIC VALVE ASSEMBLIES 3-WAY MIXING OR DIVERTING, 2-1/2 IN. TO 8 IN.

Specification Data



APPLICATION

For proportional or two-position control of hot or cold water in heating or cooling systems. Used for mixing service (VP516E and G) to direct one of two inlets to a common outlet, or for diverting (VP516F and H) to direct flow from a common inlet to one of two outlets.

CONSTRUCTION

Three-way mixing, normally open to ports B to AB; or three-way diverting, normally open to ports AB to A. Constant total flow throughout full plug travel. Single-piece body has cage-type innervalve construction permitting easy service and repair. Spring-loaded, self-adjusting Teflon packing. Operator can be rotated to align main-air connection with control-air piping and can be removed without disturbing adjustments. The medium size operator is available with silicone diaphragm for high temperature application. Diaphragms are replaceable.

The MP953A Operator used in the 2-1/2 in. thru 6 in. VP516E and F Valve Assemblies is furnished with a Gradutrol* positive-positioning relay. The start point and operating range on the positioner are adjustable to provide sequence operation with other controlled devices. The VP516G and H Assemblies are furnished without the relay.

ASSEMBLY

Table 1–VP516E-H Valve Assembly Components.

Assembly	Body	Operator	Positioner
VP516E	V5013B & D Mixing	MP[illegible]A[a]	With
VP516F	V5013C & E Diverting	MP[illegible]	With
VP516G	V5013B & D Mixing	MP[illegible]	Without
VP516H	V5013C & E Diverting	MP[illegible]	Without

[a]8-in. valves use type 01 operator

*Trademark

Rev. 11-72

BODY

SIZES: Flanged, 2-1/2, 3, 4, 5, 6 and 8 in.

NOMINAL BODY RATING: 125 psi, B & C models/250 psi P & E models.

FLOW CHARACTERISTICS: Constant total flow throughout full plug travel. Linear each port.

SEATS: Replaceable bronze. Both seats held in place by bronze cages sealed to body by rubber "O" rings.

PLUG: Bronze, metal-to-metal seating, skirt guided

STEM: Stainless steel.

LIFT:
- 2-1/2 in. and 3 in. sizes–3/4 in.
- 4, 5 and 6 in. sizes–1-1/2 in.
- 8 in. size–2 in.

PACKING: Spring loaded, self adjusting Teflon packing.

[illegible] 77-5256

OPERATOR

CONTROL AIR PRESSURE:
- 2-1/2 thru 6 in. valves–25 psi max.
- 8 in valves–50 psi max.

POSITIONER: On VP516E and F only. Start point adjustable between 3 and 10 psi, operating range adjustable to 3, 5 or 10 psi.

SPRING RANGES AVAILABLE: On VP516G and H (less positioner)
- 2-1/2 to 6 in. models:
  - Medium MP953–2 to 7, 4 to 11 or 8 to 12 psi.
  - Large MP953–4 to 11 psi and 2 to 7 psi only.
- 8 in. models:
  - 01-15 Operator–3 to 9, 9 to 15, 3 to 15, or 6 to 30 psi.
  - 01-15S Operator–3 to 15, 9 to 15, 3 to 9, or 6 to 30 psi.

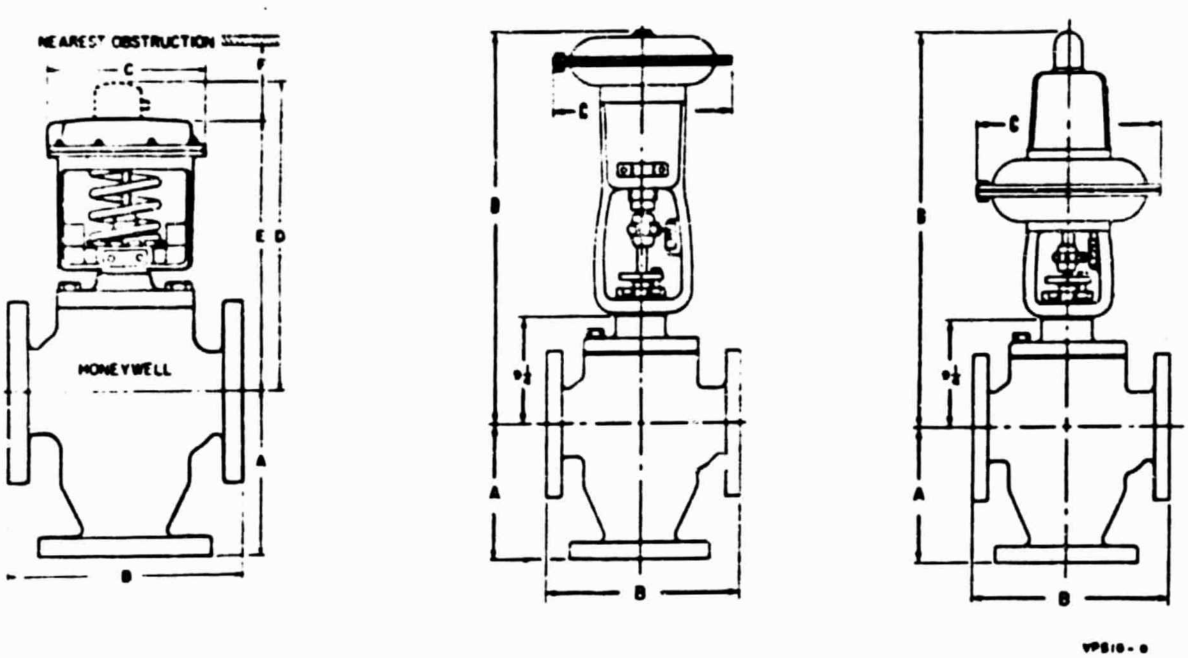


Fig. 1–Dimensions: 2-1/2 thru 6 in.–left; 8 in Direct Acting–center; 8 in Reverse Acting–right.

Table 2. Dimensions of VP 516E-H Valve Assemblies

Body	Operator	A		B		C	D		E		F
		125 psi	250 psi	125 psi	250 psi		125 psi	250 psi	125 psi	250 psi	
2-1/2	Medium MP953	6-7/16	7	9-1/2	11-1/2	8-1/4	13-3/8		11-1/8		5-3/8
3	Medium MP953	6-5/8	[illegible]	11	12-1/2	8-1/4	14		11-3/4		5-3/8
4	Large MP953	8-11/16	[illegible]	[illegible]	14-1/2	13-1/2	18-3/16	19-3/4	15-15/16	17-1/2	7-11/16
5	Large MP953	9-5/8	[illegible]	[illegible]	16-3/4	13-1/2	18-11/16	20-1/4	16-7/16	18	7-11/16
6	Large MP953	10-11/16	[illegible]	16-1/2	18-5/8	13-1/2	19-1/2	21-1/16	17-1/4	18-13/16	7-11/16
8	D.A. 01-15	14	[illegible]	[illegible]	22-3/8	17-1/2	34-5/8				
	D.A. 01-18s					20-1/2	38-1/8				
	R.A. 01-15					17-1/2	39-3/8				
	R.A. 01-18s					20-1/2	41-5/8				

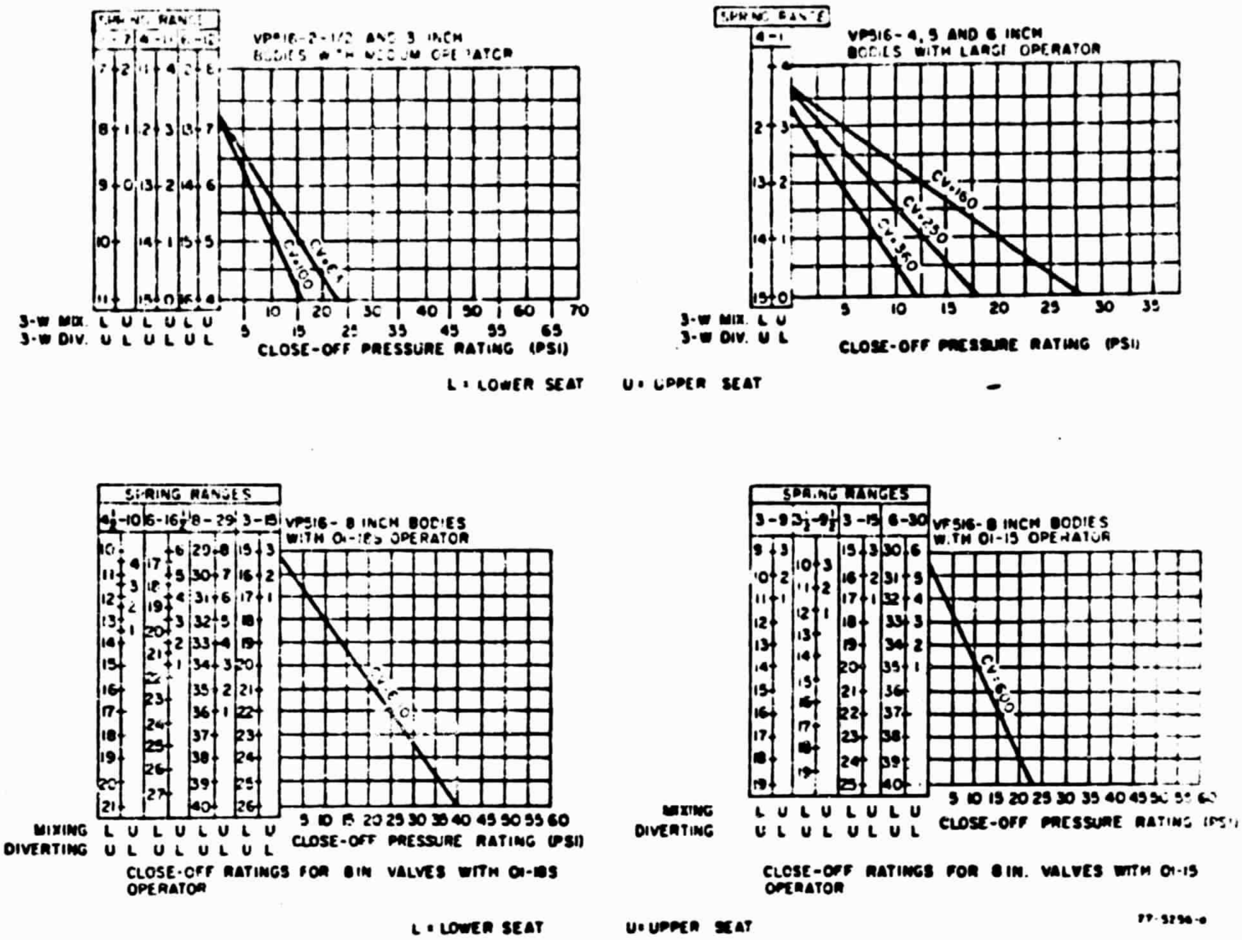
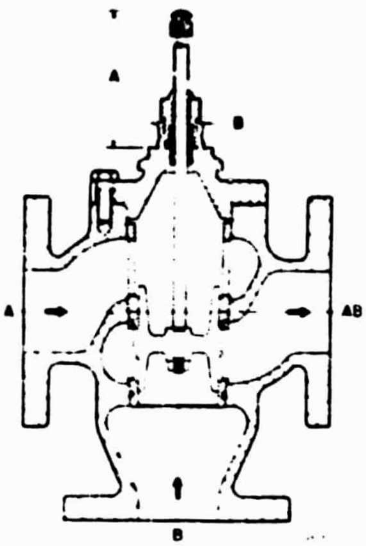


Fig 2–Close-off Ratings for VP516E through H.

Table 3—Valve Ratings

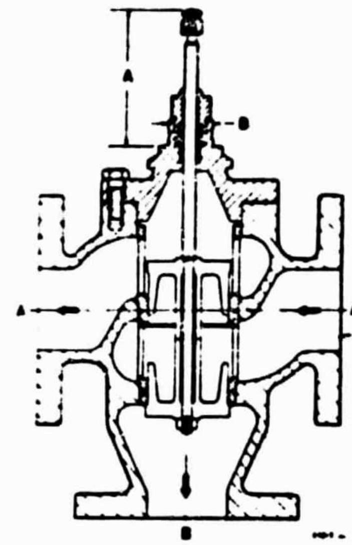
Valve Assembly	Size (Inches)	C_v	Recommended Maximum Pressure Differential	Max. Press. Differential (For Close-Off)	Packing or Operator Limitation: Maximum Temperature of Agent	Packing or Operator Limitation: Maximum Pressure of Agent	Normal Limiting Factor
VP516E thru VP516H	2½ 3 4 5 6 8	63.0 100.0 160.0 250.0 360.0 [illegible]	20 psi	See Graphs	240F	125 psi-V5013B & C 250 psi-V5013D & E	Maximum Pressure Differential

INNER VALVE CONSTRUCTION



Valve Size (In.)	Dimension A (Stem up)	Dimension B
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	3[illegible]

Fig. 3--V5013B Three-Way Mixing Valve.



Valve Size (In.)	Dimension A (Stem up)	Dimension B
2½ & 3	4[illegible]/32	1[illegible]/8
4, 5 & 6	6[illegible]/32	1[illegible]
8	7[illegible]	3[illegible]

Fig. 4–V5013C Three-Way Diverting Valve.

TYPICAL OPERATION

VP516E AND G MIXING (Fig. 5)

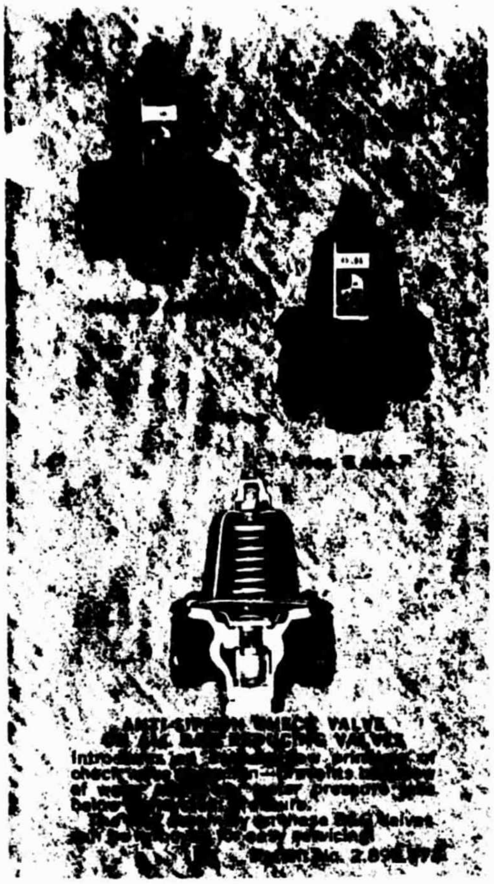
Normally open ports B to AB. An increase in control-air pressure moves the plug away from port A. Maximum control-air pressure closes port B and opens port A. Full main pressure available through a positioner (VP516E only) to provide positive valve positioning for all load conditions. Positioner also allows sequencing with other controlled devices.

VP516F AND H DIVERTING (Fig. 6)

Normally open ports AB to A. An increase in control-air pressure moves the plug away from port B. Maximum control-air pressure closes port A and opens port B. Full main pressure available through positioner (VP516F only) to provide positive valve positioning for all load conditions. Positioner also allows sequencing with other controlled devices.

Fig. 5–VP516E and G Mixing Valve Operation.

Fig. 6–VP516F and H Diverting Valve Operation.



12 lbs., suitable for 1, 2, and 3-story buildings. Adjustment easily made. Available in iron or brass body construction.

No.	Size	Body Const.	Factory Pressure Setting	Approx. Ship. Weight
12	¾"	Iron	12 Lbs. Del.	3¼ Lbs.
B7	¾"	Brass	12 Lbs. Del.	3¼ Lbs.

*Field adjustable range 8-25 PSI

The same Reducing Valve used in the B&G Dual Unit. Available only with two female connections. Brass or iron body.

No.	Size	Body Const.	Factory Pressure Setting	Approx. Ship. Weight
B3	½"	Brass	12 Lbs. Del.	3¼ Lbs.
FB3	½"	Brass	12 Lbs. Del.	3¼ Lbs.
B8	½"	Iron	12 Lbs. Del.	3 Lbs.
FB8	½"	Iron	12 Lbs. Del.	3 Lbs.

*Field adjustable range 8-25 PSI

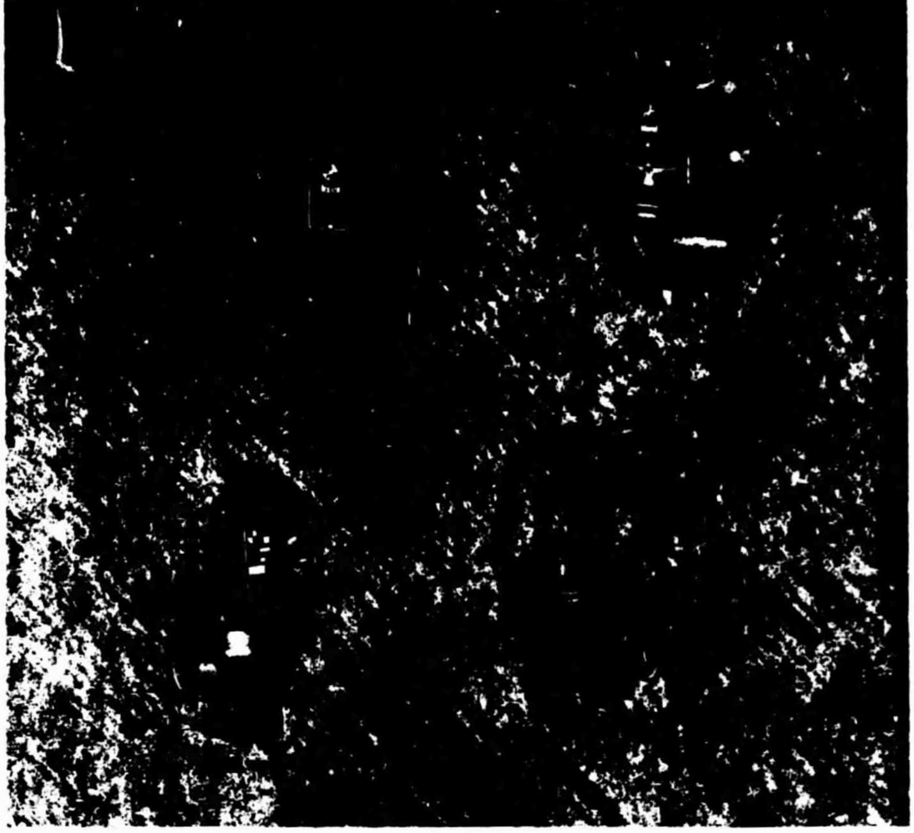
Protects plumbing fixtures against excessive line pressures. Factory adjusted for 125 lbs. initial pressure, 45 lbs. delivery pressure. Other pressures must be specified when ordering. All working parts brass construction, built-in strainer, extra large diaphragm.

No.	Size	Body Const.	Factory Pressure Setting	Approx. Ship Weight
[illegible]	½"	Brass	45 Lbs. Del.	3¼ Lbs.
[illegible]	¾	Brass	45 Lbs. Del.	3¼ Lbs.

Field adjustable range 25-60 PSI

[illegible] PSIG Working Pressure—225°F Max. Operg. Temp.

B&G ASME RELIEF VALVES



ASME RELIEF VALVES — Nos. 175-~~250-350~~-480-~~750-1050-3300-4100~~

These valves are built to ASME requirements—tested by National Board and labeled with ASME symbol. They are offered in a wide range of capacities to permit close matching of relief valve capacity to the boiler load.

B&G ASME Relief Valves are not "pop" type units. Diaphragm operation transmits more power during opening and closing of valve and also seals its spring chamber against possible corrosion. The valve seats against a face of EPT rubber which is resilient enough to prevent leakage when the valve is closed. EPT rubber is extremely resistant to the effects of high temperatures—age or use will not deform it.

The differential between opening and closing pressure is unusually low, preventing conditions under which the boiler water might flash into steam and cause hammering. Under normal operating conditions, thermal expansion in the system lifts the valve just far enough to discharge water at a low rate of flow. Under emergency conditions, the valve is opened wide to full rated capacity.

Valve Setting		Relief Valve Catalog Number and Capacity in BTU Per Hour							
15 Lbs.		No. 175-15 150,000	No. 250-15 200,000	No. 350-15 220,000	No. 480-15 300,000	No. 750-15 500,000	No. 1050-15 650,000	No. 3300-15 2,000,000	No. 4100-15 2,500,000
30 Lbs.	Standard Setting	No. 175† 175,000	No. 250† 250,000	No. 350† 350,000	No. 480† 480,000	No. 750 750,000	No. 1050 1,050,000	No. 3300† 3,300,000	No. 4100† 4,100,000
36 Lbs.		No. 175-36 230,000	No. 250-36 320,000	No. 350-36 410,000	No. 480-36 540,000	No. 750-36 830,000	No. 1050-36 1,200,000	No. 3300-36 3,800,000	No. 4100-36 4,600,000
45 Lbs.		No. 175-45 252,000	No. 250-45 441,000	No. 350-45 450,000	No. 480-45 640,000	No. 750-45 1,000,000	No. 1050-45 1,350,000	No. 3300-45 4,500,000	No. 4100-45 5,550,000
50 Lbs.		No. 175-50 270,000	No. 250-50 477,000	No. 350-50 485,000	No. 480-50 700,000	No. 750-50 1,100,000	No. 1050-50 1,440,000	No. 3300-50 4,900,000	No. 4100-50 6,050,000
75 Lbs.		No. 175-75 350,000	No. 250-75 500,000	No. 350-75 675,000	No. 480-75 980,000	No. 750-75 1,500,000	No. 1050-75 2,020,000		
100 Lbs.		No. 175-100 400,000	No. 250-100 650,000	No. 350-100 860,000	No. 480-100 1,250,000	No. 750-100 1,900,000	No. 1050-100 2,565,000		
125 Lbs.		No. 175-125 500,000	No. 250-125 750,000	No. 350-125 1,050,000	No. 480-125 1,540,000	No. 750-125 2,300,000	No. 1050-125 3,015,000		
Valve Tappings	Inlet Outlet	¾" 1"	¾" 1"	¾" 1"	¾" 1"	1" 1¼"	1¼" 1¼"	1½" 2"	2" 2"
Approx. Ship. Wt. Lbs.	Ea. Valve	3½	3½	3¼	4	5	5	18	18
	12 in Ctn.	40	40	41	41	60	58		

*Not for Domestic Service

125 PSIG Working Pressure—250°F Maximum Operating Temperature

†Patent No. 3,294,114

ORIGINAL PAGE IS OF POOR QUALITY

STOCKED—SOLD—SERVICED EVERYWHERE

JOB________________________________

ENGINEER________________________________

CONTRACTOR________________________________

SUBMITTED BY________________ DATE__________

APPROVED BY________________ DATE__________

NO.________________ SIZE__________

THRUSH RELIEF VALVE

Nos. 38 AND 138
Nos. 81 AND 181

THRUSH RELIEF VALVES

Built in accordance with the requirements of the A.S.M.E. Boiler and Pressure Vessel code

SAFE, DEPENDABLE PRESSURE RELIEF

TIME-TESTED THRUSH RELIEF VALVES ARE DESIGNED TO PROVIDE GREATER CAPACITY AND MAXIMUM PROTECTION FOR SPACE HEATING HOT WATER BOILERS AND DOMESTIC HOT WATER SUPPLY SYSTEMS. VALVES FEATURE BRASS SEAT AND A HEAT-RESISTANT, SILICONE COMPOSITION DISC THAT WILL NOT STICK, SWELL, WARP OR DISTORT IN ANY WAY. IN OPERATION, THIS DISC OPENS WIDELY TO PROVIDE FULL DISCHARGE WHEN THE PRESSURE SETTING IS REACHED. A SPECIAL COMPOSITION DIAPHRAGM ACTS AS A POSITIVE GUIDE, AND ALSO PROTECTS SPRING FROM WATER DAMAGE. SPECIFY AND INSTALL WITH CONFIDENCE . . . THRUSH RELIEF VALVES ARE DESIGNED AND BUILT TO COMPLY WITH REQUIREMENTS OF THE A.S.M.E. CODE.

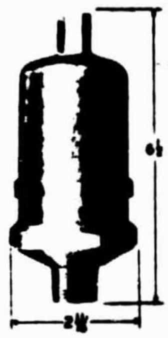
SIZES AND CAPACITIES

NO.	INLET AND OUTLET	SETTING	BTU RATING
38	¾"	30 P.S.I.	520,000
138	1"	30 P.S.I.	1,215,000
81	¾"	100 P.S.I. 125 P.S.I. 150 P.S.I.	1,340,000 1,640,000 1,940,000
181	1"	125 P.S.I. 150 P.S.I.	3,865,000 4,560,000

THRUSH Products, Inc.

HOFFMAN WATER VENTS

No. 77 WATER VENT
Designed for efficient releasing of air in hydronic heating systems, such as baseboard radiators, convector radiators and small heating units
Size Conn.:
⅛" straight shank
Max. Oper. Press.:
35 PSIG
Max Temp.:
230 F



No. 78 WATER MAIN VENT VALVE
Designed for use on high pressure hot or cold water mains and process applications Cast brass body Safety drain connection for discharging moisture entrained in the vented air Tapped at top for ⅛" I P S Built-in Check Valve
Size Conn.:
¼" straight shank
Max. Oper. Press.: 150 PSI – will withstand hydrostatic pressures of 450 PSI

No. 79 WATER MAIN VENT VALVE
Designed for use on hot or cold water mains and process applications Tapped at top for ⅛" I P S safety drain connection for discharging moisture entrained in the vented air Built-in Check Valve
Size Conn.: [illegible] female • [illegible] male straight shank
Max. Oper. Press.: 75 PSI – will withstand hydrostatic pressures of 200 PSI

No. 790 WATER VALVE
Especially designed for removing air from convectors baseboard and wall radiation Safety drain connection at the top for discharging moisture entrained in the vented air Fitting and ferrule for [illegible] OD tubing Telescopic Siphon Tube
Size Conn.: [illegible] straight shank
Max. Oper Press.: 30 PSI

No. 791 WATER VALVE
Designed for convectors and small mains Safety drain connection at top for discharging moisture entrained in the vented air Fitting and ferrule for [illegible] OD tubing Telescopic Siphon Tube
Size Conn.: [illegible] straight shank
Max. Oper. Press.: 50 PSI

No. 792 HIGH PRESSURE WATER VENT
Designed for releasing air from hot or cold water mains, hydronic heating and chilling systems storage and processing tanks filters, centrifugal pumps Cast iron body and cover, stainless steel interior.
Max. Oper. Press.:
250 PSIG
Max. Temp.:
300 F
Hy. Press.:
to 350 PSIG

No. 500 AIR VALVE
A disc type vent with built in Check Valve designed for venting systems [illegible] automatically Disc can be replaced without draining the system
Size Conn.: [illegible] shank
Max. Water Press.: [illegible]

No. 550 AIR CHAMBER
Primarily designed for use on convectors which are not provided with built-in air chambers or air collection fittings It is all brass construction and provided with a drain tube Ideal for use with the No 500 Air Vent [illegible] Straight shank connection tapped at the top for [illegible] connection Volume is 6 cubic inches
Max. Water Press.: 100 PSI
Max. Steam Press.: 25 PSI

No. 793 DRAIN VALVE
To remove water automatically from compressed air tanks, air separators, drip points and after coolers with minimum air loss Cast iron body and cover stainless steel interior
Max. Press.:
250 PSIG
Cold Water:
100 F Max temp
Hy. Press.:
to 350 PSIG

HOFFMAN SPECIALTY ITT
1700 West Tenth Street Indianapolis Indiana 46222
INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

Printed in U S A 3-76

BELL & GOSSETT ITT
Fluid Handling Division

Airtrol Tank Fittings
Model No. ATFL

IRON BODY BRONZE TRIMMED and ALL IRON SWING CHECK VALVES

Fig. 558

Bronze Trimmed, Threaded

Fig. 1258 — All Iron, Threaded
Sizes, 2 through 4

Sectional

Fig. 559

Bronze Trimmed, Flanged

Fig. 1259 — All Iron, Flanged
Sizes, 2 through 18

ORDERING

- These valves are normally carried in stock

125 Pound

BOLTED FLANGED CAP THREADED and FLANGED ENDS

PRESSURE/TEMPERATURE RATINGS

	Threaded	Flanged
2" to 12"	125	125 psi Saturated Steam
	200	200 psi Non-Shock Cold Water, Oil or Gas
14" & 16"	—	125 psi Saturated Steam
	—	150 psi Non-Shock Cold Water, Oil or Gas
18"	—	150 psi Non-Shock Cold Water, Oil or Gas

MATERIALS

DESCRIPTION	MATERIAL	ASTM Spec.
Body Bolts & Nuts	Steel	A-307, Grade B
Cap	Cast Iron	A-126, Class B
Gasket	Asbestos	Commercial
Disc Holder Shaft		
Bronze Trimmed	Brass	B-16
All Iron	Steel	A-108, Grade 1020
Pipe Plug		
Bronze Trimmed	Steel	A-108, Grade 1020
All Iron	Cast Iron	A-126, Class B
Body	Cast Iron	A-126, Class B
Seat Ring	Bronze	B-62
Disc Nut		
Bronze Trimmed	Brass	B-16
All Iron	Steel	A-307, Grade B
Disc Nut Pin	Stainless Steel	A-276, Grade 302
Disc Holder		
Bronze Trimmed	Bronze	B-62
All Iron	Malleable Iron	A-47, Grade 32510
Disc		
Bronze Trimmed 2-8	Bronze	B-62
Bronze Trimmed 10-18	Cast Iron with Bronze Disc Ring	A-126, Class B
All Iron	Cast Iron	A-126, Class B

SPECIFICATIONS

- Flanged End Valves are in accordance with ANSI B16.1 and B16.10

FEATURES

- Renewable Discs
- Renewable Screwed-in Seat Rings in Bronze Trimmed valves; integral seats in All Iron valves
- These valves may be used in horizontal or vertical position; however, the pressure must be under the disc

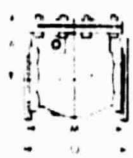


Fig 558
Fig 1258
Fig 559
Fig 1259

DIMENSIONS (Inches)

Size	2	2½	3	4	6	8	10	12	14	16	18
M	6½	7	8	10	—	—	—	—	—	—	—
A	5	5½	6	7¾	9	11	12¾	14½	16½	17½	21¼
O	8	8½	9½	11½	14	19½	24½	27½	31	36	36

WEIGHTS

Size	2	2½	3	4	6	8	10	12	14	16	18
Fig. 558	20#	28#	35#	73#	—	—	—	—	—	—	—
Fig. 559	33#	42#	52#	95#	168#	300#	460#	685#	985#	1270#	1675#
Fig. 1258	20#	28#	40#	75#	—	—	—	—	—	—	—
Fig. 1259	28#	41#	54#	95#	173#	300#	460#	685#	985#	1245#	1350#

IRON BODY BRONZE TRIMMED and ALL IRON SWING CHECK VALVES

Fig. 558

Bronze Trimmed, Threaded

Fig. 1258 — All Iron, Threaded
Sizes, 2″ through 4″

Sectional

Fig. 559

Bronze Trimmed, Flanged

Fig. 1259 — All Iron, Flanged
Sizes, 2″ through 18″

ORDERING

- These valves are normally carried in stock

125 Pound

BOLTED FLANGED CAP
THREADED and FLANGED ENDS

PRESSURE/TEMPERATURE RATINGS

	Threaded	Flanged
2″ to 12″	125	125 psi Saturated Steam
	200	200 psi Non-Shock Cold Water, Oil or Gas
14″ & 16″	—	125 psi Saturated Steam
	—	150 psi Non-Shock Cold Water, Oil or Gas
18″	—	150 psi Non-Shock Cold Water, Oil or Gas

MATERIALS

DESCRIPTION	MATERIAL	ASTM Spec.
Body Bolts & Nuts	Steel	A-307, Grade B
Cap	Cast Iron	A-126, Class B
Gasket	Asbestos	Commercial
Disc Holder Shaft		
Bronze Trimmed	Brass	B-16
All Iron	Steel	A-108, Grade 1020
Pipe Plug		
Bronze Trimmed	Steel	A-108, Grade 1020
All Iron	Cast Iron	A-126, Class B
Body	Cast Iron	A-126, Class B
Seat Ring	Bronze	B-62
Disc Nut		
Bronze Trimmed	Brass	B-16
All Iron	Steel	A-307, Grade B
Disc Nut Pin	Stainless Steel	A-276, Grade 302
Disc Holder		
Bronze Trimmed	Bronze	B-62
All Iron	Malleable Iron	A-47, Grade 32510
Disc		
Bronze Trimmed 2″-8″	Bronze	B-62
Bronze Trimmed 10″-18″	Cast Iron with Bronze Disc Ring	A-126, Class B
All Iron	Cast Iron	A-126, Class B

SPECIFICATIONS

- Flanged End Valves are in accordance with ANSI B16.1 and B16.10

FEATURES

- Renewable Discs
- Renewable Screwed-in Seat Rings in Bronze Trimmed valves; integral seats in All Iron valves
- These valves may be used in horizontal or vertical position; however, the pressure must be under the disc

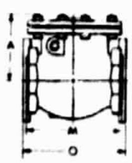


Fig. 558
Fig. 1258
Fig. 559
Fig. 1259

DIMENSIONS (Inches)

Size	2	2½	3	4	6	8	10	12	14	16	18
M	6½	7	8	10	—	—	—	—	--	—	—
A	5	5½	6	7¾	9	11	12¾	14½	16½	17½	21¼
O	8	8½	9½	11½	14	19½	24½	27½	31	36	36

WEIGHTS

Fig.	2	2½	3	4	6	8	10	12	14	16	18
Fig. 558	20#	28#	35#	73#	—	—	—	—	—	—	—
Fig. 559	33#	42#	52#	95#	168#	300#	460#	685#	985#	1270#	1675#
Fig. 1258	20#	28#	40#	75#	—	—	—	—	—	—	—
Fig. 1259	28#	41#	54#	95#	173#	300#	460#	685#	985#	1245#	1350#

IRON BODY BRONZE TRIMMED and ALL IRON SWING CHECK VALVES

Fig. 575
Bronze Trimmed, Threaded
Sizes, 2" through 4"

Sectional
Fig. 576
Bronze Trimmed, Flanged
Sizes, 2" through 10"

Sectional
Fig. 1274
All Iron, Flanged
Sizes, 2" through 10"

ORDERING

- These valves are normally carried in stock

250 Pound

BOLTED FLANGED CAP
THREADED and FLANGED

PRESSURE/TEMPERATURE RATINGS

Threaded	Flanged	
250	250	psi Steam at 450°F
500	500	psi Non-Shock Cold Water, Oil or Gas

MATERIALS

DESCRIPTION	MATERIAL	ASTM Spec
Body Bolts	Steel	A-307, Grade B
Cap	Cast Iron	A-126, Grade B
Gasket	Asbestos	Commercial
Body Nuts	Steel	A-307, Grade B
Disc Holder Shaft		
Bronze Trimmed	Brass	B-16
All Iron	Steel	A-108, Grade 1020
Pin Plug Gasket	Iron	Commercial
Pipe Plug		
Bronze Trimmed	Brass	B-16
All Iron	Steel	A-108, Grade 1020
Disc Holder		
Bronzed Trimmed		
2"-6"	Brass	B-124
8"-10"	Bronze	B-62
All Iron	Malleable Iron	A-47, Grade 32510
Disc Nut Pin	Stainless Steel	A-276, Type 302
Disc Nut		
Bronze Trimmed		
2"-6"	Brass	B-16
8"-10"	Cast Iron	A-126, Grade B
All Iron	Steel	A-307, Grade B
Disc		
Bronze Trimmed		
2"-6"	Brass	B-124
8"-10"	Cast Iron	A-126, Grade B
All Iron	Cast Iron	A-126, Grade B
Body	Cast Iron	A-126, Grade B
Seat Ring		
Bronze Trimmed	Bronze	B-62

SPECIFICATIONS

- Flanged End valves are in accordance with ANSI B16.1 and B16.10

FEATURES

- Renewable Discs
- Renewable Screwed-in Seat Rings on Bronze Trimmed valves; integral seats on All Iron valves
- Valves must be installed with pressure under the disc

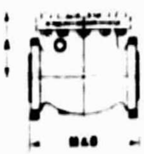


Fig. 575
Fig. 576
Fig. 1274

DIMENSIONS (Inches)

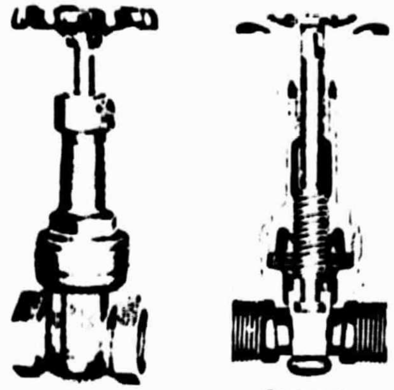
Size	2	2 1/2	3	4	6	8	10
M (Threaded)	9 1/2	10 1/4	11 1/4	13	—	—	—
O (Flanged)	10 1/2	11 1/2	12 1/2	14	17 1/2	[illegible]	24 1/2
A	6 5/16	7 1/8	7 7/8	8 15/16	10 13/16	11 3/8	14 5/16

WEIGHTS

	2	2 1/2	3	4	6	8	10
Fig. 575	40 #	55 #	90 #	120 #	—	—	—
Fig. 576	52 #	76 #	102 #	160 #	290 #	480 #	760 #
Fig. 1274	55 #	76 #	105 #	160 #	290 #	480 #	760 #

BRONZE GATE VALVES

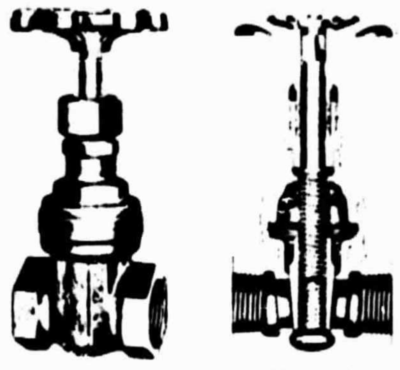
"U.S."



Sectional

Fig. 500

Inside Screw Rising Stem
Sizes, ¼" through 3"



Sectional

Fig. 507

Inside Screw Non-Rising Stem
Sizes, ¼" through 3"

ORDERING

- These valves are normally carried in stock
- Double Wedges, in Rising Stem valves, are available on special order

125 Pound

SCREWED-IN BONNET
THREADED ENDS

PRESSURE/TEMPERATURE RATINGS

125 psi Saturated Steam
200 psi Non-Shock Cold Water, Oil or Gas

MATERIALS

DESCRIPTION	MATERIAL	ASTM Spec.
Handwheel Nut	Brass	B-16
Identification Plate	Aluminum	Commercial
Handwheel	Aluminum	Commercial
Stem	Silicon Bronze	WPC Alloy #69
Packing Gland	Brass	B-16
Packing Nut*	Bronze	B-62
Packing	Graphite Asbestos	Commercial
Stuffing Box**	Silicon Bronze	WPC Alloy #69
Bonnet	Bronze	B-62
Body	Bronze	B-62
Wedge	Bronze	B-62

*Brass ASTM B-16 for ¼" through 1" valves

**Furnished on Fig. 507

SPECIFICATIONS

- Federal Specifications WW-V-54, Class A

FEATURES

- Renewable Solid Wedges
- Integral Seats
- High-Tensile Bronze Alloy Stem
- Solid and Double Wedges, in Rising Stem valves, are interchangeable

Fig. 500

Fig. 507

DIMENSIONS (Inches)

Size	1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3
A	1 3/4	2	2 3/16	2 7/16	2 3/4	3	3 3/8	4	4 1/2	5
B	4 1/4	4 1/4	4 7/8	6 1/8	7 3/8	8 3/8	9 5/8	11 11/16	14	16 1/2
C	2 1/8	2 1/8	2 1/2	2 3/4	3	3 1/4	3 5/8	4 1/16	4 3/4	5 11/16
D	3 1/2	3 1/2	3 11/16	4 9/16	5 7/16	6 1/4	6 3/4	7 13/16	9 1/4	10 5/8

WEIGHTS

Fig. 500	12 oz.	13 oz.	1 #1	1 #12	2 #8	3 #12	5 #	8 #6	15 #3	22 #3
Fig. 507	12 oz.	13 oz.	1 #1	1 #12	2 #8	3 #12	5 #	8 #6	15 #3	22 #3

Pump

SUBMITTAL DRAWING

CLASS A20 COMBINATION STARTER (FUSIBLE AND NON-FUSIBLE DISCONNECT)

LINE VOLTAGE *480* CYCLES *60*

CONTROL CIRCUIT TRANSFORMER *[illegible]*

ORIGINAL PAGE IS
OF POOR QUALITY

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[illegible]

NEMA 1 NEMA 12

Description	Required	Size	Approximate Dimensions			Approximate Shipping Weight	Modifications
			Height	Width	Depth		
GENERAL PURPOSE NEMA 1							
A3034313	*1*	0,1	24 5/8	9 13/32	5 15/16	40	*C, D, X1*
		2	28 7/32	10 19/32	5 15/16	46	
		3	36 1/32	12 21/32	7 35/64	80	
		4	42 23/32	15 11/16	7 39/64	95	
		5	60 3/8	20 1/8	10 1/4	125	
INDUSTRIAL USE NEMA 12							
		0,1	26 1/2	9 7/8	6 25/32	43	
		2	30 1/8	11 1/16	6 25/32	50	
		3	37 7/8	13 1/8	8 7/16	85	
		4	44 9/16	16 5/32	8 7/16	100	
		5	62 7/8	20 1/8	11 1/4	130	

MODIFICATIONS WITH NO DIMENSIONAL CHANGE	FORM LETTER
START STOP PUSHBUTTON in COVER	A
H-O-A SELECTOR SWITCH in COVER	C
PILOT LIGHT in COVER	D
AUX INTERLOCK 1 N.O.	X1
" " 1 N.C.	X2
" " 1 N.O. N.C.	X3
" " LATE BREAK N.C.	X4
STANDARD CONTROL TRANSFORMER with EXTRA 100 WATTS	[illegible]

[illegible]

WIRING DIAGRAM

STARTER TO HAVE FUSED PRI & SEC 480/120V CPT & RESET BUTTON IN COVER

JOB *SOLAR HEAT - TROY LIBRARY*
TROY OHIO

DISTRICT OFFICE *DAYTON, OHIO*

BY *C. [illegible]*

DATE *8-15-77*

ITE Imperial Corporation

IRON BODY BRONZE TRIMMED and ALL IRON GATE VALVES
"MODEL STAR"

Fig. 1796
Threaded, Bronze Trimmed

Fig. 1819
Threaded, All Iron
Sizes 2 through 4

Sectional

Fig. 1797
Flanged, Bronze Trimmed

Fig. 1820
Flanged, All Iron
Sizes, 2 through 16″

FEATURES

- Solid Wedges
- Renewable Seat Rings in Bronze Trimmed valves. Integral seats in All Iron valves, renewable seats can be supplied on order
- High-Tensile Bronze Stems in Bronze Trimmed valves; nickel plated in All Iron valves

250 Pound
OUTSIDE SCREW RISING STEM BOLTED FLANGED YOKE-BONNET THREADED and FLANGED ENDS

PRESSURE/TEMPERATURE RATINGS

	Threaded and Flanged
2″ to 12″	250 psi Steam at 450° F
	500 psi Non-Shock Cold Water, Oil or Gas
14″ and 16″	200 psi Steam at 450° F
	400 psi Non-Shock Cold Water, Oil or Gas

MATERIALS

DESCRIPTION	MATERIAL	ASTM Spec.
Stem Bushing Nut	Malleable Iron	A-47, Grade 32510
Handwheel	Malleable Iron	A-47, Grade 32510
Handwheel Key	Steel	A-108, Grade 1020
Cap Screw	Steel	A-449
Bearing Cap	Malleable Iron	A-47, Grade 32510
Stem Bushing		
(Black Oxide)	Malleable Iron	A-47, Grade 32510
Bonnet	Cast Iron	A-126, Grade B
Eyebolt Nuts	Steel	A-307, Grade B
Gland	Malleable Iron	A-47, Grade 32510
Eyebolts	Steel	A-307, Grade B
Packing	Asbestos	Commercial
Groov-Pin	Steel	AISI B-1113
Packing Washer	Steel	A-108, Grade 1020
P.U.P. Bushing		
All Iron	Steel	A-108, Grade 1020
Bronze Trimmed	Brass	B-16
Yokearm Ear Bolts & Nuts	Steel	A-307, Grade B
Yokearm	Cast Iron	A-126, Class B
Yokearm Bolts & Nuts	Steel	A-307, Grade B
Stem		
Bronze Trim 2″-4″	Brass	B-124
Bronze Trim 6″-16″	Bronze	B-62
All Iron	Steel*	A-108, Grade 1020
Gasket	Asbestos	Commercial
Body Bolts & Nuts	Steel	A-307, Grade B
Body	Cast Iron	A-126, Class B
Seat Rings	Bronze	B-62
Wedge		
Bronze Trim 2″-3″	Bronze	B-62
Bronze Trim 4″-16″	Cast Iron with Bronze Disc Rings	A-126, Class B
All Iron	Cast Iron	A-126, Class B

*Nickel Plated

ORDERING

- These valves are normally carried in stock

DIMENSIONS (Inches)

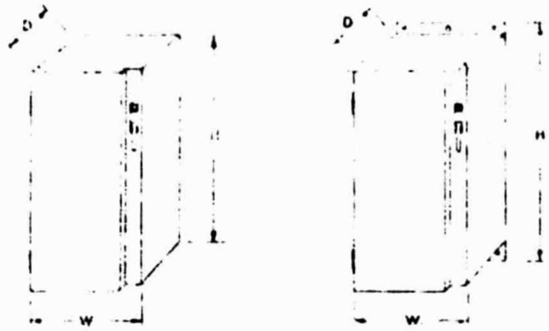
Size	2	2½	3	4	6	8	10	12	14	16
M	7	8	9	11	—	—	—	—	—	—
O*	8½	9½	11⅛	12	15⅞	16½	18	19¾	22½	24
.	16½	18⅝	21	25¹¹⁄₁₆	34½	43½	54¼	62½	72	75¼
V	8	8	10	13	16	22	22	26	26	26

* Including 1/16″ Raised Face.

	2	2½	3	4	6	8	10	12	14	16
Fig. 1796	57#	85#	110#	175#	—	—	—	—	—	—
Fig. 1797	68#	100#	134#	198#	377#	635#	940#	1320#	1790#	2035#
Fig. 1819	57#	85#	110#	175#	—	—	—	—	—	—
Fig. 1820	70#	103#	135#	198#	377#	635#	930#	1320#	1790#	2035#

CLASS A30 COMBINATION STARTER (FUSIBLE AND NON-FUSIBLE DISCONNECT)

LINE VOLTAGE 480 CYCLES 60
CONTROL CIRCUIT TRANSFORMER

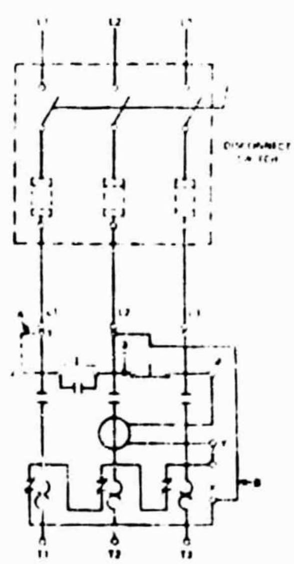


NEMA 1 NEMA 12

Description	Required	Size	Approximate Dimensions			Approximate Shipping Weight	Modifications
			Height	Width	Depth		
GENERAL PURPOSE NEMA 1							
30C4B12	1	0,1	24 5/8	9 13/32	5 15/16	40	C, D, X1
		2	28-7/32	10-19/32	5 15/16	46	
		3	36-1/32	12 21/32	7-39/64	80	
		4	42 23/32	15 11/16	7-39/64	95	
		5	60 3/8	20 1/8	10-1/4	125	
INDUSTRIAL USE NEMA 12							
		0,1	26-1/2	9-7/8	6 25/32	43	
		2	30-1/8	11 1/16	6 25/32	50	
		3	37 7/8	13 1/8	8 7/16	85	
		4	44-9/16	16 5/32	8 7/16	100	
		5	62-7/8	20-1/8	11 1/4	130	

MODIFICATIONS WITH NO DIMENSIONAL CHANGE	FORM LETTER
START STOP PUSHBUTTON in COVER	A
H-O-A SELECTOR SWITCH in COVER	C
PILOT LIGHT in COVER	D
AUX. INTERLOCK 1 N.O.	X1
" " 1 N.C.	X2
" " 1-N.O. N.C.	X3
" " LATE BREAK N.C.	X4
STANDARD CONTROL TRANSFORMER with EXTRA 100 WATTS	T1

WIRING DIAGRAM



STARTER TO HAVE FUSED PRI. + SEC.
480/120V CPT & RESET BUTTON IN
COVER

SOLAR HEAT - TROY LIBRARY
TROY OHIO

DISTRICT OFFICE: DAYTON, OHIO
C. ORTOLI
DATE: 8-15-77

.6-3N

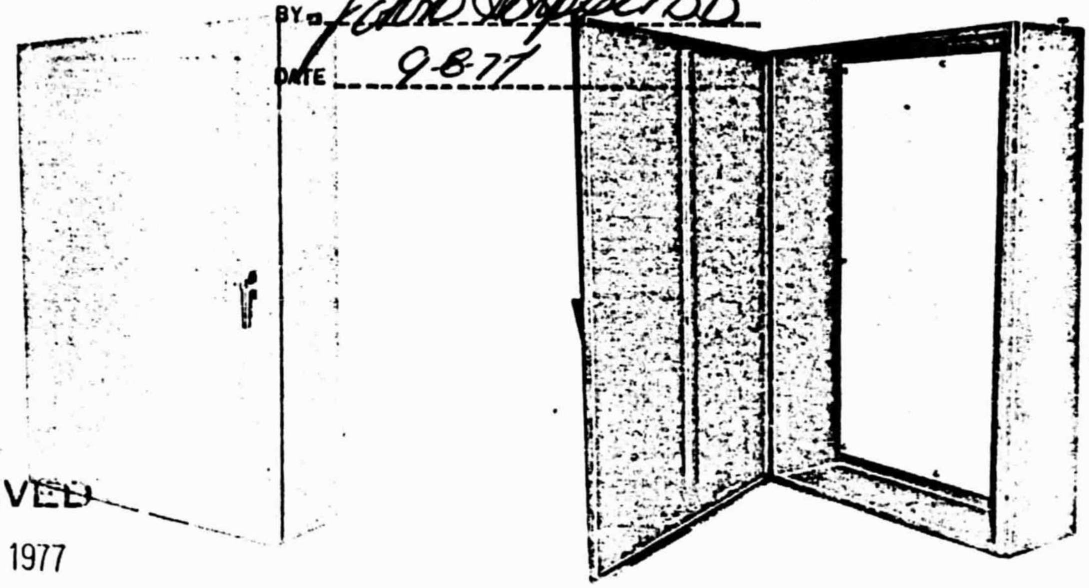
ITE Imperial Corporation

EXTRA LARGE NEMA TYPE 1 ENCLOSURES

RECEIVED
SEP 2 1977
Richard Levin Assoc. Inc.

APPROVED BY
HEARY & ASSOCIATES
FOR GENERAL LAYOUT AND/OR EQUIPMENT CAPACITY
CONTRACTOR SHALL BE RESPONSIBLE FOR CORRECT FITTING.
BY John Hongist/DD
DATE 9-8-77

STARCO, INC.
☐ Approved as Submitted
☑ Approved as Noted
☐
Date 9-2-77 By W.W.



RECEIVED
SEP 8 1977
Richard Levin Assoc., Inc.

APPLICATION – Hoffman Extra Large NEMA Type 1 Enclosures are used to house electrical and electronic controls. They are designed for installations which do not require the oil-tight and dust-tight characteristics of Hoffman NEMA Type 12 enclosures.

CONSTRUCTION – These enclosures are made from 14 gauge steel. Doors have continuous hinges and non-locking handles with a single point latch. The door can be removed by pulling the hinge pin. Body stiffeners and door stiffeners are provided in larger enclosures for extra rigidity. External feet are furnished for mounting. Collar studs are provided for mounting the optional panels. PANELS MUST BE ORDERED SEPARATELY.

ACCESSORIES –

PANELS – Panels must be ordered separately as they are not furnished with the enclosures. Panels are 12 gauge steel.

KEY-LOCKING LATCH KIT – A key-locking handle can be installed in place of the regular handle. The catalog number of the key-locking latch kit is A-L2A, and it is described in Bulletin A-80.

TERMINAL KIT ASSEMBLIES – Bracket assemblies and terminal straps are available for mounting terminal blocks. See Bulletin A-80 for details.

MISC. ACCESSORIES – Other accessories include hole seals, touch-up paint, louver plate kits, and panel support kits. See Bulletin A-80 for details.

FINISH – The standard finish is gray prime inside and out over phosphatized surfaces. Panels are white enamel.

MODIFICATIONS – Hoffman can supply holes, hubs, louvers, cutouts, special finishes, special materials, special enclosure sizes, and many other modifications. Consult the factory for prices.

INDUSTRY STANDARDS – These enclosures conform to the National Electrical Manufacturers Association (NEMA) standard for Type 1 (General Purpose) enclosures.

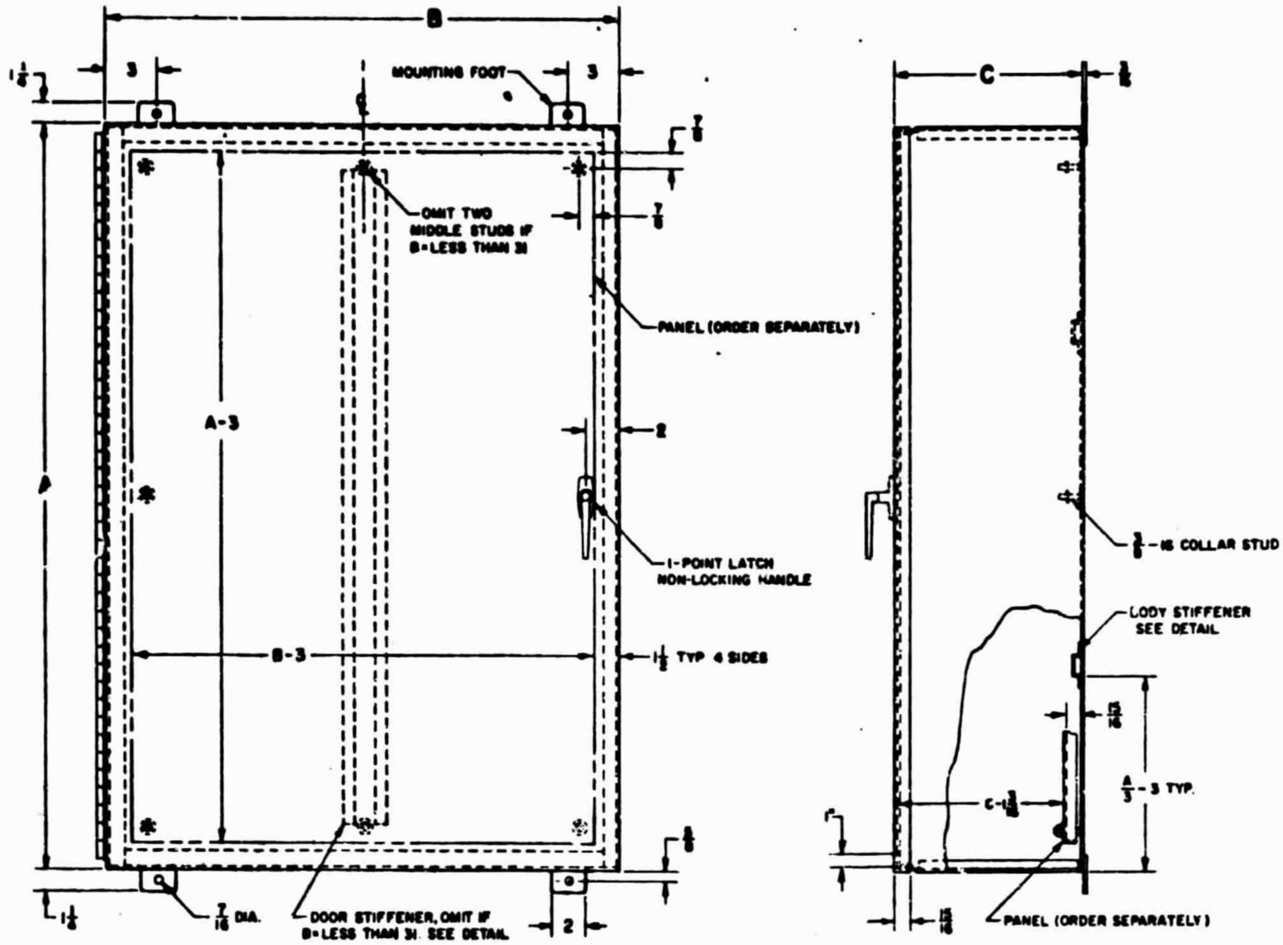
STANDARD SIZES

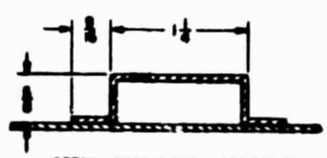
Enclosure Catalog Number	Enclosure Size A x B x C	*Panel Catalog Number	Panel Size
A-42N3009	42 x 30 x 9¼	A-42P30	39 x 27
1- A-42N3609	42 x 36 x 9¼	A-42P36	39 x 33
2- A-48N3609	48 x 36 x 9¼	A-48P36	45 x 33
A-42N3011	42 x 30 x 11¼	A-42P30	39 x 27
A-42N3611	42 x 36 x 11¼	A-42P36	39 x 33
A-48N3611*	48 x 36 x 11¼	A-48P36	45 x 33
A-48N3617	48 x 36 x 17¼	A-48P36	45 x 33

*Panels must be ordered separately.

@ ITE lock + keys to match existing

SEE DRAWING ON REVERSE SIDE





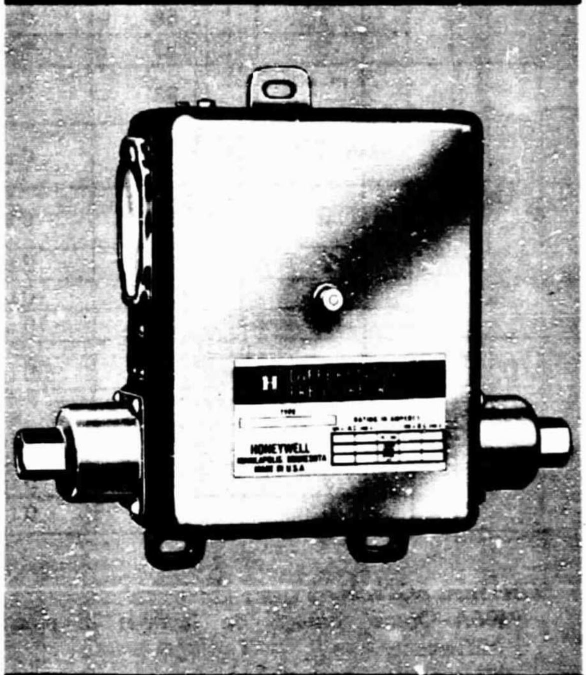
DETAIL - DOOR & BODY STIFFENERS

Honeywell

DIFFERENTIAL PRESSURETROL CONTROLLERS

TWO-POSITION MODELS, P406 AND P606, ARE USED TO PROVIDE AN ALARM FUNCTION OR TO OPERATE AS A SAFETY LIMIT CONTROL ON AN INCREASE OR DECREASE IN PRESSURE DIFFERENCE BETWEEN HIGH AND LOW SIDE OPERATING PRESSURES.

THE PROPORTIONAL MODEL, P906, IS USED TO CONTROL A PROPORTIONAL VALVE THAT MAINTAINS A SELECTED PRESSURE DIFFERENCE BETWEEN 2 POINTS.



- Adjustable main spring determines the pressure difference at which the instrument operates and against which the difference in the high and low pressure must act.
- Dust-proof, trouble-free mercury switch.
- Three mounting lugs furnished on each device to facilitate installation.
- A blank scale is supplied to be marked as required.

P406A,B; P606A; P906A

Residential Div. Form Number 60-2155-2

N.J.
REV.10-75 (.012)

SPECIFICATIONS

MODELS:

MODEL	BELLOWS OPERATING PRESSURE (IN PSI)		BELLOWS PRESSURE DIFFERENCE RANGE (IN PSI)	INSTRUMENT DIFFERENTIAL AT MIDSCALE OF PRESSURE DIFFERENCE RANGE (IN PSI)		SWITCHING ON DECREASE IN PRESSURE DIFFERENCE
	MINIMUM	MAXIMUM		MINIMUM	MAXIMUM	
P406A	22 in. Hg. Vacuum	85	0 to 45	1.5	30	Spst Makes
	5	225	0 to 70	4.0	16	
P406B	22 in. Hg. Vacuum	85	0 to 45	1.5	30	Spst Breaks
	0	20	0 to 10	12 oz/ sq. in.	6	
	2	85	0 to 50	1.5	12	
	5	225	0 to 70	4.0	16	
P606A	22 in. Hg. Vacuum	85	0 to 45	1.5	30	Spdt Makes R-B, Breaks R-W
	0	5	0 to 1	1.5 oz/ sq. in.	1	
	0	20	0 to 10	12 oz/ sq. in.	6	
	2	85	0 to 50	1.5	12	
	5	225	0 to 70	4.0	16	
	10	350	10 to 300	10.0	50	
P906A	22 in. Hg. Vacuum	85	0 to 45	1.5	30	Proportional
	0	20	0 to 10	12 oz/ sq. in.	6	
	2	85	0 to 50	1.5	12	
	5	225	0 to 70	4.0	16	

CONTROL ACTION:

P406A–Opens contacts on increase in pressure difference.

P406B–Closes contacts on increase in pressure difference.

P606A–Closes R-B contacts and opens R-W contacts on decrease in pressure difference.

P906A–Single potentiometer wiper contacts B on decrease in pressure difference.

(continued on page 3)

ORDERING INFORMATION

WHEN ORDERING REFER TO THE TRADELINE CATALOG OR PRICE SHEETS FOR COMPLETE ORDERING SPECIFICATION NUMBER, OR . . .

SPECIFY–
1. **MODEL NUMBER**
2. **OPERATING PRESSURE**

ORDER FROM–
1. **YOUR USUAL SOURCE, OR**
2. **HONEYWELL**
   1885 DOUGLAS DRIVE NORTH
   MINNEAPOLIS, MINNESOTA 55422
   (IN CANADA–HONEYWELL CONTROLS LIMITED
   740 ELLESMERE ROAD
   SCARBOROUGH, ONTARIO)
   INTERNATIONAL SALES AND SERVICE OFFICES IN ALL PRINCIPAL CITIES OF THE WORLD.

ELECTRICAL RATINGS:

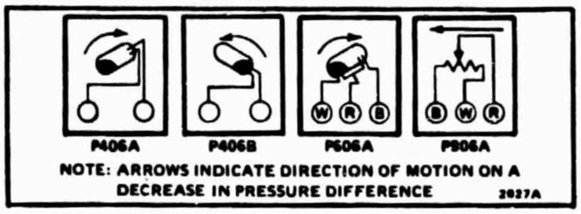
P406 and P606–Mercury switch (in amperes).

CONTROLLER	VOLTAGE TYPE	120V FULL LOAD	120V LOCKED ROTOR	120V RESISTIVE LOAD	120V HORSE-POWER	240V FULL LOAD	240V LOCKED ROTOR	240V RESISTIVE LOAD	240V HORSE-POWER
P406A and B	AC	7.2	43.2	10.0	1/3	4.9	29.4	5.0	1/2
	DC	2.4	24.0	5.0	1/6	1.2	12.0	2.0	1/6
P606A	AC	7.4	44.4	8.0	1/3	3.7	22.2	4.0	1/3
	DC	2.0	20.0	8.0	–	1.0	10.0	4.0	–

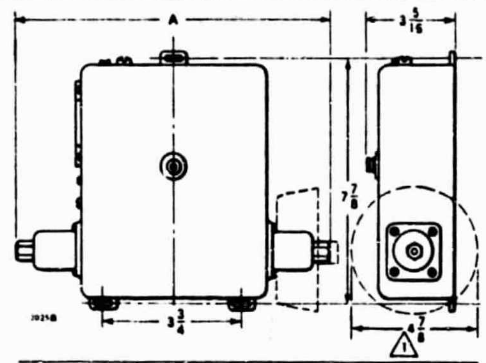
NOTE: 7.2 amp full load = 1/3 Hp at 120V.
4.9 amp full load = 1/2 Hp at 240V.
3.6 amp full load = 1/2 Hp at 240V.

P906–24V ac, 3-wire modulating control; 135 ohm potentiometer.

INTERNAL SCHEMATICS



ADJUSTMENT MEANS: Screw on top of case.
BELLOWS CONNECTION: 1/4-18 NPT.
FINISH: Gray.
DIMENSIONS (INCHES):



DIM.	INCHES	MODEL RANGE
A	11-13/16	0-1
	11- 7/16	0-10 psi range
	9-11-16	0-45, 0-50, and 0-70 psi range
	9- 7/16	10-300 psi range

⚠ 0-1 psi range only

FIG. 1–DIMENSIONS OF P406, P606, P906 (INCHES).

INSTALLATION

CAUTION

1. **Installer must be a trained, experienced serviceman.**
2. **Disconnect power supply before beginning installation.**
3. **Always conduct a complete checkout when the installation is completed.**

MOUNTING

Mount the controller on a surface that is free of excessive vibration. Level the control using the leveling pendulum (Fig. 5). This is necessary for proper mercury switch operation.

When the control is used in steam applications, it should be mounted above the level of the steam main. If this cannot be done, provide a trap to prevent condensation from collecting above the control's bellows.

NOTE: To prevent strain on the bellows, use the proper fittings when connecting the tubing or pipe to the bellows connections (see Fig. 2). Use care when running lines so that pipe dope and scale do not get into the internal lines.

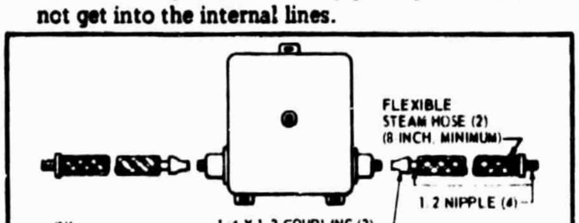


FIG. 2–RECOMMENDED TUBING FITTINGS.

WIRING

CAUTION

Disconnect power supply before beginning installation to prevent electrical shock and equipment damage.

All wiring must comply with local electrical codes and ordinances. See Fig. 3 for typical system hookup.

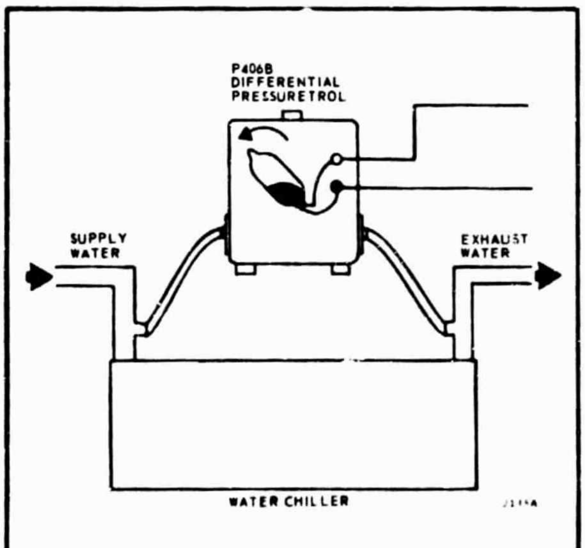


FIG. 3–TYPICAL SYSTEM HOOKUP

CALIBRATION AND OPERATION

Because these controllers have such a wide variety of applications, they are calibrated on the job with the system in operation.

IMPORTANT

The device controls the difference between the pressures exerted upon the 2 bellows, not the gauge pressure.

1. Connect a pressure gauge with adequate range to each element assembly.

2. Connect the Pressuretrol and gauges to the pressure points to be controlled, or use a compressed air supply to duplicate actual pressures.

3. Turn the instrument differential adjustment screw and the pressure difference adjustment screw counterclockwise (Fig. 5 or 6) until the scale indicators reach the low (minimum) end of the scale.

NOTE: Do not go beyond the point at which the linkage begins to show slack.

4. Apply typical operating pressures in sequence to the left and right elements (high and low pressure sides, respectively). Turn the pressure difference adjustment screw clockwise until the mercury switch just makes or breaks the circuit. This is the switch action on a decrease in pressure difference.

The proportional Pressuretrol (P906A) must be calibrated with the device it operates. The Pressuretrol is set for the pressure difference between the high and low pressures on the control.

5. Increase the pressure differential applied to the Pressuretrol by the amount of instrument differential desired.

6. Turn the instrument differential adjustment screw clockwise until the mercury switch rotates and then stops at approximately the horizontal position. Continue turning the adjustment screw an additional 2 turns.

Manually rotate operating lever clockwise until the mercury switch makes or breaks the circuit. Allow the operating lever to slowly return to its original position. If the mercury remakes or rebreaks the circuit, turn the differential adjustment screw clockwise an additional turn. Then repeat the check with the operating lever.

Turn the instrument differential adjustment screw counterclockwise until the mercury switch just makes or breaks the circuit. This is the switch action on an increase in pressure difference.

IMPORTANT

If the pressure difference set point adjustment is at minimum, be certain that there is no slack in the linkage.

7. Operate the pressures through a typical cycle checking Pressuretrol operation. Readjust settings if necessary. If there is any indication of short cycling or a hunting condition, increase the setting of the instrument differential adjustment.

8. When the system operates as desired, mark the settings on the scaleplate.

9. Remove the gauges and connect the Pressuretrol into the system with the higher pressure on the left element and the lower pressure on the right element.

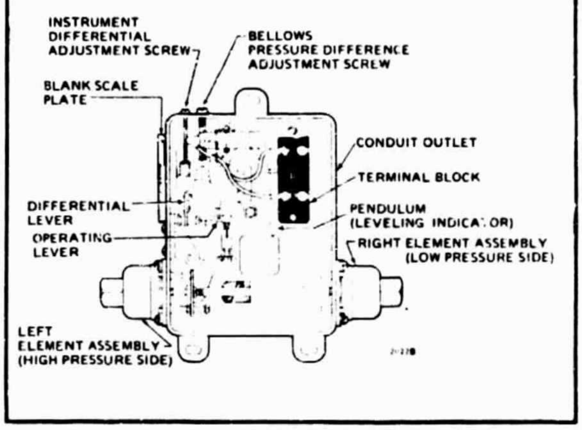


FIG. 5—INTERNAL VIEW OF THE 2-POSITION MODEL.

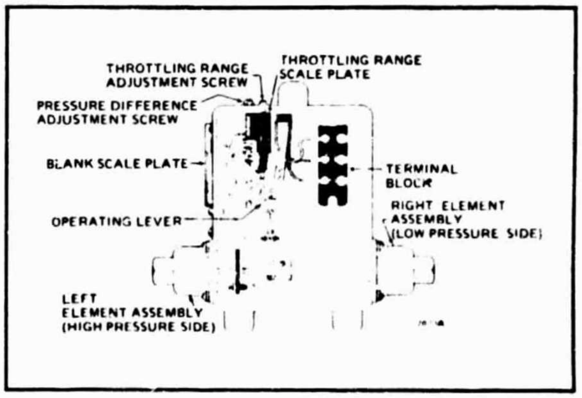
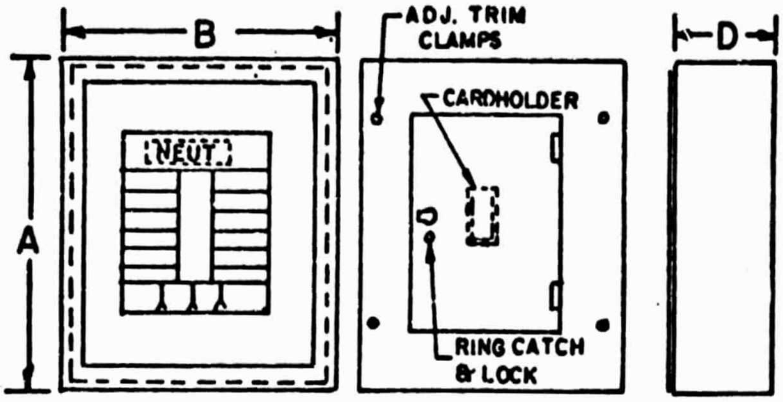


FIG. 6—INTERNAL VIEW OF THE MODULATING MODEL.

STARCO, INC.
☒ Approved as Submitted
☐ Approved as Noted
☐
Date 8-25-77 By O.O.



— FRONT VIEW — (TRIM REMOVED) — TYPICAL TRIM — (SURF. TRIM SAME SIZE AS BOX. FLUSH TRIM OVERLAPS BOX 1" ALL AROUND) — END VIEW —

TYPICAL CIRCUIT BREAKER PANELBOARD

APPROVED BY
HEAPY & ASSOCIATES
FOR GENERAL LAYOUT AND/OR EQUIPMENT CAPACITY CONTRACTOR SHALL BE RESPONSIBLE FOR CORRECT FITTING.
BY John Hayostko
DATE 8-31-77

— NOTES: —

1. BOXES TO BE MADE OF CODE GA. GALVI.
2. MAIN LUGS ARE SOLDERLESS.
3. FINISH: ASA-61
4. SERVICE: 3ϕ 4W 277/480Y

ITEM NO.	1		2			
QUAN.	1		3			
TYPE	NHB		Cat. #64 -	Locks & Keys		
SURF/FLUSH	SURF *					
M.BUS.	100-Amp					
M.LUG.	#14-1/0					
A	32					
B	20					
D	5 3/4					
MARK.						
	* w/Cat. 64-Lock + Keys					
	ND323					
TYPE C.B. I-T-E EH-14,000AIC	2-20A-3P-EH 16-EH-1P Prov. Top Feed Copper Bussing					

JOB NO.: 88031 CUST. NO.: 6336

ARROW-HART, INC.
DISTRIBUTION ASSEMBLIES DIVISION
NORWOOD, MASS.

DISTRIBUTION PANELBOARDS

Pope Elec. Supply
Dayton, Ohio
MK: Troy Library 3615

REV.	DATE	
6.		
5.		
4.		
3.		
2.		
1.		

DRAWN RCG | DATE 8-15-77 | SCALE | NO. KP-88031

Honeywell

R7406 Solar Temperature Control

- Modular construction - one basic module provides a variety of solar control functions.

- Solid state differential amplifier.

- 3 pole switching relay - two N.O. and one N.C. isolated contacts.

- Integral transformer - powers the low voltage control circuit.

- Color-coded leadwires for line voltage connections.

- Exposed terminal strip with screw terminals for low voltage connections.

- Plug-in differential resistors.

- Mounts in any position on a standard 4 x 4 inch junction box.

- Interchangeable thermistor sensors.

Form HN22423-105
Residential Division
8/9/76

R7406 Solar Temperature Control

APPLICATION

This device, when used with the proper thermistor sensors, is designed as a module capable of providing a variety of automatic control functions in the switching of circulating pumps, valves, dampers, motors, and other accessories used in solar control systems. It has a solid state differential amplifier with a 3 pole switching relay.

Control functions can be modified by changing the connections of the differential resistors, setpoint resistors, and thermistor sensors. This module can be used as a:

1. Differential temperature control
   (Relay makes on temperature differential rise)

2. Setpoint temperature control
   (Relay makes on temperature rise)

3. Setpoint temperature control
   (Relay makes on temperature drop)

SPECIFICATIONS

- ELECTRICAL RATINGS

  Voltage and frequency - 120V, 60 Hz.

  Load Relay Contacts (each pair)
  Full Load - 10A
  Locked Rotor - 60A

- Ambient Temperature Range:
  Amplifier 32°F to 150°F
  Sensors 32°F to 300°F

- Mounting: Mount on standard 4 x 4 inch junction box.

- Dimensions: See Figure 1 and 2.

- Sensors:
  HN22423-201BA Tank Sensor (immersion well type) - for mounting in a tank or pipe "T". 1/2" NPT with 3" insertion length. 3 feet of #22 150°C wire.

  HN22423-201AA Collector Sensor (surface type) - for mounting on the surface of the solar collector. A #8 to #10 mounting hole is provided. 6 feet of #22 150°C wire.

- Power Consumption:
  Relay Out - 3.5 watts max.
  Relay In - 7.0 watts max.

SYSTEM SELECTION

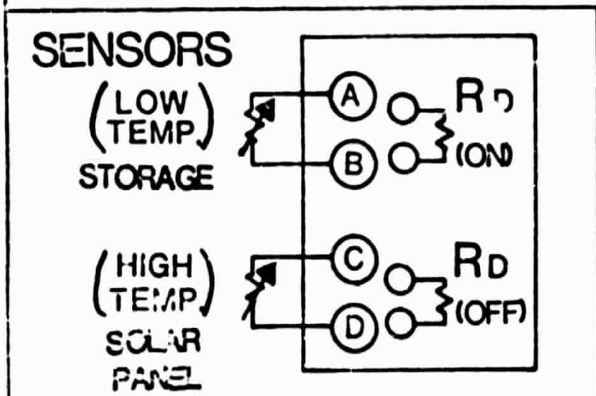
- R7406A is factory calibrated as a differential temperature control to provide a relay pull-in of 18°F and a relay drop out of 3°F.

  Plug-in resistor R_D (OFF) is 200,000 ohms, and R_D (ON) is 30,000 ohms. The low temperature sensor is connected across terminals A-B and the high temperature sensor across terminals C-D.

- To change either or both differentials, select different values for the plug-in resistors R_D (ON) and (OFF). See Fig. 4. (Example of using the module as a differential control measuring the difference in temperature between the solar panel and storage outlet.)

R7406A - TEMP. DIFFERENTIAL CONTROL

HN22423-101



RELAY PULL-IN : HIGH TEMP. > LOW TEMP.

Honeywell
MINNEAPOLIS MN 55422

TO CHANGE FACTORY CALIBRATION			
SELECT RD (OFF)		SELECT RD (ON)	
RESISTOR IN OHMS	°F DIFF	RESISTOR IN OHMS	°F DIFF.
		150,000	6
300,000	2	91,000	8
200,000	3	68,000	10
150,000	4	43,000	14
		30,000	18
		27,000	20
		24,000	22

FACTORY CALIBRATION: RELAY PULL-IN DIFF. 18 °F DROP-OUT DIFF. 3 °F

Fig. 4 - Differential Temperature Control
(Make on temperature differential increase)

SOLAR PANEL VS. STORAGE OUTLET

- To change control function and calibration refer to the chart below:

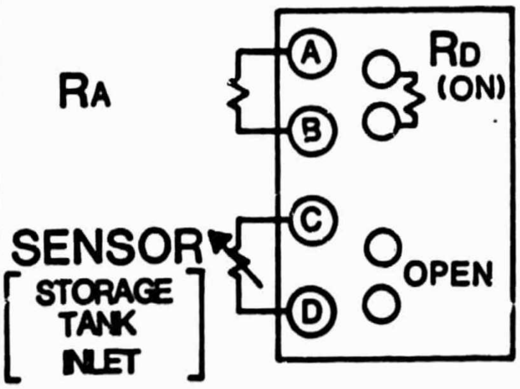
CONTROL FUNCTION	SEE FIG.	SENSOR CONNECTION		RESISTOR SELECTION			
				Differential Plug-In		Setpoint	
		A-B	C-D	R_D (Off)	R_D (On)	A-B R_A	C-D R_B
Differential Temp. Control (Make on temp. differential increase)	4	X Low Temp.	X High Temp.	X	X	None	None
Setpoint Temp. Control (Make on temp. rise)	5 6 7	None	X	None	X	X	None
Setpoint Temp. Control (Make on temp. drop)	8	X	None	None	X	None	X

Note: The setpoint resistor can be determined for any temperature from Fig. 9

- CSX 19614B is an example of the module connected as a setpoint control for the storage tank inlet calibrated for relay pull-in at 92°F and drop out at 90°F.

CSX19614B TEMPERATURE SET POINT CONTROL

STORAGE TANK INLET



RELAY PULL-IN = SET POINT + DIFFERENTIAL

TO CHANGE FACTORY CALIBRATION

SELECT R

RESISTOR IN OHMS	SET POINT °F RELAY DROP-OUT
47,000	80
43,000	83
39,000	87
36,000	90
33,000	93
30,000	97
27,000	101
24,000	106
22,000	110
20,000	114

SELECT RD (ON)

RESISTOR IN OHMS	°F DIFF.
300,000	2
200,000	3
150,000	4
110,000	5
100,000	6

Honeywell
MINNEAPOLIS, MN. 55422

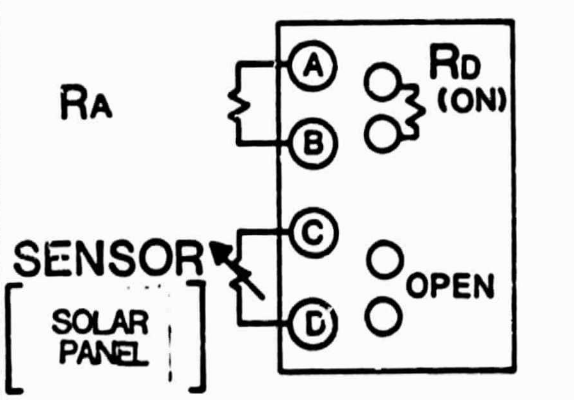
FACTORY CALIBRATION: RELAY PULL-IN 92 °F DROP-OUT 90 °F

Fig. 5 Setpoint Control
(Make on Temp. Rise)

CSX 19614C is an example of the module connected as a setpoint control for the solar panel calibrated for relay pull-in at 92°F and drop-out at 90°F.

CSX19614C TEMPERATURE SET POINT CONTROL

SOLAR PANEL



RELAY PULL-IN = SET POINT + DIFFERENTIAL

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TO CHANGE FACTORY CALIBRATION

SELECT RA	
RESISTOR IN OHMS	SET POINT °F RELAY DROP-OUT
47,000	80
43,000	83
39,000	87
36,000	90
33,000	93
30,000	97
27,000	101
24,000	106
22,000	110
20,000	114

SELECT RD (ON)	
RESISTOR IN OHMS	°F DIFF.
300,000	2
200,000	3
150,000	4
110,000	5
100,000	6

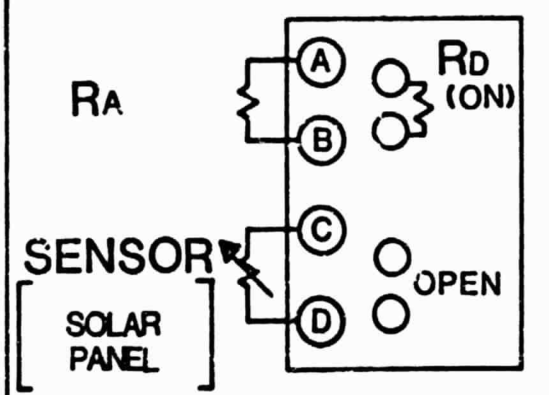
FACTORY CALIBRATION: RELAY PULL-IN 92 °F DROP-OUT 90 °F

Fig. 6 Setpoint Control
(Make on Temp. Rise)

CSX 19614D is an example of the module connected as a setpoint control for determining overtemperature of the solar panel calibrated for relay pull-in at 220°F and drop-out at 217°F.

CSX19614 D- OVER TEMPERATURE CONTROL

SOLAR PANEL



RELAY PULL-IN = SET POINT + DIFFERENTIAL

Honeywell
MINNEAPOLIS, MN. 55422

TO CHANGE FACTORY CALIBRATION

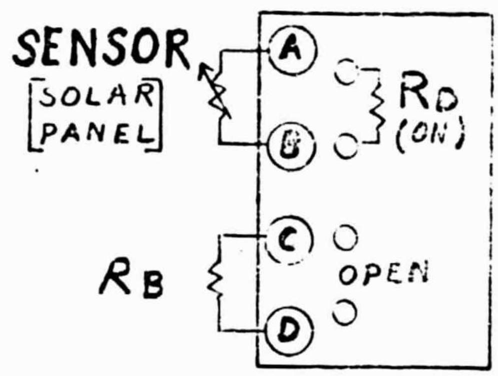
SELECT RA		SELECT RD (ON)	
RESISTOR IN OHMS	SET POINT °F RELAY DROP-OUT	RESISTOR IN OHMS	°F DIFF.
3,000	207	240,000	2
2,870	210	150,000	3
2,700	212	115,000	4
2,670	214	90,000	5
2,550	217	75,000	6
2,490	218	56,000	8
2,400	220	45,000	10
2,260	223		
2,100	227		

FACTORY CALIBRATION: RELAY PULL-IN 220 °F DROP-OUT 217 °F

Fig. 7 Setpoint
(Make on Temp. Rise)

CSX 19614E is an example of the module connected as a setpoint control for determining overtemperature of the solar panel calibrated for relay drop out at 220°F and pull-in at 217°F.

CSX 19614E – OVER TEMPERATURE CONTROL
SOLAR PANEL



RELAY PULL-IN = SET POINT MINUS DIFFERENTIAL

HONEYWELL
MINNEAPOLIS, MN. 55422

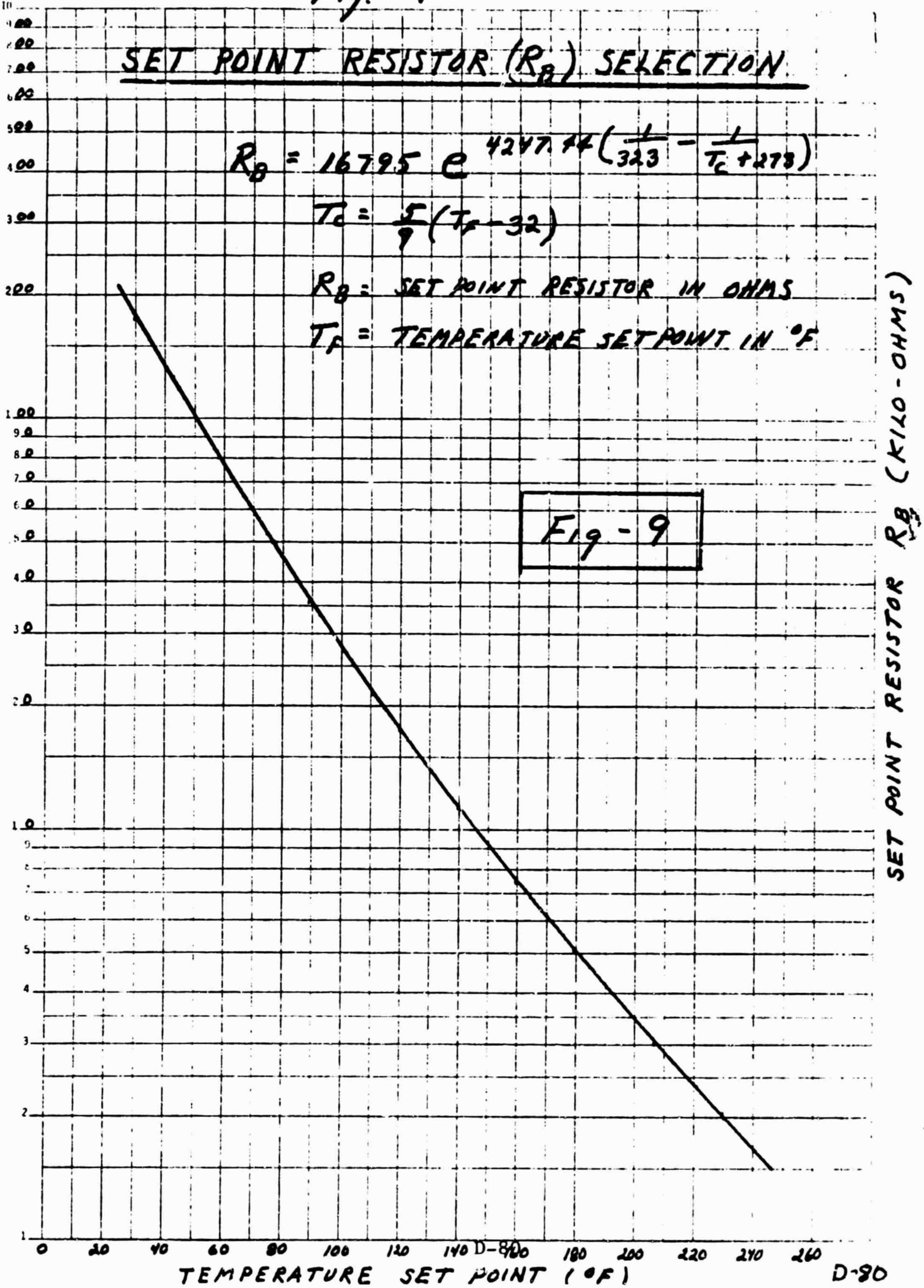
TO CHANGE FACTORY CALIBRATION

SELECT R_B		SELECT R_D (ON)	
RESISTOR IN OHMS	SET POINT °F RELAY DROP-OUT	RESISTOR IN OHMS	°F DIFFERENTIAL
2670	214	240,000	2
2490	218	150,000	3
2430	220	115,000	4
2370	221	90,000	5
2260	223	75,000	6
2100	227	56,000	8
2000	231	45,000	10

FACTORY CALIBRATION: RELAY DROP-OUT 220°F PULL-IN 217°F

Fig. 8 Setpoint
(Make on Temp. Drop)

Fig. - 7



SET POINT RESISTOR (R_B) SELECTION
$R_B = 16795\, e^{4247.44\left(\frac{1}{323} - \frac{1}{T_C + 273}\right)}$
$T_C = \frac{5}{9}(T_F - 32)$
R_B: SET POINT RESISTOR IN OHMS
T_F = TEMPERATURE SET POINT IN °F
Fig - 9
SET POINT RESISTOR R_B (KILO-OHMS)
TEMPERATURE SET POINT (°F)
0 20 40 60 80 100 120 140 160 180 200 220 240 260
1 2 3 4 5 6 7 8 9 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1.00 200 300 400 500 600 700 800 900

WIRING

CAUTION

Disconnect power supply before connecting wiring to prevent electrical shock or equipment damage.

All wiring must comply with applicable codes and ordinances. Leave enough slack in the wires to permit easy access to wires in the junction box.

SYSTEM

With the controller unmounted, connect the line voltage leads to the appropriate system wire leads. Refer to Fig. 10 or cover insert for proper connections. Use solderless connectors to splice leads. Do not exceed ratings of the control.

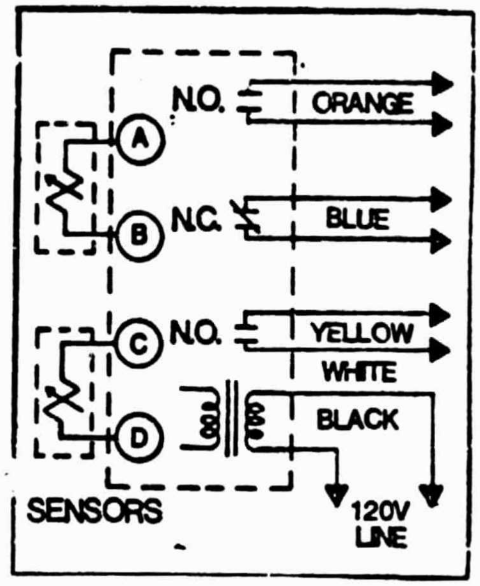


Fig. 10 Line Voltage Wiring

SENSORS

Connect low voltage leads to the sensors and control terminals as indicated in Fig. 4 through 8. A shielded 2 wire (#18 to #22) cable with the shield grounded at the control is recommended to minimize RF pick-up.

CHECKOUT

1. Disconnect terminal D, short terminals C-D, relay should pull-in.

2. Remove short, relay should drop-out.

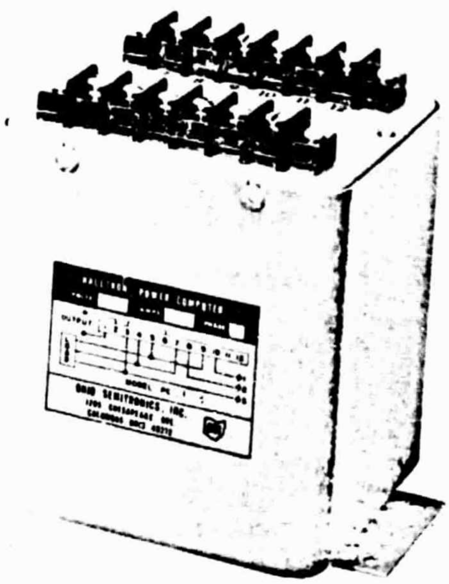
AC WATT TRANSDUCER

BULLETIN PC76-1

SINGLE PHASE 60 Hz MODELS

MODEL NUMBER PC5-	FULL SCALE INPUTS VOLTS	AMPS	WATTS	OUTPUT CALIB. 50MV=	CURRENT SENSOR DRAWING
1	120	5	600	500W	–
2	240	5	1.2K	1KW	–
3	480	5	2.4K	2KW	–
10	120	10	1.2K	1KW	–
11	240	10	2.4K	2KW	–
12	480	10	4.8K	4KW	–
19	120	15	1.8K	1.5KW	–
20	240	15	3.6K	3KW	–
21	480	15	7.2K	6KW	–
28	120	50	6K	5KW	* C
29	240	50	12K	10KW	* C
30	480	50	24K	20KW	* C
31	120	100	12K	10KW	C
32	240	100	24K	20KW	C
33	480	100	48K	40KW	C
34	120	200	24K	20KW	D
35	240	200	48K	40KW	D
36	480	200	96K	80KW	D
37	120	400	48K	40KW	D
38	240	400	96K	80KW	D
39	480	400	192K	160KW	D
40	120	600	72K	60KW	E
41	240	600	144K	120KW	E
42	480	600	288K	240KW	E
43	120	1000	120K	100KW	E
44	240	1000	240K	200KW	E
45	480	1000	480K	400KW	E
46	120	2000	240K	200KW	E
47	240	2000	480K	400KW	E
48	480	2000	960K	800KW	E
49	120	50	6K	5KW	* W
50	240	50	12K	10KW	* W
51	480	50	24K	20KW	* W
58	120	100	12K	10KW	W
59	240	100	24K	20KW	W
60	480	100	48K	40KW	W
67	120	200	24K	20KW	W
68	240	200	48K	40KW	W
69	480	200	96K	80KW	W
76	120	400	48K	40KW	X
77	240	400	96K	80KW	X
78	480	400	192K	160KW	X
85	120	600	72K	60KW	X
86	240	600	144K	120KW	X
87	480	600	288K	240KW	X
94	120	1000	120K	100KW	Y
95	240	1000	240K	200KW	Y
96	480	1000	480K	400KW	Y
103	120	1	120	100W	–
104	240	1	240	200W	–
105	480	1	480	500W	–
106	120	2.5	300	300W	–
107	240	2.5	600	600W	–
108	480	2.5	1200	1200W	–

CASE SIZE DRAWING H



MODEL PC5–4

OSI Watt Transducers utilize Hall Effect multipliers in order to provide an output which is proportional to the electrical power consumed in single phase or three phase loads or equipment. The multipliers provide instantaneous multiplication of the voltage times the current on a continuous basis.

The Watt Transducers are especially useful in monitoring, control, protection and regulation circuits. Their fast response results in accurate power measurement even when distorted or chopped waveforms are present.

Various output filtering and signal conditioning features are provided in watt transducer models to permit easy interface with circuits where amplified voltage output or current output is desirable. In all units the output signal is electrically isolated from the power lines to provide maximum flexibility in interfacing with other electrical or electronic circuits.

The unique, four-quadrant, high-accuracy multiplying properties of Hall Effect devices coupled with their demonstrated reliability provides a low-cost approach to power measurement where linearity, repeatability, and long life are important considerations.

ADJUSTMENTS

All PC5 series watt transducers have been calibrated at the factory to give the correct output at the specified power rating.

Each unit has an overall "CAL" and an optional "ZERO" adjustment located on the lid. The "CAL" adjustment is set at the factory and should not be adjusted unless recalibration is required. The optional "ZERO" adjustment is provided to correct for an output offset, "at no load condition", without effecting the calibration of the unit.

NOTE 1: For chopped waveforms select a model that does not use a current transformer W, X or Y.

NOTE 2: *Indicates 2 turns thru the external transducer or transformer window.

Standard units have millivolt output as indicated. Units having 0 to 1 milliampere or 0 to 10 volts are available as options and are ordered by adding the option letter as a suffix to the standard model number. For example PC5-1A has an output of 0-1 milliampere for 500 input.

OUTPUT OPTIONS

OPTION A: 0 to 1 milliampere DC output. No external amplifier power required. Load 0 to 10K ohms.

OPTION B: 0 to 1 milliampere DC output. External amplifier power required. 85 – 135 VAC at 2 watts. Load 0 to 10K ohms.

OPTION C: 0 to 10 volt DC output. No external amplifier power required. Load greater than 2K ohms.

OPTION D: 0 to 10 volt DC output. External amplifier power required. 85 – 135 VAC at 2 watt. Load greater than 2K ohms.

OPTION F: Filtered output. Ripple reduced to <1%. Load on output should be >1 meg ohm.

OHIO SEMITRONICS, INC.

1205 CHESAPEAKE AVENUE, COLUMBUS, OHIO 43212 PHONE 614/486-9561

PIONEER IN SOLID STATE TECHNOLOGY FOR ENERGY CONVERSION AND POWER MONITORING

BULLETIN
PC76-1

AC WATT TRANSDUCER

OSI

3 PHASE 3 WIRE 60Hz MODELS

MODEL NUMBER PC5-	FULL SCALE INPUTS VOLTS	AMPS	WATTS	OUTPUT CALIB. 100MV=	CURRENT SENSOR DRAWING	EXTERNAL SENSOR REQUIRED
4	120	5	1.04K	1KW	–	–
5	240	5	2.08K	2KW	–	–
6	480	5	4.16K	4KW	–	–
13	120	10	2.08K	2KW	–	–
14	240	10	4.16K	4KW	–	–
15	480	10	8.31K	8KW	–	–
22	120	15	3.12K	3KW	–	–
23	240	15	6.24K	6KW	–	–
24	480	15	12.5K	12KW	–	–
31-2	120	100	20.8	20KW	C	2
32-2	240	100	41.6	40KW	C	2
33-2	480	100	83.1	80KW	C	2
52	120	50	10.4K	10KW	W	• 2
53	240	50	20.8K	20KW	W	• 2
54	480	50	41.6K	40KW	W	• 2
61	120	100	20.8K	20KW	W	2
62	240	100	41.6K	40KW	W	2
63	480	100	83.1K	80KW	W	2
70	120	200	41.6K	40KW	W	2
71	240	200	83.1K	80KW	W	2
72	480	200	166K	160KW	W	2
79	120	400	83.1K	80KW	X	2
80	240	400	166K	160KW	X	2
81	480	400	332K	320KW	X	2
88	120	600	125K	120KW	X	2
89	240	600	249K	240KW	X	2
90	480	600	499K	480KW	X	2
97	120	1000	208K	200KW	Y	2
98	240	1000	416K	400KW	Y	2
99	480	1000	831K	800KW	Y	2

CASE SIZE DRAWING H

3 PHASE 4 WIRE 60Hz MODELS

MODEL NUMBER PC5-	FULL SCALE INPUTS VOLTS	AMPS	WATTS	OUTPUT CALIB. 150MV=	CURRENT SENSOR DRAWING	EXTERNAL SENSOR REQUIRED
7	120	5	1.80K	1.5KW	–	–
8	240	5	3.60K	3KW	–	–
9	480	5	7.2K	6KW	–	–
16	120	10	3.6K	3KW	–	–
17	240	10	7.2K	6KW	–	–
18	480	10	14.4K	12KW	–	–
25	120	15	5.4K	4.5KW	–	–
26	240	15	10.8K	9KW	–	–
27	480	15	21.6K	18KW	–	–
55	120	50	18K	15KW	W	• 3
56	240	50	36K	30KW	W	• 3
57	480	50	72K	60KW	W	• 3
64	120	100	36K	30KW	W	3
65	240	100	72K	60KW	W	3
66	480	100	144K	120KW	W	3
73	120	200	72K	60KW	W	3
74	240	200	144K	120KW	W	3
75	480	200	288K	240KW	W	3
82	120	400	144K	120KW	X	3
83	240	400	288K	240KW	X	3
84	480	400	576K	480KW	X	3
91	120	600	216K	180KW	X	3
92	240	600	432K	360KW	X	3
93	480	600	864K	720KW	X	3
100	120	1000	360K	300KW	Y	3
101	240	1000	720K	600KW	Y	3
102	480	1000	1.44M	1.2MW	Y	3

CASE SIZE DWG. H (BASE UNIT)
CASE SIZE DWG. K (WITH OPTION)

SPECIFICATIONS

INPUT

VOLTAGE: 0 to 110% f.s.
CURRENT: 0 to f.s.
OVERLOAD (Continuous):
- –Voltage 1.25 X Rating
- –Current:
  - –2 X Rating: 1 Ampere thru 15 Ampere Models and All Current Transformers Model W, X, Y
  - –50 X Rating: Current Transducer Models C, D & E

BURDEN (Full scale input):
- –Voltage 1.25 VA
- –Current 1.25 VA
- –Option Amplifier 2 Watts

POWER FACTOR RANGE: Unity to lead, lag 0.

FREQUENCY RANGE: 50 to 70Hz

DIELECTRIC TEST:
(Input/Output/Case): 1500 VAC

OUTPUT

OUTPUT LOADING:
- –Base Unit: >100K ohms
- –Options A & B: 0-10K ohms
- –Options C & D: > 2K ohms
- –Options F >1 meg ohms

ADJUSTMENT RANGE: (See Adj. Note)
- –Base Unit: 0 to 110%
- –With Options: ±10% Min.

RESPONSE TIME:
- –Base Unit: 1 Millisecond
- –With Options: 250 Milliseconds

TEMPERATURE EFFECT: (–10° to +60°C)

± 1% of Reading
With Options: ± 1% of Reading
± 0.1% FS

AC COMPONENT AT UNITY pf:
Base Unit: DC with an AC Component of 200% p to p
–With Option: DC with an AC Component of < 1% FS

ACCURACY (Including pf Error, Linearity, Repeatability and Initial Set Point): PC5-1 thru PC5-48
PC5-31-2 thru PC5-33-2 ± 0.5% f.s.

PC5-103 thru PC5-108
PC5-49 thru PC5-102 ± 0.75% f.s.

SEE ATTACHED SHEET FOR WIRING AND DIMENSION DIAGRAMS.

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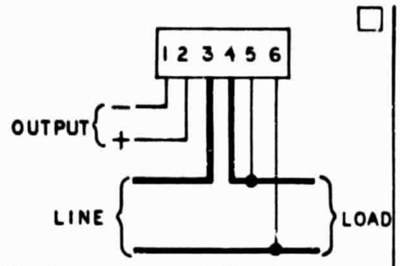
PIONEER IN SOLID STATE TECHNOLOGY FOR ENERGY CONVERSION AND POWER MONITORING

PC76-1/1076/3M

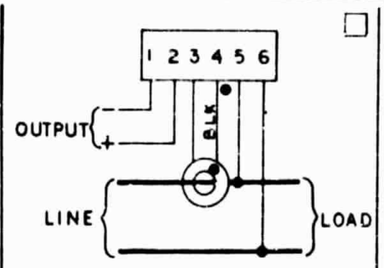
PRINTED IN USA

DWG.
PC 77-1

DIRECT CONNECTIONS FOR 1 PHASE-2 WIRE



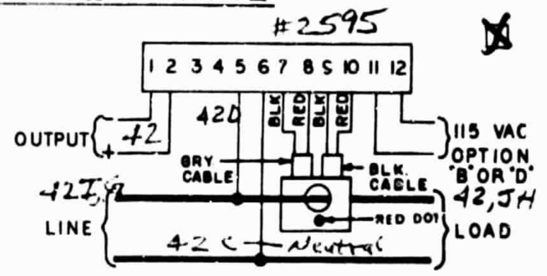
Circuit showing current directly connected through terminals 3 and 4. The voltage input is applied to terminals 5 and 6 with the output appearing on terminals 1 and 2. *Used with Options B and D only. Connect 115 vac power to terminals 11 and 12.



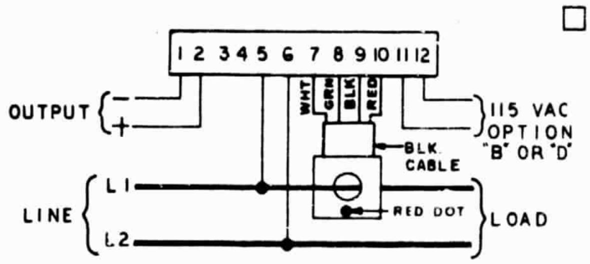
USING CURRENT TRANSFORMERS
(HIGH CURRENT)

115 vac Option B or D to terminal 11 & 12

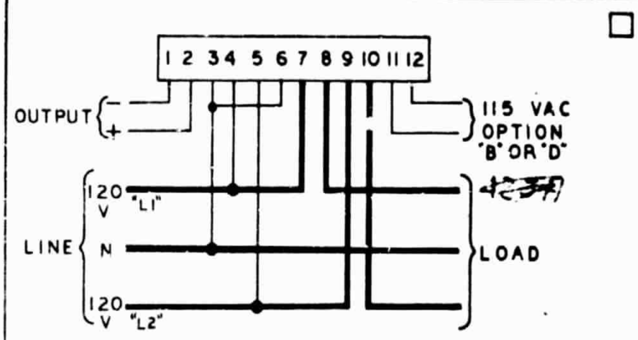
#2595



USING CURRENT TRANSDUCERS
(HIGH CURRENT)



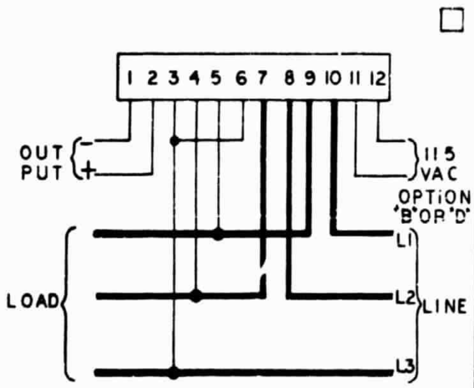
USING CURRENT TRANSDUCER
(SPLIT CORE)



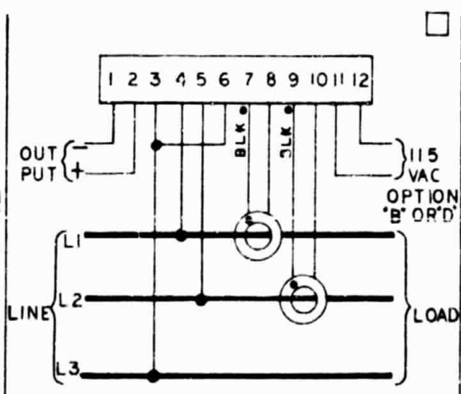
EDISON SYSTEM
(120/240 3 WIRE)

For currents above 15 amperes use 3Ø 3W Current Transformer connection diagram with L3, shown in drawing, used as neutral

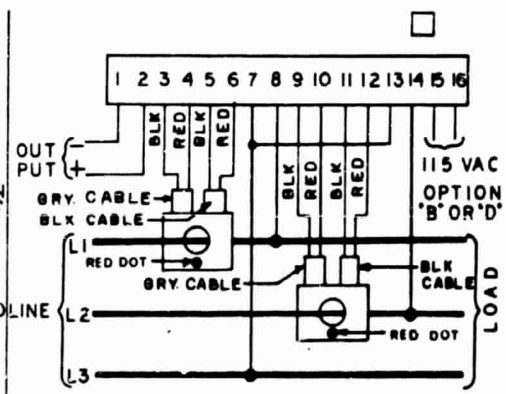
DIRECT CONNECTIONS FOR 3 PHASE-3 WIRE



Circuit used for balanced or unbalanced networks by algebraically summing the EI Cos Ø product from two phases. *Used with Options B and D only. Connect 115 vac power to terminals 11 and 12.

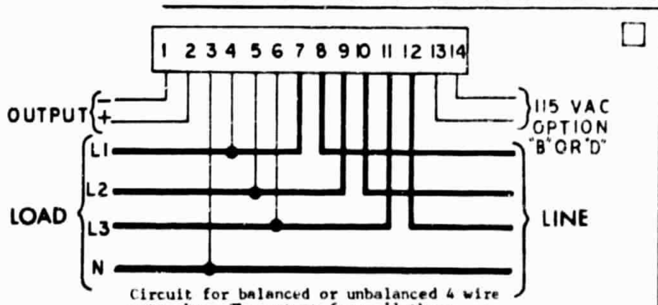


USING CURRENT TRANSFORMERS
(HIGH CURRENT)

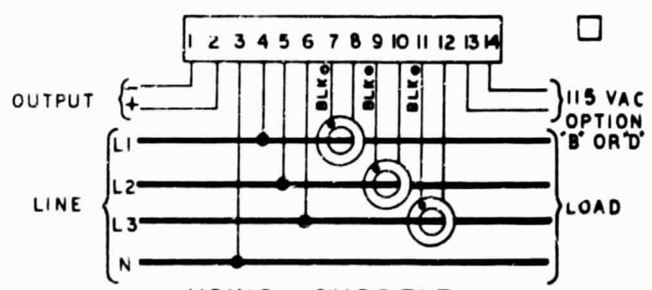


USING CURRENT TRANSDUCERS
(HIGH CURRENT)

DIRECT CONNECTIONS FOR 3 PHASE-4 WIRE



Circuit for balanced or unbalanced 4 wire networks. The output from all three phases are algebraically summed to obtain the total true power. Used with Options B and D only. Connect 115 vac power to terminals 13 and 14.



USING CURRENT TRANSFORMERS
(HIGH CURRENT)

OSI
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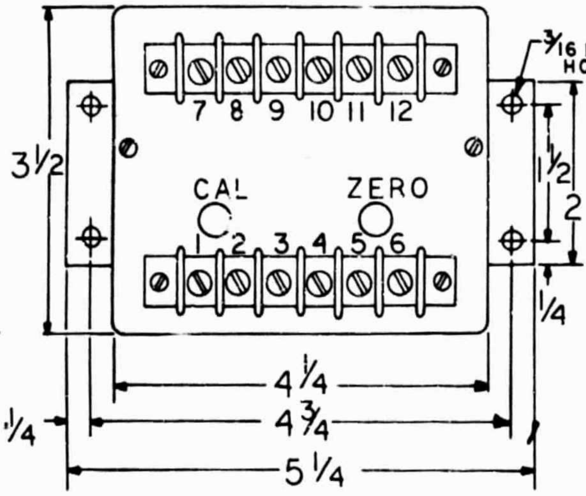
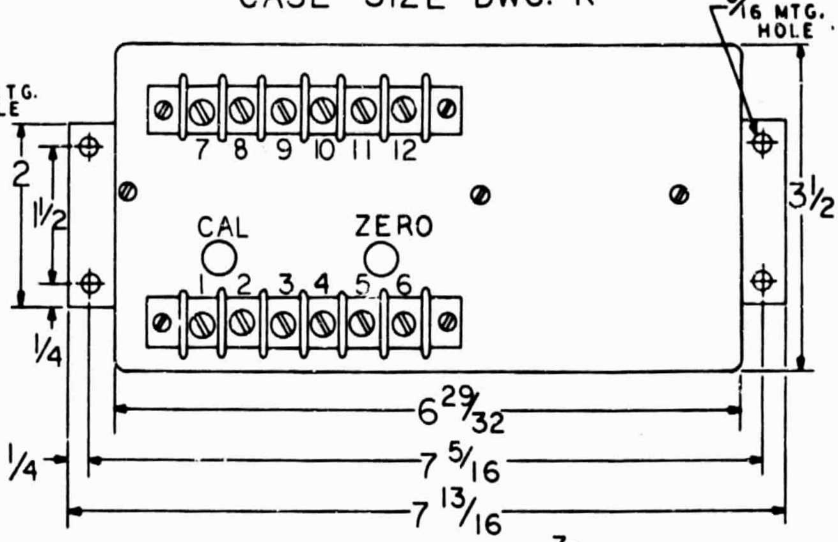
REVISION 1-4-78
DUM

CASE SIZE DWG. H

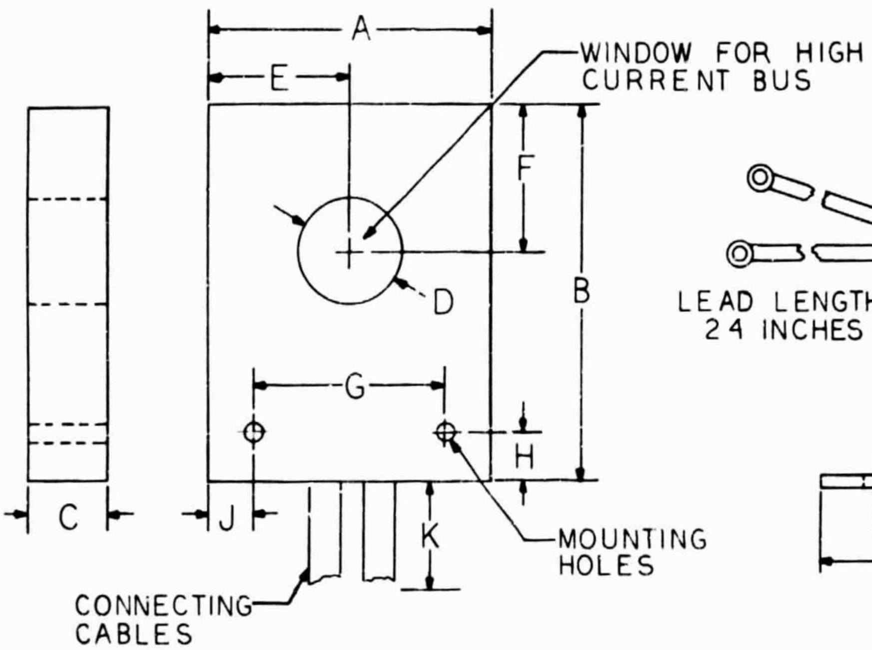


OVERALL HEIGHT 5 1/8

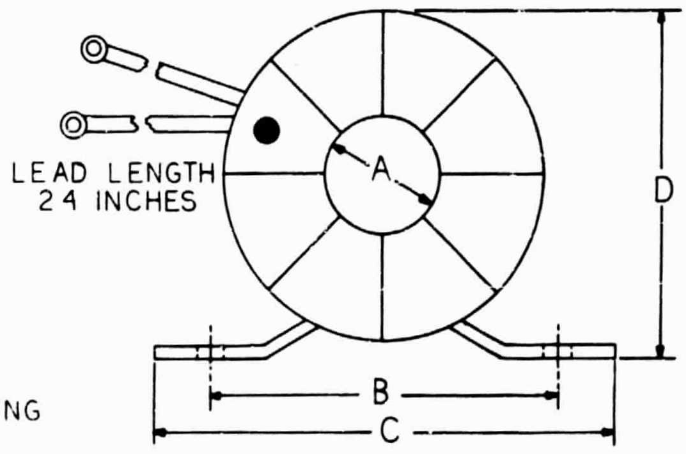
CASE SIZE DWG. K



OVERALL HEIGHT 4 7/8



OUTLINE DIMENSIONS FOR C, D & E



OUTLINE DIMENSIONS FOR W, X & Y

OUT-LINE DIM	A	B	C	D	E	F	G	H	J	K	THICK-NESS	WT. LB.	MTG. HOLE
C	2	2	3/4	3/4	1	7/8	1 1/2	1/4	1/4	15		1/4	9/64
D	3 1/8	4	7/8	1 1/8	1 9/16	1 9/16	2 1/8	1/2	1/2	15		3/4	11/64
E	4 1/8	5	1 1/4	2	2 1/16	2	3 1/4	7/16	7/16	15		2 1/8	17/64
W	1 1/4	3 7/8	5 1/8	3 7/8							1 5/8	2	9/32
X	2 1/4	5 3/4	7 1/8	5 1/8							1 1/2	3	9/32
Y	2 3/4	5 3/4	7 1/8	5 1/4							1 1/2	2 1/4	9/32

*ALL DIMENSIONS ARE IN INCHES

WATT TRANSDUCER

SPECIFICATIONS Model PC5-54F

APPLICATION:	3Ø 3 Wire
VOLTAGE:	480 VAC
CURRENT:	0-50 Amperes
OUTPUT:	100mV dc = 40KW
ACCURACY (calibration, linearity, and PF):	±1.0% FS
OUTPUT TERMINATION (LOAD,	>1 meg ohm
AMPLIFIER POWER:	

INPUTS

OVERLOAD	
Voltage (continuous):	1.25 X rating
Current (continuous):	2 X rating
(5 sec/hour):	10 X rating
BURDEN	
Voltage (max. at rated input):	1.25 VA
Current (max. at rated input):	1.25 VA
Amplifier:	2.0 VA
DIELECTRIC TEST	
Input/output/case:	1500 volts rms
POWER FACTOR RANGE:	0.5 lead to 0.5 lag
FREQUENCY:	50 to 70 Hz

OUTPUT

ADJUSTMENT (accessible from top of case):	+10%
RESPONSE:	5 milliseconds
With Option A to D:	<400 milliseconds
TEMPERATURE EFFECT (-10°C to +60°C):	±1%
AC COMPONENT (Without Amplifier):	200% ptp
OUTLINE DRAWING: (on back)	Dimensions
AC Ripple	<1.0% FS

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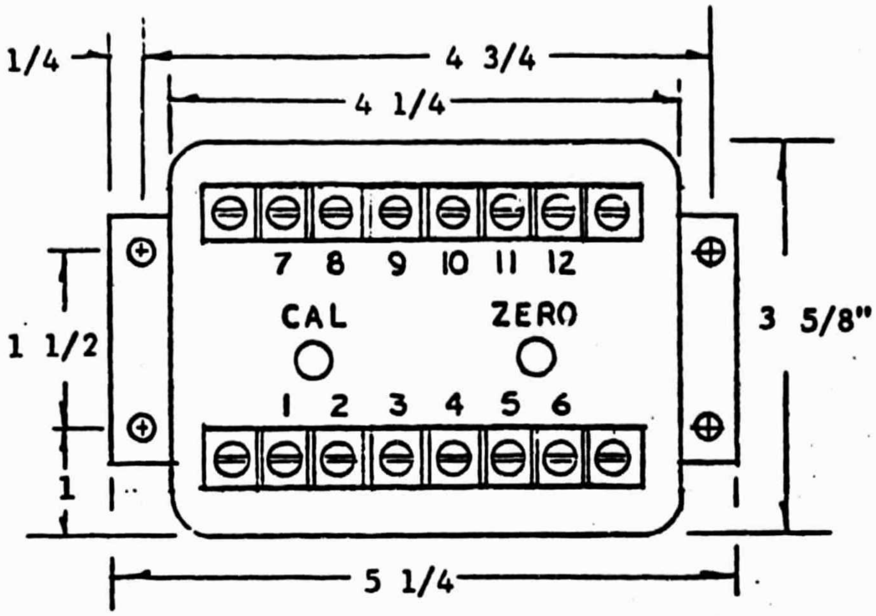
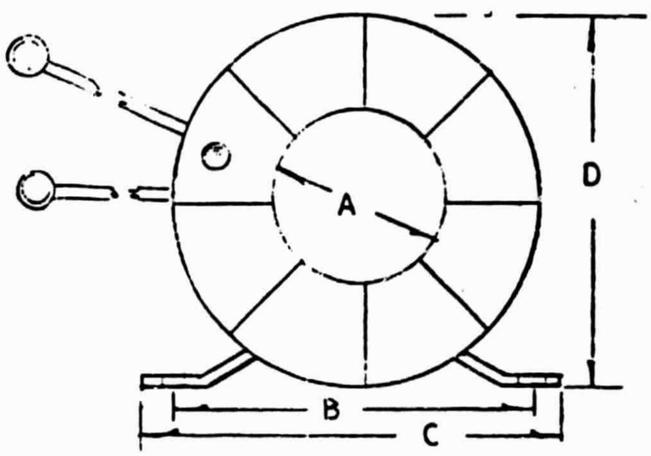
DIMENSIONS



Overall Height 5 1/8"
Mounting Holes 3/16"
#8-32 Terminal Screws

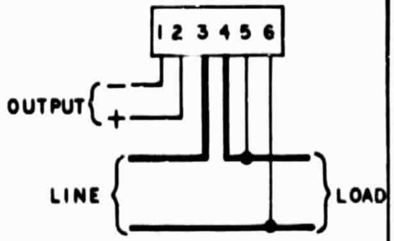


Lead Length - 24 inches

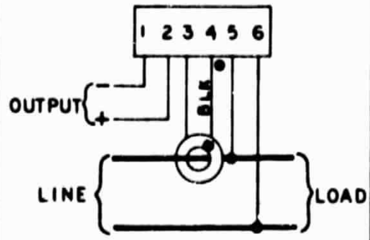
SIZE	A	B	C	D	MTG. HOLES	THICKNESS	WT. (lb.)
P	1 1/4	4	5 1/4	4	9/32	2 3/4	4

ALL DIMENSIONS IN INCHES

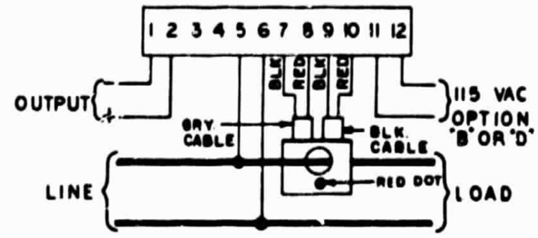
DIRECT CONNECTIONS FOR 1 PHASE-2 WIRE



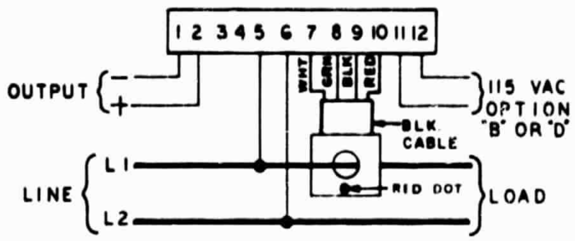
Circuit showing current directly connected through terminals 3 and 4. The voltage input is applied to terminals 5 and 6 with the output appearing on terminals 1 and 2. *Used with Options B and D only. Connect 115 vac power to terminals 11 and 12.



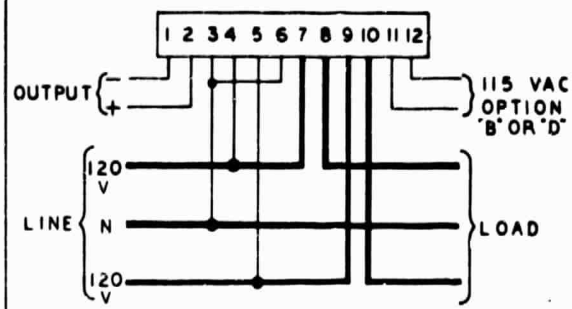
USING CURRENT TRANSFORMERS
(HIGH CURRENT)
115 vac Option B or D to terminal 11 & 12



USING CURRENT TRANSDUCERS
(HIGH CURRENT)

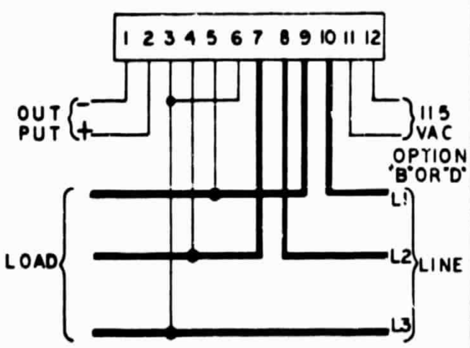


USING CURRENT TRANSDUCER
(SPLIT CORE)



EDISON SYSTEM
(120/240 3 WIRE)

DIRECT CONNECTIONS FOR 3 PHASE-3 WIRE



Circuit used for balanced or unbalanced networks by algebraically summing the E I Cos θ product from two phases.
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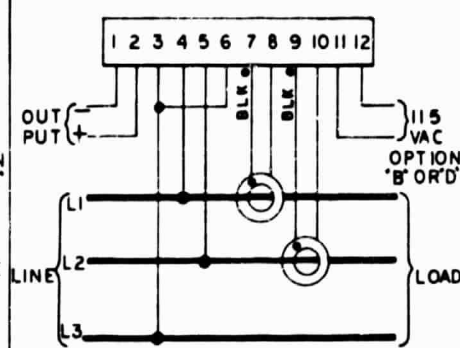
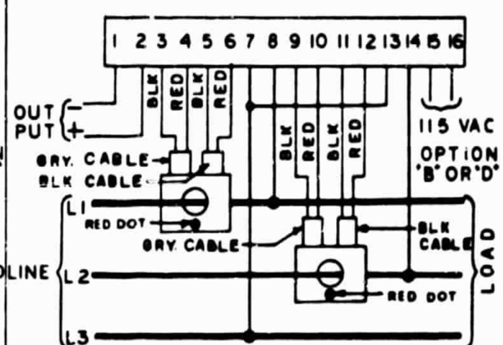
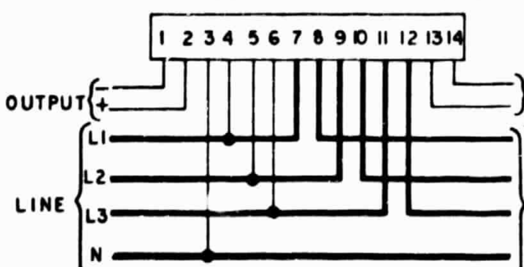


USING CURRENT TRANSFORMERS
(HIGH CURRENT)



USING CURRENT TRANSDUCERS
(HIGH CURRENT)

DIRECT CONNECTIONS FOR 3 PHASE-4 WIRE



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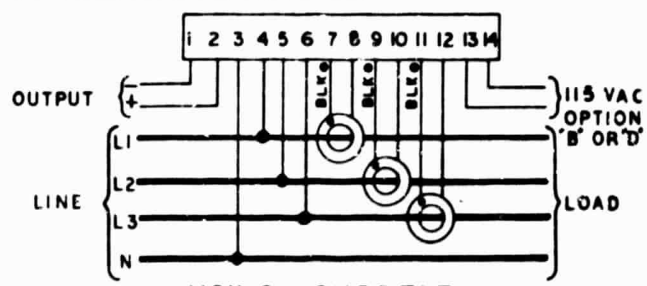
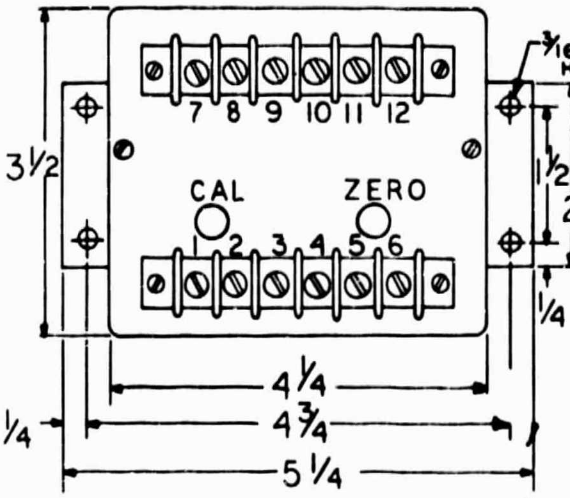


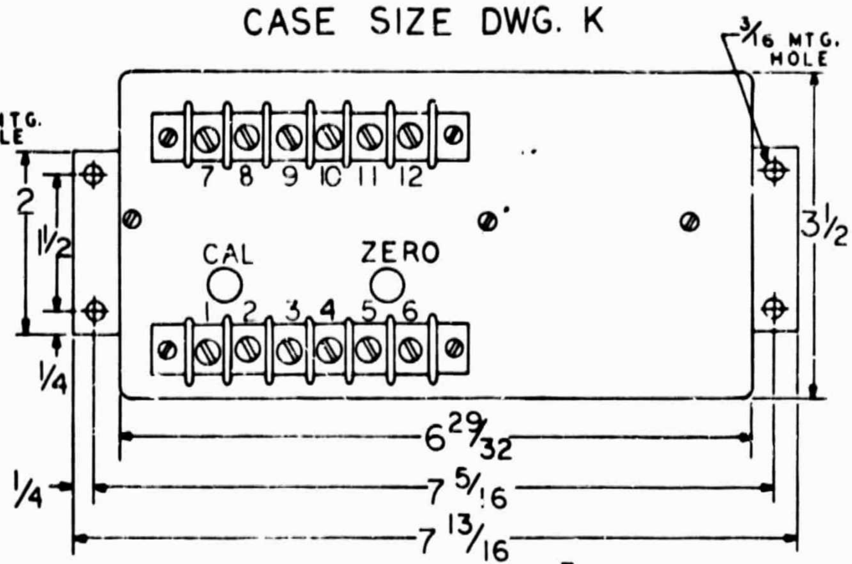
USING CURRENT TRANSFORMERS
(HIGH CURRENT)

CASE SIZE DWG. H

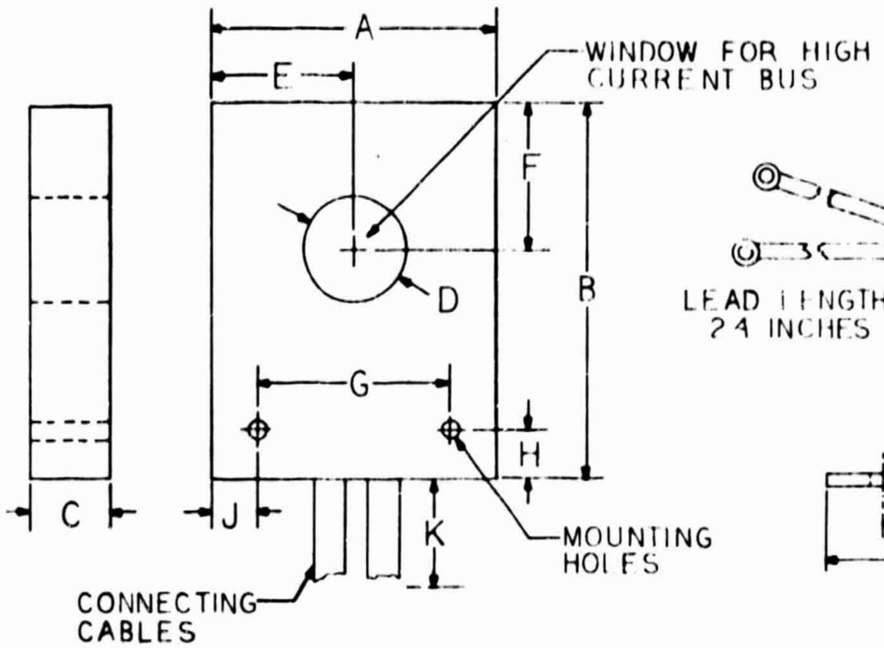


OVERALL HEIGHT 5 1/8

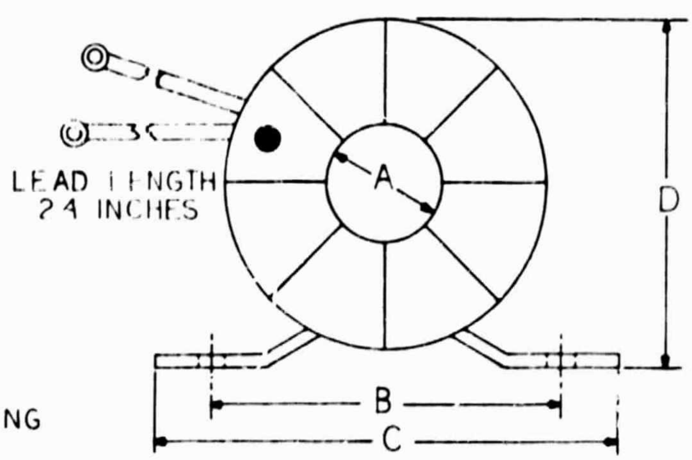
CASE SIZE DWG. K



OVERALL HEIGHT 4 7/8



OUTLINE DIMENSIONS FOR C, D & E



OUTLINE DIMENSIONS FOR W, X & Y

OUT-LINE DWG	A	B	C	D	E	F	G	H	J	K	THICKNESS	WT. LB.	MTG. HOLE
C	2	2	3/4	3/4	1	7/8	1 1/2	1/4	1/4	15		3/4	9/64
D	3 1/8	4	7/8	1 1/8	1 9/16	1 9/16	2 1/8	1/2	1/2	15		1	11/64
E	4 1/8	5	1 1/4	2	2 1/16	2	3 1/4	7/16	7/16	15		2 1/8	17/64
W	1 1/4	3 7/8	5 1/8	3 7/8							1 5/8	2	9/32
X	2 1/4	5 3/4	7 1/8	5 1/8							1 1/2	3	9/32
Y	2 3/4	5 3/4	7 1/8	5 1/4							1 1/2	2 1/4	9/32

● ALL DIMENSIONS ARE IN INCHES

PRODUCT DATA

Certain-teed snap* on fiber glass pipe insulation

CERTAINTEED
CSG GROUP

Description

Certain-teed Snap'On pipe insulation is composed of extremely fine diameter glass fibers bonded together with a phenolic resin and molded in one-piece sections. Made with a single seam Certain-teed Snap'On spreads open to receive the pipe and snaps quickly in place. Certain-teed Snap'On has all the desirable features of glass. The glass fiber will not burn, is not affected by moisture, will not corrode metals, and is permanent. Certain-teed Snap'On pipe insulation will permit expansion and contraction of the pipe without cracking and it will not shrink. Many types of jackets are available to provide a wide range of applications and requirements.

Benefits

Certain-teed Snap'On has one of the lowest "K" factors of any general-purpose pipe insulation available today. Its thermal efficiency is such that for most insulation jobs less wall thickness is required. That is why Certain-teed Snap'On is more economical for all applications within its temperature range when compared with other pipe insulations. The accompanying thermal conductivity charts illustrate the heat-saving properties of Certain-teed Snap'On pipe insulation.

Specification Compliances

Certain-teed Snap'On fiber glass pipe insulation meets the following federal and military specifications.

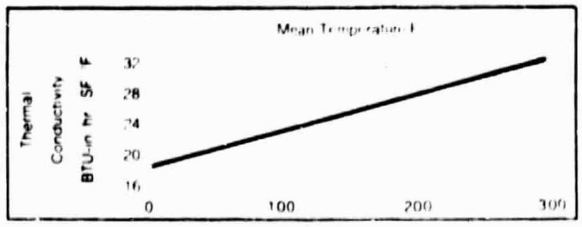
HH-I-558B—Form D, Type III, Class 12 or Class 13
MIL-I-22344B
ASTM C547-67

Temperature Limit

Certain-teed Snap'On pipe insulation is designed for heated piping to 500 F. At continuous 500 F service the binder on the inner third of the thickness will gradually dissipate but this will not affect the insulation performance. The binder in the outer two thirds will remain intact and maintain the strength of the insulation.

Snap'On with vapor barrier jackets are suitable for operating temperatures to −20F.

Thermal Efficiency



Recommendations for Installing Certain-teed Snap'On with Self Sealing FRJ Jacket

1. Make certain FRJ Jacket is clean.
2. Make all cuts and fabrications before removing release paper.
3. Make sure to rub hard to assure a positive seal.
4. Do not install when air temperature is lower than 35 F or over 120 F.
5. Do not leave adhesive strip exposed to the air. Adhere self sealing lap immediately after removing paper backing.

Recommended Jackets—Jackets meet requirements of HH-I-100B Type I

Type of Jacket	Description	Sec. Length	Vapor Barrier	*Composite U.L. Rating Flame Spread 25 Smoke Developing 50 Fuel Contributed 50	Where to Use
PLAIN	No jacket. Smooth glass fiber surface	3' and 6' Depending on Size	No	Yes	On interior concealed hot piping. Excellent for industrial applications where no vapor barrier is required. Recommended where weather-proofing jackets, aluminum, or sheet metal coverings are to be field applied.
FLAME RESISTANT JACKET	This jacketing is of laminated construction using aluminum foil, 6×6 glass reinforcing, flame extinguishing adhesive, and either white or black kraft paper. The jacket is embossed to provide a pleasing appearance. Perm rating of less than 0.01. Furnished with a 1½" overlapping longitudinal seam and 3" wide strips to seal end joints. (50 Beach puncture) 35 lbs./in. tensile strength	3'	Yes	Yes	On interior concealed hot or cold lines where flame resistant characteristics are required. When used out of doors an additional weatherproofing jacket is required. (NOTE: Aluminum foil is applied next to pipe insulation)
FLAME RESISTANT JACKET WITH SELF SEALING TAPE	This jacket is the same as the flame resistant jacket described above with a self sealing tape to seal the longitudinal joint and self sealing butt strap to seal end joints.	3'	Yes	Yes	Same as flame resistant jacket with the self sealing tape. See above.
ALL SERVICE JACKET (ASJ)	Laminated aluminum foil, glass reinforcing and white kraft paper. Perm rating of 0.01 (55 Beach puncture). 35 lbs./in. tensile strength.	3'	Yes	Yes	ASJ is specifically designed for all hot, cold, or dual temperature piping.
UNIVERSAL GLASS CLOTH	Saran glass cloth laminated jacket. Tough, attractive white finish. Noncombustible. Perm rating of 0.02. (300 Beach puncture)	3'	Yes	Yes	On all hot, cold or dual-service piping where appearance and rated noncombustible fire safety is desired.

*CERTAIN-TEED PIPE INSULATIONS. These are Certain-teed fire safety pipe insulations which have been tested on a composite basis (insulation, jacket and jacket adhesive) and meet the fire hazard safety requirements of rigid building codes and Government guide specifications.

Recommended Thicknesses* Heated Piping Insulation

Commercial (full time) Operating Temperature (F)

Size	150	200	250	300	350	400	450	500
0.50	0.5	1.0	1.5	1.5	2.0	2.5	2.5	3.0
0.75	1.0	1.0	1.5	2.0	2.0	2.5	3.0	3.0
1.00	1.0	1.5	1.5	2.0	2.5	3.0	3.0	3.5
1.25	1.0	1.5	2.0	2.5	2.5	3.0	3.5	4.0
1.50	1.0	1.5	2.0	2.5	3.0	3.5	3.5	4.0
2.00	1.5	2.0	2.5	2.5	3.0	3.5	4.0	4.5
2.50	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
3.00	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
3.50	1.5	2.5	3.0	3.5	4.0	4.5	5.0	5.5
4.00	1.5	2.5	3.0	3.5	4.0	4.5	5.0	5.5
4.50	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0
5.00	2.0	2.5	3.0	4.0	4.5	5.0	5.5	6.0
6.00	2.0	2.5	3.5	4.0	4.5	5.0	5.5	6.5
7.00	2.0	3.0	3.5	4.0	4.5	5.5	6.0	6.5
8.00	2.0	3.0	3.5	4.0	5.0	5.5	6.0	6.5
9.00	2.0	3.0	3.5	4.5	5.0	5.5	6.0	7.0
10.00	2.0	3.0	4.0	4.5	5.0	5.5	6.5	7.0
12.00	2.5	3.0	4.0	4.5	5.0	6.0	6.5	7.0
14.00	2.0	3.0	4.0	4.5	5.0	5.5	6.5	7.0
16.00	2.0	3.0	4.0	4.5	5.0	5.5	6.5	7.0
18.00	2.0	3.0	4.0	4.5	5.0	5.5	6.5	7.0
20.00	2.0	3.0	3.5	4.5	5.0	5.5	6.0	7.0
24.00	2.0	3.0	3.5	4.0	5.0	5.5	6.0	6.5
30.00	2.0	2.5	3.5	4.0	4.5	5.0	5.5	6.0
36.00	1.5	2.5	3.0	3.5	4.0	4.5	5.0	5.5
Flat	2.5	3.5	4.5	5.0	6.0	6.5	7.5	8.0

Process (full time) Operating Temperature (F)

Size	150	200	250	300	350	400	450	500
0.50	0.5	1.0	1.0	1.5	1.5	1.5	2.0	2.0
0.75	0.5	1.0	1.0	1.5	1.5	2.0	2.0	2.5
1.00	0.5	1.0	1.5	1.5	2.0	2.0	2.5	2.5
1.25	1.0	1.0	1.5	2.0	2.0	2.5	2.5	3.0
1.50	1.0	1.5	1.5	2.0	2.0	2.5	3.0	3.0
2.00	1.0	1.5	2.0	2.0	2.5	3.0	3.0	3.5
2.50	1.0	1.5	2.0	2.5	2.5	3.0	3.5	3.5
3.00	1.0	1.5	2.0	2.5	3.0	3.5	3.5	4.0
3.50	1.5	2.0	2.0	2.5	3.0	3.5	4.0	4.0
4.00	1.5	2.0	2.5	2.5	3.0	3.5	4.0	4.5
4.50	1.5	2.0	2.5	3.0	3.5	3.5	4.0	4.5
5.00	1.5	2.0	2.5	3.0	3.5	4.0	4.5	4.5
6.00	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
7.00	1.5	2.0	3.0	3.5	3.5	4.0	4.5	5.0
8.00	1.5	2.5	3.0	3.5	4.0	4.5	5.0	5.5
9.00	1.5	2.5	3.0	3.5	4.0	4.5	5.0	5.5
10.00	1.5	2.5	3.0	3.5	4.0	4.5	5.0	5.5
12.00	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
14.00	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
16.00	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
18.00	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
20.00	1.5	2.5	3.0	3.5	4.0	4.5	5.0	5.5
24.00	1.5	2.5	3.0	3.5	4.0	4.5	5.0	5.0
30.00	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
36.00	1.5	2.0	2.5	3.0	3.0	3.5	4.0	4.5
Flat	2.0	3.0	3.5	4.0	5.0	5.5	6.0	6.5

Commercial (part time) Operating Temperature (F)

Size	150	200	250	300	350	400	450	500
0.50	0.5	1.0	1.0	1.5	1.5	2.0	2.0	2.0
0.75	0.5	1.0	1.0	1.5	1.5	2.0	2.0	2.5
1.00	0.5	1.0	1.5	1.5	2.0	2.0	2.5	2.5
1.25	1.0	1.0	1.5	2.0	2.0	2.5	2.5	3.0
1.50	1.0	1.5	1.5	2.0	2.5	2.5	3.0	3.0
2.00	1.0	1.5	2.0	2.0	2.5	3.0	3.0	3.5
2.50	1.0	1.5	2.0	2.5	2.5	3.0	3.5	4.0
3.00	1.0	1.5	2.0	2.5	3.0	3.5	3.5	4.0
3.50	1.5	2.0	2.0	2.5	3.0	3.5	4.0	4.5
4.00	1.5	2.0	2.5	3.0	3.0	3.5	4.0	4.5
4.50	1.5	2.0	2.5	3.0	3.5	4.0	4.0	4.5
5.00	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
6.00	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
7.00	1.5	2.5	3.0	3.5	4.0	4.5	4.5	5.0
8.00	1.5	2.5	3.0	3.5	4.0	4.5	5.0	5.5
9.00	1.5	2.5	3.0	3.5	4.0	4.5	5.0	5.5
10.00	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
12.00	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
14.00	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
16.00	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
18.00	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
20.00	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
24.00	1.5	2.5	3.0	3.5	4.0	4.5	5.0	5.5
30.00	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
36.00	1.5	2.0	2.5	3.0	3.0	3.5	4.0	4.5
Flat	2.0	3.0	3.5	4.0	5.0	5.5	6.0	6.5

Utility (full time) Operating Temperature (F)

Size	150	200	250	300	350	400	450	500
0.50	0.5	1.0	1.5	1.5	2.0	2.0	2.5	2.5
0.75	1.0	1.0	1.5	2.0	2.0	2.5	2.5	3.0
1.00	1.0	1.5	1.5	2.0	2.5	2.5	3.0	3.0
1.25	1.0	1.5	2.0	2.0	2.5	3.0	3.0	3.5
1.50	1.0	1.5	2.0	2.5	2.5	3.0	3.5	4.0
2.00	1.0	1.5	2.0	2.5	3.0	3.5	3.5	4.0
2.50	1.5	2.0	2.5	2.5	3.0	3.5	4.0	4.5
3.00	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
3.50	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
4.00	1.5	2.0	3.0	3.5	4.0	4.5	4.5	5.0
4.50	1.5	2.5	3.0	3.5	4.0	4.5	5.0	5.5
5.00	1.5	2.5	3.0	3.5	4.0	4.5	5.0	5.5
6.00	2.0	2.5	3.0	3.5	4.5	5.0	5.5	6.0
7.00	2.0	2.5	3.5	4.0	4.5	5.0	5.5	6.0
8.00	2.0	2.5	3.5	4.0	4.5	5.0	5.5	6.5
9.00	2.0	3.0	3.5	4.0	4.5	5.0	6.0	6.5
10.00	2.0	3.0	3.5	4.0	5.0	5.5	6.0	6.5
12.00	2.0	3.0	3.5	4.0	5.0	5.5	6.0	6.5
14.00	2.0	3.0	3.5	4.0	5.0	5.5	6.0	6.5
16.00	2.0	3.0	3.5	4.0	5.0	5.5	6.0	6.5
18.00	2.0	3.0	3.5	4.0	5.0	5.5	6.0	6.5
20.00	2.0	3.0	3.5	4.0	4.5	5.5	6.0	6.5
24.00	2.0	2.5	3.5	4.0	4.5	5.0	5.5	6.0
30.00	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
36.00	1.5	2.0	3.0	3.5	3.5	4.0	4.5	5.0
Flat	2.5	3.5	4.0	5.0	5.5	6.5	7.0	7.5

*Thicknesses appearing above are economic thicknesses under average operating condition. Special conditions may warrant the use of other thicknesses. Economic thicknesses for heated pipes are derived from ECON I Manual of National Insulation Manufacturers Association.

Minimum Nominal Fiber Glass Pipe Insulation Thickness Needed to Prevent Condensation

Ambient Conditions (Still air)	Operating Conditions (Pipe Temp)	Pipe Size (Nominal)	Thickness (Nominal) (inches)
80 F & 90% RH (26.7 C)	40 F (4.4 C)	½ to 3	1½
		3½ to 20	2
		24 to 36	2½
	34 (1.1 C)	½ to 2	1½
		2½ to 9	2
		10 to 36	3
	0 F (−17.8 C)	½ to 1	2
		1¼ to 2	2½
		2½ to 8	3
		9 to 30	3½
	−20 F (−28.9 C)	½ to 7	3
		2½ to 8	3½
		9 to 14	4
80 F & 70% RH	40 F (4.4 C)	½ to 9	½
		10 to 36	1
	34 (1.1 C)	½ to 1¼	½
		1½ to 6	¾
		7 to 36	1
	0 (−17.8 C)	to ½	¾
		¾ to 4½	1
		5 to 36	1½
	−20 F (−28.9 C)	½ to 1	1
		1¼ to 12	1½
		14 to 30	2
80 [illegible]	40 F (4.4 C)	½ to 11	½
		12 to 36	1
	34 (1.1 C)	½ to 10	[illegible]
		12 to 36	[illegible]
		½ to 1¼	[illegible]
		1½ to 6	[illegible]
		7 to 36	[illegible]
	20 F (−6.7 C)	½ to ¾	[illegible]
		1 to 4½	[illegible]
		5 to 36	[illegible]

This chart was developed to aid designers and buyers in choosing the proper insulation thickness for piping systems. For more details on specific or unusual problems consult your nearest Certain-teed District Office. Temperature Conversion—°C = 5/9 (°F − 32)

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Sizes and Thicknesses

MULTIPLE LAYERS ONLY

Nom. Pipe Size	Pipe O.D.	½" Wall Thick Wall	½" Wall Thick Insul. O.D.	¾" Wall Thick Wall	¾" Wall Thick Insul. O.D.	1" Wall Thick Wall	1" Wall Thick Insul. O.D.	1½" Wall Thick Wall	1½" Wall Thick Insul. O.D.	2" Wall Thick Wall	2" Wall Thick Insul. O.D.	2½" Wall Thick Wall	2½" Wall Thick Insul. O.D.	3" Wall Thick Wall	3" Wall Thick Insul. O.D.	2½" Wall Thick (Multiple Layers Only) Wall*	2½" Wall Thick (Multiple Layers Only) Insul. O.D.	3" Wall Thick (Multiple Layers Only) Wall*	3" Wall Thick (Multiple Layers Only) Insul. O.D.*
IRON PIPE																			
½"	84	504	1.90	76	2.38	1.01	2.88	1.57	4.00	2.07	5.00					2.35	5.56	2.87	6.63
¾"	1.05	66	2.38	66	2.38	91	2.88	1.47	4.00	1.97	5.00					2.78	6.63	3.01	7.63
1"	1.32	52	2.38	77	2.88	1.09	3.50	1.59	4.50	2.12	5.56					2.65	6.63	3.13	7.63
1¼"	1.66	60	2.88	91	3.50	91	3.50	1.66	5.00	1.94	5.56					2.48	6.63	2.95	7.63
1½"	1.90	48	2.98	79	3.50	1.04	4.00	1.54	5.00	1.82	5.56					2.36	6.63	2.83	7.63
2"	2.38	55	3.50	80	4.00	1.05	4.50	1.58	5.56	2.11	6.63	2.61	7.63	3.11	8.63				
2½"	2.88	55	4.00	80	4.50	1.05	5.00	1.33	5.56	1.86	6.63	2.36	7.63	2.86	8.63				
3"	3.50	48	4.50	73	5.00	1.01	5.56	1.55	6.63	2.05	7.63	2.55	8.63	3.05	9.63				
3½"	4.00	48	5.00	76	5.56	1.29	6.63	1.29	6.65	1.79	7.63	2.79	9.63	2.79	9.63				
4"	4.50	51	5.56	1.04	6.63	1.04	6.63	1.54	7.63	2.04	8.63	2.54	9.63	3.10	10.75				
4½"	5.00	79	6.63	79	6.63	1.29	7.63	1.29	7.63	1.79	8.63	2.85	10.75	2.85	10.75				
5"	5.56	75	7.12	75	7.12	1.00	7.63	1.50	8.63	2.00	9.63	2.57	10.75	3.07	11.75				
6"	6.63	50	7.63	79	8.19	97	8.63	1.47	9.63	2.03	10.75	2.53	11.75	3.03	12.75				
						96	9.63	1.53	10.75	2.03	11.75	2.53	12.75	3.15	14.00				
						1.02	10.75	1.52	11.75	2.02	12.75	2.65	14.00	3.15	15.00				
						1.02	11.75	1.52	12.75	2.14	14.00	2.64	15.00	3.14	16.00				
						95	12.75	1.57	14.00	2.07	15.00	2.57	16.00	3.07	17.00				
						1.07	14.00	1.57	15.00	2.07	16.00	2.57	17.00	3.07	18.00				
						1.06	15.00	1.56	16.00	2.06	17.00	2.56	18.00	3.06	19.00				
14-33" Actual						Available in normal 1", 1½", 2", 2½" and 3" wall thicknesses													
36" Actual						Available in normal 1" and 1½" wall thicknesses													
COPPER TUBING																			
½"	⅝"	629	1.90	87	2.37	1.08	2.80	1.43	3.50	—	—								
¾"	⅞"	504	1.90	74	2.38	99	2.88	1.55	4.00	2.05	5.00								
⅞"	1"	65	2.38	91	2.88	1.22	3.50	1.47	4.00	1.97	5.00								
1"	1⅛"	62	2.38	87	2.88	1.18	3.50	1.43	4.00	4.00	5.00								
1¼"	1⅜"	49	2.38	74	2.88	1.06	3.50	1.56	4.50	2.09	5.56								
1½"	1⅝"	60	2.88	91	3.50	1.16	4.00	1.66	5.00	1.94	5.56								
2"	2⅛"	68	3.50	93	4.00	1.18	4.50	1.71	5.56	2.24	6.63								
2½"	2⅝"	68	4.00	93	4.50	93	4.50	1.46	5.56	1.99	6.63								
3"	3⅛"	67	4.50	92	5.00	1.20	5.56	1.74	6.63										
3½"	3⅝"	67	5.00	67	5.00	95	5.56	1.48	6.63										
4"	4⅛"	70	5.56	70	5.56	1.23	6.63	1.73	7.63										
5"	5⅛"					1.23	7.76	1.73	8.63										
6"	6⅛"	72	7.63	72	7.63	1.22	8.63	1.72	9.63										

Iron pipe: **Standard section lengths are 3 feet. All sizes below solid horizontal (———) line available in 6 foot lengths, unfaced, on request**

***May vary**

Copper tubing: **Standard section lengths are 3 feet. All sizes below solid horizontal (———) line available in 6 foot lengths, unlaced, on request**

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5587 New Peachtree Road
Atlanta, GA 30341
404 457-1172

BALTIMORE DISTRICT
4756 Trident Court
Baltimore, MD 21227
301 247-2170

CHICAGO DISTRICT
854 Fairway Drive
Bensenville, IL 60106
312 921-6123

HOUSTON DISTRICT
6610 Harwin Street
Suite #260
Houston, TX 77036
713 783-7270

KANSAS CITY DISTRICT
4000 Somerset Drive
Prairie Village, KS 66208
913 381-9010

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14401 Industry Circle
La Mirada, CA 90638
213 868-9926

NEW YORK DISTRICT
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Edison, NJ 08817
201 225-1555

PITTSBURGH DISTRICT
2247 Babcock Blvd
Pittsburgh, PA 15237
412 821-6252

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4756 Trident Court
Baltimore, MD 21227
301 247-0544

NORTH CENTRAL SERVICE CENTER—CHICAGO
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HEAVY & ASSOCIATES
FOR GENERAL LAYOUT ... EQUIPMENT CAPACI...
CONTRACTOR SHALL BE RESPONSIBLE FOR CORRE...
FITTING.

BY Gene Watts...

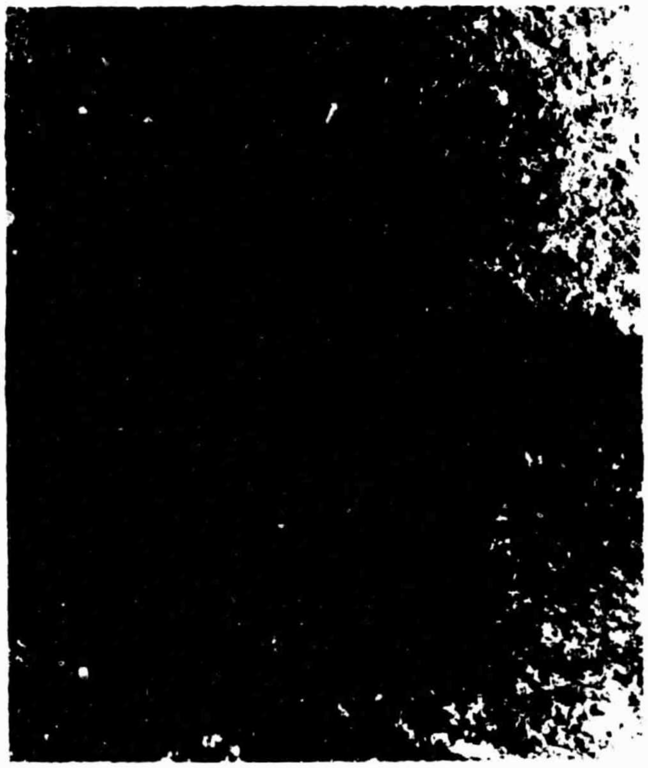
DATE 11-29-77

FOAMGLAS-an excellent underground piping insulation offering time and money-saving benefits.

The combination of high compressive strength and impermeability makes FOAMGLAS one of the finest insulations available for underground piping systems. Simply by applying FOAMGLAS to the pipe or tubing section and sealing it according to our standard specifications, a line can be installed via the "direct burial" method. That is, merely by first covering the insulated piping with a sand bed, backfill can be put directly over the line. This eliminates need for concrete tunnels or other costly protective systems. You can even insulate the pipe section above ground (where it's easy) and lower into trench.

Underground, FOAMGLAS will retain its constant efficiency because its all-glass cells are completely closed and thus impermeable. Moisture problems are eliminated. FOAMGLAS is not affected by soil acids, being all glass it is inorganic. Even when buried in wet, sandy soil for as long as ten years with no maintenance whatsoever, FOAMGLAS continues to perform perfectly. Because of its high compressive strength, surface traffic over the insulated piping will not crush or compress FOAMGLAS.

Pittsburgh Corning also handles the necessary materials required for a complete installation. We will be happy to send you a complete, detailed application specification for FOAMGLAS underground systems. Write for a copy of FI-104e.



A water table just below the surface was one deciding factor in the selection of moisture-proof FOAMGLAS pipe insulation on this chilled water system at Tulane University. The FOAMGLAS supported an overburden of up to seven feet and it was unaffected by soil moisture conditions.

Forty-foot lengths of pipe were insulated with FOAMGLAS above ground and then lowered onto a sand bed in 6 to 11 feet deep trenches at International Business Machines, San Jose, California, plant. Figures proved this technique to be two or three times less costly than the concrete tunnel method.

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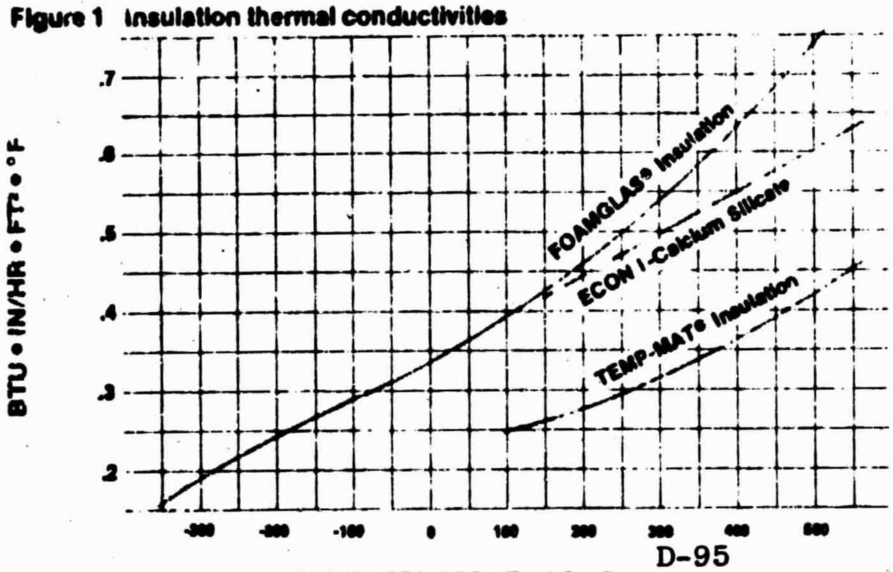
Table 1. Outstanding Properties of FOAMGLAS® Insulation

Physical Properties	English	Metric	ASTM Test
Absorption of moisture (% by volume)	0.2	0.2	C240
Acid resistance	Impervious to common acids and their fumes except hydrofluoric acid.		
Capillarity	None	None	
Combustibility	Noncombustible, will not burn.		
Composition	Pure glass, totally inorganic, contains no binder.		
Compressive strength, average	100 psi	7.0 kg/cm²	C165 – Surfaces capped with hot asphalt per C240-72. Other cappings will give different values.
Density, average	8.5/lb/ft³	136 kg/m³	C303
Dimensional stability	Excellent		
Flexural strength, block average	80 psi	5.6 kg/cm²	C203 C240
Hygroscopicity	No increase in weight at 90% relative humidity		
Linear coefficient of thermal expansion	4.6 x 10⁻⁶/°F	8.3 x 10⁻⁶/°C	
Minimum service temperature	-459°F	-273°C	
Modulus of elasticity, approx.	1.5 x 10⁵ psi	10,000 kg/cm²	C623
Shear strength	50 psi	3.5 kg/cm²	
Specific heat	.18 Btu/lb/°F	.18 kcal/kg °C	
Strain point (glass)	940°F	504°C	C336
Thermal conductivity	50°F:0.36 Btu-in/hr. ft² deg F 75°F:0.38 Btu-in/hr. ft² deg F	10°C:.045 kcal/m h °C 25°C:.047 kcal/m h °C	C177 C518
Thermal diffusivity	.020 ft²/hr	.0052 cm²/sec	
Water-vapor permeability	0.00 perm in	0.00 perm cm	C355

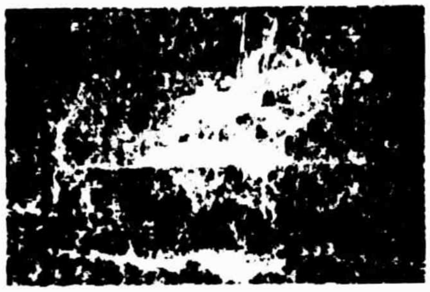
Statement of limitations

Because of its impermeability, high strength and ability to withstand [illegible] application limitations of FOAMGLAS insulation are very few. When [illegible] stated in the application specifications, the limitations [illegible] the [illegible] forming warranty with respect to FOAMGLAS insulation. [illegible] warranties expressed or implied including the warranty of merchantability.

Figure 1 Insulation thermal conductivities



MEAN TEMPERATURE



Impermeable

[illegible]

FOAMGLAS insulation maintains constant insulating efficiency

[illegible] or gases [illegible] conductor and [illegible] causes [illegible] insulating efficiency [illegible] the sealed glass cells [illegible] insula- [illegible]

[illegible] GLAS insulation [illegible] the corrosion of equipment, stainless steel piping or metallic insulation jacketing material.

Because it is all glass, FOAMGLAS insulation is not affected by common acids and corrosive chemical spills that destroy the insulating efficiency, and often even the insulating materials. Therefore, FOAMGLAS insulation users do not worry about costly periodic replacement of insulation.

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