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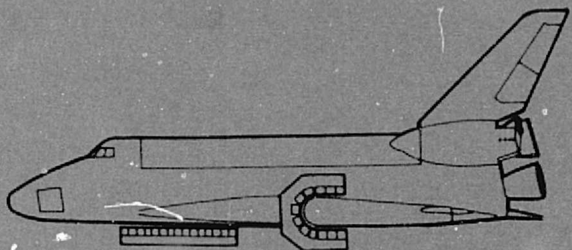

A LEADING EDGE HEATING ARRAY

AND

A FLAT SURFACE HEATING ARRAY

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OPERATION, MAINTENANCE AND REPAIR MANUAL

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FOREWORD

The Leading Edge/Flat Surface Heating Array was developed by McDonnell Douglas Corporation (MDC) in St. Louis, Missouri to provide an economical means of repeatedly imposing entry heating conditions (at gas pressures corresponding to flight) on a variety of test articles ranging from leading edges (with radii as small as 3.4 inches) to large flat panels with a heated area of 4 x 8 feet. The array consists of a set of variable length heater modules, a set of variable length heat absorbing modules, a set of optical pyrometers, and a support structure. Each module can be assembled in either a 48 inch or 72 inch configuration. The array is designed to heat Thermal Protection System (TPS) test articles to 3200°F following an entry temperature-time curve at gas pressures ranging from 0.5 to 760 torr in a non-oxidizing environment. The heater modules use graphite strip heater elements which operate from an ignitron controller coupled with an intermediate step down transformer. The heating array in either the leading edge or flat surface configuration was designed to fit within and interface with critical components of the 10 foot diameter vacuum chamber at NASA-JSC.

This manual contains; a general description of the heating array and components, assembly instructions, installation instructions, operation procedures, maintenance instructions, repair procedures, schematics, spare parts lists, engineering drawings of the array, and functional acceptance test log sheets. The proper replacement of components, correct torque values and step-by-step maintenance instructions along with pretest checkouts are described. Part nomenclature defined on the drawings is used throughout the manual.

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1.0 INTRODUCTION

A modular graphite radiant heater concept was developed by McDonnell Douglas Corporation (MDC) to test full scale segments of the Space Shuttle wing leading edge. The selected modular concept permits efficient placement of heater modules for testing various radius leading edges. This arrangement maintains uniform heating of the test article in the spanwise direction while providing a means of varying the heater environment in the chordwise direction through individual control of the heater modules.

The graphite heater system described herein was developed to overcome several problems that exist with tungsten filament quartz lamps. When used at high temperature and/or heat fluxes, quartz lamps have a relatively short life, are expensive to replace, arc over at low pressure due to the high operating voltages, and require high density installation to achieve the required high heat flux which in turn causes over-temperature of the quartz envelope. The graphite heater system has low cost graphite elements, which have a long life, are simple to replace, and which operate at low pressure as well as pressures in excess of one atmosphere. High heat flux density is inherently attained by the nature of the heater element design.

The leading edge of the Shuttle wing experiences a variable heat flux and temperature profile around the moldline. During Shuttle entry at high angles of attack (30 degrees), the leading edge is heated on the lower surface then internally radiates energy to the upper surface where it is rejected. Absorber modules were designed for the leading edge heating array to accommodate this heat rejection. These units replace heater modules in those regions around the leading edge where this heat rejection occurs. Figure 1 shows the leading edge test configuration, eight 72 inch heater modules and seven 72 inch absorber modules.

Design features are incorporated into some components of the leading edge array which permits using those components to form a large flat surface heating array. Modules in addition to those required for the leading edge array are supplied so that a flat surface heater can be assembled with a heated area up to 4 x 8 feet. Figure 2 shows two flat surface configurations, twelve 72 inch heater modules and ten 48 inch heater modules.

A support structure is supplied which can be converted to support the heater and/or absorber modules in either the leading edge or flat surface configuration. The heater support structure was designed to fit within the available envelope of a 10-ft diameter test chamber located in Building 260 at NASA-JSC, and interface with the necessary utilities within the chamber.

Each heater and absorber has provisions to mount special optical pyrometer assemblies. These pyrometers were developed under Contract NAS 9-13544, to sense the surface temperatures of test articles without altering the surface of the test article.

Although the heating array was designed specifically with Space Shuttle in mind, the flexibility that has been designed into the array will allow it to be utilized for a variety of test programs.

HEATING ARRAY - LEADING EDGE CONFIGURATION

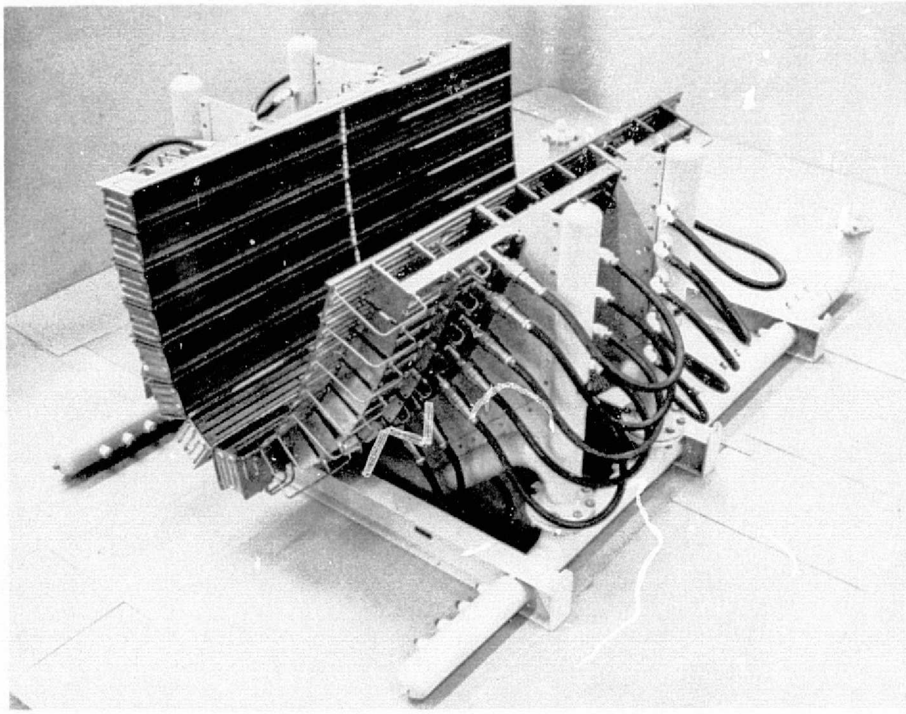


FIGURE 1

HEATING ARRAY— FLAT CONFIGURATIONS

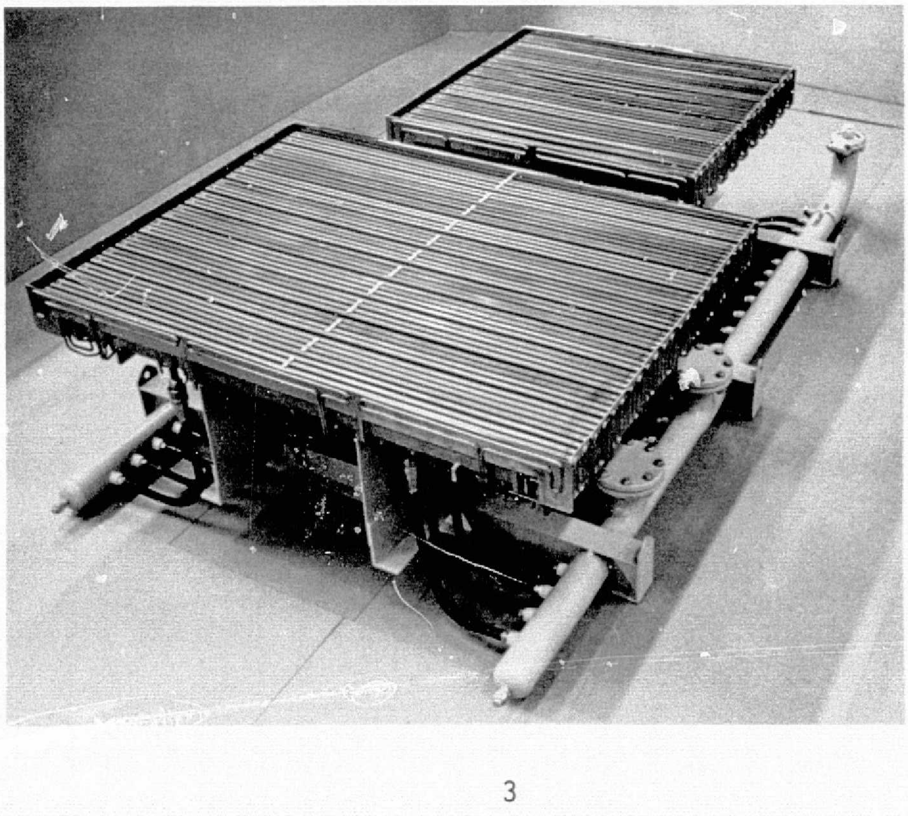


FIGURE 2

2.0 GENERAL DESCRIPTION

The individual components of the heating array are described in the following paragraphs. Design features incorporated in the units provide convenience, and effectiveness. The components include a variable length heater module, a variable length absorber module, a support structure to support these modules around a leading edge test article and in a flat array, and optical pyrometers for measuring test articles surface temperatures above 2000°F.

2.1 Variable Length Heater Module - The variable length heater module shown in Figure 3 consists of three sections; the electrode end, the expansion end, and a center section which can be removed to vary the heater length from 72 to 48 inches. This design feature provides for an efficient method of testing various size test panels where an array formed of 48 inch heater modules will provide the necessary heat flux uniformity.

Figure 4 is a layout of the heater module in the 72 inch and 48 inch configurations. The heater is approximately 5 inches wide by 75 inches long in the 72 inch configuration and contains two two-pass serpentine graphite heater elements. Each pass has constant cross-sectional dimensions throughout the heated length of 0.8 inch inch wide by 0.42 inch thick. Both ends are thickened to 0.75 inch for the electrical power connections and end supports.

The structural backbone of the heater is formed by two rectangular coolant manifold tubes. These tubes have gasketed, flanged ends and the end heater sections can be bolted together without the center section to form the 48 inch heater configuration. A no-spill quick disconnect coupler is provided, one in each end section for the coolant supply and return. The center section has no couplers but receives coolant automatically when installed between the two end sections. All of the heater components are supplied coolant from these manifold tubes. Coolant flow rates for the 72 and 48 inch heaters are approximately 24 and 18 gpm respectively with a 60 psi pressure drop (ΔP). Each heater module is equipped with a coolant interlock flow switch.

Mounting flanges are welded to the heater module coolant manifold tubes. The heater is supported from the two flanges extending from the center heater section when the heater is in the 72-inch configuration, and from the two flanges on each end section when in the 48-inch configuration. With this arrangement either heater

72 INCH VARIABLE LENGTH HEATER MODULE

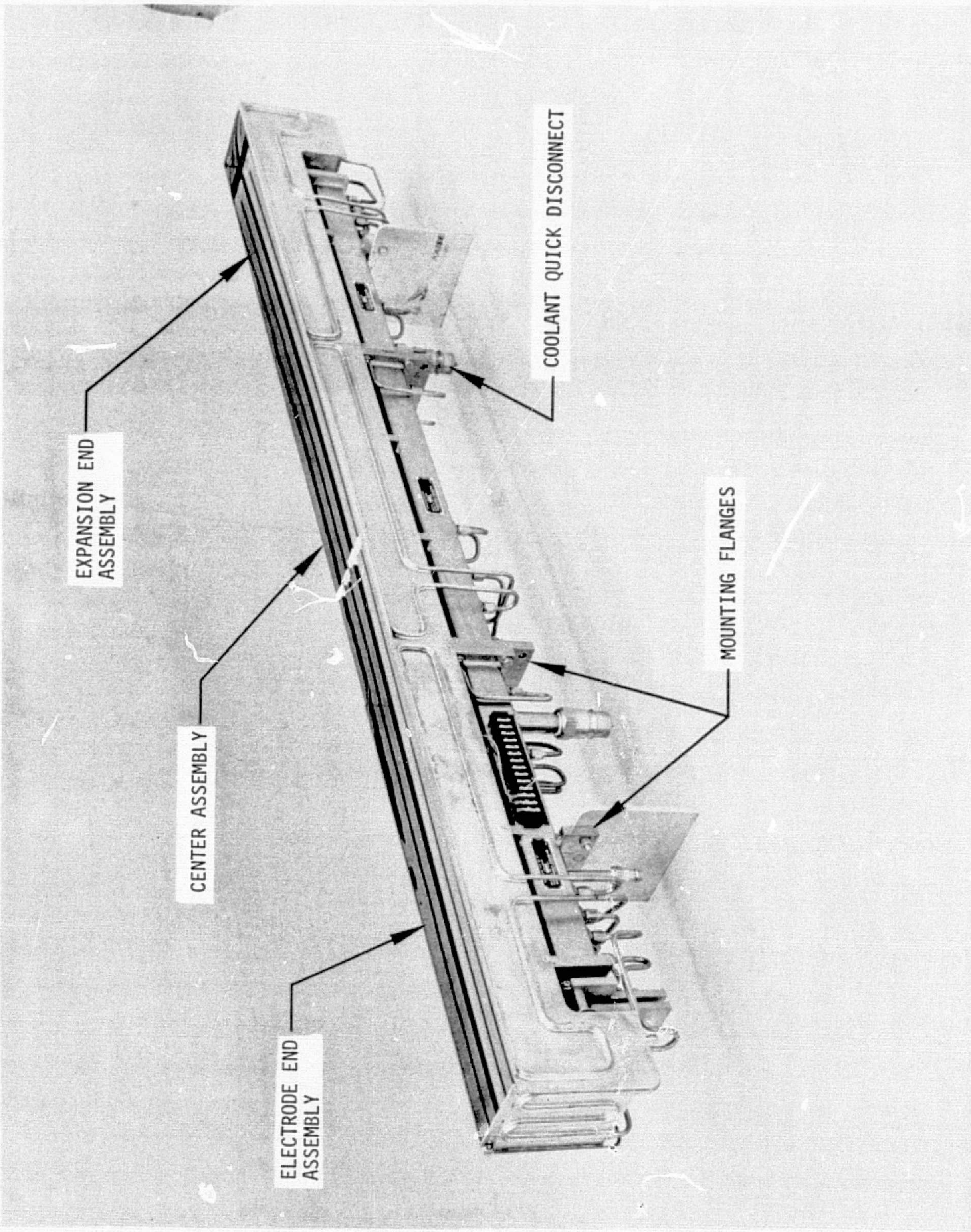


FIGURE 3

VARIABLE LENGTH HEATER MODULE ASSEMBLIES

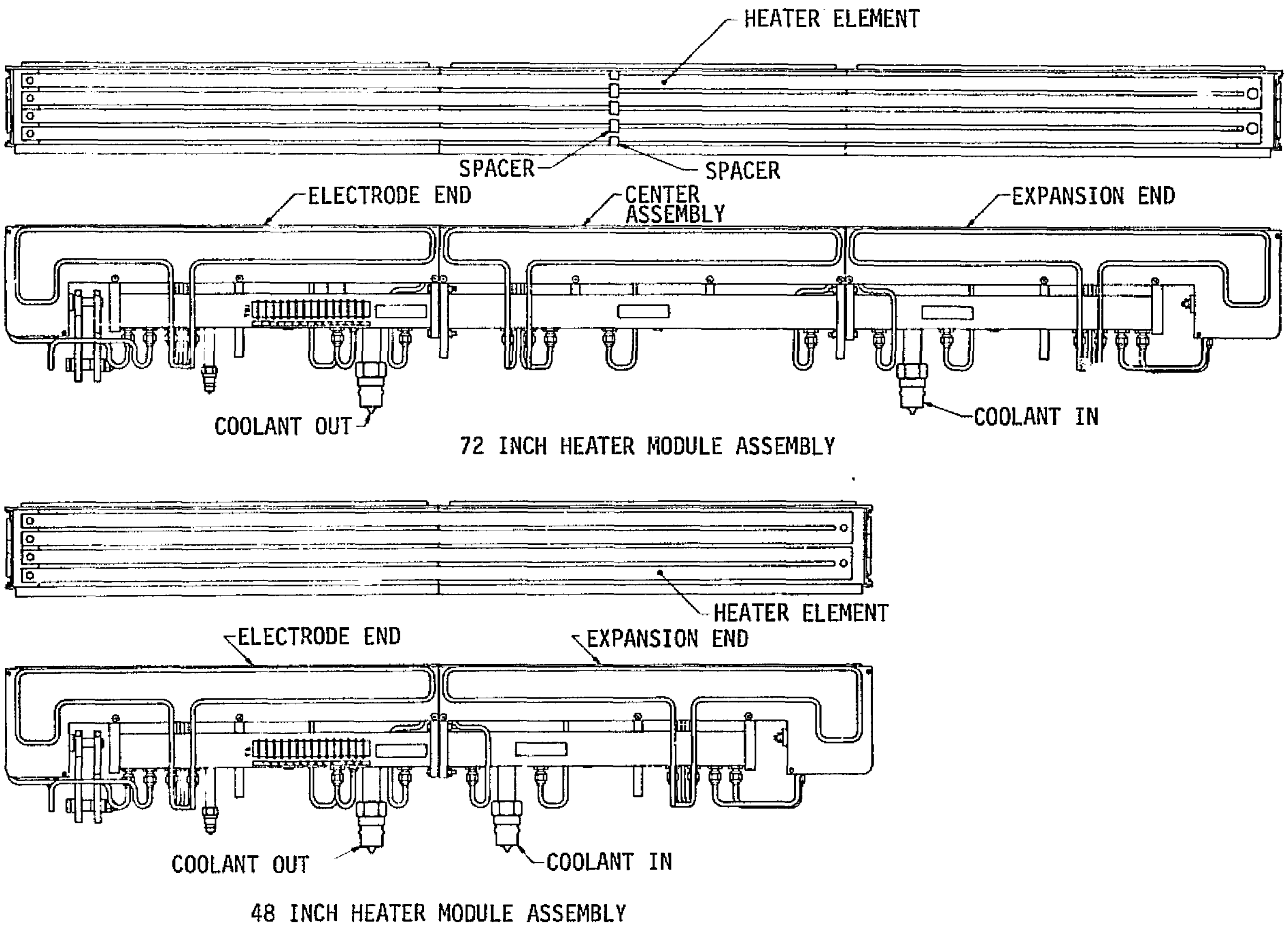


FIGURE 4

configuration can be mounted on the array support plates without altering the spacing between the plates.

The Electrode End Assembly details are shown in Figure 5. Water-cooled copper tapered pegs brazed into brass end blocks retain one end of the heater elements and transmit power to the element. This tapered peg mounting feature retains the element through friction and provides positive electrical contact between the graphite and the copper peg. Two tapered pegs in the center end block make a common connection between the two elements. Copper electrode rods are brazed into sockets in each end block. These rods pass through the brass end manifold, and copper bus plates (terminals) are clamped to the rod ends. The end blocks and rods are electrically insulated from the heater structure by ceramic insulators and phenolic sleeves. O-rings fitted in grooves seal the water passages between the components. A constant clamping force is exerted on the O-ring seals by a wave spring washer held in place with a snap retaining ring.

Figure 6 shows the bus plate details and how they attach to the electrode rods. The two bus plates connect the heater elements in parallel and supply the two connecting points for power leads. One bus plate attaches to the outside electrode rods, and the other attaches to the center electrode rod. This rod is common to the two middle copper tapered pegs. The bus plate assemblies have been designed to accommodate two conductor water-cooled power cables with Flex Lo-X Type 12S terminals manufactured by Flex-Cable Corp. If this type of power lead is used, the power lead end connection is placed between the two bus plates and clamped up with the insulated bolt to provide electrical contact to each of the two conductors.

Figure 7 shows the details of the expansion end assembly. This assembly is designed to support the end of the heating element, and take up thermal expansion of the heating element during operation. It consists of a graphite lever pinned at the bottom to the water cooled brass end block through a protruding ear. The upper end of the lever is tapered to accept the heating element. This design feature effectively fixes the expansion end of the heating element, and combined with the electrode end design prevents excessive sag in the element. As the element expands during heater operations, the lever arm pivots and provides additional moment on the element and reduces the sag at the center of the element. As on the electrode end, the electrical insulation is provided by a ceramic insulator between the end block and the water manifold and a pheolic sleeve and washer around the clamping stud. O-rings seal the water passages between components.

ELECTRODE END ASSEMBLY DESIGN DETAILS

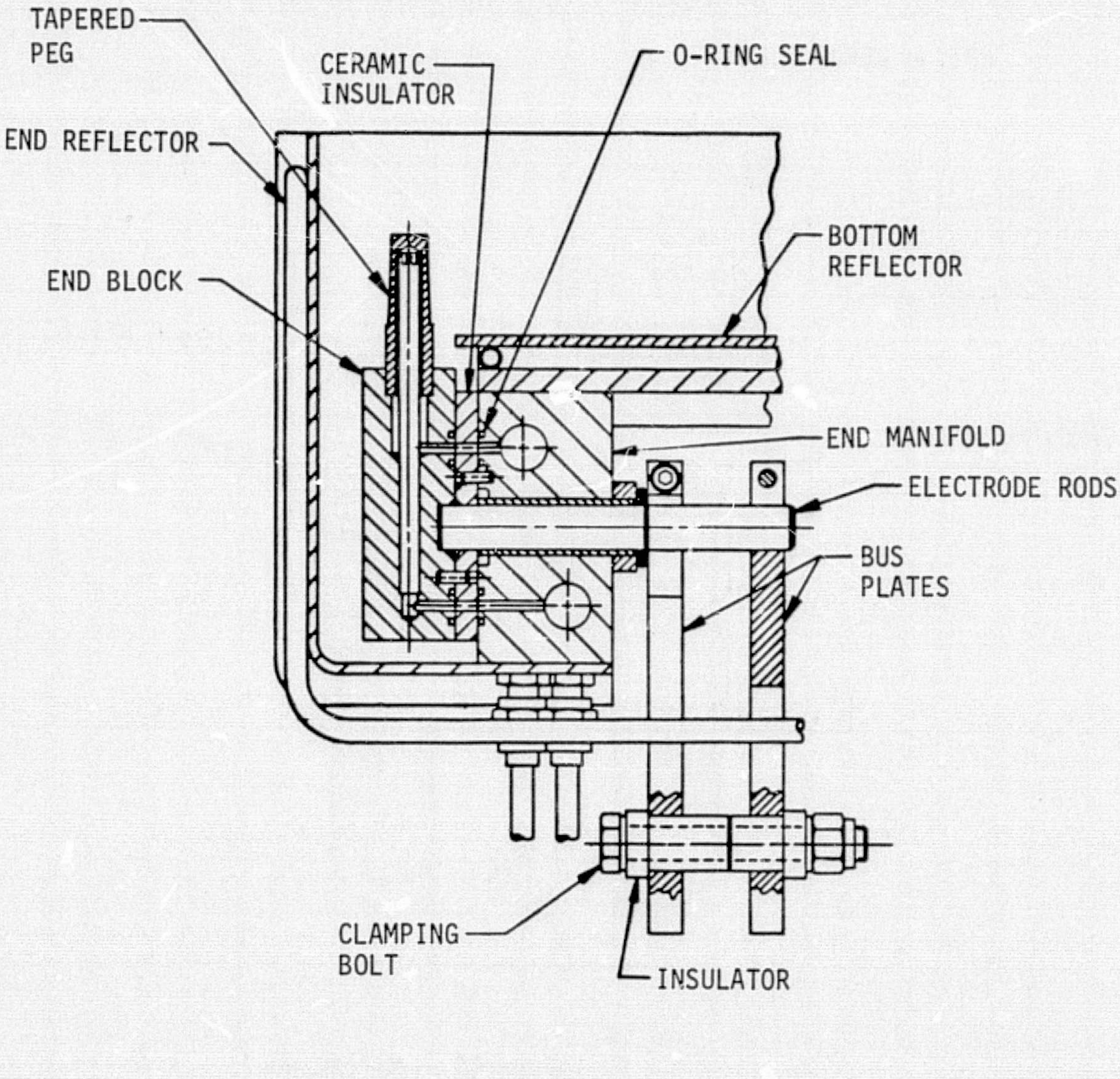


FIGURE 5

ELECTRODE END ASSEMBLY
BUS PLATE DETAILS

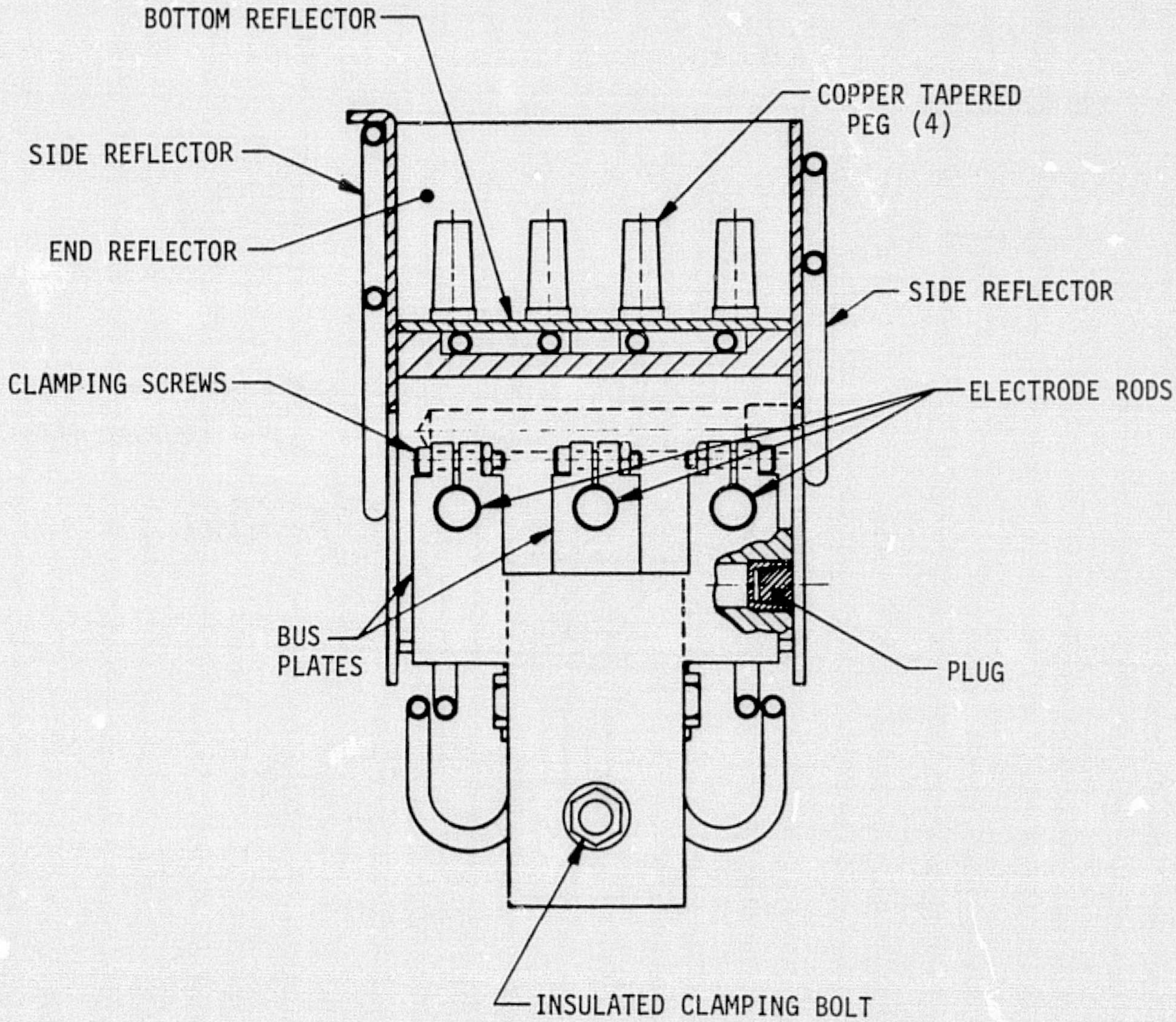


FIGURE 6

EXPANSION END ASSEMBLY DESIGN DETAILS

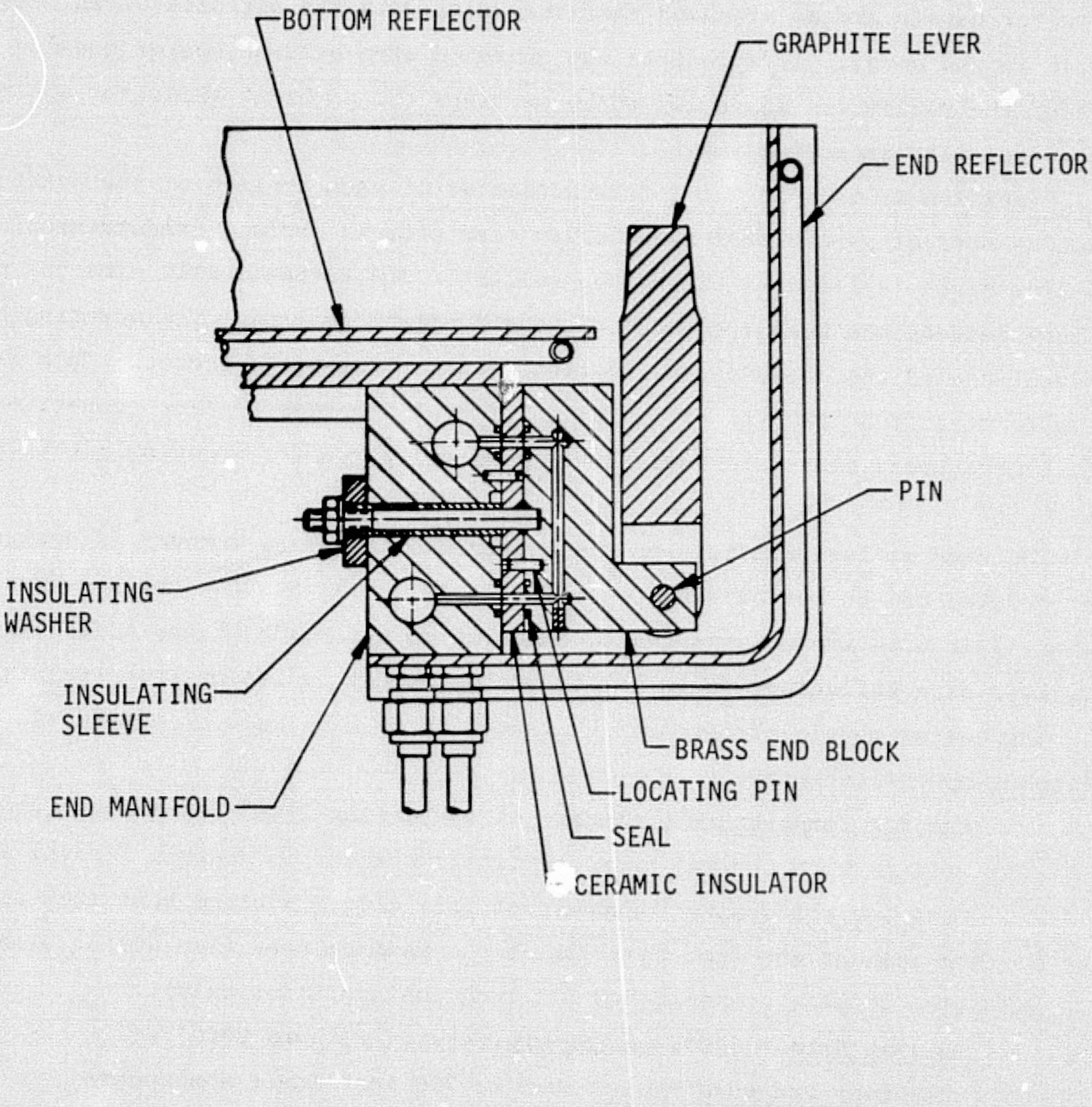


FIGURE 7

Water-cooled reflector panels surround the heated zone on five sides leaving only the area above the elements open for radiating to the test article. The surfaces of the reflector panels facing the heater elements are gold plated to give a high spectral reflectance which provides efficient operation and enhances the heat flux uniformity. Coolant circuits are attached to the outer surfaces of the reflector panels to remove absorbed energy. The coolant circuits on the side reflector panels are so situated that they nest with the circuits of an adjacent module in the array. This reduces the unheated area between heater modules. One side of the reflectors has a lip which overlaps the adjacent reflector and prevents stray radiation from escaping.

Provision is made in the bottom reflector of each section of the heater to mount an optical pyrometer for measuring test article surface temperatures. The mounting block is fixed to the bottom reflector and automatically aims the pyrometer to look between the heater elements at the specimen surface. The mounting block is water-cooled and prevents overheating of the pyrometer detector. This allows the pyrometer to be removed or installed without breaking coolant connections. Gold plated brass plugs are supplied to plug all pyrometer mounting blocks not in use.

The side reflector panels of the heater module can be removed if desired so that modules can be butted side to side to form a flat heating array. When a large number of modules are so arranged the modules at the edges of the array have the outermost side reflectors installed to prevent stray radiation from escaping.

The heater module performance characteristics will meet or exceed all of the following specifications:

Maximum Temperature - Capable of sustaining 3200°F on the surface of a test article with thermal characteristics similar to shuttle leading edge.

Spanwise Uniformity - Capable of providing a minimum heat flux along a 60 inch span of not less than 85% of the maximum heat flux during steady state operation at peak temperatures (72 inch configuration only).

Heating Rate - 600°F per minute between 80° and 2800°F.

Operating Pressure Range - 0.5 to 760 torr inert atmosphere

Power Control - Heater is designed to operate off of standard ignitron power controllers through a 4:1 stepdown transformer.

2.2 Variable Length Absorber Module - The absorber is shown in Figure 8. The variable length concept is carried through to the absorber module; it also consists of three sections with the center section removable to shorten the overall length of the unit. The overall dimensions of the absorber are approximately the same as the 72 inch heater module. The coolant manifolds also form the structural backbone of the absorber and supply coolant to the module components. A water-cooled energy absorbing panel is mounted on each section of the absorber. This panel is contoured at the edges to assume the same shape as the side reflectors of a heater module. The absorber module is thus interchangeable with a heater module in an array where the heater module is being utilized with the side reflectors attached. Any desired coating can be applied to the surface of these panels to obtain the desired emittance characteristics. As with the heater modules, each absorber module panel is equipped with a water-cooled mounting block for an optical pyrometer.

The absorber module mounting flanges and spacing are the same as those for the heater module. The coolant flow rates that can be expected for a 72 inch absorber module is 7 gpm at 60 psi ΔP. As with the heater modules, quick disconnect no-spill couplers are provided on each end section of the absorber for coolant supply and return hoses. Each absorber module is equipped with a coolant interlock flow switch. Figure 9 shows an absorber module in the 72 and 48 inch configuration.

2.3 Heating Array Support Structure - The heating array support structure can be converted to support the heaters and absorbers in either a leading edge configuration (Figure 10) or a flat array configuration (Figure 11). This support structure is sized so that it fits inside the 10-ft diameter altitude chamber located in Building 260 at NASA Johnson Space Center (JSC). When the support structure is configured for the flat configuration, up to twenty four heaters can be arranged side by side to form a flat, horizontal heating array. When the support is configured to test wing leading edge sections, heaters and absorbers are attached to contoured mounting plates. The mounting plates provided with the array are fitted to a particular leading edge section. Other contoured surfaces can be tested by replacing these mounting plates with ones designed to support the heaters and absorbers around the desired contour. All external surfaces of the support are painted with a solvent resistant polyurethane paint.

The base of the support structure is formed by parallel 4-inch coolant headers with appropriate cross member stiffeners between them, and support pads along the outer edges. Two short nozzles with bolted flanges are located atop each header

72 INCH VARIABLE LENGTH ABSORBER MODULE

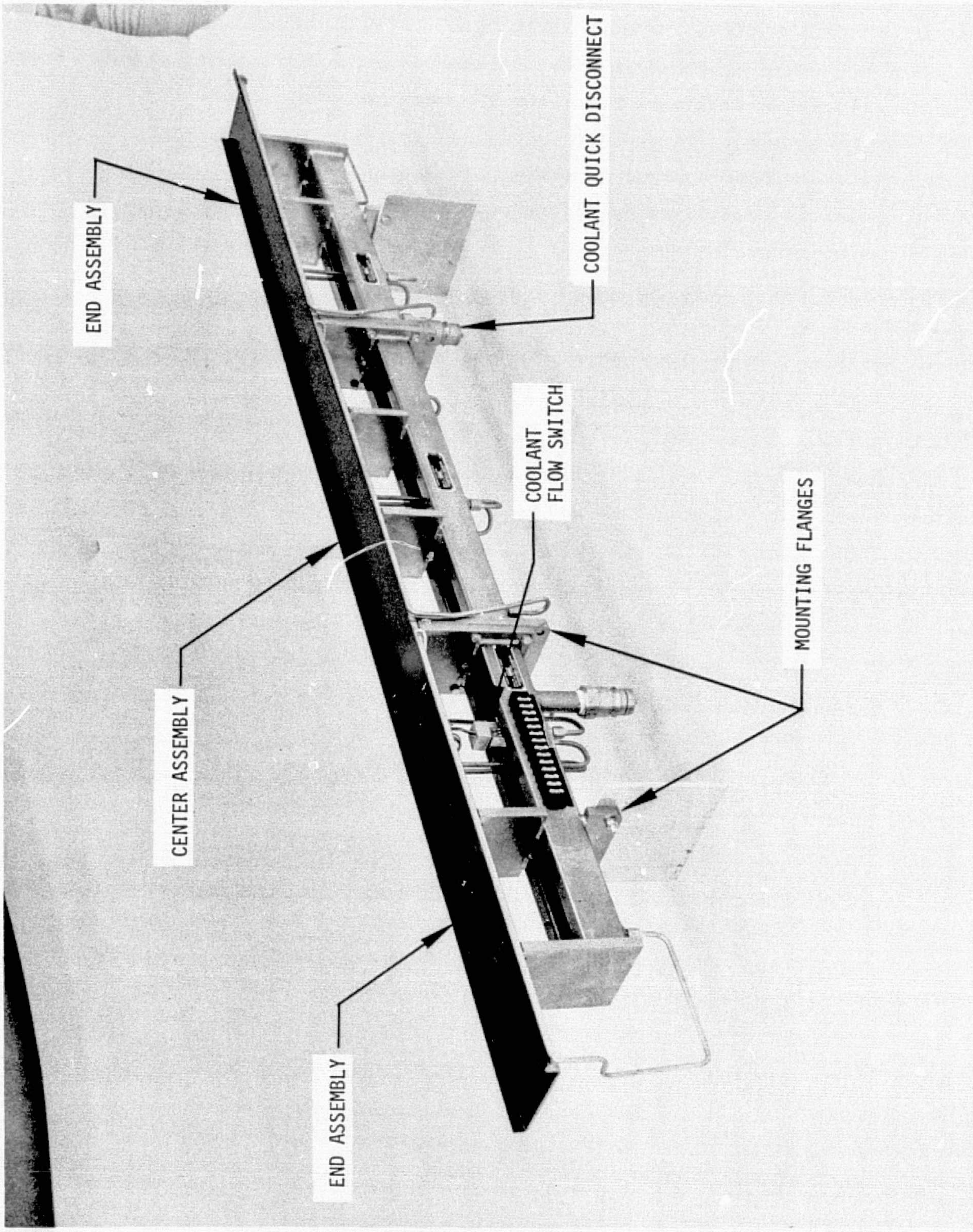
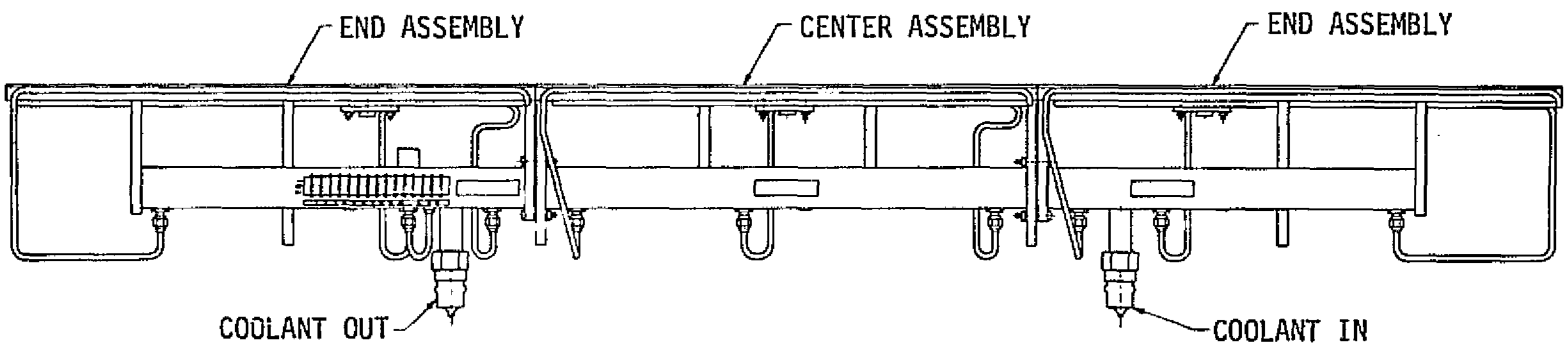
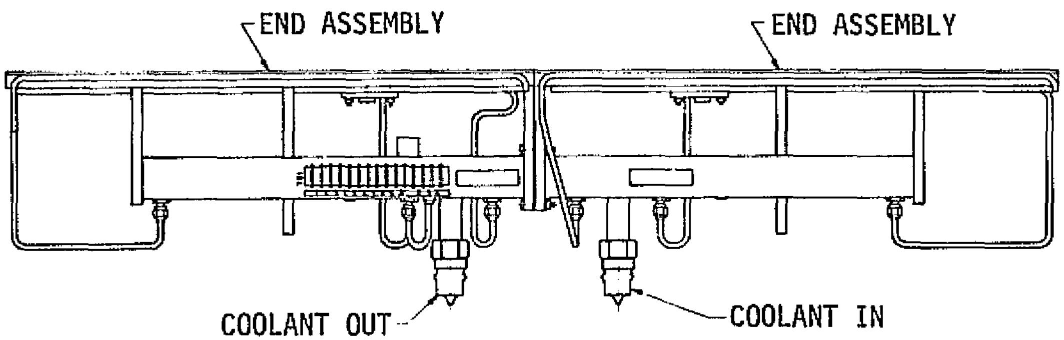


FIGURE 8

VARIABLE LENGTH ABSORBER MODULE ASSEMBLIES



72 INCH ABSORBER MODULE ASSEMBLY



48 INCH ABSORBER MODULE ASSEMBLY

FIGURE 9

HEATING ARRAY SUPPORT STRUCTURE

LEADING EDGE CONFIGURATION

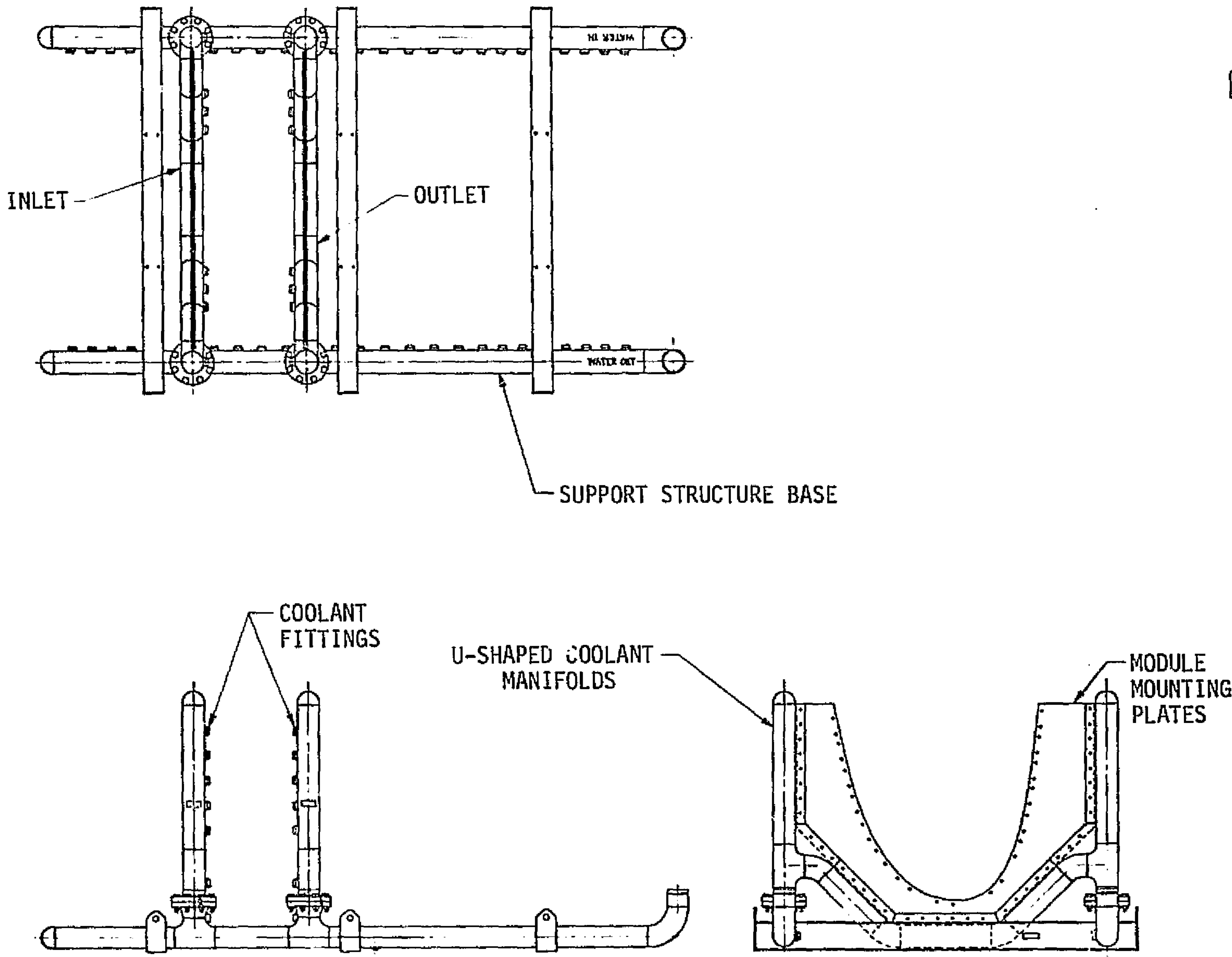


FIGURE 10

HEATING ARRAY SUPPORT STRUCTURE - FLAT CONFIGURATION

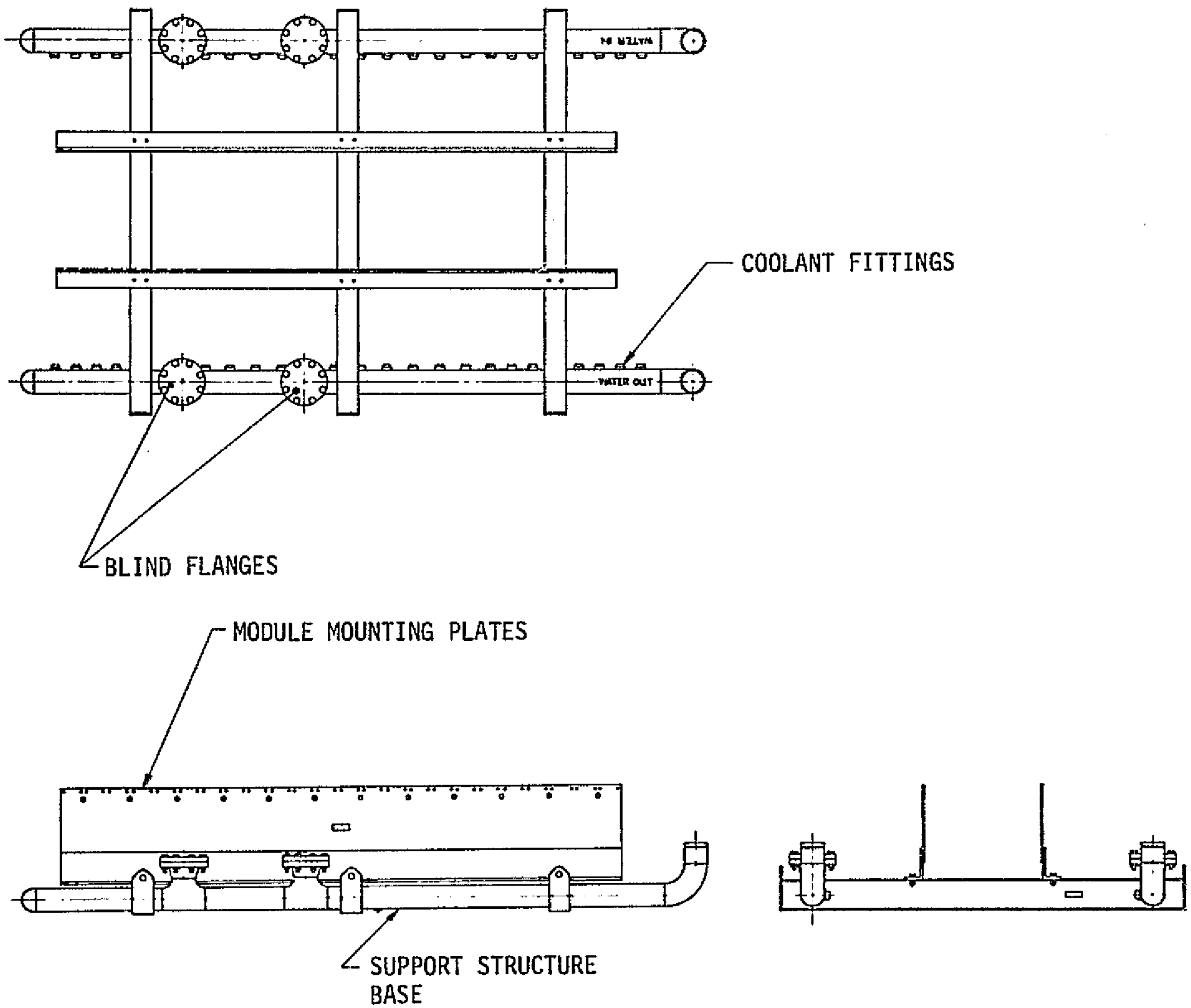


FIGURE 11

opposite each other. One nozzle on each header is deadheaded and acts as a support point only. The other two, located diagonally from each other are connected to the header coolant passages. When configured to test leading edge test articles, two U-shaped coolant manifolds fabricated from 4-inch pipe and weld fittings are bolted in place on top of the header nozzles. Welded to the inside of these U-shaped manifolds are attachment flanges to which module mounting plates are bolted. The array is formed by bolting the individual modules to these plates around the contour of a leading edge shaped cutout. Fittings for individual coolant supply and return hoses to each module are spaced around the periphery of the manifolds. The coolant path thus formed is through one 4-inch header, to a U-shaped manifold, through the heater and absorber modules connected in parallel, to the other U-shaped manifold and header, to the coolant system return.

When the support is configured to support heaters in a flat array, the U-shaped manifolds are removed and the open flanged nozzles are capped with blind flanges. Module mounting plates are then bolted to the cross member stiffeners of the support structure base. The flat array is formed by bolting the individual modules to these plates. Fittings for the individual coolant supply and return hoses to each module are located along the inside of the base 4-inch coolant headers. The coolant path thus formed then is through one 4-inch header, directly to the heaters, to the other 4-inch header, and then to the coolant return.

2.4 Optical Pyrometer Assembly - Optical pyrometer assemblies are provided to indicate the specimen surface temperatures above 2000°F. They were developed especially for use with graphite radiant heaters. These pyrometers were fabricated by Thermogage Incorporated, of Frostburg, Maryland, to MDC specifications. The optical pyrometer is shown in Figure 12. It uses a silicon photovoltaic cell having a spectral response from wavelengths of about 0.35 to 1.10 microns with peak sensitivity at 0.83 micron. A lens and field stop define the amount of light reaching the silicon cell from the specimen. Characteristically the pyrometer indicates the temperature of an area on the specimen about 0.07 inch in diameter at a specimen to heater element distance of 1.5 inches. Additional apertures between the lens and the specimen surface reduce the amount of stray light reaching the cell. The focal plane location of the installed instrumentaand these apertures combine to effectively eliminate any effect of radiation from the heater element on specimen surface temperature indication.

OPTICAL PYROMETER ASSEMBLY

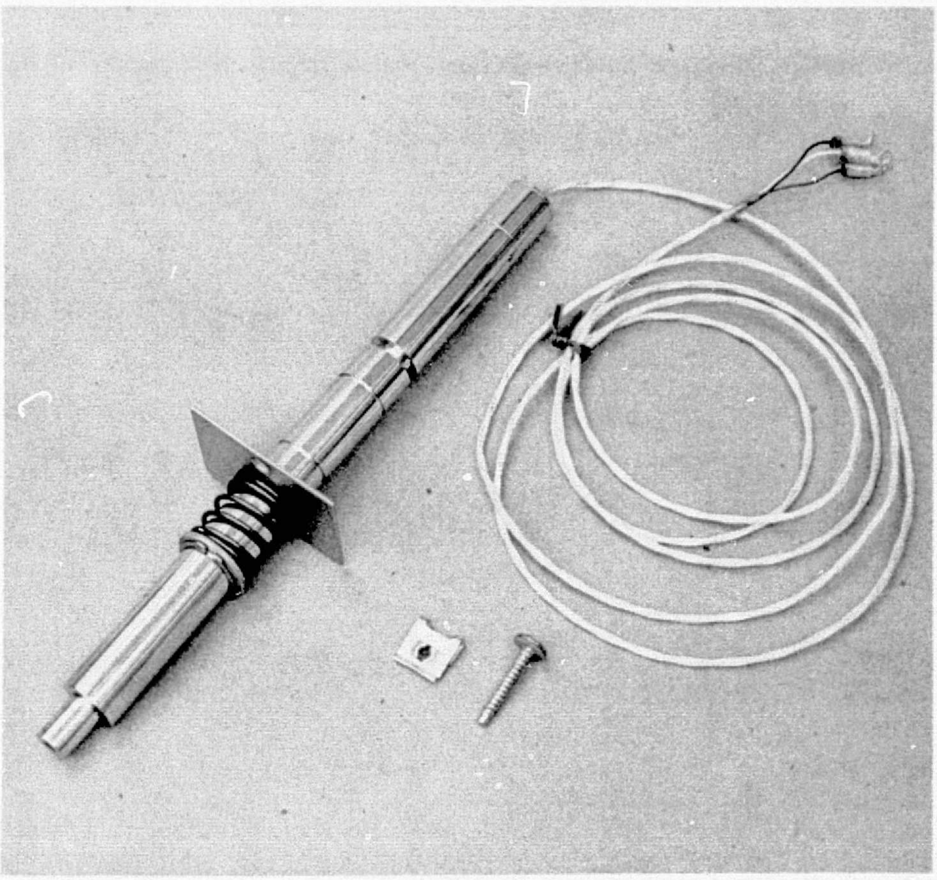


FIGURE 12

The pyrometer provides a nominal DC output of 0 to 50 millivolts for a blackbody specimen temperature from 2000°F to 3500°F. All pyrometer assemblies were calibrated by the McDonnell Standards Laboratory over the temperature range of 2000°F to 3400°F. Based on radiation theory, an exponential function was least squares fitted through the calibration data for each pyrometer. The resulting function has the following form:

$$T = \left(\frac{B}{C - \ln\left[\frac{V_o}{\varepsilon}\right]} \right) - 460$$

where: T = Temperature, °F

V_o = Pyrometer Output, millivolts

ε = Surface emissivity

B, C = Constants

The values of the Constants for each pyrometer are given in Figure 13.

Three mounting locations are provided in each 72 inch heater or absorber module so that the optical pyrometer can be easily installed to view a representative part of the specimen surface. A water cooled mounting block at each location provides support for the nose of the pyrometer and provides sufficient conductive cooling so that no additional cooling connections to the pyrometer itself are necessary. This mounting block also automatically aims the pyrometer upon installation so that it views the specimen surface between the gaps of the heating elements. A spring-loaded mounting plate is attached to the pyrometer body by snap rings. This mounting plate is joined to the heater or absorber module coolant manifolds by a screw.

2.5 Heating Array Interfaces - The coolant interfaces with the JSC closed loop coolant system occur at the end of the support structure base headers. Valves, pipe sections, and couplings are provided to connect the heating array to the coolant supply and return penetrations in the altitude chamber.

The electrical power interface between JSC provided equipment and the heater occurs at the bus plates of the individual heater modules. Provision is made to connect a two-conductor water-cooled wire to the bus plates of each heater module. If power cables other than the type provided for is used, some adaptation must be made to interface with the type power cables utilized.

PYROMETER CALIBRATION DATA SUMMARY

Equation form:

$$T = \left(\frac{B}{C - \ln[\frac{Vo}{\varepsilon}]}\right) - 460$$

where: T = Temperature, °F

Vo = Pyrometer output, millivolts

ε = Surface emissivity

B, C = Constants

with values of B and C as follows:

Pyro S/N	B	C
345	2.9403×10^4	10.6841
369	2.8763	10.9737
370	2.9132	10.6321
371	2.9107	10.9080
372	2.9099	11.0440
373	2.8968	11.0415
374	2.9617	11.3542
375	2.8456	10.9489
376	2.9028	10.9971
377	2.9042	10.7079
378	2.8740×10^4	10.6831

Pyro S/N	B	C
379	2.9135×10^4	10.9066
380	2.9300	11.0587
381	2.8907	10.8506
382	2.8991	10.9191
383	2.9279	11.0121
384	2.9273	10.7947
385	2.8783	10.9392
386	2.8922	10.6329
387	2.9224	11.0190
388	2.9468	10.8614
389	2.9319×10^4	10.9548

FIGURE 13

Instrumentation interface is provided at a barrier terminal strip attached to the main coolant headers of each heater and absorber module. The leads from the pyrometer assemblies and the coolant flow switches are routed to this terminal strip, where JSC instrumentation wire bundles can be easily connected.

3.0 HEATING ARRAY ASSEMBLY

The heating array can be assembled either inside the test chamber or in a staging area and installed as a unit. Assembly outside the test chamber is recommended because of the added accessibility. The following paragraphs describe step by step how the array should be assembled for either a flat surface array or a leading edge array. Where the text refers to part numbers and assemblies, they can be located on one of the drawings included in Appendix A and the Drawing and Specification Package supplied with the array. Two handling tools are provided to assist in handling the heater and absorber modules. Figure 14 shows how they are attached to the modules.

3.1 Assembly Of a Flat Surface Array - Assembly of the heating array into a configuration to test flat panels begins with the basic unit of the support structure, the T-055427-5 Base Assembly. Locate the -5 Assembly in an area which is accessible to a hoist (4000 lb rated) used to install the assembled array into the test chamber. Refer to drawing T-055427-1, Support Structure, and T-055425-3 Heating Array Installation, while following the step by step assembly instructions.

Step 1 - Install asbestos ring gaskets and blind flanges on the four 4-inch pipe flanges on the T-055427-5 Base Assembly.

Step 2 - Bolt the T-055427-11 and -12 Heater Support Assemblies to the T-055427-5 Base Assembly as shown on T-055427-1.

Step 3 - Assemble the required number of T-055428 Variable Length Heater Module Assemblies per Section 6.1 to provide the heated area desired. Assemble the heater modules without heating elements.

Step 4 - Install T-055490-1 Pyrometer Assemblies at the locations desired in the heater module assemblies as each module is installed in the array. Install the Pyrometer Assemblies per T-055495-1, Pyrometer Assembly Installation.

Step 5 - Install the heater modules on the heater support assemblies beginning with the center module(s). Utilize the heater handling tools provided. Attach and check out the instrumentation leads to the heater terminal strips as each heater is installed in the array. In some instances it may be necessary to route the pyrometer leads through the holes provided in the Heater Support Assemblies.

INSTALLATION OF HEATER HANDLING TOOLS

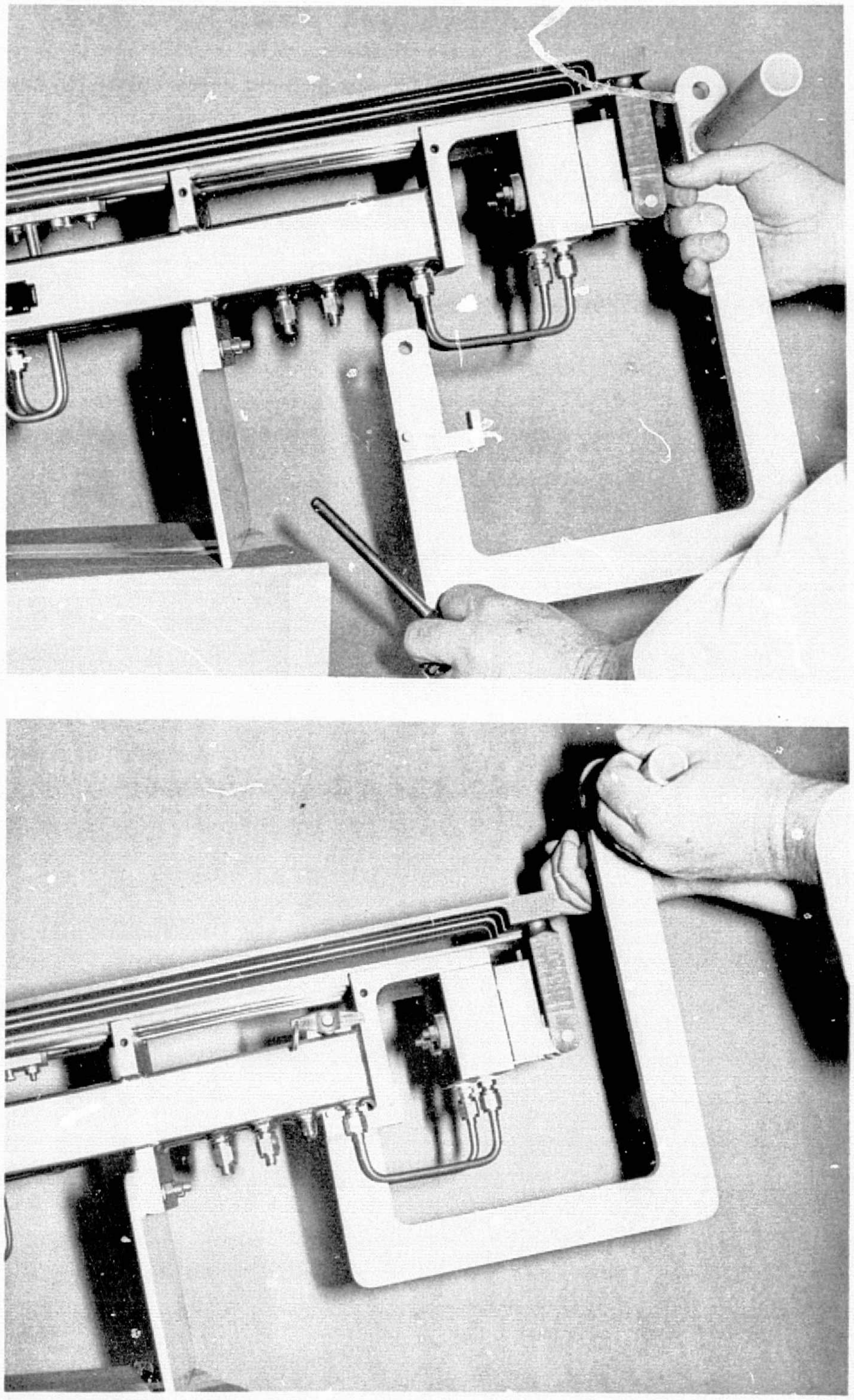


FIGURE 14

Step 6 - Install SM-801-B Coupler Bodies on one end of two R7-KF12-12PSX12PS-27 (27 inch) Hose Assemblies per T-055428-1 Heater Module in the array, or two -39 (39 inch) Hose Assemblies per T-055428-3 Heater Module in the array. Apply thread dope to the other end of the Hose Assemblies and screw into the Threadolet fittings of the T-055427-5 Assembly. Then connect the Hose Assemblies to the heater modules with the quick connect couplings as shown in Figure 15.

Step 7 - Plug all unused ports of the T-055427-5 Assembly with MS20913-6J Plugs. Apply thread dope to the plugs to prevent galling.

Step 8 - Install the T-055437 Heater Elements. Place the expansion end of the element on the T-055432-53 Lever. Insert the T-055429-7 Spacer between the passes of the element if the T-055437-1 Heater Element is being installed. Place the other end of the element on the T-055430-61 Pins and press firmly into place. It may be necessary to raise the center of the heater element slightly. When installing the second T-055437-1 Element in a module place an additional T-055429-7 Spacer between the two elements.

Step 9 - Install outside side reflector panels on the heaters at each end of the heating array.

Figure 16 shows the Heating Array assembled into two optional flat arrays. The larger array is composed of twelve 72 inch heater modules and the other is composed of ten 48 inch heater modules.

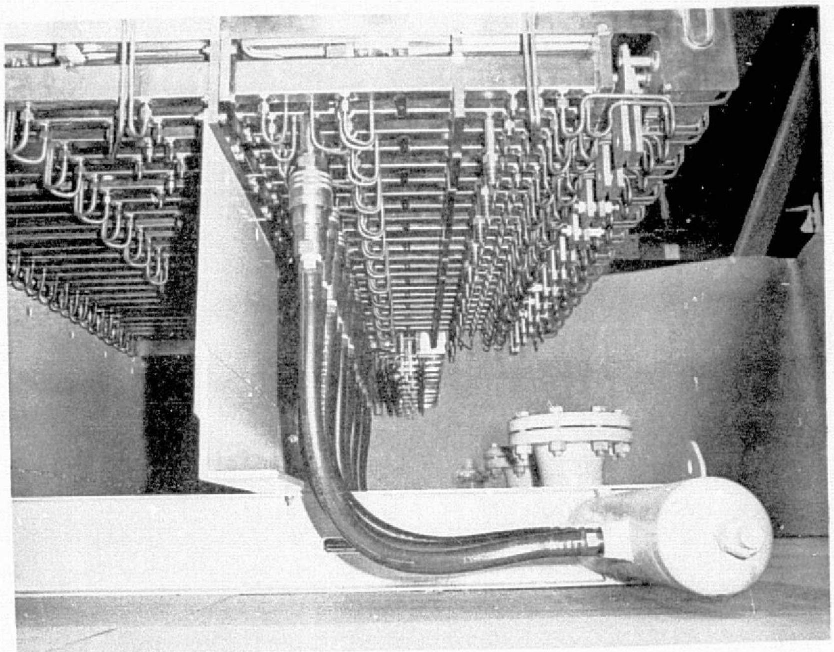
3.2 Assembly of a Leading Edge Heating Array - Locate the T-055427-5 Base Assembly in the staging area. Refer to drawing T-055427-3, "Support Structure" and to T-055425-1, "Heating Array Installation", while following the step-by-step assembly instructions.

Step 1 - Install asbestos ring gaskets and the T-055427-7 Heater Support Assemblies on the T-055427-5 Base Assembly. Match flange markings i.e., A to A and B to B.

Step 2 - Install the two T-055427-49 Plates onto the T-055427-7 Heater Support Assemblies. Mount the -49 Plates on the same side of the mounting flange as the Threadolet fittings.

Step 3 - Assemble the required number of T-055429-1 Variable Length Heater Modules and T-055433-1 Variable Length Absorber Modules per Section 6.1.

COOLANT HOSE ASSEMBLY INSTALLATION— 72-INCH HEATER MODULES



COOLANT HOSE ASSEMBLY INSTALLATION - 48-INCH HEATER MODULES

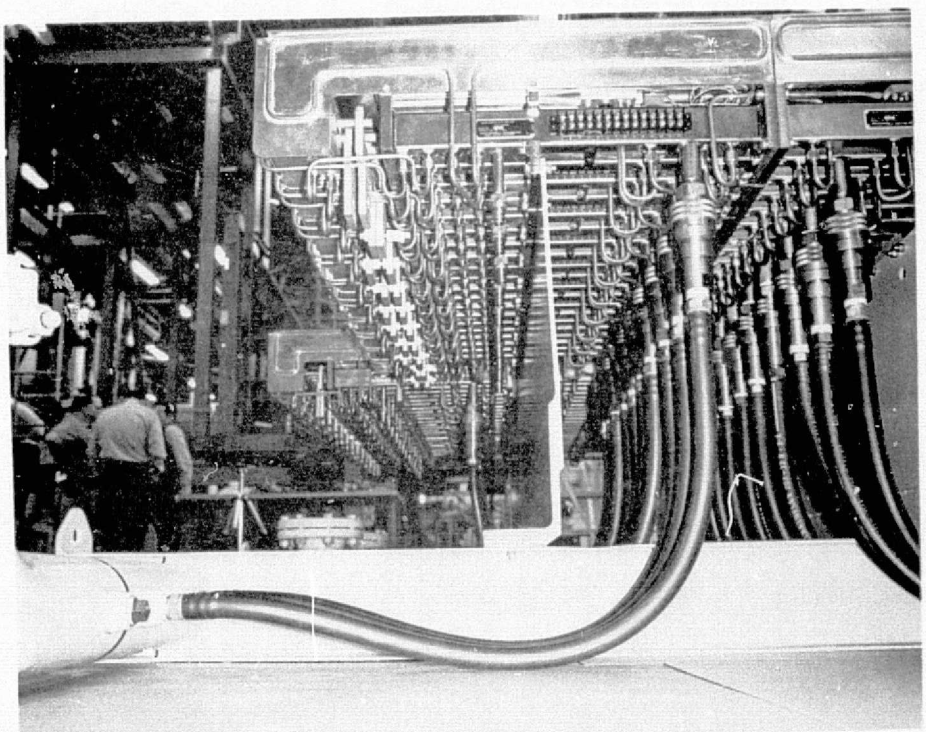


FIGURE 15

HEATING ARRAY - FLAT CONFIGURATIONS

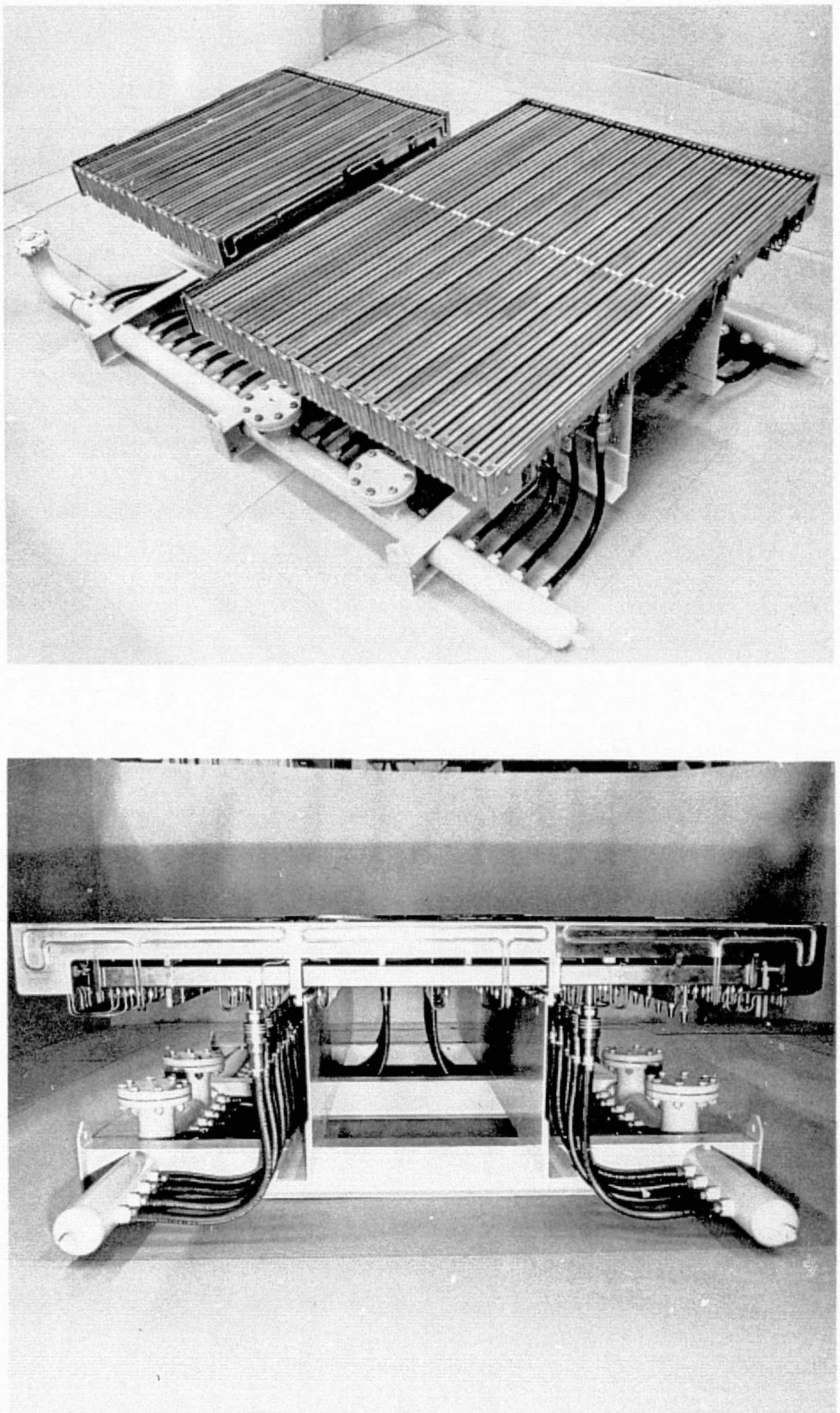


FIGURE 16

Step 4 - Install T-055490-1 Pyrometer Assemblies at the desired locations in the heater assemblies and T-055490-3 Pyrometer Assemblies at the desired locations in the absorber assemblies. Install the pyrometer assemblies per T-055495-1 and -3, "Pyrometer Assembly Installation."

Step 5 - Install the heaters and absorbers onto the T-055427-49 Plates as shown in T-055425-1 Installation. Utilize the heater handling tools provided. Be sure the coolant circuits and overlapping lip on the side relfectors nest with those of the adjacent module. Attach the instrumentation leads to the heater and absorber terminal strips as each heater and absorber is installed in the array.

Step 6 - Install 3/4" 90° street elbows in the Threadolet fittings on the T-055427-7 Heater Support Assemblies. Use pipe dope on the threads of the fittings. Orient the elbows when they are tightened, approximately as shown in the T-055425-1 Installation.

Step 7 - Install SM801-B Coupler Bodies to one end of R7-KF12-12PSX12PS-39 (39 inch) Hoses. Apply thread dope to the other end and screw the hose assemblies into the street elbows.

Step 8 - Make any final orientation adjustment of the street elbows required and attach the hoses to the heaters and absorbers with the quick connect couplers as shown in Figure 17.

Step 9 - Plug all unused ports of the T-055427-3 Assembly with MS20913-6J Plugs. Use pipe dope on the threads to prevent galling.

Step 10 - Install the T-055437-1 Variable Length Heater Module Heating Elements in the heater modules. Install T-055429-9 Spacers between the element and the lower side reflector of all heater modules oriented on their side.

Figure 18 shows the Heating Array in the Leading Edge Configuration, with eight 72 inch Heater Modules and seven 72 inch Absorber Modules installed.

COOLANT HOSE ASSEMBLY INSTALLATION-LEADING EDGE ARRAY

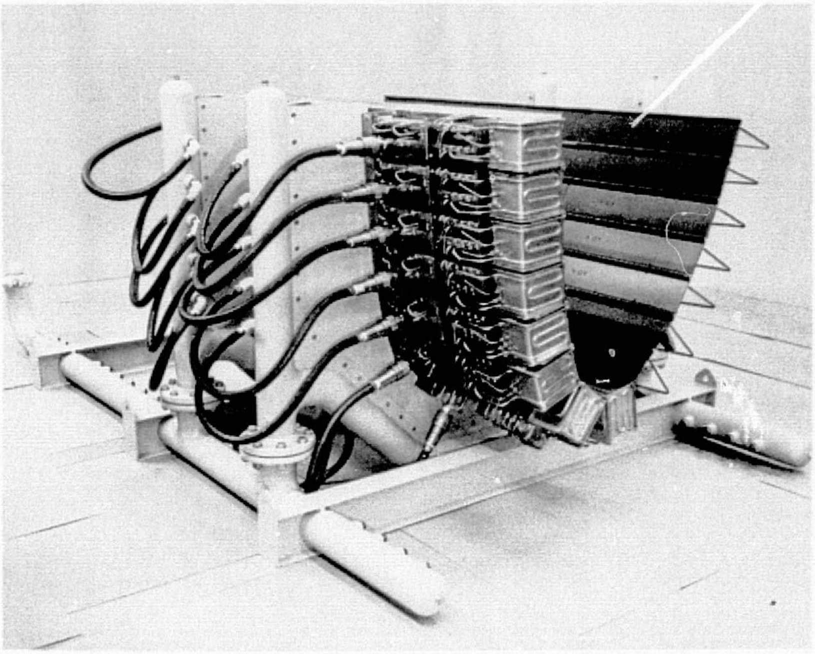


FIGURE 17

HEATING ARRAY-LEADING EDGE CONFIGURATION

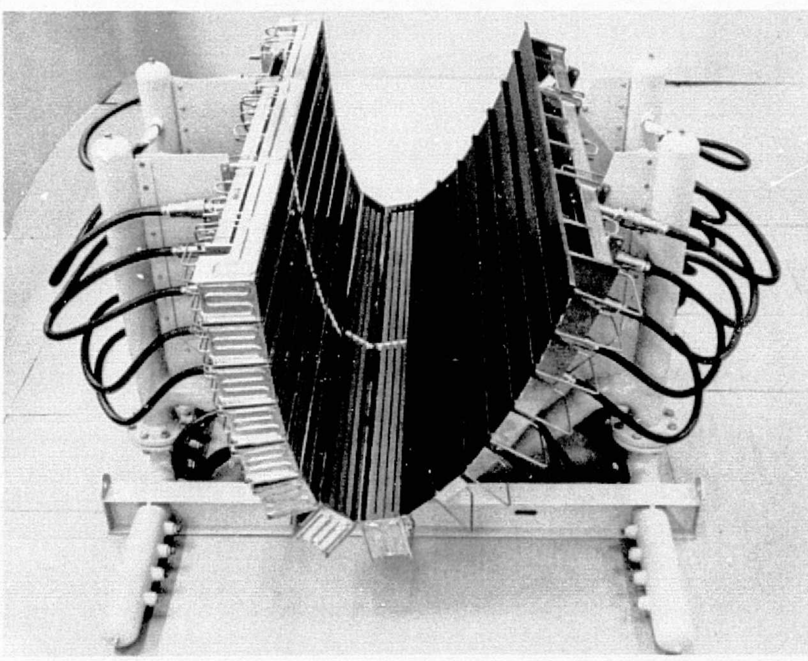


FIGURE 18

4.0 HEATING ARRAY INSTALLATION AND REMOVAL

Installation of the heating array into the test chamber located in Building 260 at JSC is essentially the same for either configuration of the array. The installation procedures cover the initial installation into the chamber. The first part of the initial installation procedures involves locating the support structure on the chamber support rails and mating the coolant hardware to the chamber interface. This may be done more conveniently using only the T-055427-5 Base Assembly. Following this portion of the initial installation procedures the array can be installed into the test chamber fully assembled. Refer to drawing T-055425, Heating Array Installation, while following the step by step installation instructions.

4.1 Heating Array Installation –

Step 1 – Locate the T-055427-5 Base Assembly beneath the hoist used to lift the array onto the test chamber support rails. Attach the Base Assembly to the hoist at the T-055427-47 Hoist Plates.

Step 2 – Open the door of the 10-Ft diameter test chamber with the SED36112683-701 Beam Assembly (lower support beams) attached to the chamber door. The turnbuckles and the upper support beams of the SED36112683-301 Drawer Assembly must be removed from the chamber door to install the heating array on the lower support beams. Also, the SED36112683-703 Adjustable Supports attached to the lower support beams should be removed or placed so as not to interfere with the heating array when it is lowered onto the support beams.

NOTE: Drawings SED36112683-301 and -701 were prepared by JSC and are available at JSC.

Step 3 – Hoist the T-055427-5 Base Assembly onto the SED36112683-701 Beam Assembly with the capped ends of the base assembly next to the chamber door. Center the Base Assembly on the support beams transversely and locate longitudinally approximately as shown in T-055425.

Step 4 – Carefully close the chamber door making sure the base assembly clears all chamber protrusions as the unit enters the chamber.

Step 5 – Finalize the position of the -5 Base Assembly on the support rails by moving the assembly longitudinally until the black locating stripes on the Base Assembly Headers are at the center flange of the chamber.

Refer to T-055425-1 Installation. Clamp or bolt the -5 Base Assembly to the support beams as desried. Identify the position of one with respect to the other so the heating array can be relocated in the precise same location during subsequent installations.

Step 6 - Assemble the piping hardware between the Base Assembly and the chamber coolant penetrations as shown in T-055425-1. Four lengths of 4-inch pipe are supplied with grooves for the Victaulic Couplings cut in one end. Use these pipes to fabricate the T-055425-5 and -7 Pipes to the required length on initial assembly. The Victaulic Couplings allow some degree of mismatch both lengthwise and off-center. Orient the T-055425-5 Pipes so the drain plug is on the bottom.

<u>NOTE</u>: The following steps assume the array has been installed in the test chamber fully assembled and connected to the coolant interfaces. Many of the steps are generalized since the requirements for their completion depends upon the JSC systems.

Step 7 - Connect the power leads from one power control channel to each heater module. If the two-conductor water-cooled cable is used, place the cable terminal between the T-055430-31 and -33 Terminals and tighten the insulated bolt. If any other type power cables are used, some adaptation to attach the power cables to the terminals may be required. This adaptation may require a different spacing of the terminals. If so, the bus plates should be loosened from the T-055430-43 Pins by loosening the socket head screws clamping the terminals to the pins. Orient the heater terminals so the machined surfaces face the power lead terminals. Clamp the power leads to the heater terminals. <u>Support the power leads to relieve the stresses on the heater electrodes</u>. Tighten the screws clamping the terminals to the -43 Pins.

Step 8 - Check for electrical shorts between the T-055430-31 and -33 Terminals and ground.

Step 9 - Connect the wire bundle containing all instrumentation leads including safety interlocks, control feedback circuits, and pyrometer leads. The interlock associated with the coolant flow switch on each heater module can be wired so that flow either makes or breaks the flow switch contacts. Refer to the flow switch information in Section 7.6.4.3. The output of the pyrometer assemblies is DC with the red lead positive, the black negative, and the white being the shield ground.

Step 10 - Open all coolant supply and return valves and establish coolant flow to the array. Check the array for coolant leaks and correct where required.

Step 11 - Check the coolant ΔP between the headers of the T-055427-5 Base Assembly during initial checkout. The differential pressure should be a minimum of 80 psi, with a supply pressure of 100 psi.

4.2 Heating Array Removal -

Step 1 - Remove the test article, guard insulation, etc., from over the heater.

Step 2 - Disconnect the power leads to the heater modules and instrumentation and interlock wire bundle.

Step 3 - Close all four 4" Victaulic butterfly valves.

Step 4 - Drain the T-055425-5 Pipes of coolant trapped between the butterfly valves. A drain plug is located in each pipe.

Step 5 - Remove the T-055425-5 Pipes (two places).

Step 6 - Open the chamber door with the SED36112683-701 Beam Assemblies attached.

Step 7 - Remove the bolts or clamps attaching the T-055427 Heating Array to the -701 Beam Assemblies.

Step 8 - Attach the overhead hoist to the heating array pickup points and remove the heating array from the test chamber.

5.0 HEATING ARRAY OPERATING INSTRUCTIONS

Operation and control techniques for graphite radiant heaters are basically similar to those used with other radiant heating equipment, in particular, tungsten filament quartz lamps. Power is supplied to graphite heaters by the standard ignitron power controllers, as with quartz lamps. The ignitrons require a feedback signal to affect control of the power supplies. Normally a thermocouple or heat flux sensor provides this signal. For special cases where a thermocouple material may react at high temperature with the test article, or the undesirability of altering the structure of the test article, special techniques for controlling the power input are required.

The following paragraphs present our recommended methods of controlling and operating the heating array.

5.1 Power Circuitry - Figure 19 shows the recommended electrical power circuit for operating a single graphite heater module. A standard ignitron power controller with a 0 to 440 volt output is fed into 4:1 stepdown transformers, which supply the reduced voltage to the heater module terminals. Both the 72-inch and 48-inch heater configuration are designed to supply the necessary power when operating from 0 to 100 volts. Figure 20 shows the typical voltage-current relationships that can be expected from the 72 and 48 inch heater modules. The total power required from any individual heater module depends on peak temperature requirements and the thermal properties of the test article. The heater modules described in this manual have been specifically designed to test Shuttle wing leading edge test sections and other large TPS panels located near the nose of the orbiter. Where different voltage-current characteristics are required for particular test programs some redesign of the heating elements can be accomplished. Redesign of the heating elements is sometimes necessary to maintain the operation of the heater module in the optimum control voltage range of an ignitron controller.

5.2 Control Methods - The graphite heating array can be controlled from a wide variety of feedback sensors. Figure 21 lists the different control parameters which can be utilized along with the associated sensor requirements. Control of graphite heaters by all but one of the control parameters listed has been demonstrated during previous McDonnell Douglas graphite heater work. The design of the heating array has the provisions for being controlled by any of the listed methods except by pyrometer measurement of element temperature. Also, two different sensors

RECOMMENDED HEATER MODULE POWER CIRCUIT

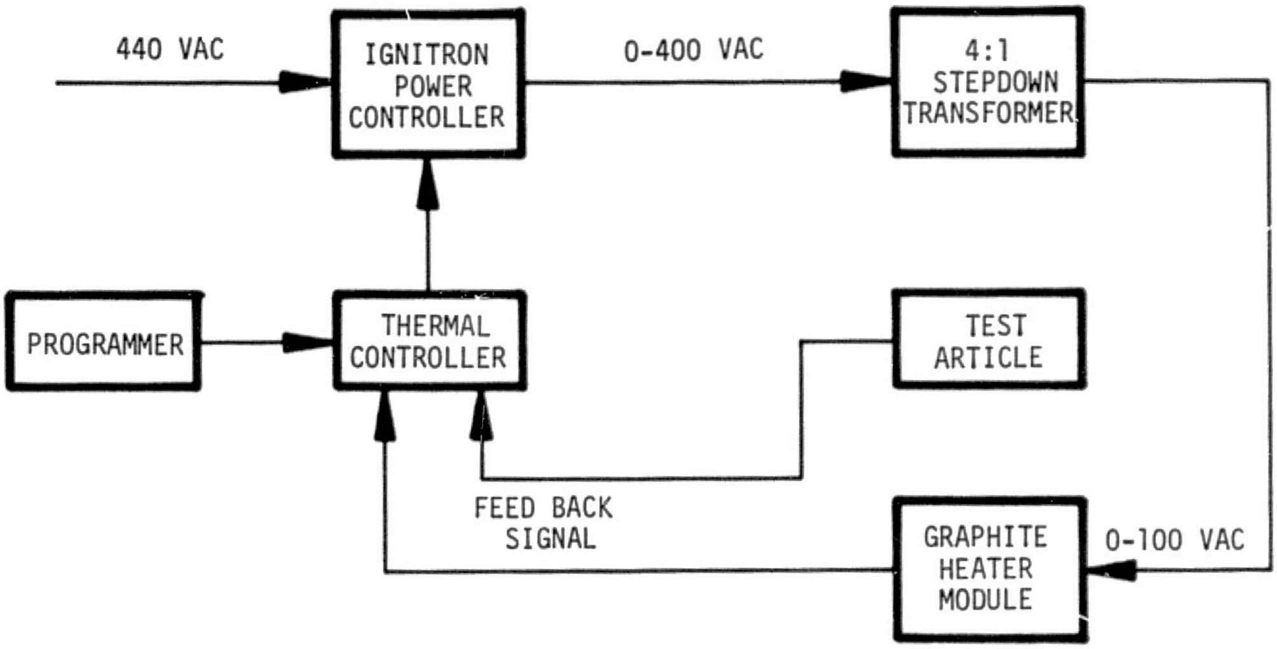


FIGURE 19

TYPICAL HEATER MODULE VOLTAGE-CURRENT RELATIONSHIP

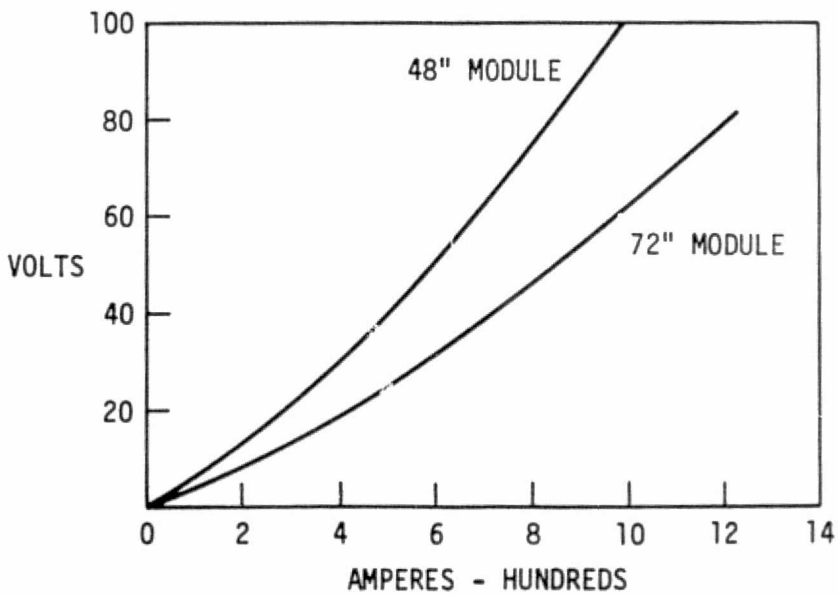


FIGURE 20

CONTROL PARAMETERS FOR THE HEATING ARRAY

Parameter	Relation To Service Environment	Used With Graphite Heaters?	Provision In Heater Modules	Sensor	Location
Incident Flux On Specimen	Direct	Yes	Yes	Gardon Foil	In or Adjacent To Specimen
Thermocouple Indication of Specimen Temperature	Direct	Yes	Yes	W/W-Re T/C	On Specimen
Pyrometer Indication of Specimen Temperature	Direct	Yes	Yes	Thermogage Pyrometer	In Heater Array
Radiated Flux From Back Side of Elements	Indirect	Yes	Yes	Gardon Foil	In Heater Array
Pyrometer Indication of Element Temperature	Indirect	No	No	--	--
Electrical Power Supplied to Heater	Indirect	Yes	Yes	Hall-Effect Power Sensor	Wiring to Heater

FIGURE 21

may be used to control the heating array in different portions of a test profile. This may be necessary due to the range limitations of the selected control sensor. An example, the low cost optical pyrometer developed for this heating array to measure specimen surface temperatures has an output that is nonlinear with temperature. If the pyrometer is used for heater control, it may be necessary to supplement the pyrometer when close control of the array is desired at specimen surface temperatures below 2000°F. Figure 22 schematically shows how control sensors might be combined in the power control system to control the individual heater modules. We have successfully used automatic changeover of feedback parameters during test profiles. The design of the heating array is fully compatible with these techniques.

5.3 Safety Features - THE MOST DISASTROUS THING THAT CAN OCCUR TO A HEATER MODULE IS TO OPERATE THE UNIT WITHOUT COOLANT FLOW. Therefore, a safety flow switch has been incorporated in the coolant circuit of each individual heater module and absorber module. The leads of the flow switch are routed to the terminal strip mounted on one section of each heater and absorber unit. When coolant flows through the heater or absorber, a reed switch is actuated within the flow switch. This makes or breaks contacts depending on which leads from the flow switch are used. It is recommended that the flow switch be wired into the control circuit of the power controllers to prevent heater operations when coolant is shut off to the heating array.

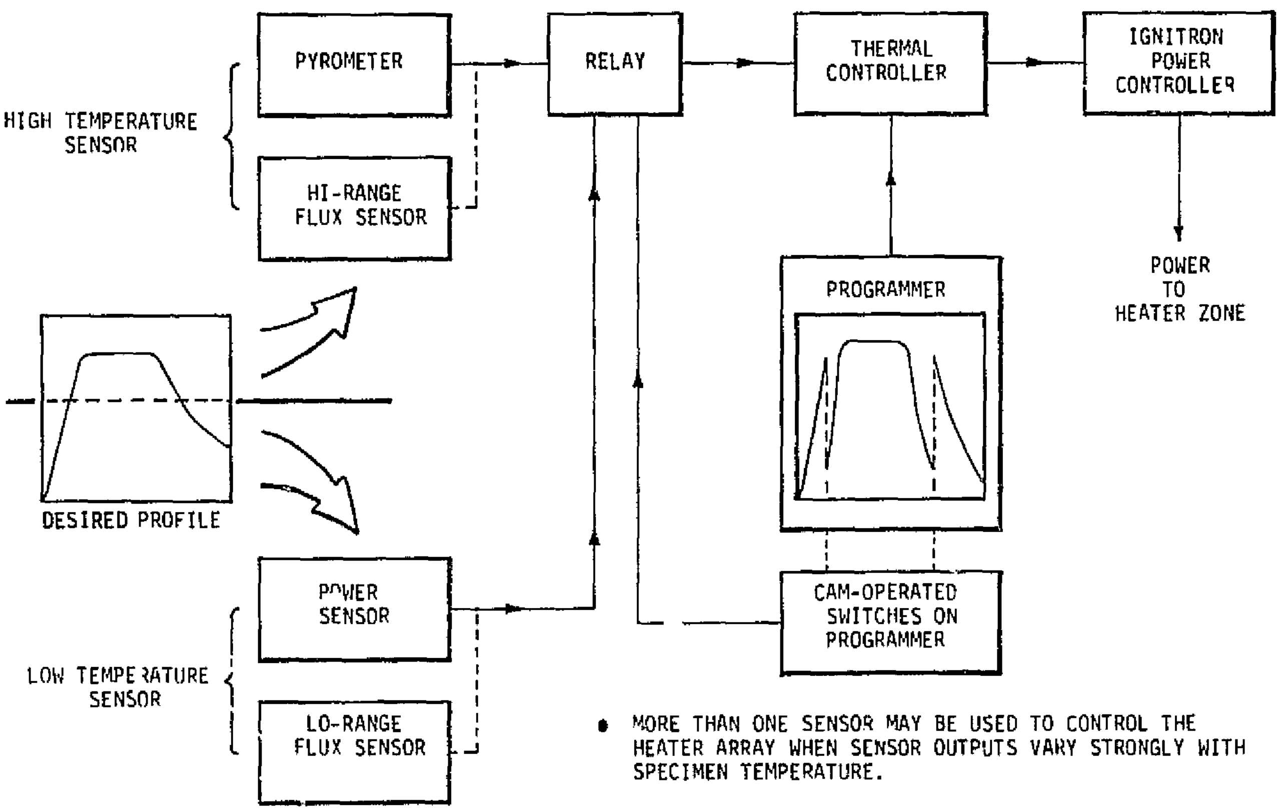
The heater units contain an additional feature which may be used to protect a test article from being damaged due to overheating. Unlike surface thermocouples on a test article which are exposed to high temperature and thus high temperature material interactions, the pyrometer supplied with the heating array becomes a reliable instrument to use as an over-temperature alarm. Its output is not linearly related to temperature and it deals with a larger signal as the temperature approaches the high levels of Shuttle reentry. Therefore, the output of the optical pyrometer may be used to trigger alarm systems to either shut down the power control equipment or to give a visual or audio alarm to heater array operators to warn of over-temperature conditions on the test article surface.

5.4 Heating Array Operating Procedure -

Step 1 - Install the test article over the array.

Step 2 - Install guard insulation around the test article extending to the edges of the heating array to prevent stray radiation from escaping

COMBINING CONTROL SENSORS



- MORE THAN ONE SENSOR MAY BE USED TO CONTROL THE HEATER ARRAY WHEN SENSOR OUTPUTS VARY STRONGLY WITH SPECIMEN TEMPERATURE.

FIGURE 22

to the chamber surroundings. It is recommended that the guard insulation near the test article exhibit similar thermal characteristics as the test article itself. This reduces edge effects near the periphery of the test article.

Step 3 - Close the test chamber doors.

Step 4 - Inert the atmosphere within the chamber. This can be done by evacuating the test chamber and back-filling to the desired pressures with an inert gas such as nitrogen. Repeat as necessary.

Step 5 - Turn on coolant to the heating array and power leads.

Step 6 - Checkout all instrumentation and interlock systems.

Step 7 - Apply the desired thermal profile to the test article. During the thermal profile the pressure within the test chamber may be varied between 0.5 and 760 torr using an inert gas to increase pressure. This allows a combination heating and pressure profile to be applied to a test article simulating reentry conditions.

Step 8 - Following the application of a thermal profile to the test article, additional thermal cycles may be applied by returning temperatures on the test article to the desired pretest conditions. Otherwise, shut down the power controllers at the end of the heating cycle.

CAUTION: DO NOT SHUT OFF COOLANT TO THE HEATING ARRAYS UNTIL IT HAS COOLED BELOW 200°F.

Step 9 - Following cool down of the test article and heating array, return the chamber pressure to ambient conditions.

CAUTION: BE SURE CHAMBER ENVIRONMENT WILL SUPPORT LIFE BEFORE ADMITTING PERSONNEL.

Step 10 - Remove the test article and guard insulation from over the heating array.

Step 11 - Remove the heating elements from the heater modules (if required).

Step 12 - Clean the gold-plated reflector panels per Section 6.3 (if required).

Step 13 - Replace the heating elements (if required).

6.0 HEATING ARRAY MAINTENANCE

The heating array is designed for minimum maintenance requirements. The only components of the array normally requiring replacement at periodic intervals are the heating elements. It is recommended that the heating elements be examined at periodic intervals for evidence of oxidation due to a contaminated test environment.

Cleanliness of all parts of the heater modules is essential for trouble-free performance, particularly in the areas near electrically hot components. Dirt, residual carbon, and debris should be thoroughly removed from all heater modules at breaks in the test program.

The current path must be clean to prevent I^2R heating at the electrical interfaces. Scotch Brite scouring pads work very well to clean the metallic components of the electrical interfaces, such as the heater terminals and power cable terminals.

The only other normal maintenance requirement consists of keeping the heater and absorber modules free of coolant leaks. Before each test series, apply coolant pressure to the heating array and inspect for leakage.

The following paragraphs describe the procedure necessary to assemble 48 or 72-inch heaters, how to change heating elements, and the care and cleaning procedures necessary for the gold-plated reflector panels.

6.1 Assembly Of 48-Inch or 72-Inch Heaters/Absorbers - The major subassemblies of the heaters and absorbers have nameplates attached containing a serial number. Although the subassemblies are interchangeable with those of another heater or absorber module, the history of the modules is maintained on a serialized unit basis. It is suggested the heaters and absorber modules be assembled using units containing the same serial number.

To assemble a 72-inch heater or absorber, place the T-055525 Assembly Tool in the configuration shown in Figure 23. Place a completely assembled heater or absorber center assembly on the center supports of the assembly tool. Apply a thin coat of Permatex Form-A-Gasket No.2 pliable sealant to both sides of a T-055429-5 Gasket. Restrict the coating to an area about 1/4 inch around the large coolant passage holes. Place the gasket on one end of the center heater or absorber assembly. Place the heater or absorber end assembly on the assembly tool and sandwich the gasket between the two flanges. Be sure the sides of the

HEATER ASSEMBLY TOOL-
72 INCH CONFIGURATION

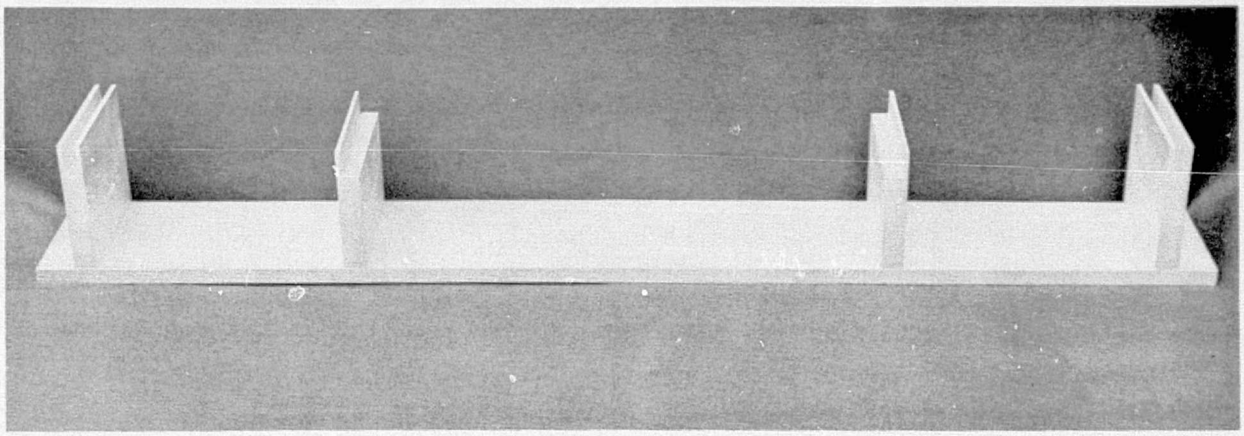


FIGURE 23

HEATER ASSEMBLY TOOL-
48 INCH CONFIGURATION

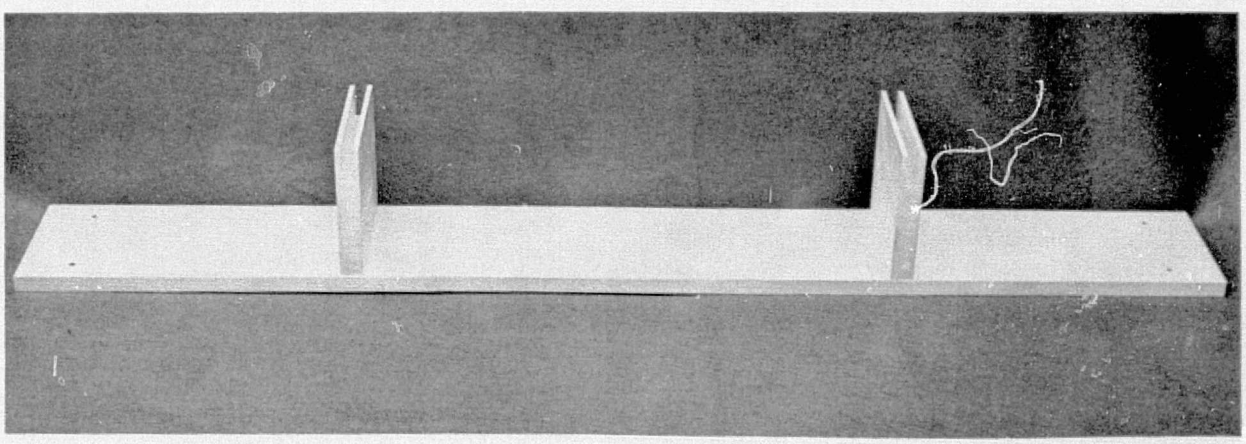


FIGURE 24

assemblies are flush and no gasket material protrudes past the flanges. Install the six flange bolts, washers, and nuts, and torque the bolts to 80 in-lbs. Repeat this procedure for the other end assembly.

To assemble a 48-inch heater or absorber, place the assembly tool in the configuration shown in Figure 24. Install the end assembly of a heater or absorber in the support slot. Prepare a T-055429-5 Gasket as before with Permatex Form-A-Gasket No.2. Place this gasket on the flange surface of the end assembly. Install the other end of the heater or absorber on the support of the assembly tool and sandwich the gasket between the two flanges. Be sure the sides of the assemblies are flush and no gasket material protrudes past the flanges. Install the six flange bolts, nuts, and washers, and torque the bolts to 80 in-lb.

After assembling a heater or absorber, leak check each unit before installing it in an array. This step may save considerable time and effort.

The heating elements can be installed in the heater assemblies before or after they have been mounted in the array support structure. Additional care in handling may be necessary with elements installed.

6.2 <u>Heating Element Installation and Removal</u> - When installing new graphite elements, bake them out at a temperature somewhat above the peak temperatures expected during that operating period to drive off unwanted volatiles. These volatiles coat reflectors excessively and are apt to cause arcing. This is preferably done in a high temperature inert atmosphere furnace but in the absence of a furnace, this can be accomplished using the heater assembly itself. The procedure is to operate the heater with new elements installed using a dummy test specimen. Gradually increase the power to the heating elements until they reach the desired temperature and hold for 20 minutes. Remove the elements and clean the reflectors after bakeout of new elements.

Prior to installing elements in a heater the T-055430-61 Pins and the gold-plated reflector panels should be cleaned. The pins are easily cleaned with Scotch Brite scouring pads. The procedure outlined in Section 6.3 should be followed when cleaning the reflector panels.

The heating elements are more rugged than they appear and are easily handled. Lift the heating element by gripping the split (electrode) end of the element with one hand and support the element near the center with the other hand as shown in Figure 25. Place the solid (expansion) end of the element on the T-055432-53 Lever. Insert the T-055429-7 Spacer between the passes of the element

HANDLING 72 INCH HEATING ELEMENTS

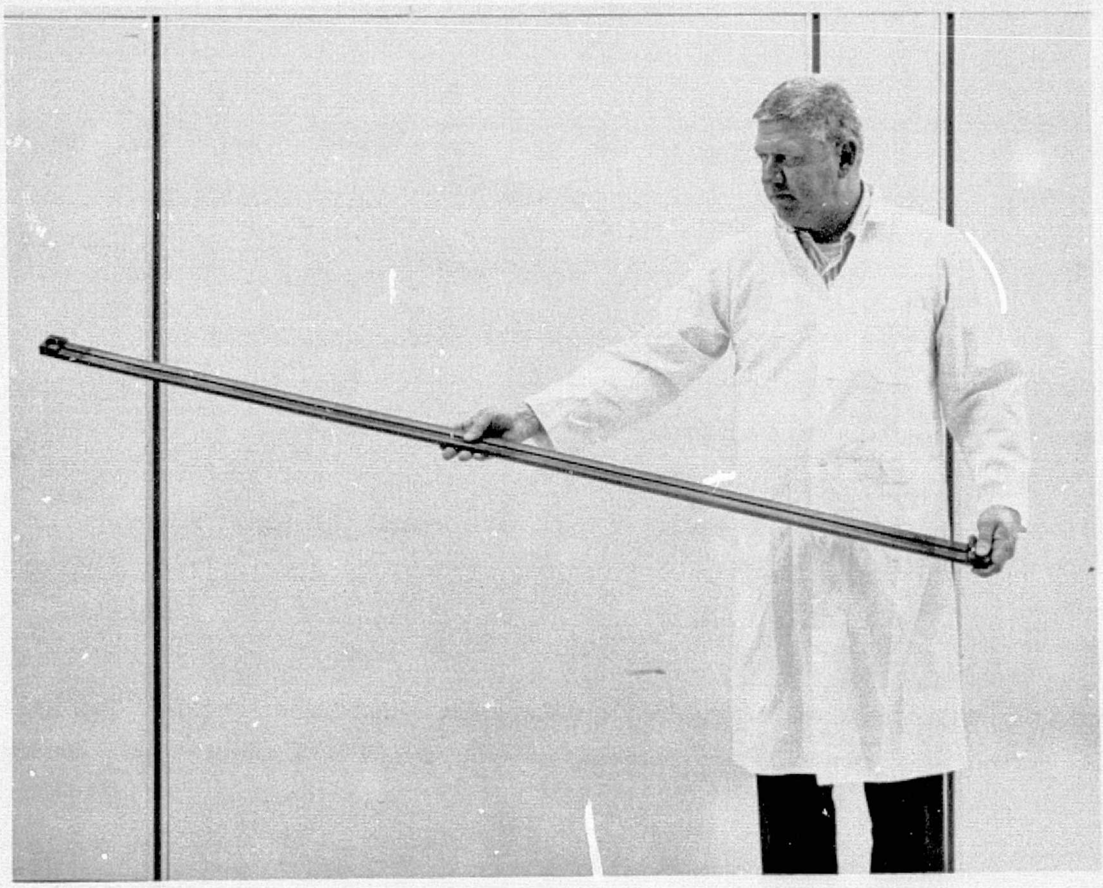


FIGURE 25

if the T-055437-1 Heater Element is being installed. Place the other end of the element on the T-055430-61 Pins and press firmly into place. It may be necessary to raise the center of the heater elements slightly. When correctly installed, the upper surface of the heater elements should be nearly flush with the top of the -53 Levers and -61 Pins as shown in Figure 26. When installing the second T-055437-1 Element in a module, place an additional T-055429-7 Spacer between the two elements. When the heater module is to be operated in any orientation other than upright, such as on its side in the leading edge configuration, install a T-055429-9 Spacer between the T-055437-1 Element and the bottom side reflector. Locate the spacers near the center of the elements. However, do not interfere with the site path of a pyrometer assembly if it is installed in the center heater section.

To remove the heating elements from a heater module, hook the Element Removal Tool beneath the expansion end of the heater element as shown in Figure 27. Utilize the slide block on the removal tool to gently tap the heater element until loosened from the lever. Lift the element and let it rest on top of the lever. Repeat this procedure at the electrode end of the element until both passes of the element can be lifted free of the T-055430-61 Pins. Grip the elements as before and lift the element from the module.

6.3 Gold Plated Reflector Panel Cleaning Procedures - A portion of the development program resulting in the gold plated reflector panels was directed towards obtaining a durable surface which could withstand the cleaning requirements of graphite heater reflectors. The gold on the reflector panels is electroplated and contains a small percentage of alloys which enhance the durability of the gold surface but do not degrade the reflective properties. Special cleaning techniques are recommended to maintain the highly reflective characteristics of the gold panels and to prevent scratches and damage from improper techniques or materials. The following procedures outline the recommended cleaning techniques.

Step 1 - Materials required.

a) acetone (commercial grade)

b) alcohol (commercial grade)

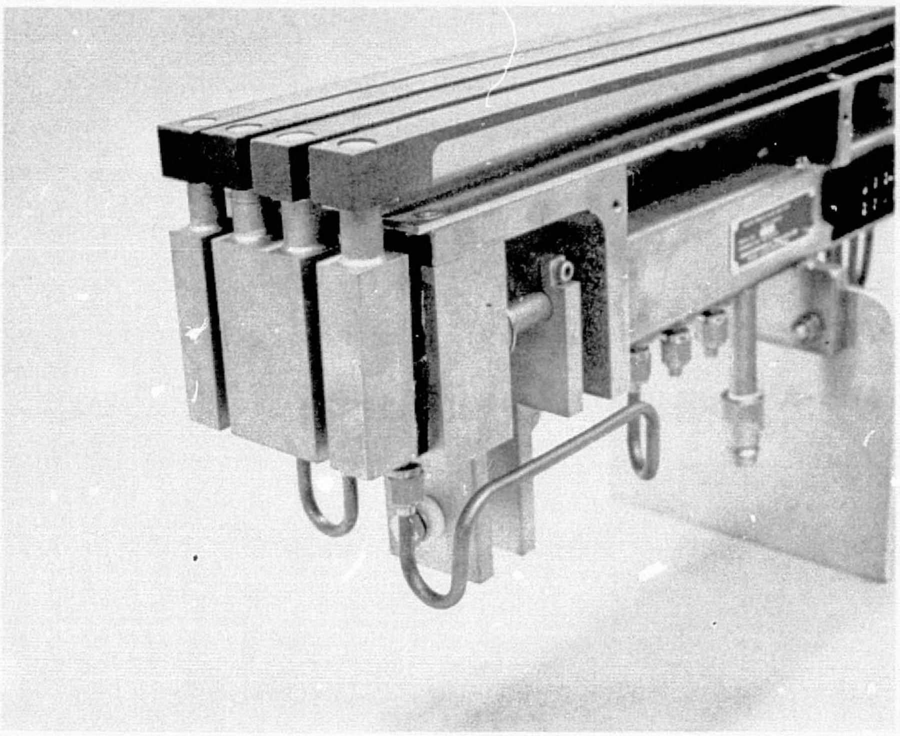
c) Fanfare aerosol cleaner (Industrial Soap Co.)

d) Rymple Cloth (The Kendall Co.)

e) Liquid soap and warm water.

CAUTION: Use only that portion of the cleaning process necessary to return the luster of the gold plating.

HEATER ELEMENT INSTALLATION DETAILS



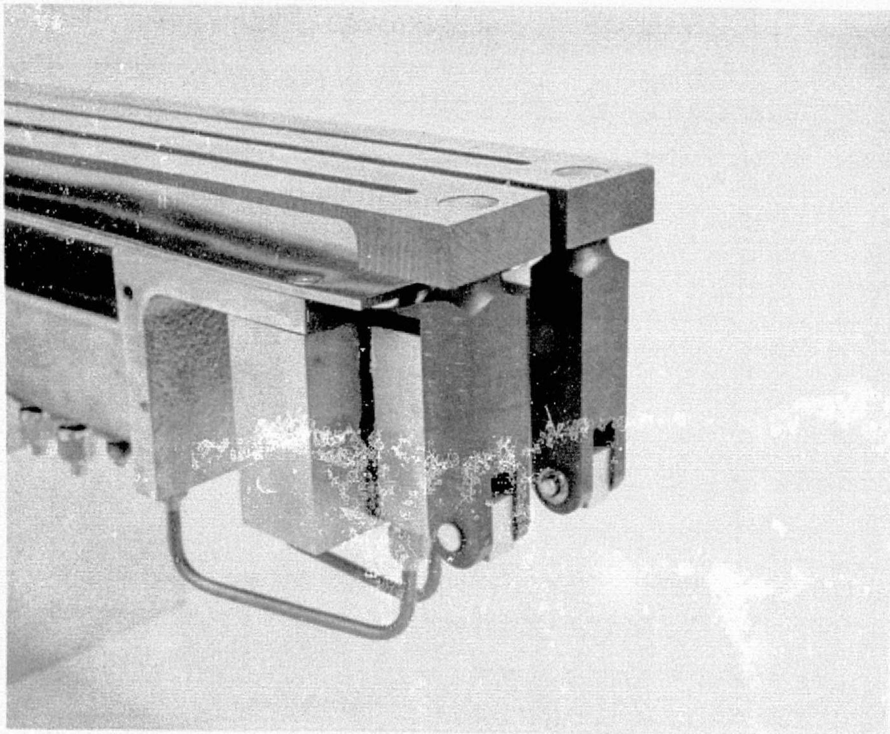


FIGURE 26

REMOVING HEATING ELEMENTS FROM TAPERED PEGS

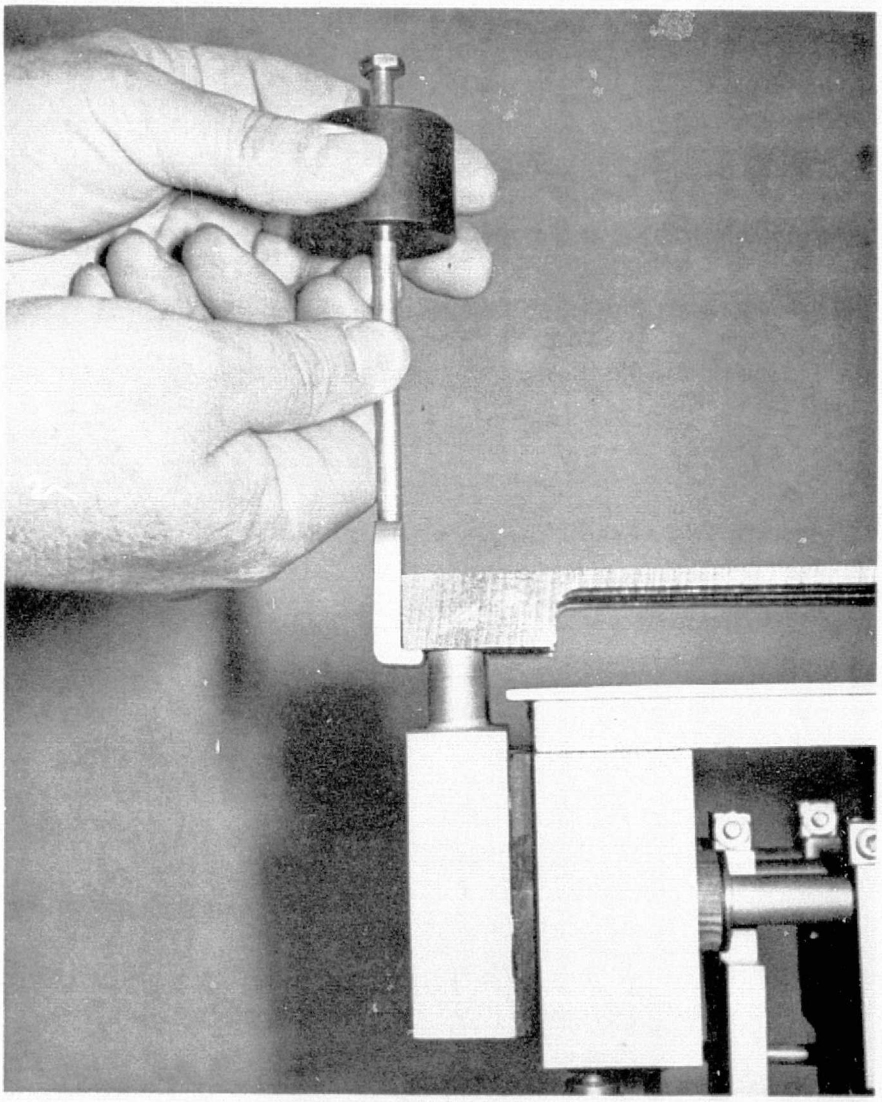


FIGURE 27

Step 2 - If the reflectors are removed from the heater wash with soap and warm water, using Rymple Cloth to loosen the dirt. Dry promptly.

Step 3 - If the reflectors are installed on the heater,

a) remove the heater elements

b) place a 10-32 screw into the view port of all pyrometers

c) spray Fanfare cleaner on gold plated surfaces, protecting end assemblies by covering with paper or cloth

d) wipe and polish with Rymple Cloth immediately, changing cloths frequently to prevent abrading gold surface with deposits embedded in cloth

e) loosen stubborn deposits with a pad of Rymple Cloth dampened with acetone and/or alcohol

f) remove screws in pyrometer view ports.

7.0 HEATER REPAIR

Utilization of the many years of graphite heater experience in the MDC Laboratory has resulted in a rugged and durable heater design. Extended periods of trouble-free performance can be expected. The following paragraphs describe the minor difficulties which might be encountered during operation of the heating array. Most of them are easily corrected with only minor service.

7.1 Trouble Shooting - The following paragraphs describe the most frequently encountered problems with the heaters. The probable cause of the difficulty is described, with full instructions on how to correct the problem in subsequent sections.

7.1.1 Coolant Leaks - Coolant leaks can occur at the O-rings in the heater end assemblies, at the flanges between heater assemblies, or at one of the many AN fittings on the coolant manifolds. Generally a leak at one of the O-rings between the heater end assembly components requires disassembly of the component and replacement of the O-rings. Sections 7.2 and 7.3 describe this procedure. A coolant leak at the gasket between heater sections can sometimes be cured by retorquing the flange bolts. If this procedure fails it may be necessary to disassemble the heater sections and replace the gasket. If coolant leaks occur at any of the fittings on the heater coolant manifolds, these are generally cured by tightening the fitting.

7.1.2 Low Coolant Flow - Each heater assembly comes with an individual log sheet where the coolant flow rate through the unit was initially measured. The flow rate measurement was made with the T-055431-11 Pyrometer mounting block on the Expansion End Assembly disconnected from the heater manifolds, and pressure gages attached at these fittings to measure the pressure drop. Therefore the flow rates shown on the log sheets do not include the coolant that normally flows through the mounting block (approximately 0.5 gpm). If the heater is subjected to a periodic flow rate check and the coolant flow rate appears to have diminished, the coolant circuits should be examined for obstructed passages. Be certain that the low coolant flow is not a result of low supply pressure and therefore a low ΔP across the heater. Either check the flow rate at the same ΔP as shown on the log sheet or multiply the measured flow rate by the square root of the ratio of the two ΔP's before comparing with the flow rate given in the log sheet. If it appears that a coolant circuit obstruction exists, the first circuits to be examined should be those containing an orifice which restricts the flow through that particular circuit. These circuits are the three pyrometer mounting sensor blocks, the end reflectors, and the expansion end assembly. If an obstruction is not readily evident, it may be necessary to check each circuit individually. Refer to Figure 28 for the flow split to each circuit.

7.1.3 Unable to Apply Power - If power cannot be applied to a heater module check for open interlocks in the control circuit which will prevent the firing of ignitrons. Also examine the heater for broken elements.

7.1.4 Electrical Arcing - Arcing within a heater module is generally an unpredictable phenomena, however the possibilities of this occurring can be reduced by maintaining the heater operation within its pressure/temperature operating envelope.

7.1.5 Excessive Voltage - An imbalance between between the normal voltage-current relationship with the voltage being on the high side can generally be attributed to dirty or corroded electrical connections. This can occur at any of the many electrical interfaces between the powers source and the heater elements. Those specifically associated with the heaters occurs between the power cables and the T-055430-31 and -33 terminals, or between the heater terminals and the T-055430-43 Pins. These areas can easily be cleaned with Scotch Brite scouring pads.

7.1.6 Excessive Current - When the imbalance between the normal voltage-current relationship appears to be a high current condition, electrical shorts should be expected. Correcting this condition is accomplished by troubleshooting the entire electrical system.

7.1.7 Excessive Power - When it appears that the heater modules are requiring more power than is normal for a particular test condition, the most probable cause is dirty reflectors. With deposits on the gold plated reflector panels, the panels absorb a higher percentage of the energy from the heater elements, thus requiring higher input power to supply the necessary energy to the test article. Obviously the corrective action is to clean the reflectors per Section 6.3.

7.1.8 Low Heat In a Control Zone - If it appears that a particular control zone is not receiving the necessary heat to maintain test conditions, there are several areas to examine. This condition can be attributed to broken elements, malfunctioning feedback sensors, malfunctioning power control equipment, or open interlocks.

COOLANT FLOW DISTRIBUTION

Coolant Circuit	Flow Rate @ 60 psi ΔP (gpm)	Percent of Total (%)
T-055430-3 Side Reflector Assy.	2.31	8.71
T-055430-5 Side Reflector Assy.	2.20	8.29
T-055430-7 Bottom Side Reflector Assy.	1.93	7.27
T-055430-9 End Reflector Assy.	1.04	3.92
T-055430-13 (2) plus -15 Electrode Blocks	2.37	8.93
T-055431-11 (A1) Block Assy.	0.48	1.81
T-055431-3 Bottom Reflector Assy.	1.95	7.35
T-055431-5 Side Reflector Assy.	2.44	9.20
T-055431-7 Side Reflector Assy.	2.37	8.93
T-055431-11 (A2) Block Assy.	0.45	1.70
T-055431-11 (A3) Block Assy.	0.46	1.73
T-055432-3 Side Reflector Assy.	2.31	8.71
T-055432-5 Side Reflector Assy.	2.19	8.25
T-055432-7 Bottom Reflector Assy.	1.95	7.35
T-055432-9 End Reflector Assy.	1.00	3.77
T-055432-13 (2) Support Block Assy's.	1.08	4.07

FIGURE 28

7.2 O-Ring Replacement-Electrode End Assembly -

Step 1 - Remove the T-055430-3 and -5 Side Reflector Assemblies.

Step 2 - Remove the two T-055430-17 Tube Assemblies.

Step 3 - Remove the T-055430-9 End Reflector Assembly.

Step 4 - Remove the T-055430-7 Bottom Reflector Assembly.

Step 5 - Remove the entire electrode end subassembly intact by removing the two AN509-10 Screws that are under the bottom reflector assembly.

Step 6 - Remove the T-055430-31 and -33 Terminals by loosening the screws clamping the terminals to the T-055430-13 and -15 Electrode Block Assemblies.

Step 7 - Compress the U500-0210 Spring Washers using the compression tool shown in Figure 29. Place the "feet" of the tool on the edges of the flat washer under the N510C-50 Retaining Ring. Screw the threaded rod into the ends of the T-055430-43 Pins compressing the wave spring washer and O-rings until the retaining rings can be removed. Remove the N5100-50 Retaining Rings.

Step 8 - Remove the Electrode Block Assemblies from the T-055430-63 Manifold. A total of sixteen AN6227-B5 O-rings will be found in O-ring grooves in the -63 Manifold and the -13 and -15 Electrode Block Assemblies.

Step 9 - Remove the old O-rings and install new ones after first lubricating them with a silicon grease.

Step 10 - Reassemble the electrode end subassembly making certain that the chamfer in the hole of the T-055430-69 and -71 Insulator is against the T-055430-13 and -15 Electrode Block Assemblies. Also, maintain alignment and spacing of the electrode block assemblies with respect to the T-055430-63 Manifolds.

Step 11 - Reassemble the electrode end assembly by reversing the disassembly sequence.

7.3 O-Ring Replacement-Expansion End Assembly -

Step 1 - Remove the T-055432-3 and -5 Side Reflector Assemblies.

Step 2 - Remove the two T-055430-17 Tube Assemblies

Step 3 - Remove the T-055432-9 End Reflector Assembly.

Step 4 - Remove the T-055432-7 Bottom Reflector Assembly.

Step 5 - Remove the expansion end subassembly intact by removing the two AN509-10R9 Screws that are under the bottom reflector assembly.

Step 6 - Remove the nut and washers from the T-055432-39 Stud.

Step 7 - Slide the T-055432-13 Support Block Assemblies from the T-055432-45 Manifolds. A total of eight AN6227-B5 O-Rings will be found in O-ring grooves in the -13 Support Block Assemblies and -45 Manifolds.

Step 8 - Remove the old O-rings and install new ones after first lubricating the O-rings with silicon grease.

Step 9 - Reassemble the expansion end subassembly making sure the chamfer in the T-055432-47 Insulator is against the Support Block Assembly. Tighten the clamping nut only enough to compress the O-rings. Maintain alignment and spacing of the support block assemblies with respect to the -45 Manifold.

Step 10 - Reassemble the expansion end assembly reversing the disassembly sequence.

7.4 <u>Heater Element Replacement</u> - Refer to Section 6.2

7.5 <u>Repairing Arc Damage</u> - In the event an electrical arc occurs during heater operation it generally leaves some evidence behind such as pitted or melted areas on metallic parts, soot, or a combination of the two. It is most important that the evidence of any arcing be removed prior to further operation of the heater modules. It may be necessary to file and/or sand metallic pieces to smooth and round all sharp edges. Clean the area thoroughly.

7.6 <u>Supplementary Heater Information</u>

7.6.1 <u>Coolant Flow Split</u> - Figure 28 lists the percent of the total coolant flow each coolant circuit normally requires. These data are experimentally determined.

7.6.2 <u>Weights</u> - Figure 30 gives the weights of each section of a heater module and the total weights of an assembled 48-inch and 72-inch heater, and a 72-inch absorber module. Following the heater and absorber data, the calculated weights of the components of the support structure are listed.

7.6.3 <u>Summation of Heater and Absorber Log Sheet Information</u> - Figure 31 summarizes the primary information given on the individual heater and absorber module log sheets.

7.6.4 <u>Purchased Parts Supplemental Information</u> - This section contains information on some of the components of the heater array which is not contained in Process Specification or on the Heater Array Engineering Drawings. Most of this

ELECTRODE END ASSEMBLY COMPRESSION TOOL

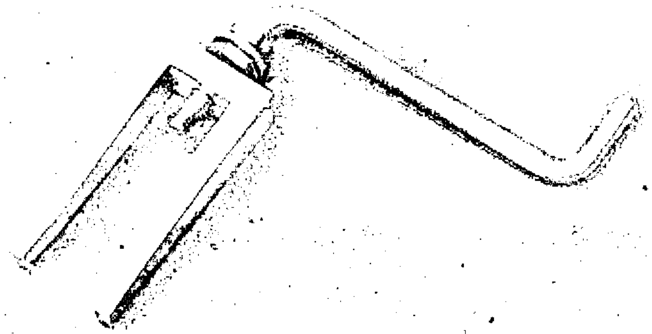


FIGURE 29

TABLE OF WEIGHTS

Part No.	Part Name	Weight (lbs)
T-055428-1	Heater Module Assy	94
T-055428-3	Heater Module Assy.	70
T-055429-1	Heater Module Assy.	120
T-055429-3	Heater Module Assy.	90
T-055433-1	Absorber Module Assy.	84
T-055427-1	Support Structure	1031
T-055427-3	Support Structure	915
T-055427-5	Base Assy.	515
T-055427-7	Heater Support Assy	200
T-055427-11	Heater Support Assy.	218
T-055427-12	Heater Support Assy	218

FIGURE 30

HEATER-ABSORBER MODULE LOG SHEET SUMMARY

Part Number	S/N	Operational Checkout			
		Water @ 60 psi ΔP (gpm)	Specimen Temperature (°F)	Volts	Amperes
T-055429-1	01	24.78	3256	65	1000
	02	24.13	3289	65	990
	03	24.22	3200	70	1100
	04	25.16	3200	68	1060
	05	24.49	3200	65	1000
	06	24.14	3200	66	1020
	07	24.51	3221	66	1020
	08	24.33	3214	65	1010
	09	24.55	3233	65	1010
	10	24.60	3206	67	1040
	11	24.51	3200	70	1100
	12	24.82	3207	70	1100
T-055429-3	13	17.80	3224	70	790
	14	17.92	3226	66	760
	15	18.19	3249	65	750
	16	18.04	3241	65	750
	17	17.94	3216	65	750
	18	18.19	3267	65	750
	19	17.88	3244	65	740
	20	18.04	3248	65	740
	21	18.42	3284	65	740
	22	17.78	3228	65	740
T-055433-1	01	6.75			
	02	6.63			
	03	6.75			
	04	6.63			
	05	6.82			
	06	7.01			
	07	7.01			

FIGURE 31

information has been extracted from vendor catalogues or manuals. More detailed information should be obtained directly from the vendor.

7.6.4.1 Victaulic Pipe Couplings - Pipe couplings manufactured by the Victaulic Company of America are used to connect the heating array coolant system to the coolant supply and return fittings in the test chamber. The couplings have three major parts; a single gasket and two housing clamps, plus two bolts and nuts. They are self-centering over the pipe ends and may be quickly installed. The housing clamps float in grooves in the pipe ends. This feature combined with the resiliency of the Victaulic gasket, permits some angular deflection from the centerline. For the 4 inch NPS couplings used in the heating array, the total allowable angular deflection is 3° 11' per coupling. Also, each coupling allows some end play between the pipe ends. This eliminates the need for close tolerance fabrication during array installation in the test chamber. The allowable pipe end separation for the 4 inch NPS couplings is 0 to 0.25 inch.

Installation of the Victaulic couplings is accomplished with four steps.

Step 1 - Grease the pipe ends lightly (or gasket lips) with silicone grease and slip the gasket completely over one pipe end.

Step 2 - Bring the pipe ends together and slide the gasket back into central spanning position, then smear grease on the outside of the gasket.

Step 3 - Put the housing clamps over the gasket, insert the bolts and nuts.

Step 4. - Take up nuts uniformly until housing clamps are firmly together, metal to metal. Excessive bolt tension is unnecessary.

7.6.4.2 Quick Disconnect Couplers - Industrial type brass quick disconnect couplers are provided at each heater and absorber coolant connection. These couplers are manufactured by the Bruning Company of Lincoln, Nebraska. These couplers have a no-spill, no-air inclusion feature which allows them to be disconnected without coolant spillage. The coupler seals are compatible with water and steam up to temperatures as high as 300°F. The flow-pressure drop data for the two coupling sizes utilized in the heating array is presented in Figure 32.

7.6.4.3 Safety Coolant Flow Switches - Each heater and absorber module has a safety flow switch incorporated in its design. These flow switches are Model FS-927, manufactured by Delaval, Gems Sensor Division in Farmington, Conn. Operation of the FS-927 units is extremely simple. A magnet equipped piston displaced by the pressure differential from fluid flow magnetically actuates an SPDT Reed

Switch sealed within the unit. This switch in turn can be used to actuate an alarm system or shut down the power system. The flow switches have been set to actuate at a standard flow setting of 0.1 gpm. The flow swtiches have an upper operating temperature limit of 300°F. Figure 33 gives the wiring diagram of the flow switch. It can be wired so that flow makes or breaks the contacts.

7.6.4.4 Lee Plug Installation and Removal - The Lee Plug is a cylindrical plug with a tapered reamed hole part way through its center and numerous small grooves on its outside diameter. It is slipped into a reamed counterbore in the product. A tapered pin is then driven into the plug until the ends of the pin and the plug are flush with each other. Controlled expansion causes the lands and grooves in the plug to bite into the surrounding material forming independent seals and retaining rings. The result is a positive reliable leak-proof seal. This device has been utilized in several areas of the heater and absorber modules.

Installation procedures for the Lee Plug are as follows:

Step 1 - The hole the plug is to fit into and the plug should be clean and dry.

Step 2 - Insert the plug into the hole until firmly seated on the shoulder of the reamed hole.

Step 3 - Pins are factory prewaxed for easily installation. Additional lubrication is usually unnecessary.

Step 4 - Start pin, small end first, into tapered hole. Avoid tilting the pin.

Step 5 - Firmly support the item to be plugged.

Step 6 - Press or drive pin only until exposed end of pin is flush with exposed end of plug.

Step 7 - The flushness tolerances are 0.003 inch into plug or 0.005 inch out of plug.

Removal procedures are as follows:

Step 1 - Drill and tap a hole in the pin.

Step 2 - Extract the pin using a long bolt screwed into the pin and a sliding striker bushing.

Step 3 - Tap the plug.

Step 4 - Extract the plug using the bolt and striker.

PRESSURE DROP DATA FOR BRUNING COUPLERS

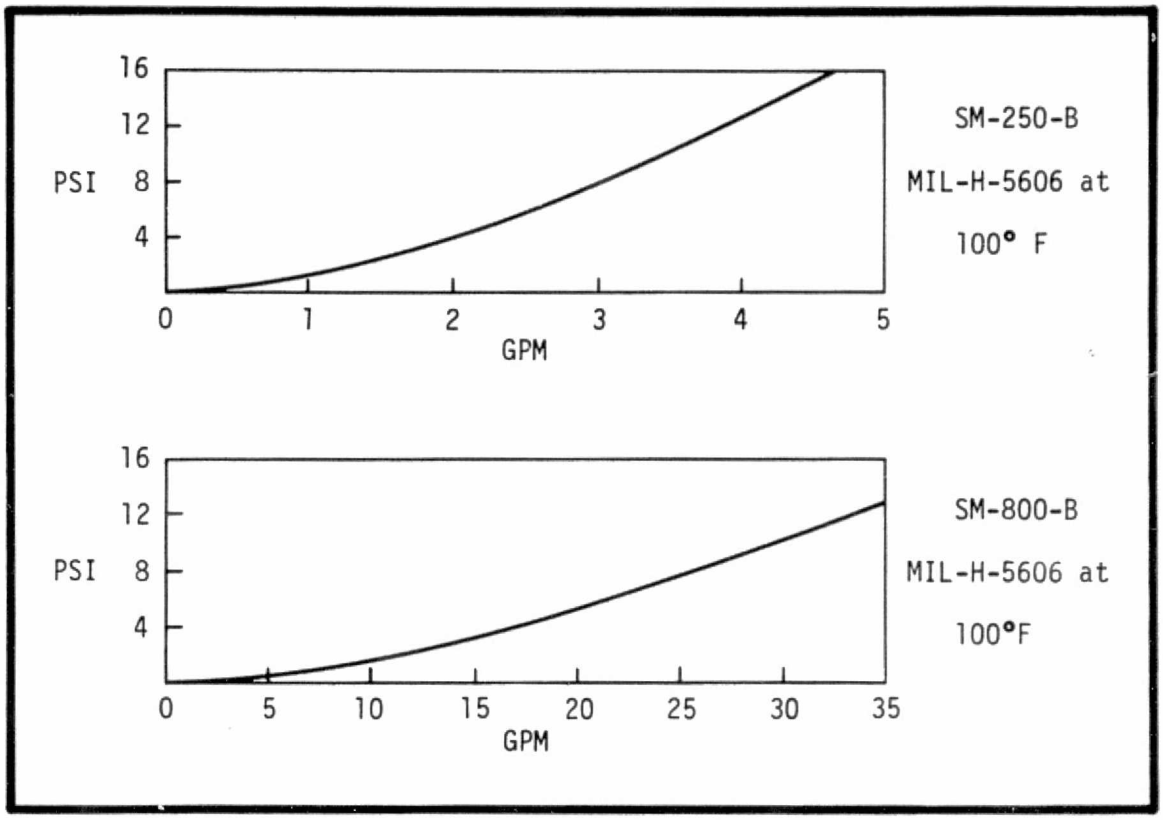


FIGURE 32

COOLANT FLOW SWITCH WIRING DIAGRAM

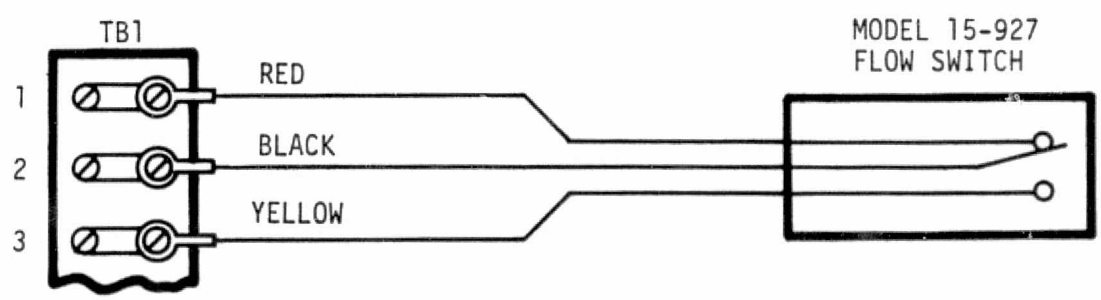


FIGURE 33

8.0 SPARE PARTS AND MATERIALS

Figure 34 lists the spare parts supplied with the heater and the recommended quantity levels to maintain. Based on our experience, the only expendable item is the graphite heating element, which may slowly deteriorate. The rate of deterioration depends to a great extent on the effectiveness of the inert gas purge and peak operating temperatures. Element life as high as 200 cycles have been obtained with other graphite heaters, however, we recommend inspecting the heater elements for deterioration after each 50 thermal cycles.

Figure 35 lists additional parts and materials needed for normal operation and maintenance of the heating array. Sample amounts of these items are provided with the Array.

SPARE PARTS LIST

Part No.	Part Name	Quantity Supplied	Recommended Level To Be Maintained Max.	Min.
AN929-4J	Cap Assy.	184	200	150
AN6227-B5	O-ring	200	200	50
T-055429-5	Gasket	50	50	25
T-055429-7	Spacer	42	60	36
T-055429-9	Spacer	24	24	12
T-055430-69	Insulator	5	10	5
T-055430-71	Insulator	5	10	5
T-055432-47	Insulator	5	10	5
T-055432-53	Lever	22	12	5
T-055437-1	Heating Element	50	125	25
T-055437-3	Heating Element	70	150	50
	4 inch Flat Ring Gasket	12	12	4
7M27A4	Seal	200	500	200

FIGURE 34

RECOMMENDED MATERIALS LIST

P/N	Material	Manufacturer
#77, Grade H	Gasket	Victaulic Co.
RF300	Thermoflex Insulation	Johns-Manville
G300	Silicone Grease	General Electric
	Fanfare Aerosol Cleaner	
#2	Form-a-gasket	Permatex
	Rymple Cloth	Kendall Co.
	Thread Dope	

FIGURE 35

9.0 ENGINEERING DRAWINGS AND PROCESS SPECIFICATIONS

Figure 36 is an organization tree of all the engineering drawings supplied with the Radiant Heating Array. Reduced copies of the drawings are included in the Appendix of this manual. In some cases, a reading glass is required for detailed reading of these reproductions. Normal size drawings are included in the Drawing and Specification Package delivered with the Array.

Figure 37 lists the Process Specifications referred to on the engineering drawings that are not readily available to NASA. The Process Specifications are included in the Drawing and Specification Package provided under this contract.

ENGINEERING DRAWING ORGANIZATIONAL TREE

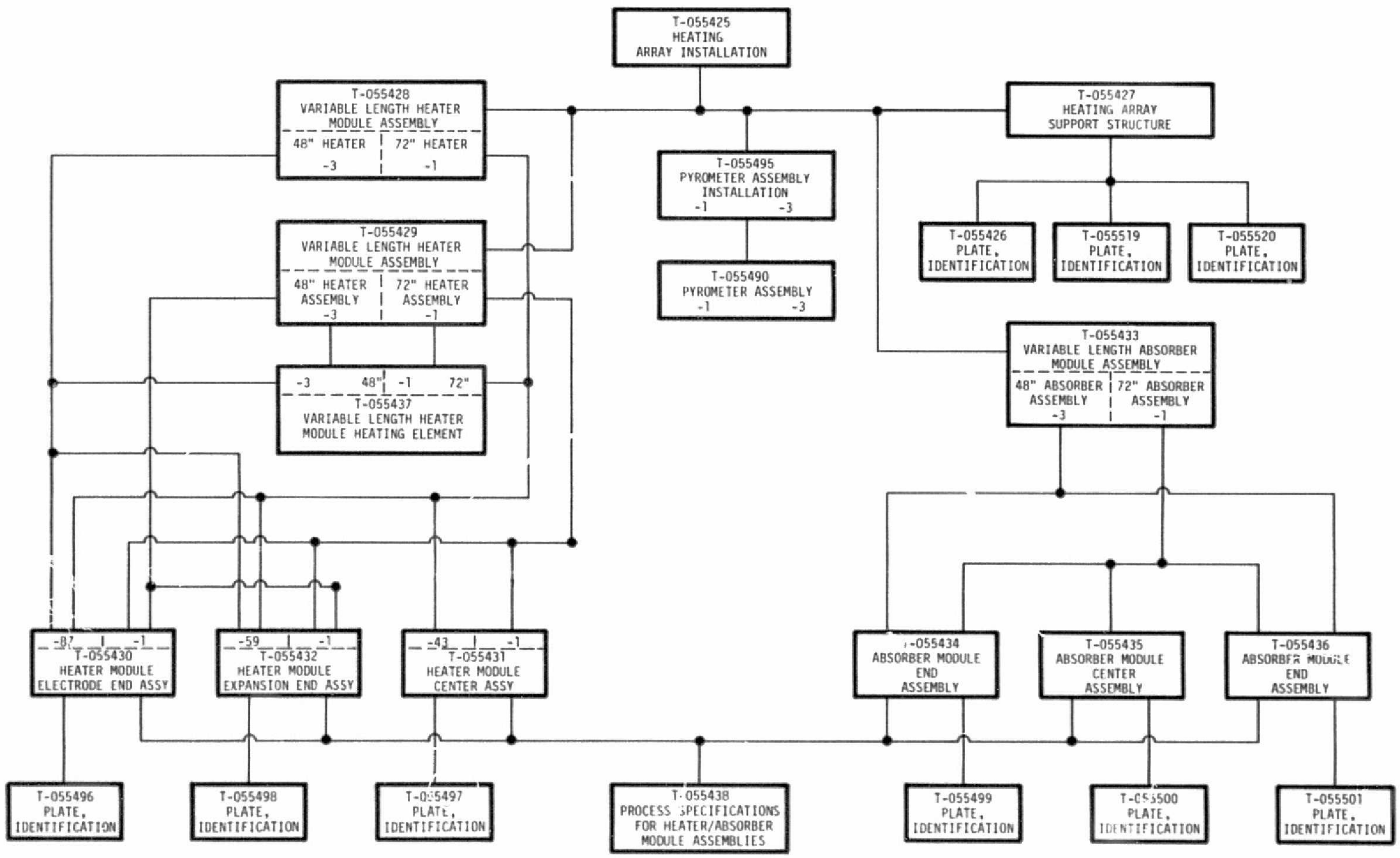


FIGURE 36

PROCESS SPECIFICATIONS

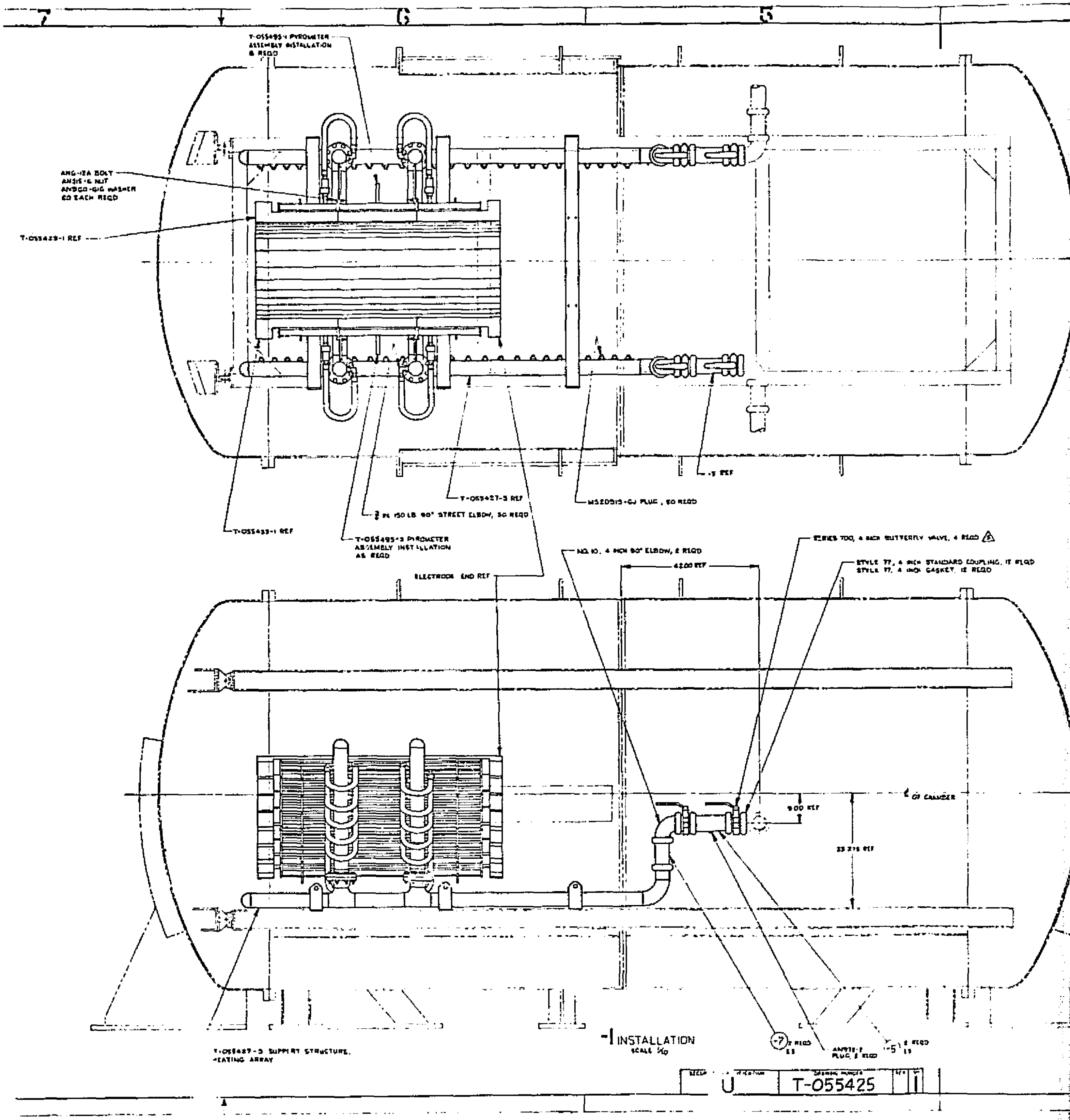
P.S. No.	Title
T-055438-1	Coolant Circuit Installation on Gold Plated Copper Sheets
T-055438-3	Waterproofing for Machinable Ceramic Parts
T-055438-5	Cleaning of Gold Plated Graphite Heater Reflectors
MMS-420	Aliphatic Polyurethane Finish System
MMS-425	High Temperature Epoxy Primer
P.S. 11002	Nameplates, Adhesive Bonded In Place; Application Of
P.S. 12040	Cleaning, Abrasive
P.S. 13105	Plating, Electroless Nickel
P.S. 13318	Painting Of Aerospace Ground Equipment (AGE)
P.S. 14008	Flaring Per MS33583 & MS33584 Tubing
P.S. 16001	Marking Of Fabricated Parts
P.S. 17150	Assembly Of Electrical Cable Terminals & Splices
P.S. 17153	Termination & Grounding Of Shielding On Wire & Cable
P.S. 22120	Soldering - General
P.S. 22250	Fusion Welding Steels & Corrosion & Heat Resistant Alloys

FIGURE 37

APPENDIX A

ENGINEERING DRAWINGS

This Appendix contains reduced copies of the engineering drawings employed to fabricate the heating array. This set of drawings can be used as a reference when performing maintenance.



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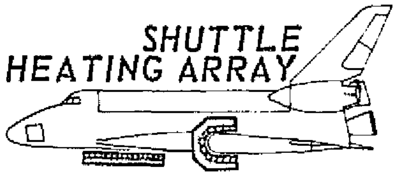
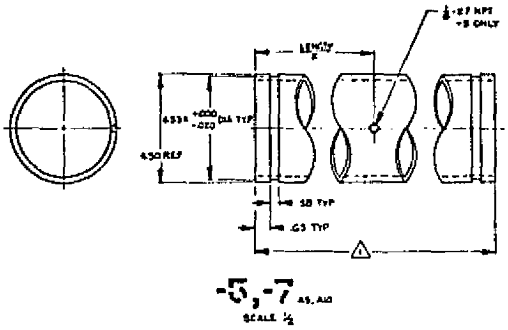
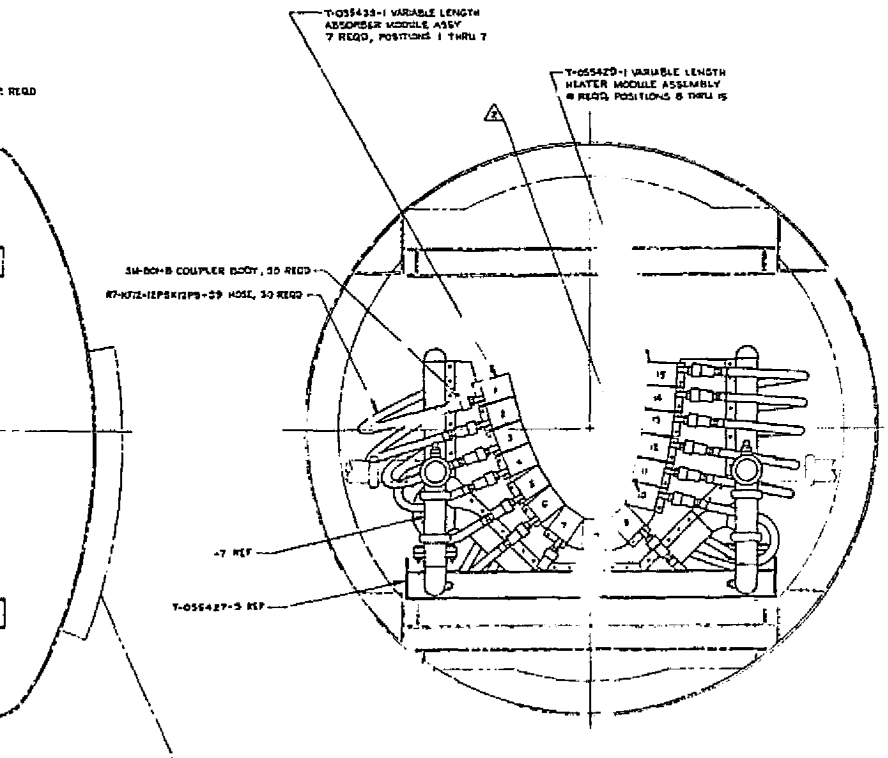






NOTES:

1. LENGTH OF -5 / -7 TO BE DETERMINED AT INSTALLATION
2. POSITION NUMBERS 1 THRU 15 SHOWN ON -1 INSTL AND 1 THRU 22 ON -3 INSTL ARE FOR REFERENCE ONLY AND DO NOT APPEAR ON THE HEATER / ABSORBER MODULES
3. THE FOLLOWING TABLE SHOWS THE QTY REQD PER ITEM ON THE -3 INSTALLATION

QTY REQD 48" HEATER CONFIGURATION	QTY REQD 72" HEATER CONFIGURATION	ITEM
22	12	T-055435-1 PYROMETER
44	24	SM-801-B COUPLER
4	24	MS20913-6J PLUG
88	48	AN6-12A BOLT
88	48	NAS679C6M NUT
88	48	AN960-616 WASHER

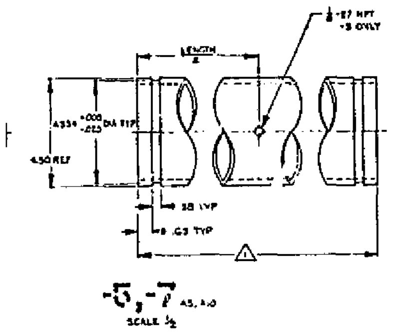
4. THE [illegible] MUST BE REMOVED FROM T-055429-1, POSITION 1 / 15, / T-055429-3, POSITION 1 / 22, WHEN INSTALLED IN THE -3 INSTL
5. SERIES 700 4 INCH BUTTERFLY VALVES MAY BE ROTATED TO ANY POSITION IF ADDITIONAL CLEARANCE ABOVE THE VALVE IS REQUIRED

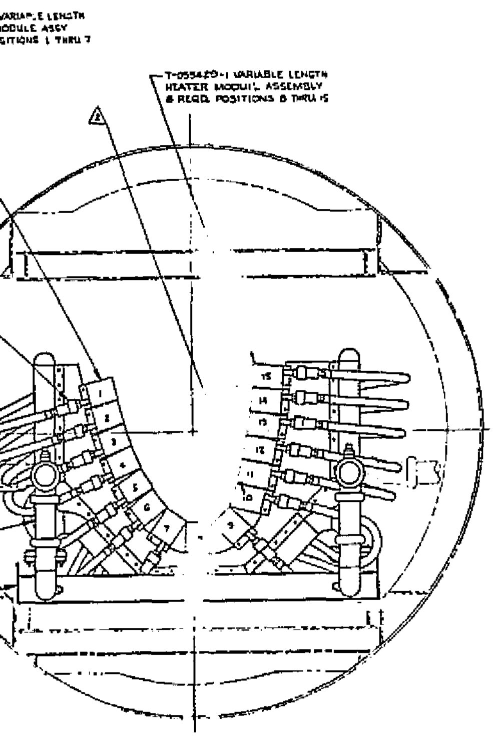
QTY -3	QTY -1		PART NO	NOMENCLATURE	STOCK	MATERIAL
	60		AN960-616	WASHER		
	60		AN315-6	NUT		
	60		AN6-12A	BOLT		
3			AN960-516	WASHER		
3			AN315-5	NUT		
3			AN5-12A	BOLT		
	30		¾ IN. 6010	ELBOW, 90° STREET	STANDARD WEIGHT	MALLEAB[LE]
3	60		MS20913-6J	PLUG		
2	8		1/8 NPT	PLUG, SOCKET HEAD		
3	30		SM-801-B	COUPLER BODY	BRUNING CO	
24			[illegible] HOSE		IMPERIAL EASTMAN CORP	
44	30		[illegible] HOSE		IMPERIAL EASTMAN CORP	
4	4		SERIES 700, 4 INCH	BUTTERFLY VALVE	VICTAULIC COMPANY OF AM[ERICA]	
12	12		STYLE 77, 4 INCH	STANDARD COUPLING	VICTAULIC COMPANY OF AM[ERICA]	
2	2		NO. 10, 4 INCH	90° ELBOW	VICTAULIC COMPANY OF AM[ERICA]	
12	12		STYLE 77 4 INCH	GASKET, GE [illegible]	VICTAULIC COMPANY OF AM[ERICA]	
1			T-055427-1	SUPPORT STRUCTURE		
	1		T-055427-3	SUPPORT STRUCTURE		
10			T-055428-1	HEATER MODULE ASSY		
22			T-055428-3	HEATER MODULE ASSY		
5	8		T-055429-1	HEATER MODULE ASSY		
2			T-055429-3	HEATER MODULE ASSY		
	7		T-055433-1	ABSORBER MODULE ASSY		
3	8		T-055435-1	PYROMETER ASSY INSTL		
	AS REQD		T-055435-3	PYROMETER ASSY INSTL		
2	2		-7	PIPE	4" O.D.	STEEL PI[PE]
2	2		-5	PIPE	4" O.D.	STEEL PI[PE]
-3	-1					
QTY REQD	QTY REQD	CODE IDENT NO	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	STOCK	MA[TERIAL]

-3		1	T-055426	
-1		1	T-055425	
DASH NO	QTY REQD	FIN ASSY / NEXT ASSY	USED ON	APPLICATION

Par[t]

[FOL]DOUT FRAME 2





NOTES:

1. LENGTH OF -5 / -7 TO BE DETERMINED AT INSTALLATION
2. POSITION NUMBERS 1 THRU 15 SHOWN ON -1 INSTL AND 1 THRU 22 ON -3 INSTL ARE FOR REFERENCE ONLY AND DO NOT APPEAR ON THE HEATER / ABSORBER MODULES.
3. THE FOLLOWING TABLE SHOWS THE QTY REQD PER ITEM ON THE -3 INSTALLATION

QTY REQD 48" HEATER CONFIGURATION	QTY REQD 72" HEATER CONFIGURATION	ITEM
22	12	T-055495-1 PYROMETER
44	24	SM-B01-B COUPLER
4	24	MS20913-6J PLUG
88	48	AN6-12A BOLT
88	48	NAS679C6M NUT
88	48	AN960-616 WASHER

4. THIS SIDE (ARROW) MUST BE REMOVED FROM T-055429-1, POSITION 1 / 8, / T-055429-3, POSITION 1 / 22, WHEN INSTALLED IN THE -3 INSTL.
5. SERIES 700, 4 INCH BUTTERFLY VALVES MAY BE ROTATED TO ANY POSITION IF ADDITIONAL CLEARANCE ABOVE THE VALVE IS REQUIRED.

QTY REQD (-3)	QTY REQD (-1)	CODE IDENT NO	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	STOCK	MATERIAL OR MATERIAL CODE	DRAWING OR SPECIFICATION NO	NOTE NO	ZONE
	60		AN960-616	WASHER					
	60		AN315-6	NUT					
	60		AN6-12A	BOLT					
△			AN960-516	WASHER					
△			AN315-5	NUT					
△			AN5-12A	BOLT					
	20		4 IN. NO 1B	ELBOW, 90° STREET	STANDARD WEIGHT	MALLEABLE IRON			
△	30		MS20913-6J	PLUG					
2	2		1/8 NPT	PLUG, SOCKET HEAD					
△	30		SM-B01-B	COUPLER BODY	BRUNING CO				[illegible]
24			[illegible]-27	HOSE	IMPERIAL EASTMAN CORP				[illegible]
44	30		[illegible]-29	HOSE	IMPERIAL EASTMAN CORP				[illegible]
4	4		SERIES 700, 4 INCH	BUTTERFLY VALVE	VICTAULIC COMPANY OF AMERICA				[illegible]
12	12		STYLE 77, 4 INCH	STANDARD COUPLING	VICTAULIC COMPANY OF AMERICA				[illegible]
2	2		NO. 10, 4 INCH	90° ELBOW	VICTAULIC COMPANY OF AMERICA				[illegible]
12	12		STYLE 77, 4 INCH	GASKET, GR H	VICTAULIC COMPANY OF AMERICA				[illegible]
1			T-055427-1	SUPPORT STRUCTURE					[illegible]
	1		T-055427-3	SUPPORT STRUCTURE					[illegible]
10			T-055428-1	HEATER MODULE ASSY					[illegible]
20			T-055428-3	HEATER MODULE ASSY					[illegible]
2	8		T-055429-1	HEATER MODULE ASSY					[illegible]
2			T-055429-3	HEATER MODULE ASSY					[illegible]
	7		T-055433-1	ABSORBER MODULE ASSY					[illegible]
△	8		T-055495-1	PYROMETER ASSY INSTL					[illegible]
	AS REQD		T-055495-3	PYROMETER ASSY INSTL					[illegible]
2	2		-7	PIPE	4" O.D. × △	STEEL PIPE, BLACK IRON	N.P.S. SCH 40		[illegible]
2	2		-5	PIPE	4" O.D. × △	STEEL PIPE, BLACK IRON	N.P.S. SCH 40		[illegible]
-3	-1								

PARTS LIST

TOLERANCE UNLESS NOTED .XX ± .03 .XXX ± .010

-3	1		T-055425
-1	1		T-055425
DASH NO	FIN. ASSY / QTY REQD	NEXT ASSY	USED ON

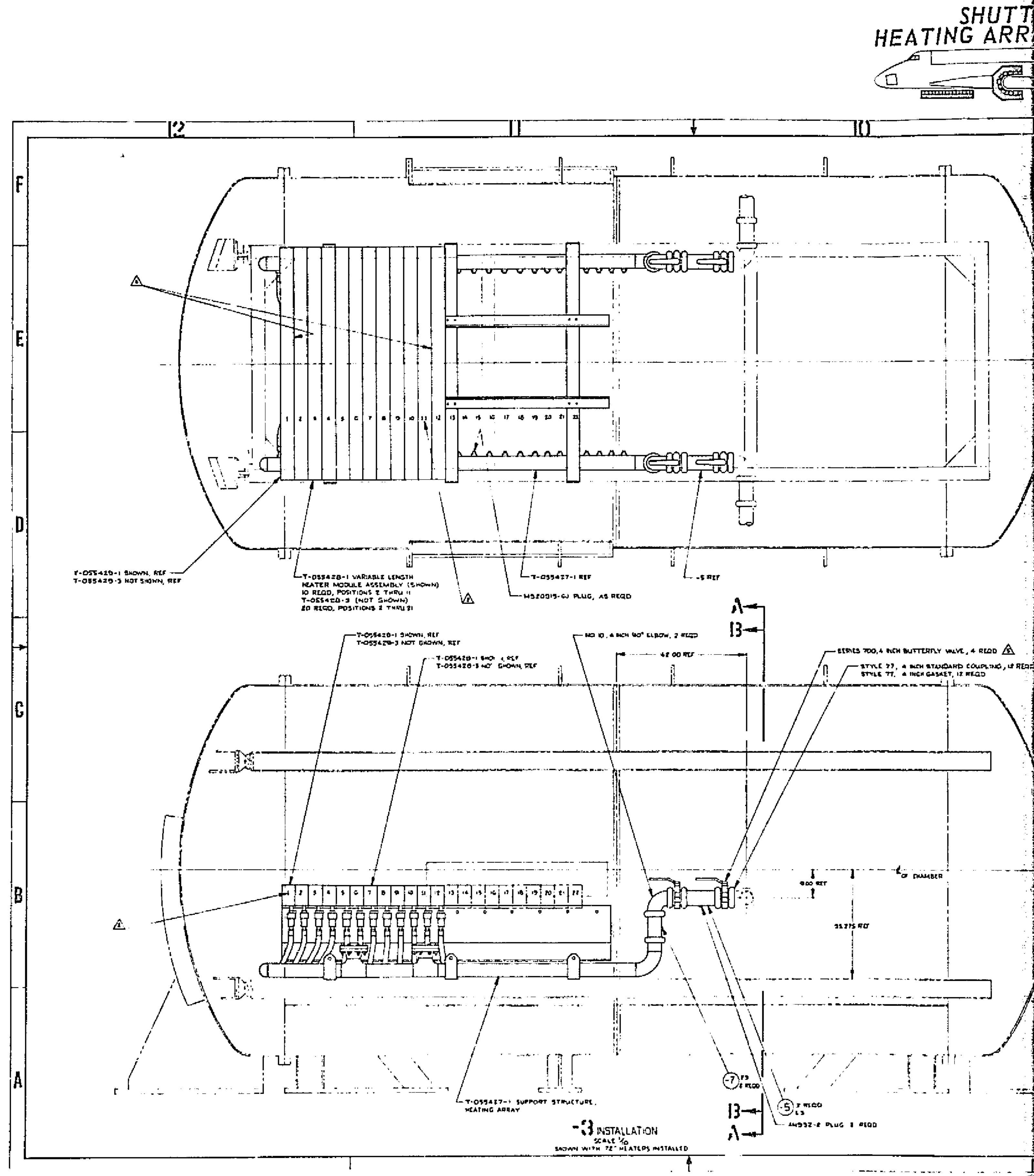
APPLICATION

MCDONNELL AIRCRAFT COMPANY
MCDONNELL DOUGLAS CORPORATION

HEATING ARRAY INSTALLATION

CODE IDENT NO 76301 T-055425

Part 1 of Sheet 1



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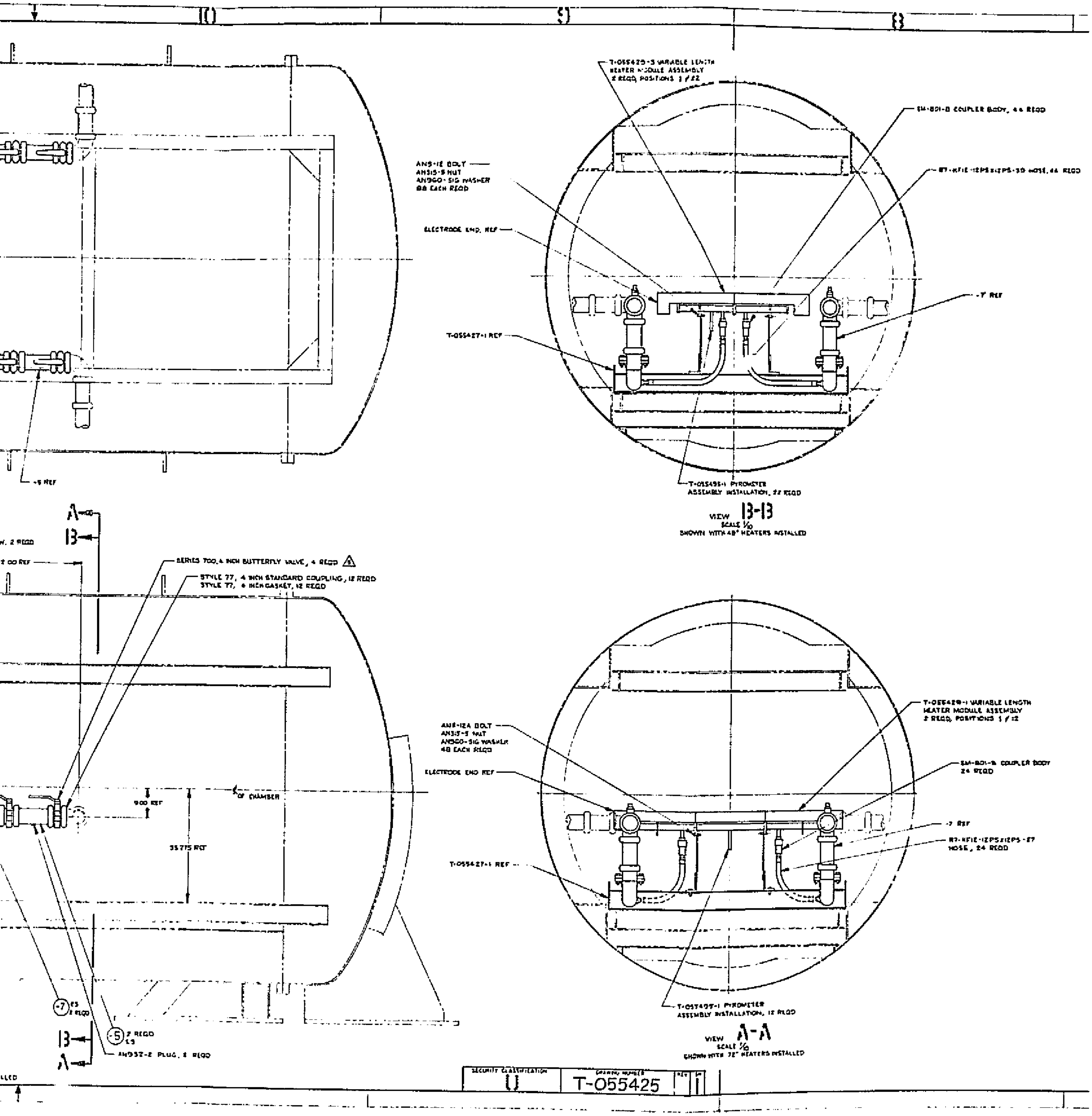
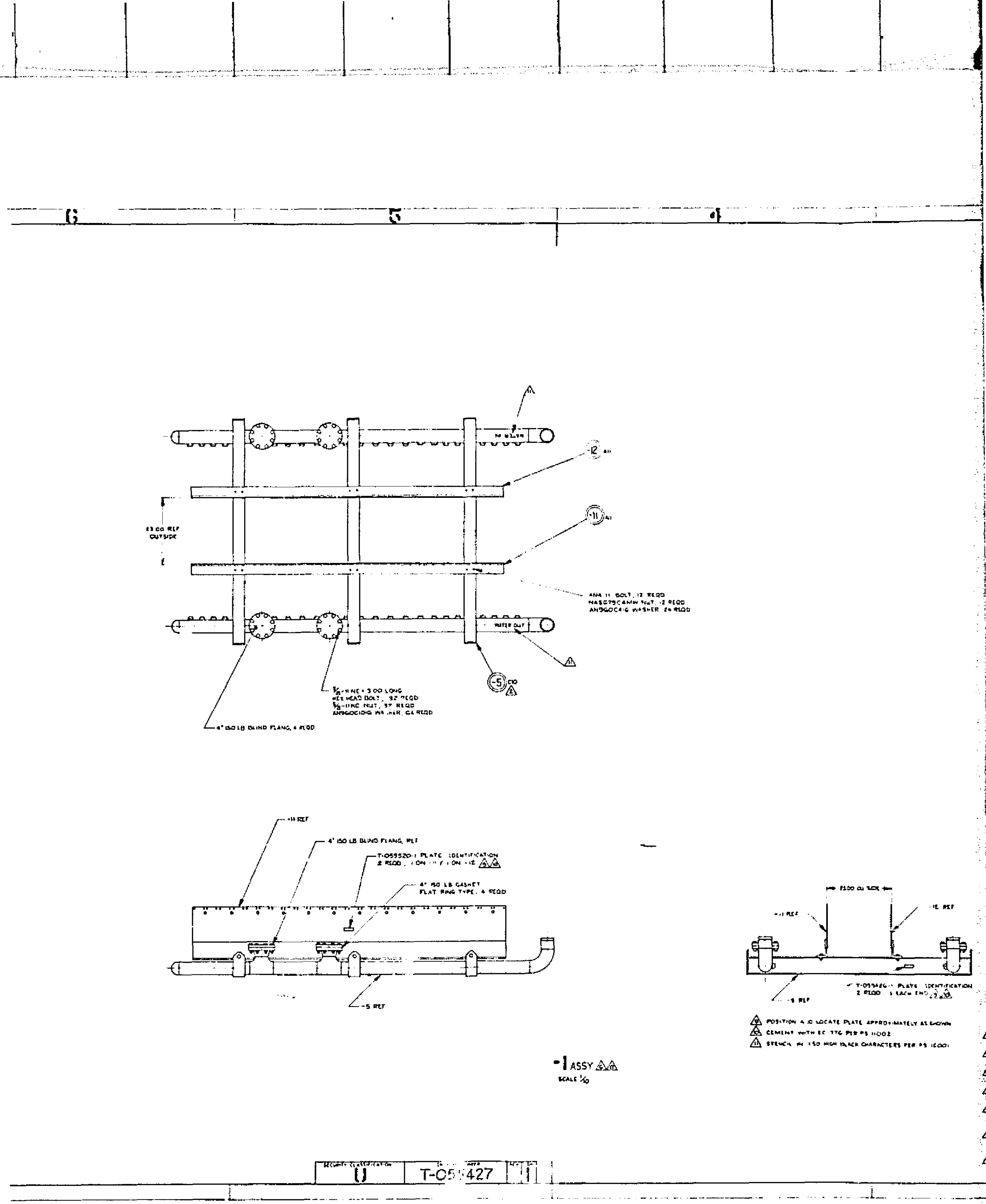


Part 2 of Sheet 1



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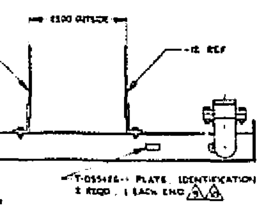


...O LOCATE PLATE APPROXIMATELY AS SHOWN

...M SC-776 PER PS 11002

...150 HIGH BLACK CHARACTERS PER PS 16001

NOTES:

1 ARC WELD PER P.S. 22250.

2 ONE -5 ASSY REQD. SAME ASSY IS USED IN EITHER -1 OR -3 SUPPORT STRUCTURE.

3 STEEL STAMP "A" AS SHOWN ON EDGE OF FLANGE, ONE PLACE ONLY, ON -5 / -7 ASSEMBLIES.

4 STEEL STAMP "B" AS SHOWN ON EDGE OF FLANGE, ONE PLACE ONLY, ON -5 / -7 ASSEMBLIES.

5 -7 ASSEMBLIES TO BE MOUNTED ON -5 ASSEMBLY AS SHOWN (A TO A / B TO B) IN -3 ASSEMBLY.

6 CLEAN PER PS 12040 AND APPLY TWO COATS OF MMS420 FED-STD-595 COLOR NO 15450 TOPCOAT OVER TWO COATS OF MMS425 PRIMER PER PS 13318.

7 ELECTROLESS NICKEL PLATE INTERIOR SURFACES OF -5 / -7 ASSEMBLIES, .0015 - .0020 THICK PER P.S. 13105.

8 BLAST CLEAN OR WIRE BRUSH PER PS 12040 TO REMOVE RUST.

-14 QTY REQD	-13 QTY REQD	-12 QTY REQD	-11 QTY REQD	-9 QTY REQD	-7 QTY REQD	-5 QTY REQD	-3 QTY REQD	-1 QTY REQD	CODE IDENT NO	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	STOCK	MATERIAL OR MATERIAL CODE	DRAWING OR SPECIFICATION NO	NOTE NO	ZONE
								2		T-035920-1	PLATE, IDENTIFICATION					[illegible]
							2			T-035519-1	PLATE, IDENTIFICATION					[illegible]
								2		T-035426-1	PLATE, IDENTIFICATION					B3
							64	64		AN960C1016	WASHER					
							152	24		AN960C416	WASHER					
							72	12		NAS679C4MW	NUT					
							32	32		5/8-11 NC	NUT					
							32	32		5/8-11 NC × 3.00 LG	BOLT					
								76		AN4-10	BOLT					
							12			AN4-11	BOLT					
					1	2				AN932-2	PLUG					
					16	48				3-3 × 5/8	THREADOLET	BONNEY FORGE				
							4	4		4" 150 LB	GASKET, FLAT RING TYPE					
2	2									4" 150 LB	FLANGE, WELD NECK					
							4			4" 150 LB	FLANGE, SLIP-ON					
								4		4" 150 LB	FLANGE, BLIND					
				4						4" PIPE, 45° LG RAD	ELBOW					
						2				4" PIPE, 90° LG RAD	ELBOW					
				2		2				4" PIPE	CAP					
2	2			2						4" PIPE	TEE					
							2			-49	PLATE	.25 × 44.00 × 80.00	ALUMINUM ALCLAD	2024-T351 QQ-A-250/5		[illegible]
						4				-47	↓	.25 × 4.00 × 8.56	STEEL, HOT ROLLED	TYPE 1020		
1	1									-45		1.00 × 4.00 DIA	↓	↓		[illegible]
				1						-43		.25 × 2.00 × 27.25				B3
				2						-41		.25 × 2.00 × 16.00				B4
				2						-39		.25 × 8.00 × 11.63				C4
				2						-37	↓	.25 × 2.00 × 24.38	↓	↓		B4
		1	1							-35	PLATE	.25 × 11.00 × 106.8	STEEL, HOT ROLLED	TYPE 1020		B2
				1						-33	PIPE	4" OD × 19.23	STEEL PIPE, BLACK IRON IPS	SCH 40		B3
				2						-31	↓	× 14.45	↓	↓		A4
				2						-29		× 9.13				B3
				2						-27		× 18.63				B4
1	1									-25		× 64.13				A6
1	1									-23		× 15.00				[illegible]
1	1									-21	↓	× 24.38	↓	↓		[illegible]
						3				-19	PIPE	4" OD × 9.00	STEEL PIPE, BLACK IRON IPS	SCH 40		D2
		1	1							-17	ANGLE	[illegible]	STEEL 106.8 LG			[illegible]
						3				-15	WIDE FLANGE BEAM	6 IN × 8.5 LB	STEEL 77.0 LG			[illegible]
						1				-14	MANIFOLD ASSY					[illegible]
						1				-13	MANIFOLD ASSY					[illegible]
								1		-12	HEATER SUPPORT ASSY					[illegible]
								1		-11	HEATER SUPPORT ASSY					D4
					1					-9	MANIFOLD ASSY					[illegible]
							2			-7	HEATER SUPPORT ASSY					[illegible]
							1	1		-5	BASE ASSY				7	[illegible]

PARTS LIST

NEXT ASSY	USED ON	APPLICATION
-3	1	T-055425	T-055425
-1	1	T-055425	T-055425

DWN H. H. LINZE

TOLERANCE UNLESS NOTED .XX ± .03 .XXX ± .010

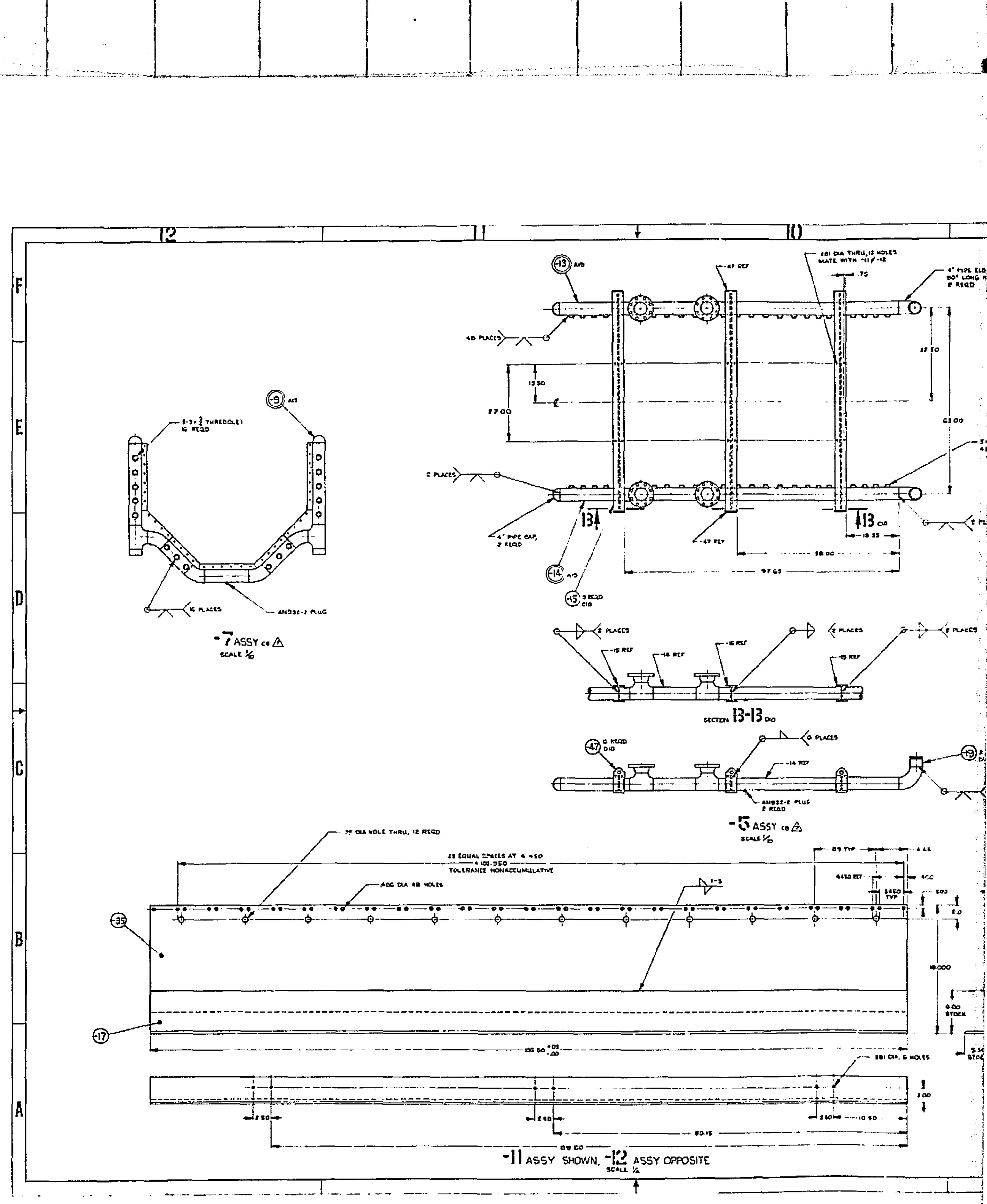
McDONNELL AIRCRAFT COMPANY

McDONNELL DOUGLAS CORPORATION

SUPPORT STRUCTURE, HEATING ARRAY

CODE IDENT NO 76301

T-055427



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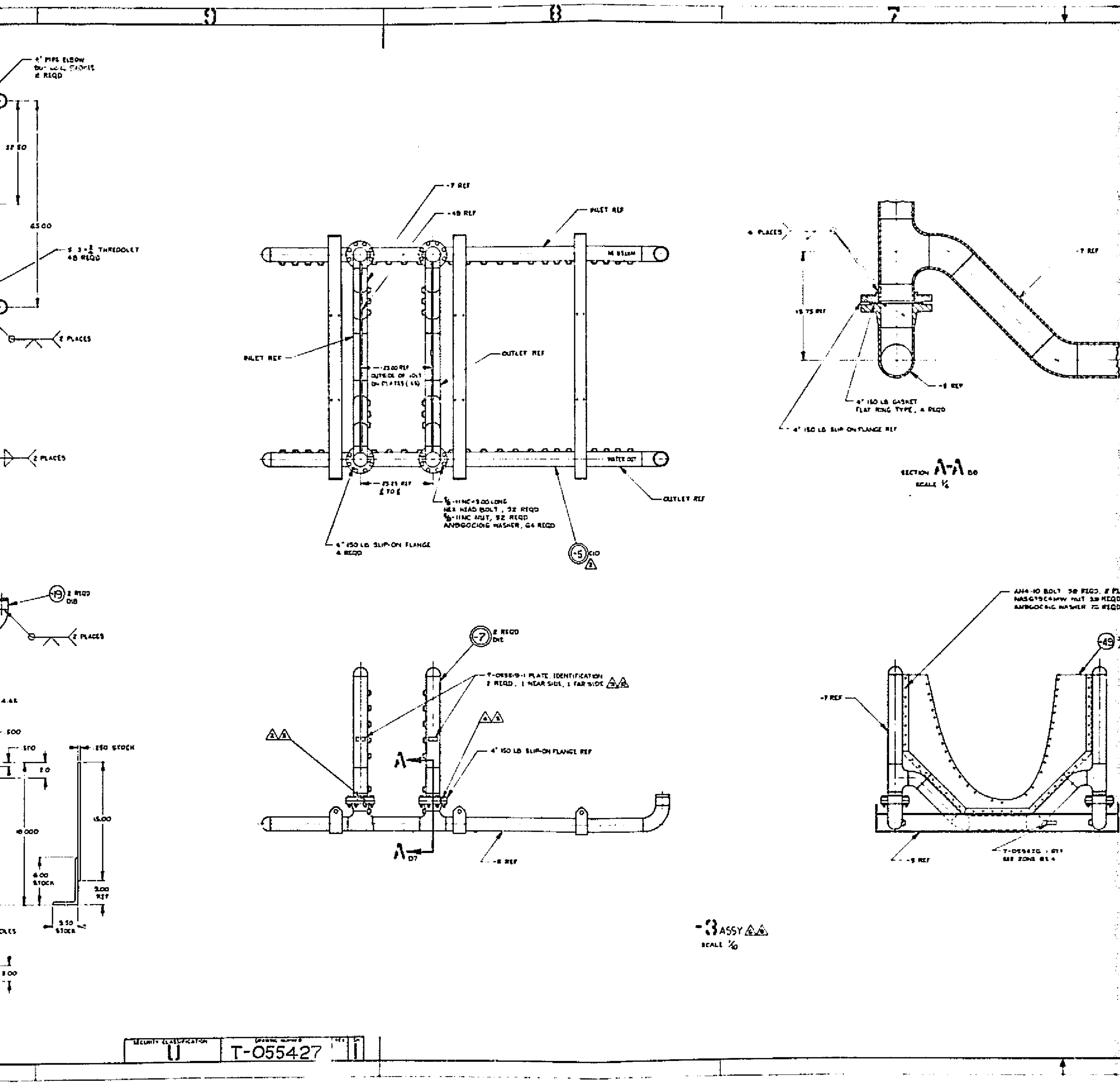
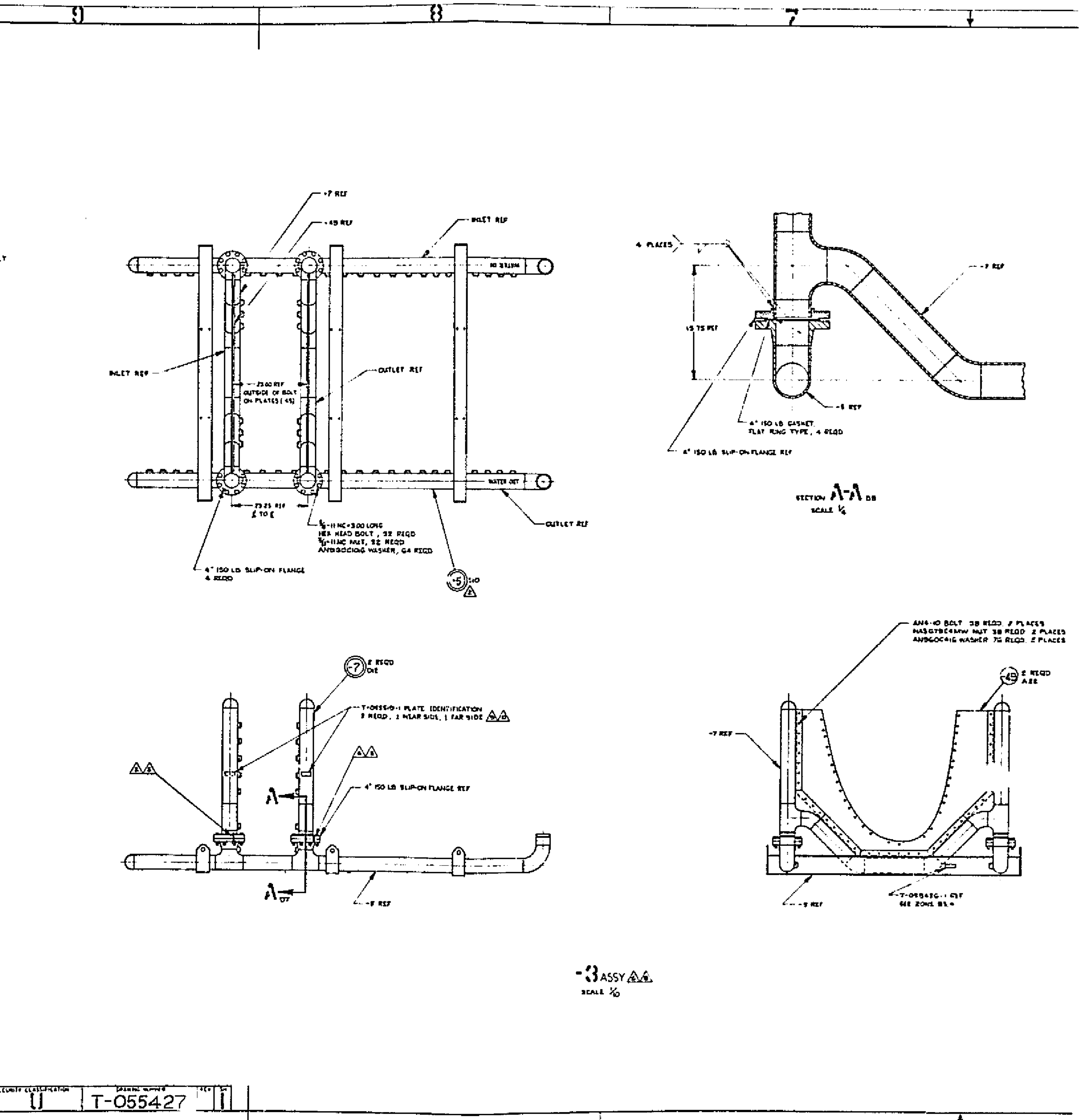
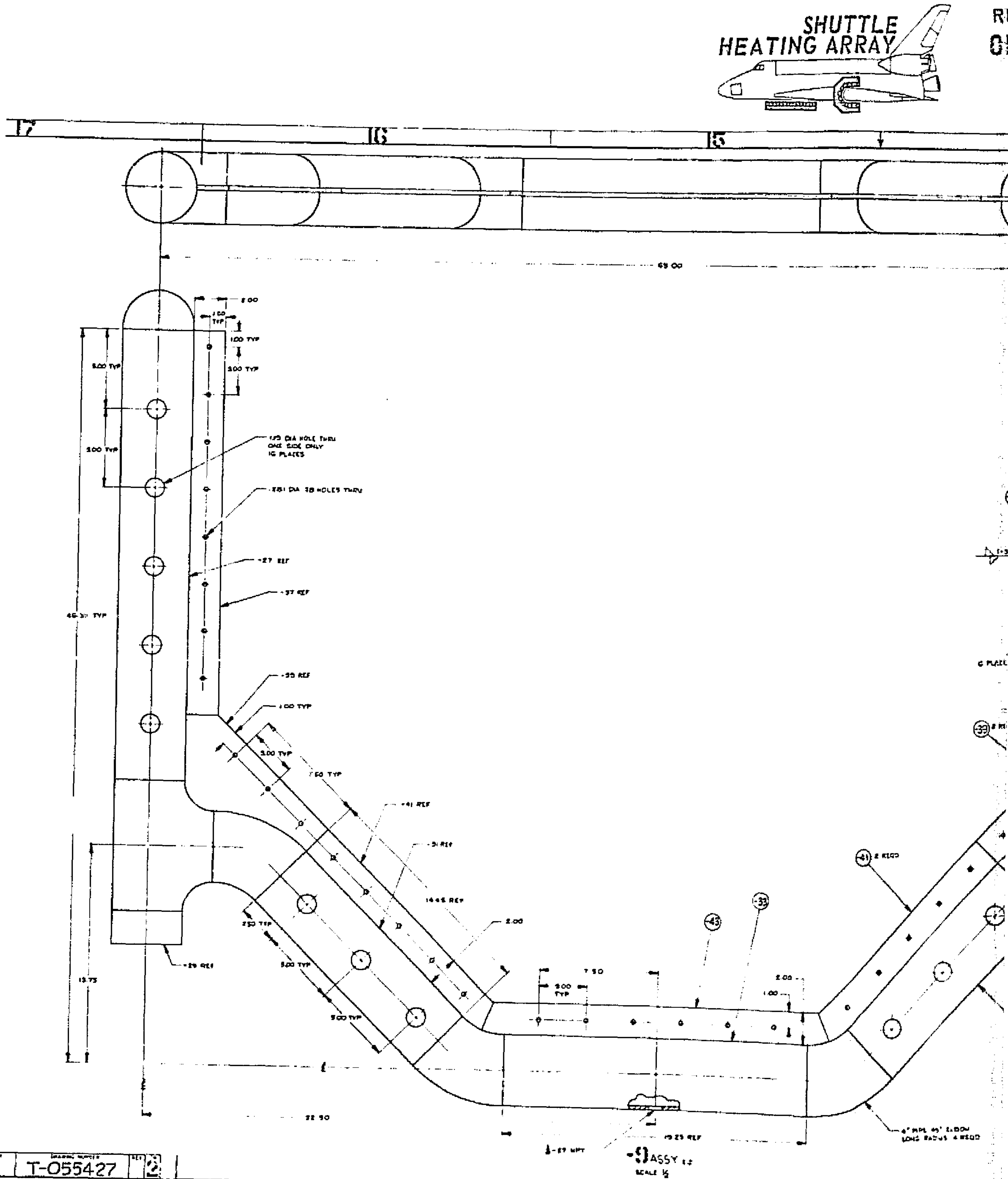

INLET REF
OUTLET REF
4" 150 LB SLIP-ON FLANGE 4 REQD
4" 150 LB SLIP-ON FLANGE REF
4" 150 LB GASKET FLAT RING TYPE, 4 REQD
SECTION A-A
-3 ASSY
U
T-055427



Part 2 of Sheet 1



U | T-055427 | 2

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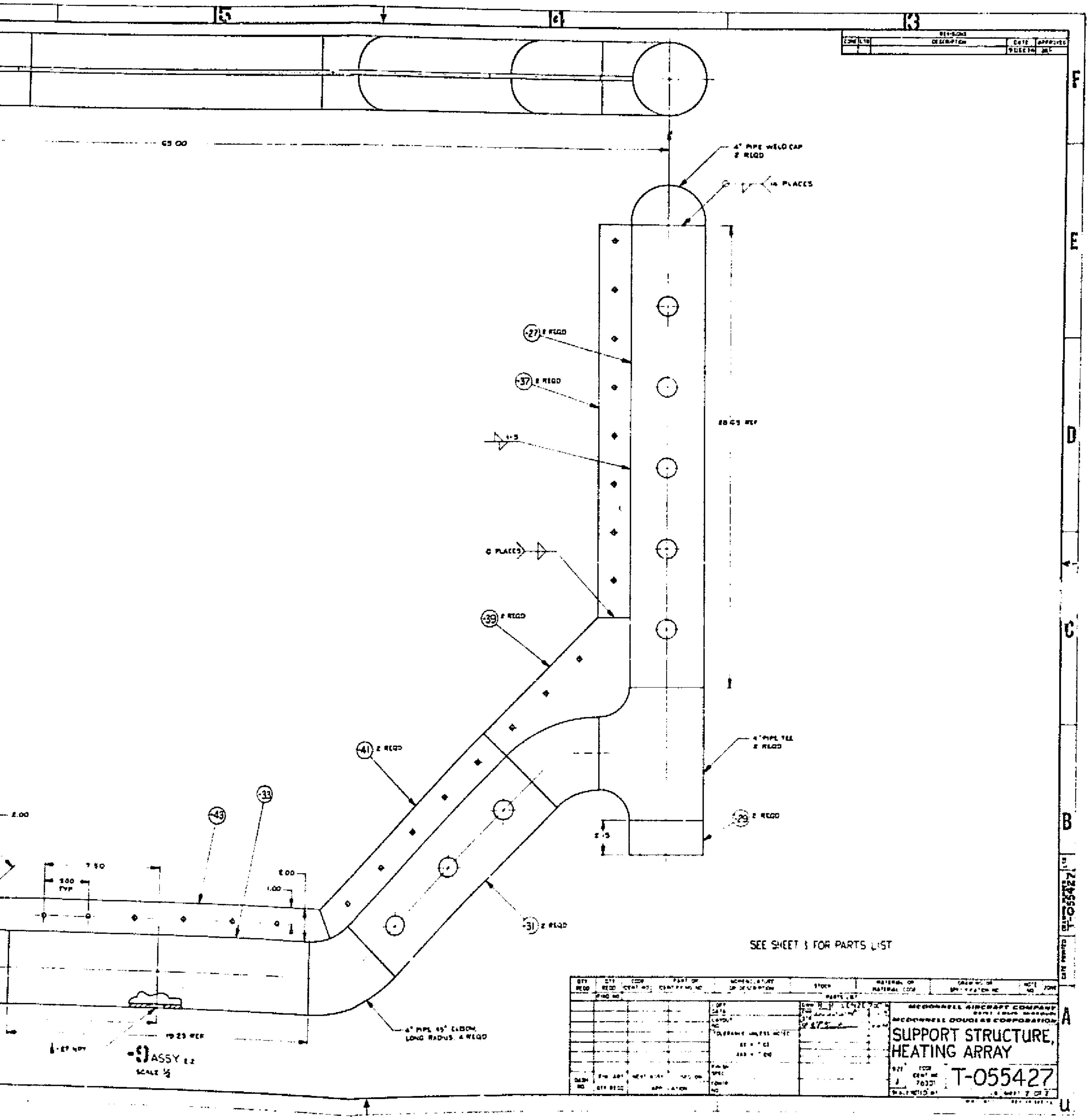

Part 1 of Sheet 2

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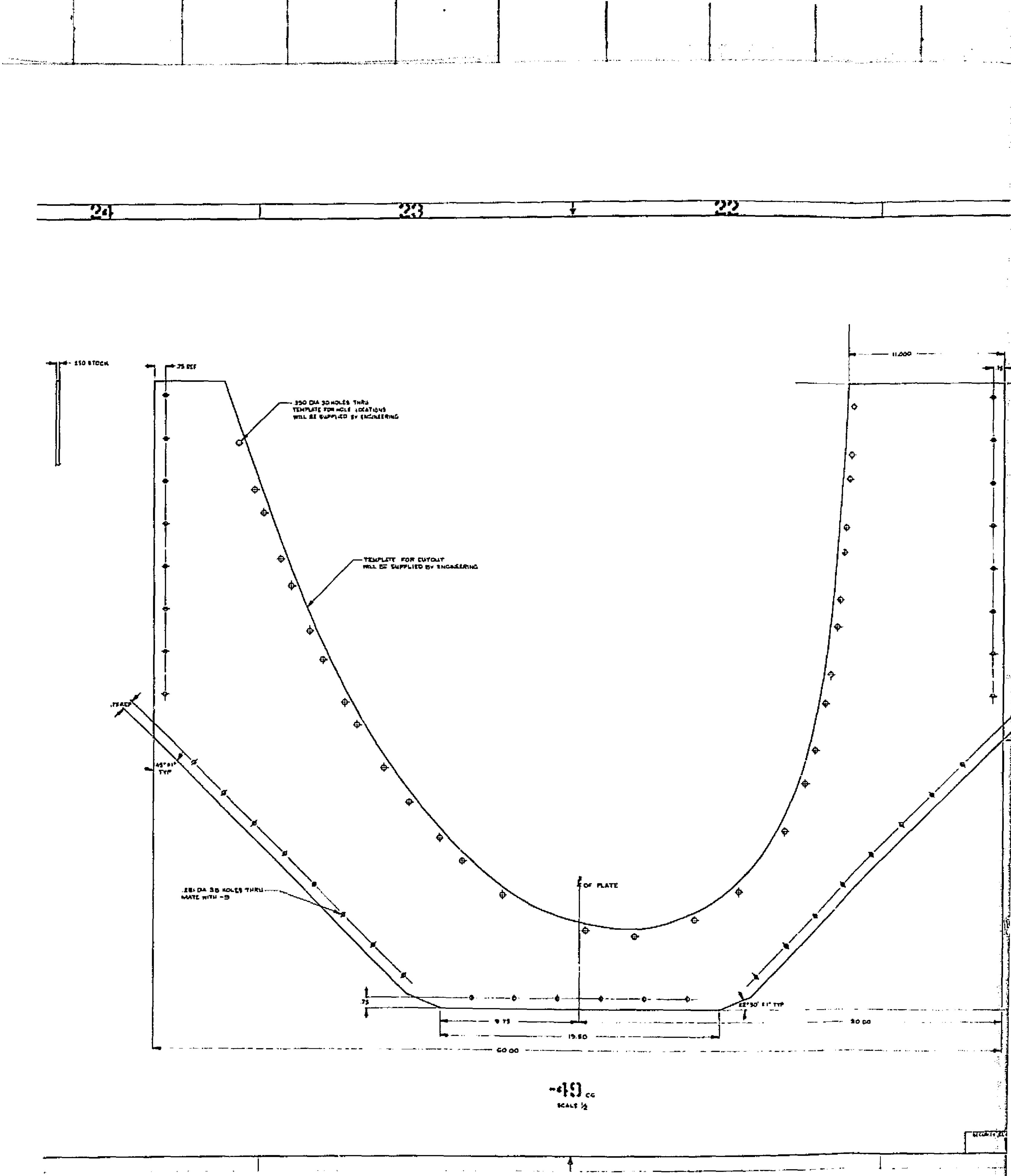

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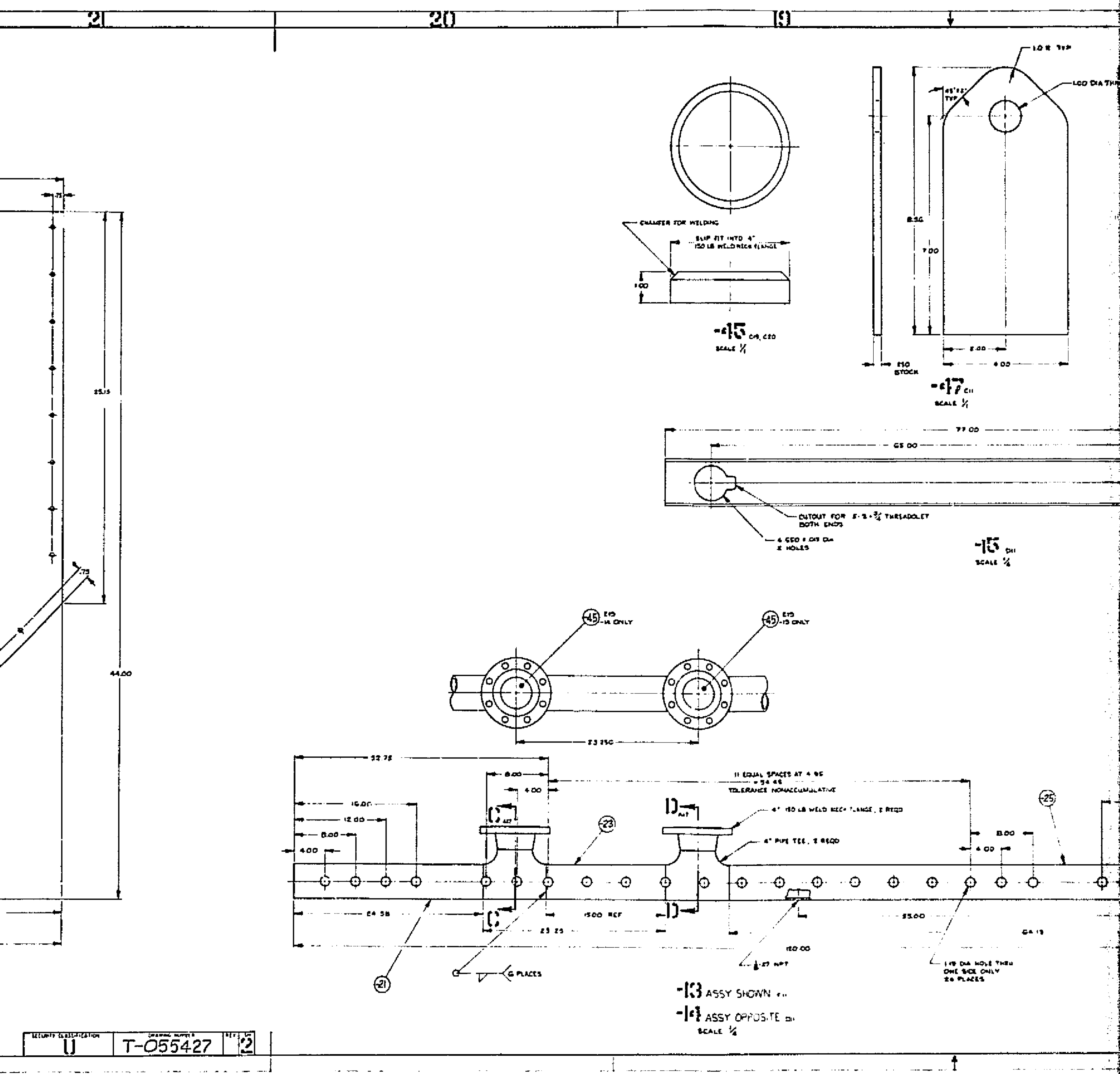
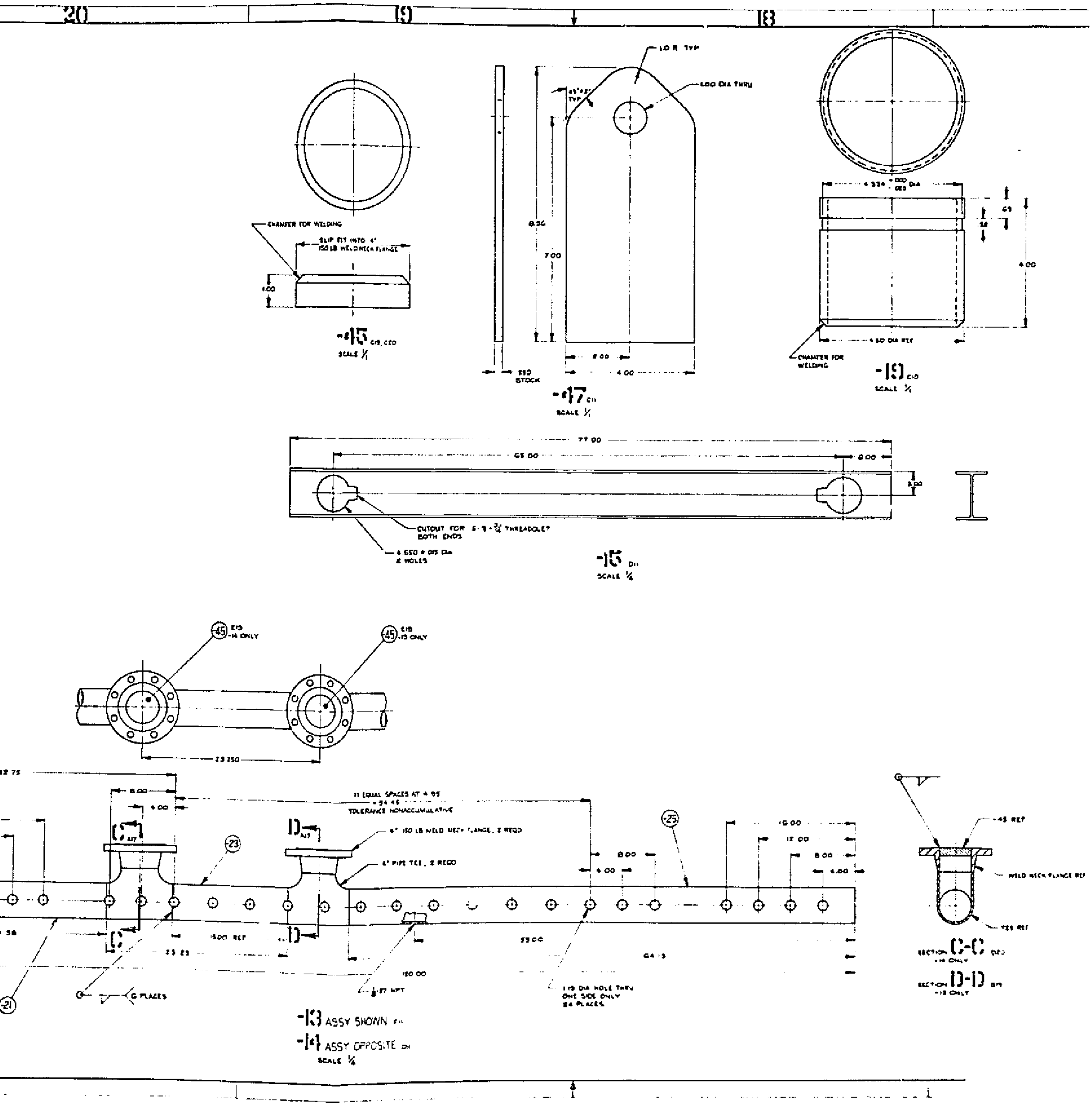
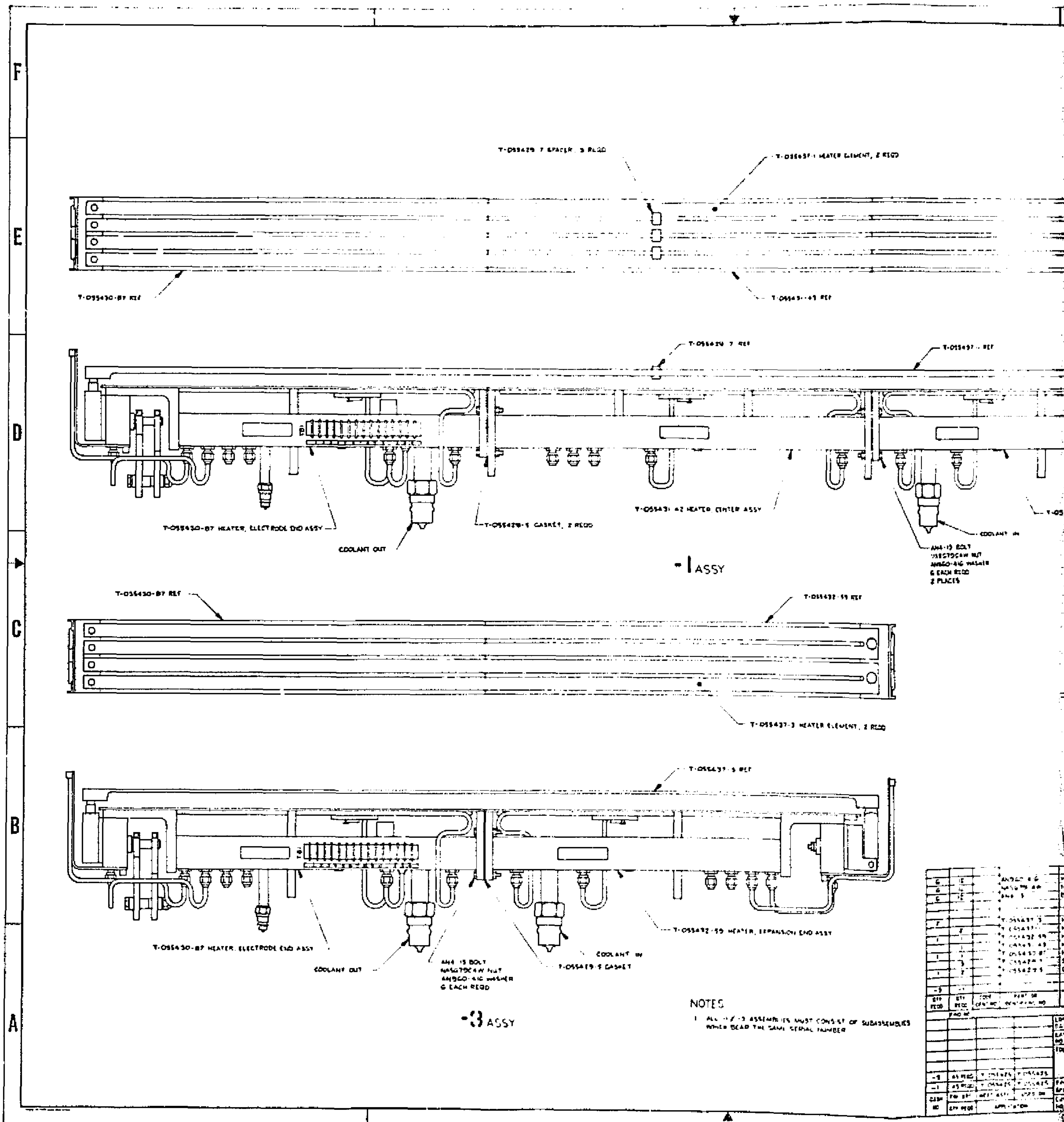
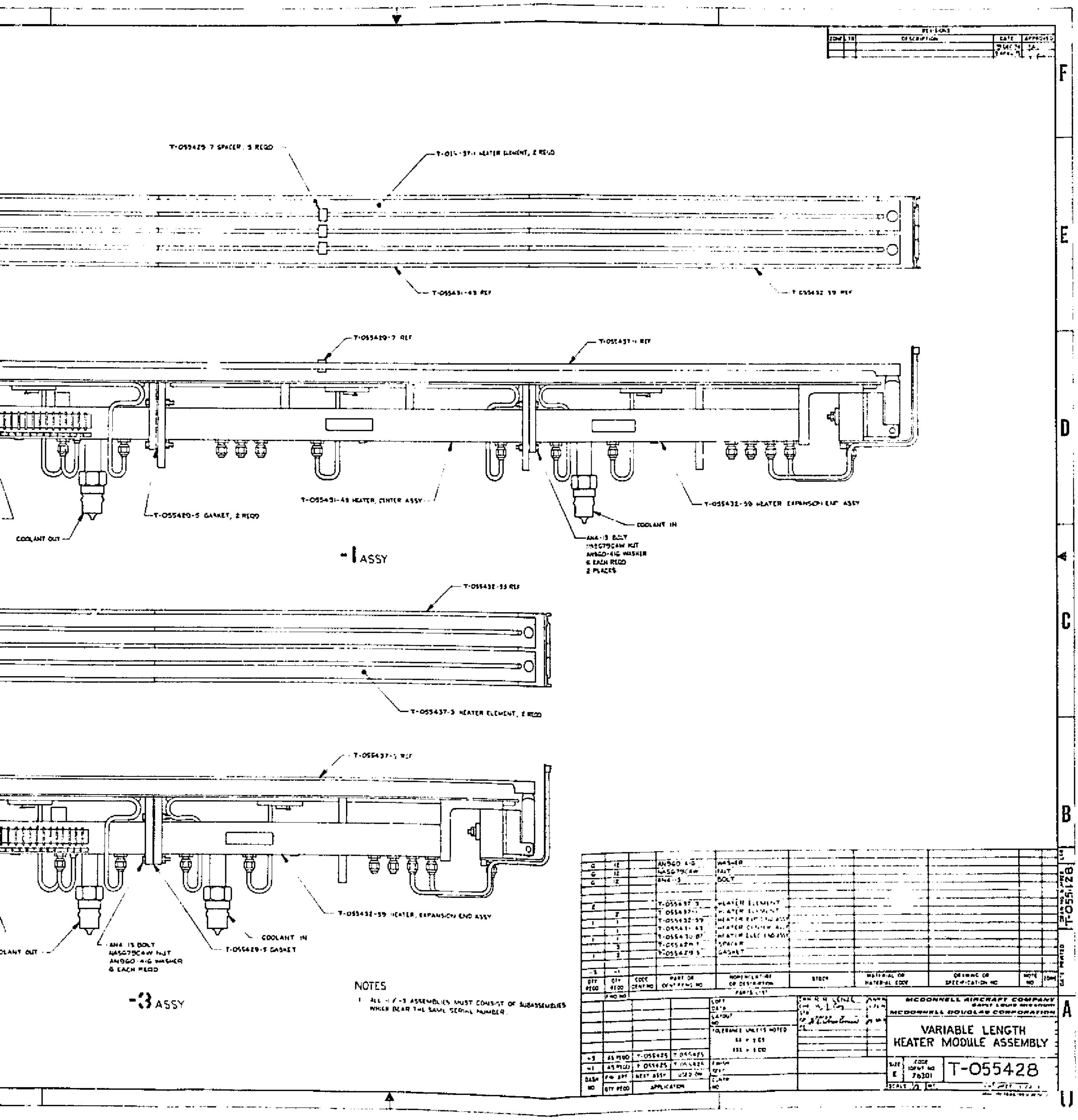
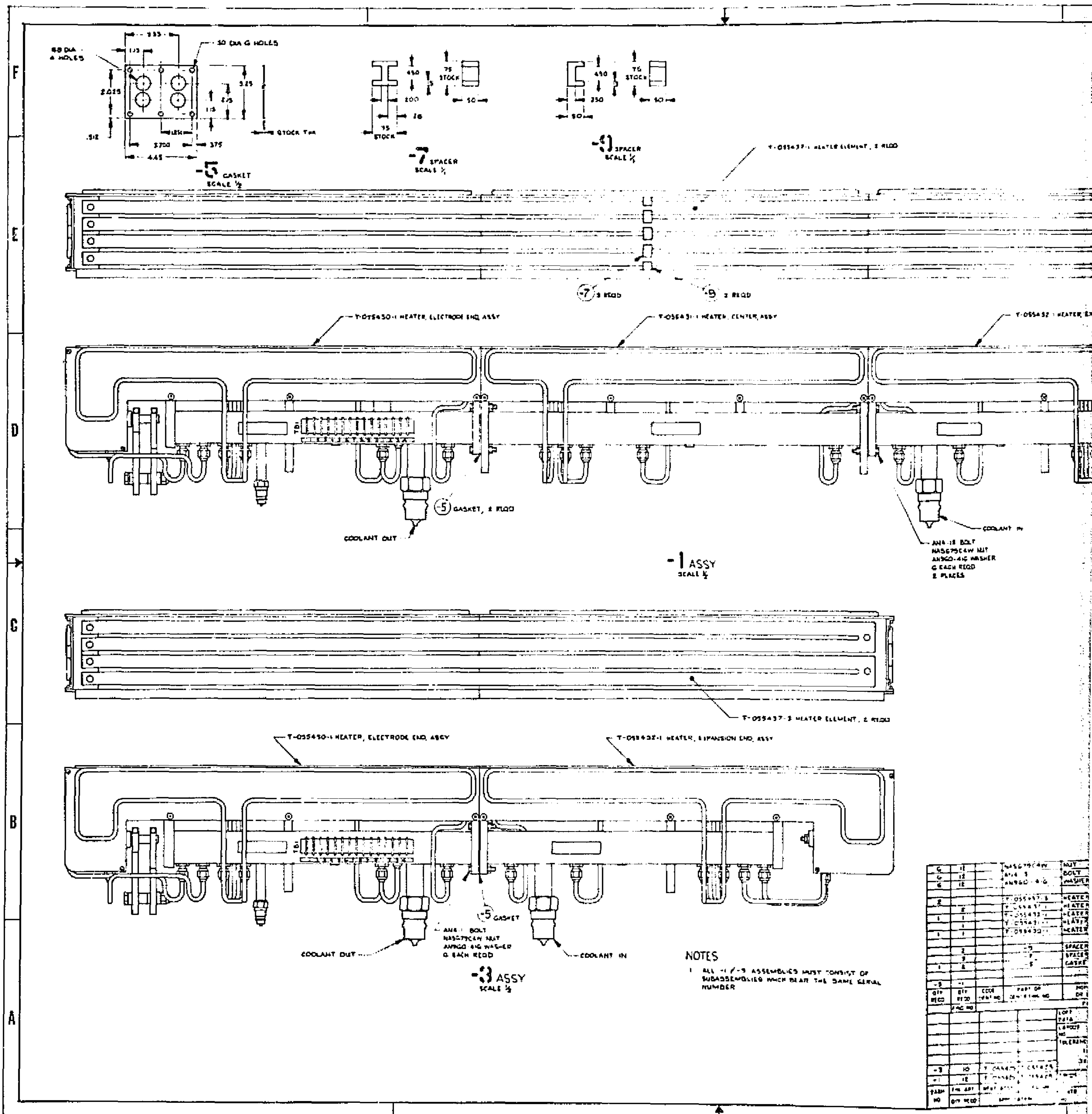

21
20
19
CHAMFER FOR WELDING
-15
SCALE ½
-17
SCALE ½
77.00
65.00
-15
SCALE ¼
11 EQUAL SPACES AT 4.95
TOLERANCE NONACCUMULATIVE
4" 150 LB WELD NECK FLANGE, 2 REQD
4" PIPE TEE, 2 REQD
6 PLACES
-13 ASSY SHOWN
-14 ASSY OPPOSITE
SCALE ¼
U
T-055427
2


20
19
18
1.0 R TYP
1.00 DIA THRU
CHAMFER FOR WELDING
SLIP FIT INTO 4" 150 LB WELDNECK FLANGE
-45
SCALE 1/1
8.56
7.00
4.00
2.00
-47
SCALE 1/1
-19
SCALE 1/1
77.00
65.00
6.00
CUTOUT FOR 5-3-3/4 THREADOLET BOTH ENDS
2 HOLES
-15
SCALE 1/4
23.250
11 EQUAL SPACES AT 4.95 = 54.45
TOLERANCE NONACCUMULATIVE
4" 150 LB WELD NECK FLANGE, 2 REQD
4" PIPE TEE, 2 REQD
16.00
12.00
8.00
4.00
15.00 REF
59.00
64.15
120.00
6 PLACES
ONE SIDE ONLY
24 PLACES
-13 ASSY SHOWN
-14 ASSY OPPOSITE
SCALE 1/4
-45 REF
WELD NECK FLANGE REF
TEE REF
SECTION C-C
SECTION D-D


F
E
D
C
B
A
COOLANT OUT
COOLANT IN
-1 ASSY
-3 ASSY
NOTES


-1 ASSY
-3 ASSY
COOLANT IN
COOLANT OUT
NOTES
McDONNELL AIRCRAFT COMPANY
McDONNELL DOUGLAS CORPORATION
VARIABLE LENGTH HEATER MODULE ASSEMBLY
T-055428



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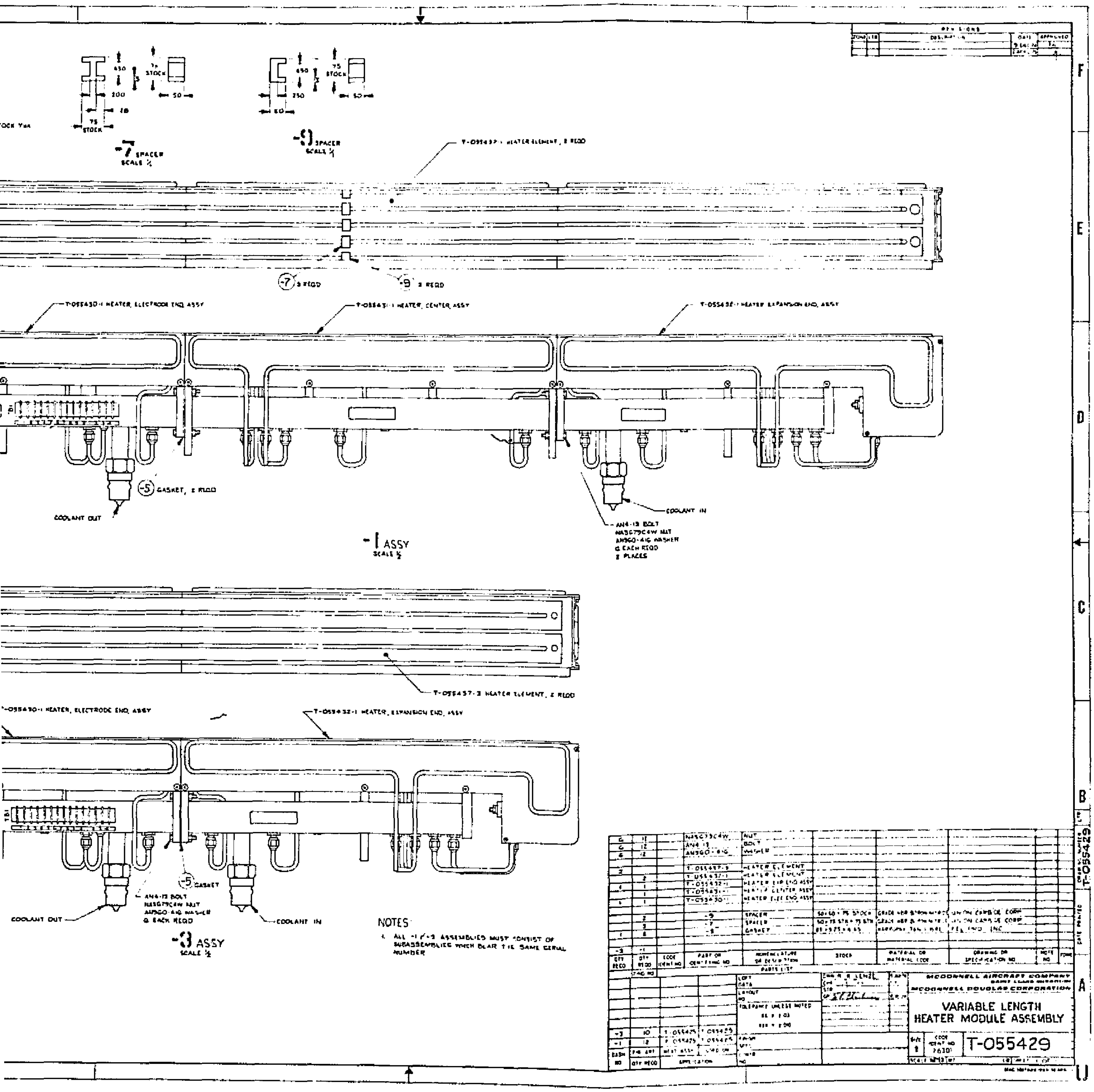
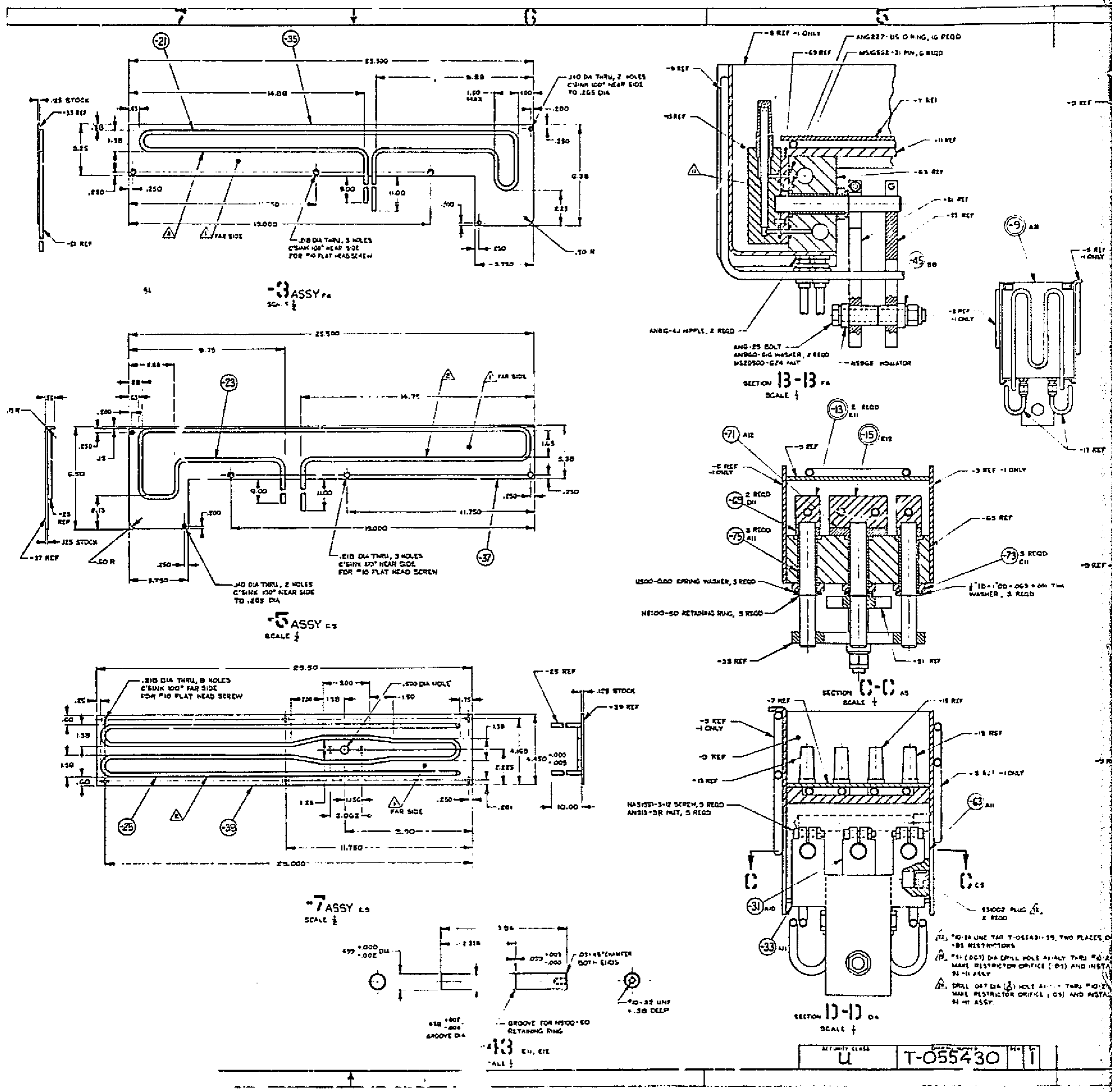
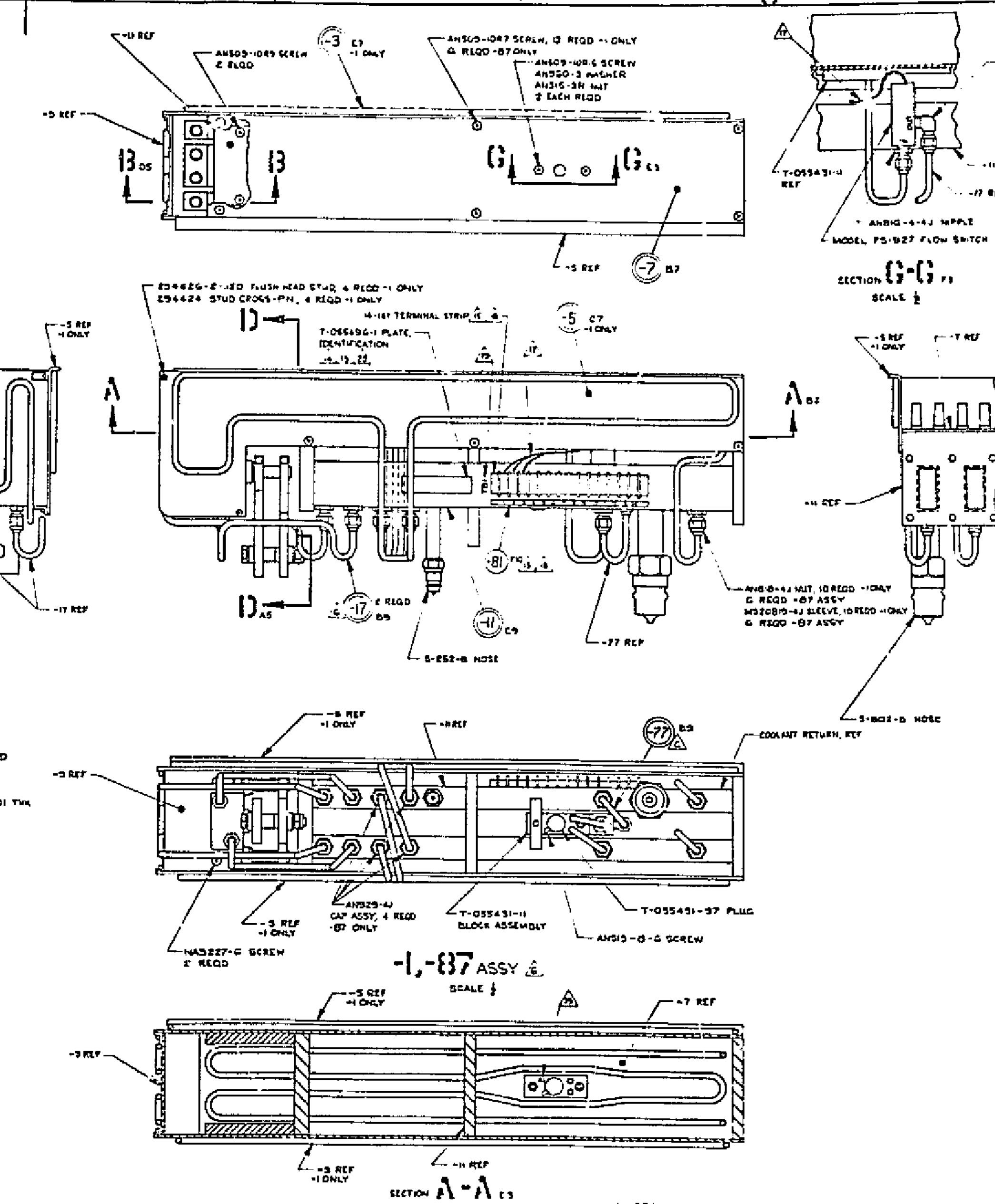
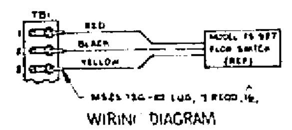

-7 SPACER SCALE ½
-9 SPACER SCALE ½
-7 2 REQD
-9 2 REQD
-5 GASKET, 2 REQD
-5 GASKET
COOLANT OUT
COOLANT IN
-1 ASSY SCALE ½
-3 ASSY SCALE ½
AN4-13 BOLT
NAS679C4W NUT
AN960-416 WASHER
& EACH REQD
NOTES:
1. ALL -1 & -3 ASSEMBLIES MUST CONSIST OF SUBASSEMBLIES WHICH BEAR THE SAME SERIAL NUMBER
PARTS LIST
NUT
BOLT
WASHER
HEATER ELEMENT
SPACER
GASKET
UNION CARBIDE CORP
MCDONNELL AIRCRAFT COMPANY
MCDONNELL DOUGLAS CORPORATION
VARIABLE LENGTH HEATER MODULE ASSEMBLY
76301
T-055429


-3 ASSY
-5 ASSY
-7 ASSY
SECTION B-B
SECTION C-C
SECTION D-D
U
T-055430
1





REDUCED TO 50% OF ORIGINAL

Find No.	Qty	Part or Identifying No.	Nomenclature or Description	Material
		AN929-4J	CAP ASSY	
	3	MS25036-102	LUG	
	1	MS20822-4-4J	ELBOW	
	1	AN816-4-4J	NIPPLE	
	3	[illegible]-100	WASHER	.063 [illegible]
	10	MS20819-4J	SLEEVE	
		MS20426-3-5	RIVET	
	6	MS16562-3-	PIN	
	2	AN960-C6	WASHER	
	8	AN960-3	WASHER	
	10	AN818-4J	NUT	
	1	MS20500-624	NUT	
	9	AN315-3R	NUT	
	9	NAS125-3-2	SCREW	
	1	AN515-8-6	↓	
	2	AN509-10R5	↑	
	2	AN509-10R6		
	12	AN509-10R7	SCREW	
	1	AN6-25	BOLT	
	2	AN816-4J	NIPPLE	
	2	AN815-4J	UNION	
	16	AN6227-05	O-RING	
	2	NAS220-6	SCREW	
	1	16-161	TERMINAL STRIP	CINCH
	3	U500-020	SPRING WASHER	ASSOC
	1	MODEL FS-927	FLOW SWITCH	THE G[illegible]
	1	5-252-8	HOSE	[illegible]
	1	5-802-8	HOSE	[illegible]
	4	Z94426-2-150	FLUSH HEAD STUD	MONAD[illegible]
		Z94432	RECEPTACLE	MONAD[illegible]
	4	Z94424	STUD CROSS-PIN	MONAD[illegible]
	3	N5100-50	RETAINING RING	KEIMA[illegible]
	1	M5965	INSULATOR	NYLON
	2	53-002	PLUG	LEE C[illegible]
	1	T-055490-1	PLATE, IDENTIFICATION	
		T-055431-30	NIPPLE	
	1	T-055431-57	PLUG	
	1	T-055431-11	BLOCK ASSEMBLY	
-83			RESTRICTOR	MAKE[illegible]
-82			RESTRICTOR	MAKE[illegible]
-81			MARKER	MAKE[illegible]
-79			TUBE	.250 [illegible]
-77			TUBE ASSEMBLY	
-75			SLEEVE	[illegible]
-73			SPACER	[illegible]
-71			INSULATOR	[illegible]
-69			INSULATOR	[illegible]
-67			BLOCK	[illegible]
-65			BLOCK	[illegible]
-63			MANIFOLD	[illegible]
-61			PIN	[illegible]
-59			PLATE	[illegible]
-57			PIPE	[illegible]
-55			PIPE	[illegible]
-53			PLATE	[illegible]
-51			PLATE	.500 [illegible]
-49			ANGLE	MAKE[illegible]
-47			RECTANGULAR TUBE	[illegible]
-45			INSULATOR	[illegible]
-43			PIN	.500 [illegible]
-41			PLATE	.125 [illegible]
-39			PLATE	.125 [illegible]
-37			PLATE	.125 [illegible]
-35			PLATE	.125 [illegible]
-33			TERMINAL	[illegible]
-31			TERMINAL	[illegible]
-29			TUBE	.250 [illegible]
-27				
-25				
-23				
-21				[illegible]
-19			TUBE	[illegible]
-17			TUBE ASSEMBLY	
-15			ELECTRODE BLOCK ASSY	
-13			ELECTRODE BLOCK ASSY	
-11			MANIFOLD ASSY	
-9			END REFLECTOR ASSY	
-7			BOTTOM REFLECTOR ASSY	
-5			SIDE REFLECTOR ASSY	
-3			SIDE REFLECTOR ASSY	

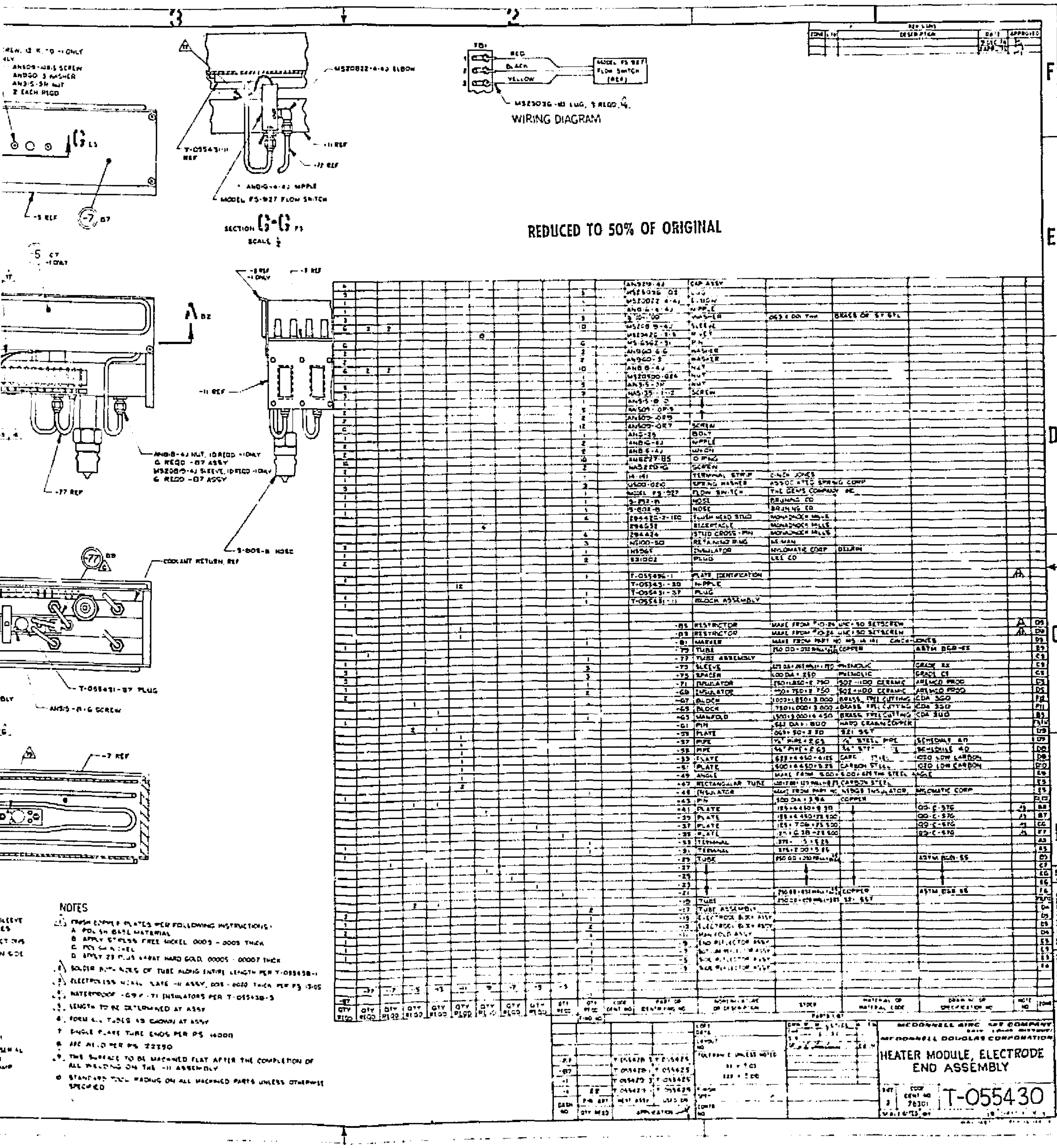
Column headings: -87 QTY REQD; -77, -17, -5, -11, -13, -9, -7, -3, -1 QTY REQD; CODE IDENT NO.; PART OR IDENTIFYING NO.; NOMENCLATURE OR DESCRIPTION; FIND NO.

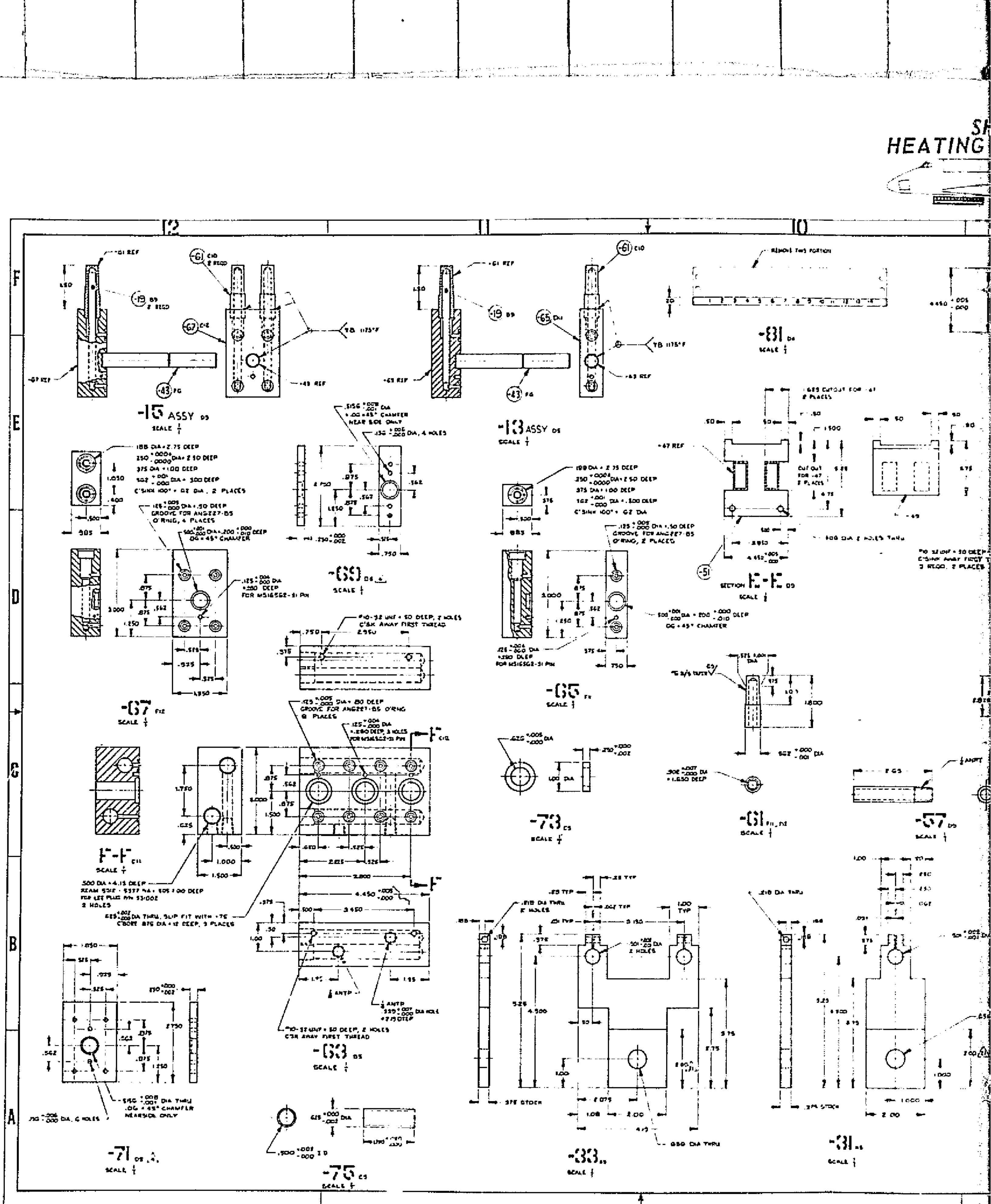
Next Assy	Used On
-87	T-055420 / T-055475
-87	T-055420 / T-055425
-1	T-055473 / T-055475
-1	T-055424 / T-055423

TOLERANCE UNLESS NOTED: .XX ± .03; .XXX ± .010

NOTES

1. FINISH COPPER PLATES PER FOLLOWING INSTRUCTIONS:
   A. POLISH BASE MATERIAL
   B. APPLY STRESS FREE NICKEL .0003 - .0005 THICK
   C. POLISH NICKEL
   D. APPLY 23 PLUS KARAT HARD GOLD .00005 - .00007 THICK
2. SOLDER BOTH SIDES OF TUBE ALONG ENTIRE LENGTH PER T-055450-1
3. ELECTROLESS NICKEL PLATE -11 ASSY, .001 - .0010 THICK PER PS 13105
4. WATERPROOF -69 & -71 INSULATORS PER T-055450-3
5. LENGTH TO BE DETERMINED AT ASSY
6. FORM ALL TUBES AS SHOWN AT ASSY
7. SINGLE FLARE TUBE ENDS PER PS 14009
8. ARC WELD PER PS 27750
9. THIS SURFACE TO BE MACHINED FLAT AFTER THE COMPLETION OF ALL WELDING ON THE -11 ASSEMBLY
10. STANDARD TOOL RADIUS ON ALL MACHINED PARTS UNLESS OTHERWISE SPECIFIED
11. FILL COUNTER BORE CAVITY IN -63 MANIFOLD AROUND -75 SLEEVE WITH GENERAL ELECTRIC RTV-60 SILICONE RUBBER, 5 PLACES
12. INSTALL P/N 53-002 PLUGS PER MANUFACTURERS INSTRUCTIONS
13. SELECT COPPER SHEET FREE FROM SCRATCHES AND GOUGES ON SIDE TO BE GOLD PLATED
14. POSITION AND LOCATE PLATE APPROXIMATELY AS SHOWN
15. CEMENT WITH EC 776 PER PS 10002
16. ASSEMBLE ELECTRICAL CABLE PER P.S. 17150
17. SEE WIRING DIAGRAM FOR TERMINATION OF WIRES
18. CEMENT WITH EC 68/A, 3M COMPANY
19. RUBBER STAMP IN .25 HIGH WHITE CHARACTERS PER PS 20001
20. SERIALIZE HEATER MODULES BY STEEL STAMPING PROPER SERIAL NUMBER ON NAMEPLATE. SERIAL NUMBERS SHALL RUN IN SEQUENCE, STARTING WITH THE NUMBER 1. STEEL STAMP NAMEPLATE BEFORE ATTACHING TO ASSEMBLY
21. MACHINE ONE SIDE FLAT TO DIMENSION SHOWN


WIRING DIAGRAM
RED
BLACK
YELLOW
MODEL FS-927 FLOW SWITCH (REF)
SECTION G-G
REDUCED TO 50% OF ORIGINAL
COOLANT RETURN, REF
-T-055431-37 PLUG
AN3-21 SCREW
AN929-4J CAP ASSY
MS20622-4-4J ELBOW
AN816-4-4J NIPPLE
WASHER
SLEEVE
RIVET
PIN
WASHER
WASHER
NUT
NUT
NUT
SCREW
SCREW
BOLT
NIPPLE
UNION
O RING
SCREW
TERMINAL STRIP CINCH JONES
SPRING WASHER ASSOCIATED SPRING CORP
MODEL FS-927 FLOW SWITCH THE GEMS COMPANY INC
FLUSH HEAD STUD
RECEPTACLE
STUD CROSS PIN
RETAINING RING
INSULATOR
PLUG
T-055496-1 PLATE IDENTIFICATION
NIPPLE
T-055431-37 PLUG
BLOCK ASSEMBLY
-85 RESTRICTOR
-83 RESTRICTOR
-81 MARKER
-79 TUBE
-77 TUBE ASSEMBLY
-73 SLEEVE
-75 SPACER
-71 INSULATOR
-69 INSULATOR
-67 BLOCK
-65 BLOCK
-63 MANIFOLD
-61 PIN
PLATE
PIPE
PIPE
PLATE
PLATE
ANGLE
RECTANGULAR TUBE
INSULATOR
PIN
PLATE
PLATE
PLATE
PLATE
TERMINAL
TERMINAL
TUBE
TUBE
TUBE ASSEMBLY
NOTES
MCDONNELL DOUGLAS CORPORATION
HEATER MODULE, ELECTRODE END ASSEMBLY
T-055430



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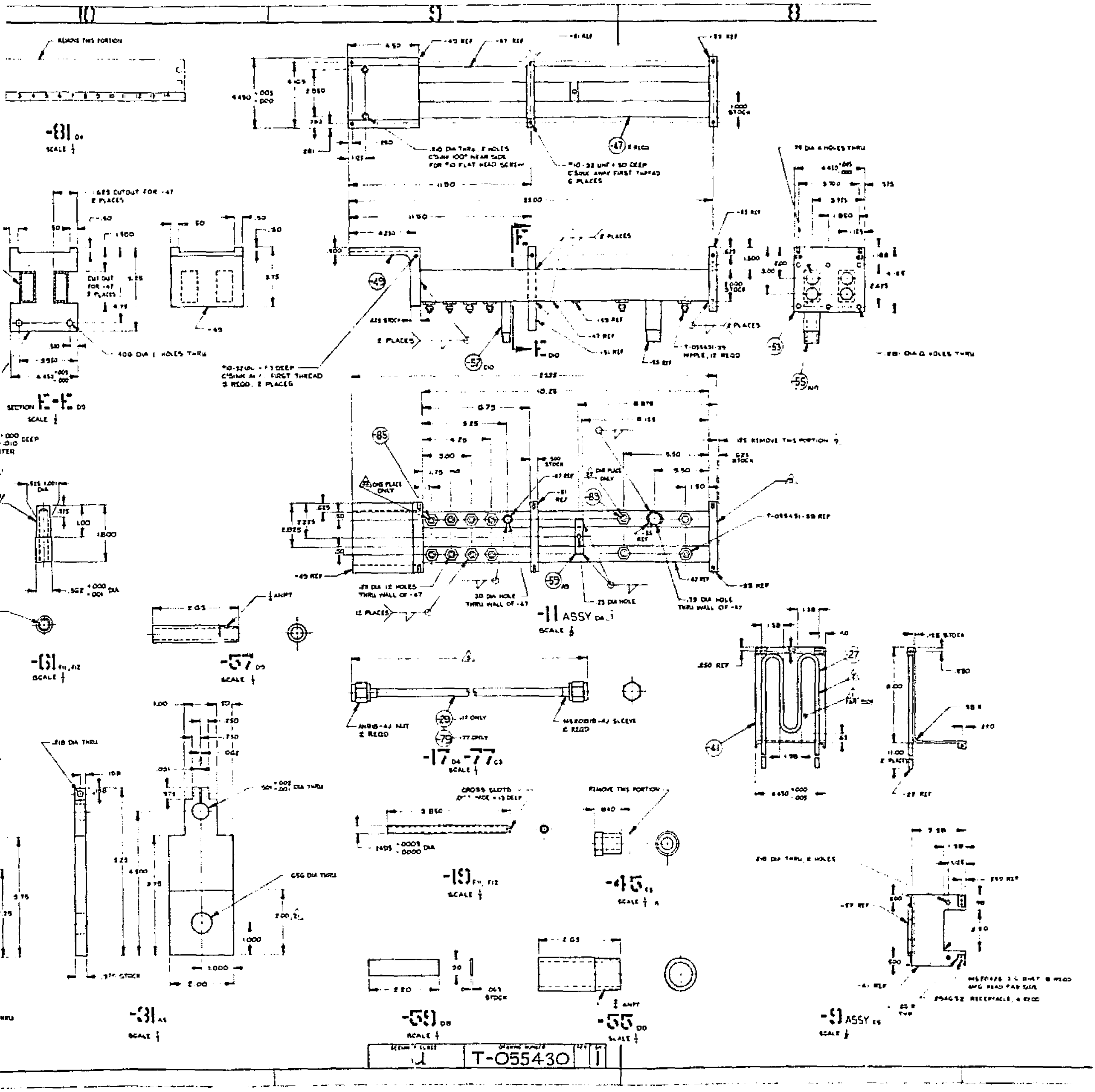
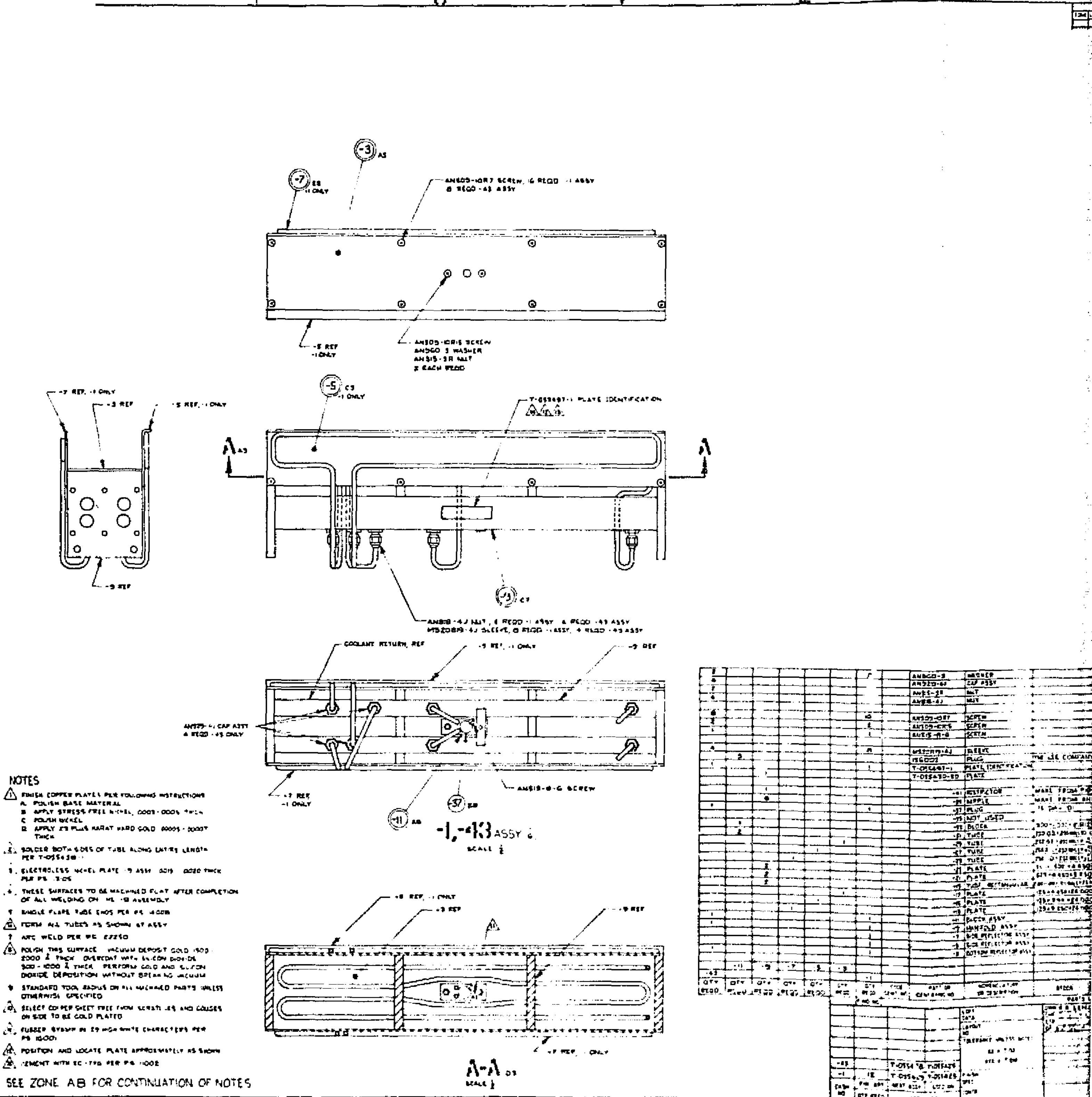


Part 2 of Sheet 1



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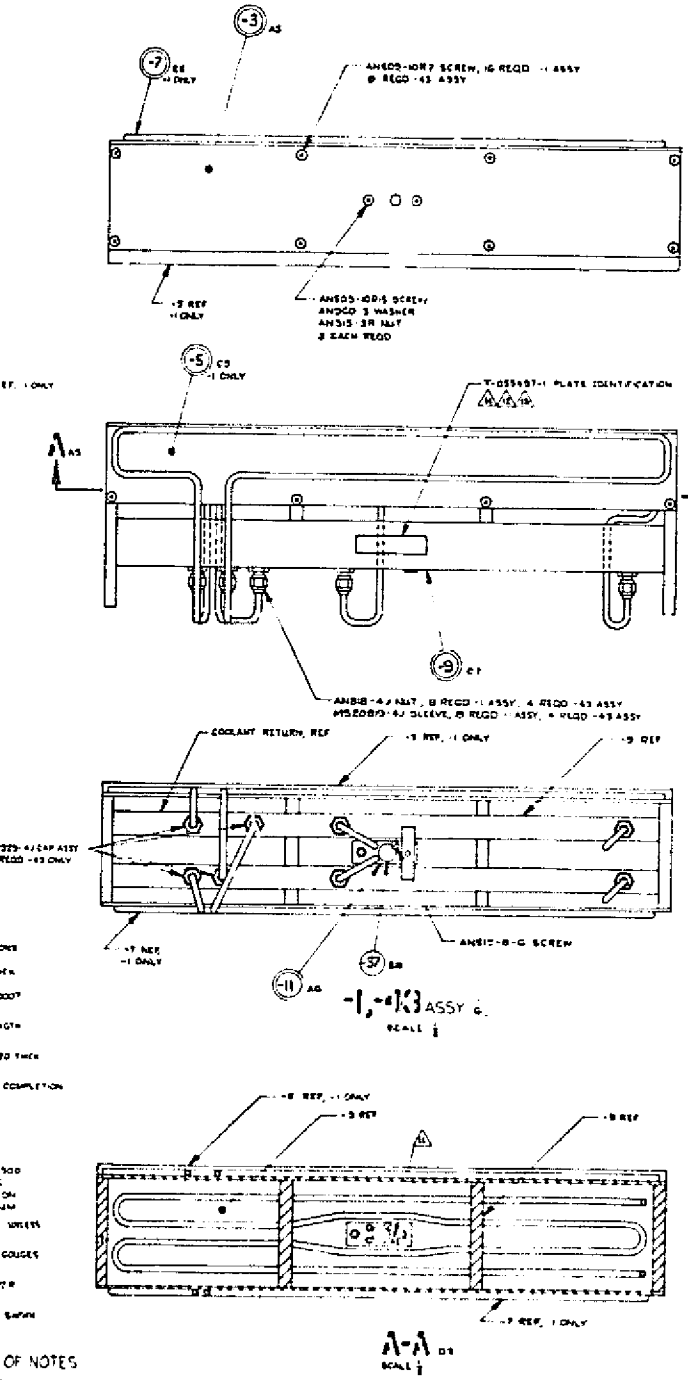


QTY REQD -41	QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	CODE IDENT NO	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	STOCK	MATERIAL OR MATERIAL CODE	DRAWING NO OR SPECIFICATION NO	NOTE NO	ZONE
2						7		AN960-3	WASHER					
4								AN929-4J	CAP ASSY					
1						2		AN315-3R	NUT					
4						8		AN818-4J	NUT					
8						16		AN505-10R7	SCREW					
7						2		AN505-10R5	SCREW					
1						1		AN515-8-6	SCREW					
4						8		MS20819-4J	SLEEVE					
	2							15E002	PLUG	THE LEE COMPANY				
1						1		T-055497-1	PLATE, IDENTIFICATION				Δ	
	1							T-055430-33	PLATE					
	8							-61	RESTRICTOR	MAKE FROM [illegible] SETSCREW			Δ	D7
4								-59	NIPPLE	MAKE FROM AN815-4J UNION				C7
						1		-57	PLUG	[illegible]	BRASS			B5
								-55	NOT USED					
	1							-53	BLOCK	[illegible]	BRASS FREE CUTTING	CDA 360		B6
	2							[illegible]	TUBE	[illegible]	COPPER	ASTM B68-55		B6
				1				[illegible]	TUBE	[illegible]	COPPER	ASTM B68-55		B5
					1			-47	TUBE	[illegible]	COPPER	ASTM B68-55		C5
			1					[illegible]	TUBE	[illegible]	COPPER	ASTM B68-55		C5
		2						[illegible]	PLATE	[illegible]	CARBON STEEL	1020 LOW CARBON		E6
		2						[illegible]	PLATE	[illegible]	CARBON STEEL	1020 LOW CARBON		E6
		2						[illegible]	TUBE, RECTANGULAR	[illegible]	CARBON STEEL	1020 LOW CARBON		E7
					1			-27	PLATE	[illegible]	COPPER	QQ-C-576	[illegible]	D6
				1				-25	PLATE	[illegible]	COPPER	QQ-C-576	[illegible]	D5
			1					[illegible]	PLATE	[illegible]	COPPER	QQ-C-576	[illegible]	E5
1						1		-11	BLOCK ASSY					B5
1						1		-9	MANIFOLD ASSY					C7
						1		-7	SIDE REFLECTOR ASSY					E7
1						1		-5	SIDE REFLECTOR ASSY					D8
						1		-3	BOTTOM REFLECTOR ASSY					E9
-41	-11	-9	-7	-5	-3	-1								

PARTS LIST

-43		T-055428 T-055415
-41	12	T-055429 T-055425
DASH NO	QTY REQD	NEXT ASSY / USED ON

APPLICATION

TOLERANCE UNLESS NOTED .XX ± .03 .XXX ± .020

MCDONNELL AIRCRAFT COMPANY

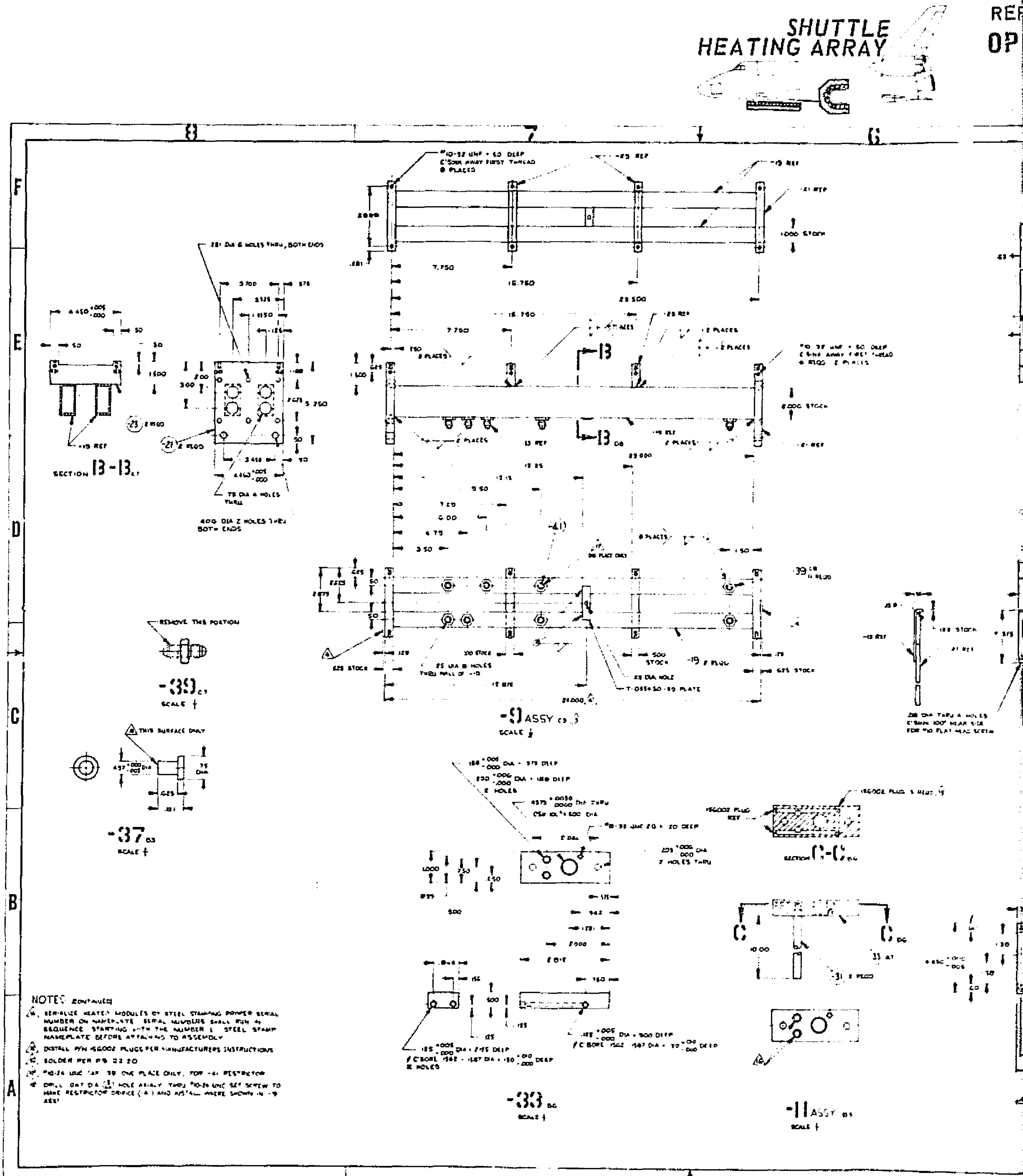
MCDONNELL DOUGLAS CORPORATION

HEATER MODULE CENTER ASSEMBLY

CODE IDENT NO 76301 T-055431

SHEET 1 OF 1

Part 1 of Sheet 1



FOLDOUT FRAME

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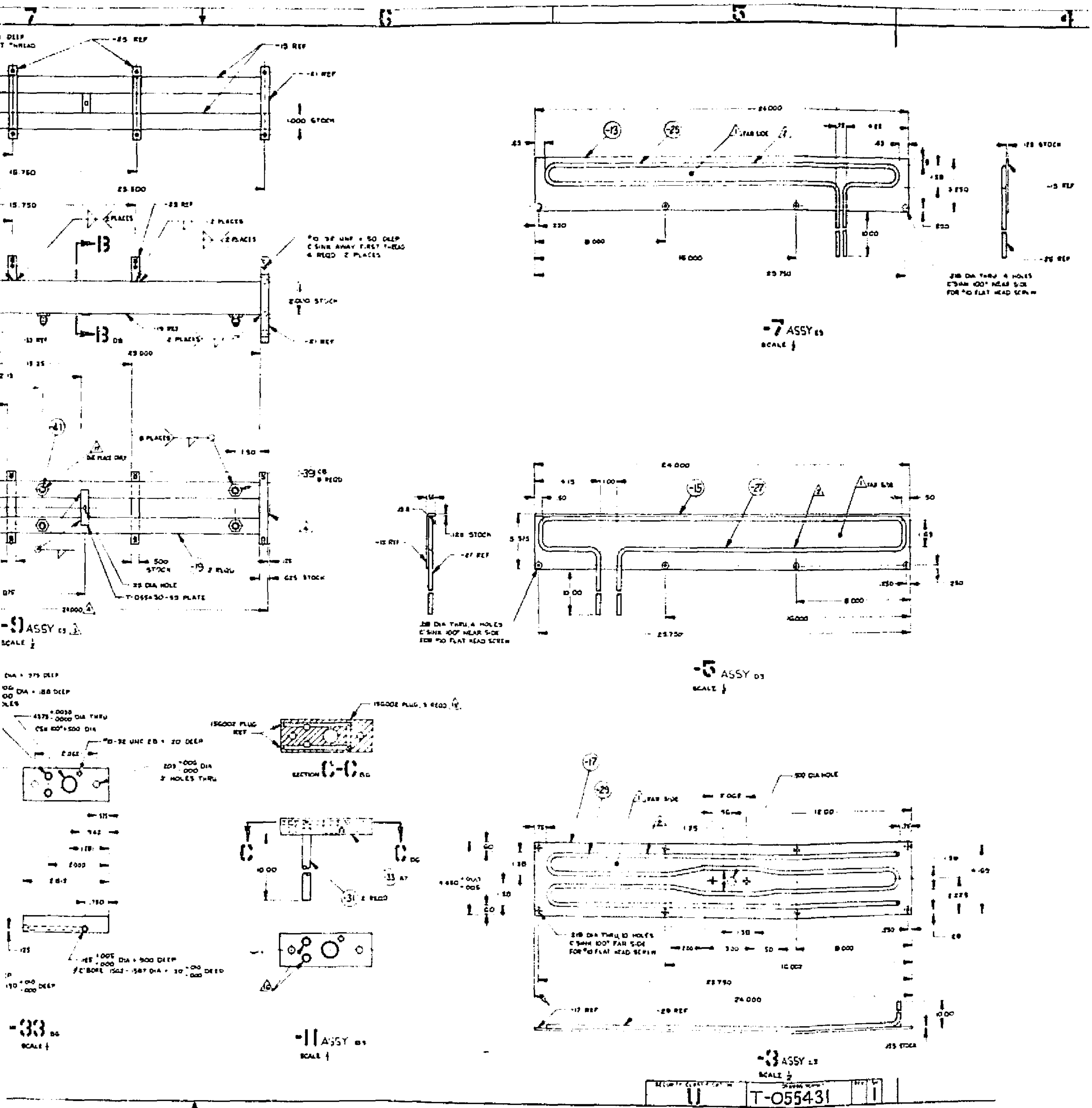
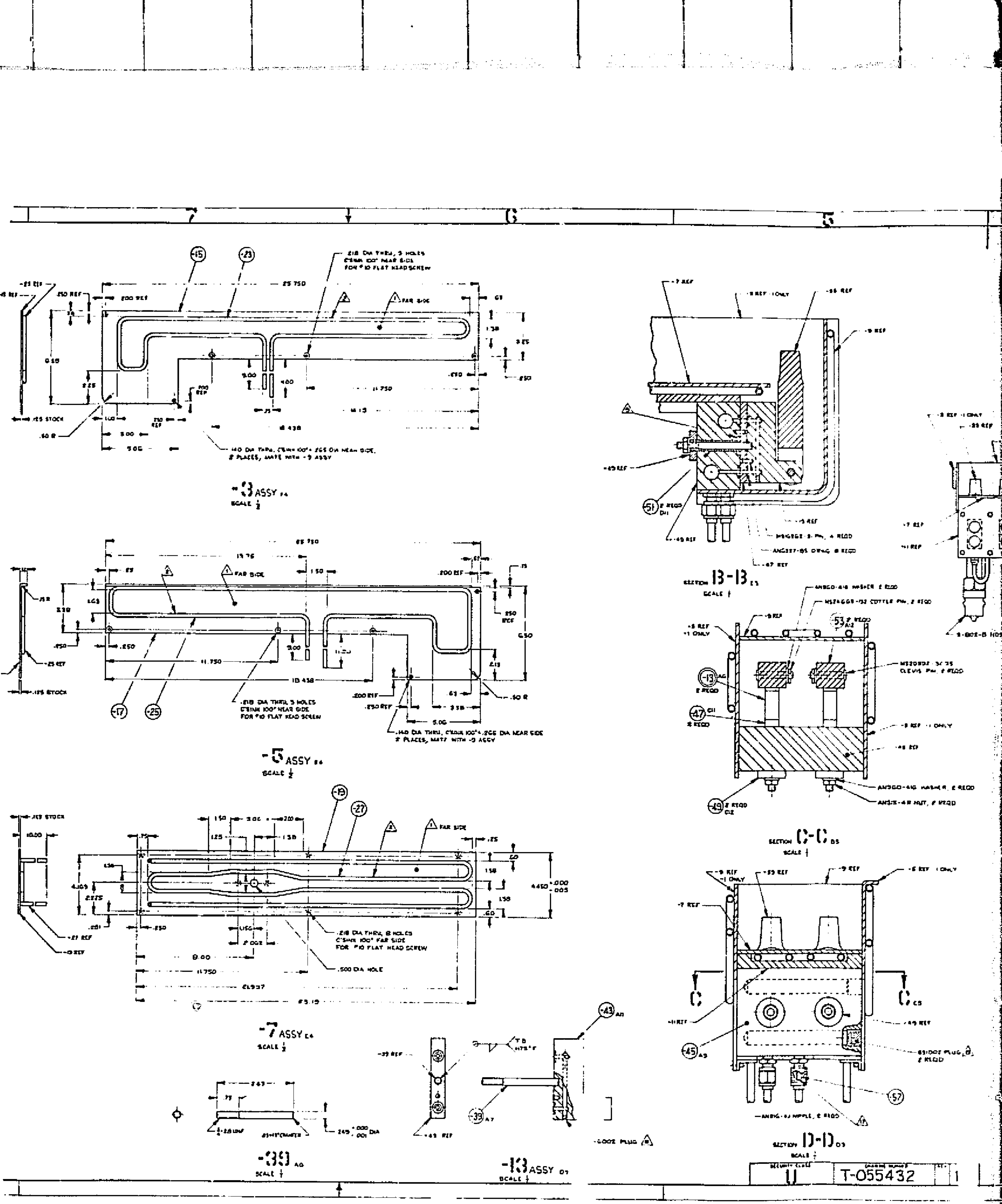
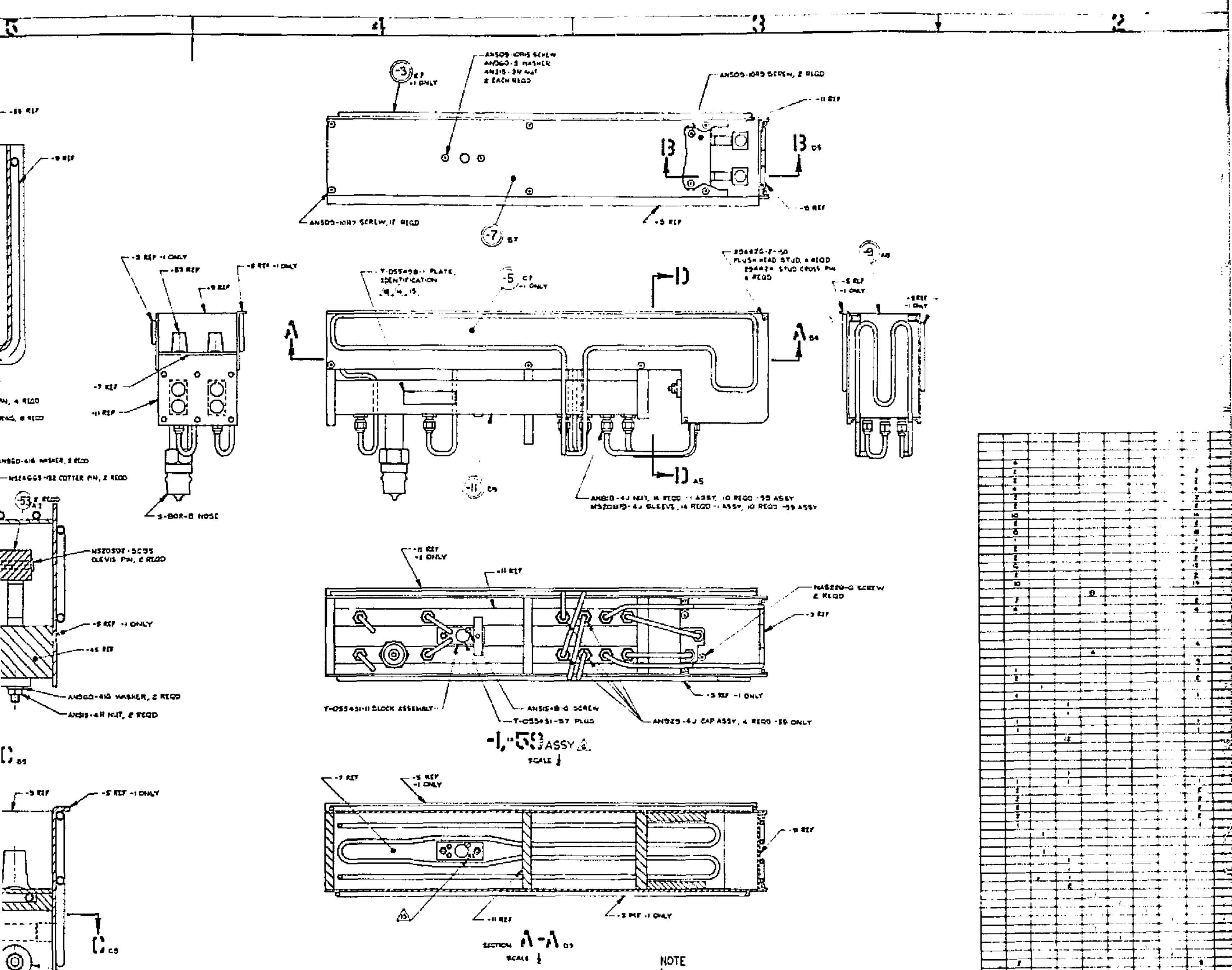

-7 ASSY
SCALE 1/2
-9 ASSY
SCALE 1/2
-5 ASSY
SCALE 1/2
SECTION C-C
-33
SCALE 1
-11 ASSY
SCALE 1
-3 ASSY
SCALE 1/2
U
T-055431


-3 ASSY
SCALE ½
-5 ASSY
SCALE ½
-7 ASSY
SCALE ½
-39
SCALE 1/1
-13 ASSY
SECTION B-B
SECTION C-C
SECTION D-D
U
T-055432
1

OUT FRAME /

SHUTTLE
HEATING ARRAY



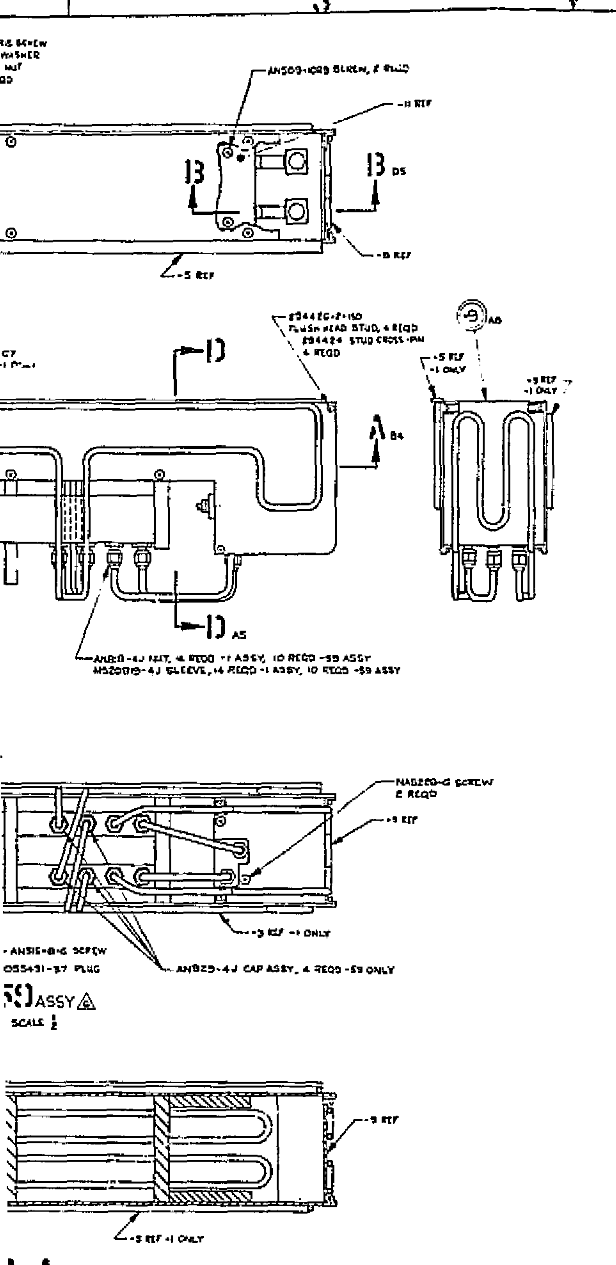
NOTE

11. STANDARD TOOL RADIUS ON ALL MACHINED PARTS UNLESS OTHERWISE SPECIFIED
12. SELECT COPPER SHEET FREE OF SCRATCHES AND GOUGES ON SIDE TO BE GOLD PLATED
13. RUBBER STAMP IN .25 HIGH WHITE CHARACTERS PER PS 15001
14. POSITION AND LOCATE PLATE APPROXIMATELY AS SHOWN
15. CEMENT WITH EC 776 PER PS 11002
16. SERIALIZE HEATER MODULES BY STEEL STAMPING PROPER SERIAL NUMBER ON NAMEPLATE. SERIAL NUMBERS SHALL RUN IN SEQUENCE, STARTING WITH THE NUMBER 1. STEEL STAMP NAMEPLATE BEFORE ATTACHING TO ASSEMBLY
17. 10-32UNC TAP T-055431-59, 2 PLACES ONLY / AN816-4J ONE PLACE ONLY FOR -55 & -57 RESTRICTOR
18. .51 (.067) DIA DRILL HOLE AXIALY THRU 10-24 SETSCREW TO MAKE RESTRICTOR ORIFICE (-57) AND INSTALL WHERE SHOWN IN -1, -11 & -59 ASSY
19. DRILL .047 DIA (3/64) HOLE AXIALY THRU 10-24 SETSCREW TO MAKE RESTRICTOR ORIFICE (-55) AND INSTALL WHERE SHOWN IN -11 ASSY

1. FINISH COPPER PLATES PER FOLLOWING INSTRUCTIONS:
   A. POLISH BASE MATERIAL
   B. APPLY STRESS FREE NICKEL, .0003 - .0005 THICK
   C. POLISH NICKEL
   D. APPLY 23 PLUS KARAT HARD GOLD, .00005 - .0001 THICK
2. SOLDER BOTH SIDES OF TUBE ALONG ENTIRE LENGTH PER T-055438
3. ELECTROLESS NICKEL PLATE -11 ASSY, .0007 - .0010 THICK PER PS 13109
4. ARC WELD PER PS 22250
5. SINGLE FLARE TUBE ENDS PER PS 14000
6. FORM ALL TUBES AS SHOWN AT ASSY
7. THIS SURFACE TO BE MACHINED FLAT AFTER COMPLETION OF ALL WELDING ON THE -11 ASSEMBLY
8. INSTALL 51002 & 16002 PLUGS PER MANUFACTURERS INSTRUCTIONS
9. FILL COUNTER BORE CAVITY IN -48 MANIFOLD AROUND -51 SLEEVE WITH GENERAL ELECTRIC RTV-30 SILICONE RUBBER, 2 PLACES
10. WATERPROOF -47 INSULATOR PER T-055438-3

T-055432 | 11

FOLDOUT FRAME 2



PARTS UNLESS OTHERWISE ...
AND GOUGES ON SIDE TO BE ...
... PER PS 16001
... AS SHOWN
... PING PROPER SERIAL NUMBER ... RUN IN SEQUENCE, STARTING ... PLATE BEFORE ATTACHING
... AN816-4J ON PLACE ONLY
... SETSCREW TO MAKE RESTRICTOR ... -11 & -59 ASSY
... SETSCREW TO MAKE RESTRICTOR ... -11 ASSY.

NOTE

1. FINISH COPPER PLATES PER FOLLOWING INSTRUCTIONS:
   A. POLISH BASE MATERIAL
   B. APPLY STRESS FREE NICKEL, .0003 - .0005 THICK
   C. POLISH NICKEL
   D. APPLY 23 PLUS KARAT HARD GOLD, .00005 - .00007 THICK
2. SOLDER BOTH SIDES OF TUBE ALONG ENTIRE LENGTH PER T-055438-1
3. ELECTROLESS NICKEL PLATE, -11 ASSY, .0015 - .0020 THICK PER PS 13109
4. ARC WELD PER P.S. 22250
5. SINGLE FLARE TUBE ENDS PER P.S. 14000
6. FORM ALL TUBES AS SHOWN AT ASSY
7. THIS SURFACE TO BE MACHINED FLAT AFTER COMPLETION OF ALL WELDING ON THE -11 ASSEMBLY
8. INSTALL P/N 531002 & 156002 PLUGS PER MANUFACTURES INSTRUCTIONS
9. FILL COUNTER BORE CAVITY IN -45 MANIFOLD AROUND -51 SLEEVE WITH GENERAL ELECTRIC RTV-30 SILICONE RUBBER, 2 PLACES
10. WATERPROOF -47 INSULATOR PER T-055478-3

QTY REQD	QTY REQD -59	QTY REQD -13	QTY REQD -11	QTY REQD -9	QTY REQD -7	QTY REQD -5	QTY REQD -3	QTY REQD -1	CODE IDENT NO	PART OR IDENTIFYING NO / FIND NO	NOMENCLATURE OR DESCRIPTION	STOCK	MATERIAL OR ALTERNATE CODE	DRAWING OR SPECIFICATION NO	NOTE NO	ZONE
	4									AN929-4J	CAP ASSY					
	2							2		MS3328-6	SCREW					
	2							2		AN815-4J	NIPPLE					
	4							4		AN960-416	WASHER					
	2							2		AN960-7	WASHER					
	2							2		AN315-4R	NUT					
	10							14		AN818-4J	NUT					
	2							2		AN316-3R	NUT					
	8							8		AN6227-8S	O-RING					
	1							1		AN515-8-6	SCREW					
	2							2		AN509-10R15	SCREW					
	2							2		AN509-10R9	SCREW					
	6							12		AN509-10R7	SCREW					
	2							2		MS24665-137	COTTER PIN					
	10							14		MS20819-4J	SLEEVE					
				8						MS20426-3-5	RIVET					
	2							2		MS20392-3C35	CLEVIS PIN					
	4							4		MS16562-31	PIN					
								4		254424	STUD CROSS-PIN	MONADNOCK MILLS				
				4						254632	RECEPTACLE	MONADNOCK MILLS				
								4		254420-2-150	FLUSH HEAD STUD	MONADNOCK MILLS				
	1							1		B-002-B	NOSE	BRUNING CO				
	2							2		531002	PLUG	LEE CO.				
		1								156002	PLUG	LEE CO.				
	1							1		T-055498-1	PLATE, IDENTIFICATION					
			1							T-055430-89	PLATE					
			1							T-055430-95	PIPE					
	1							1		T-055431-11	BLOCK ASSEMBLY					
	1							1		T-055431-57	PLUG					
			12							T-055431-59	NIPPLE					
			1							-57	RESTRICTOR	MAKE FROM #10-24	UNC × .50 SETSCREW			D9
	1		1					1		-55	RESTRICTOR	MAKE FROM #10-24	UNC × .50 SETSCREW			D9
	2							2		-53	LEVER	.075 × 1.00 × 4.688	GRAPHITE, GRADE ATJS	UNION CARBIDE		D5
	2							2		-51	SLEEVE	.375 OD × .01 WALL × .722	PHENOLIC	GRADE XX		D6
	2							2		-49	SPACER	.100 DIA × .570	PHENOLIC	GRADE CE		C5
	2							2		-47	INSULATOR	.250 × .500 × 2.75	502-1100 CERAMIC	AREMCO PROD.		C5
	1							1		-45	MANIFOLD	1.500 × 3.000 × 4.450	BRASS, FREE CUTTING	CDA 360		A5
		1								-43	BLOCK	.500 × 1.91 × 2.75	BRASS, FREE CUTTING	CDA 360		B6
										-41	NOT USED					
		1								-39	STUD	.250 DIA × 2.05	BRASS, FREE CUTTING	CDA 360		A6
			1							-37	PLATE	.075 × 4.125 × 4.450	CARBON STEEL	1020 LOW CARBON		D10
			1							-35	PLATE	.500 × 4.450 × 5.25	CARBON STEEL	1020 LOW CARBON		E8
			1							-33	ANGLE	MAKE FROM .500 ×	.500 × .075 THK STEEL	ANGLE		D9
			2							-31	RECTANGULAR TUBE	1.00 × 2.63 × .12 WALL	CARBON STEEL			E10
				1						-29	TUBE	.250 OD × .010 WALL	COPPER	ASTM B68-55		C8
					1					-27	TUBE	.250 OD × .030 WALL		ASTM B68-55		CC
						1				-25	TUBE	.250 OD × .030 WALL		ASTM B68-55		C7
							1			-23	TUBE	.250 OD × .030 WALL		ASTM B68-55		F7
				1						-21	PLATE	.175 × 4.450 × 10.38		QQ-C-576		B8
					1					-19	PLATE	.175 × 4.450 × 25.19		QQ-C-576		C7
						1				-17	PLATE	.175 × 7.00 × 25.500		QQ-C-576		C7
							1			-15	PLATE	.175 × 7.75 × 25.500	COPPER	QQ-C-576		F7
	2							2		-13	SUPPORT BLOCK ASSY					C5
	1							1		-11	MANIFOLD ASSY					D4
	1							1		-9	END REFLECTOR ASSY					C3
	1							1		-7	BOTTOM REFLECTOR ASSY					E4
								1		-5	SIDE REFLECTOR ASSY					F4
								1		-3	SIDE REFLECTOR ASSY					F4

PARTS LIST

DASH NO	QTY REQD	NEXT ASSY	USED ON
-59		T-055428-3	T-055425
-59		T-055428-1	T-055425
-1		T-055429-3	T-055425
-1	22	T-055429-1	T-055425
	FIN ART	APPLICATION	

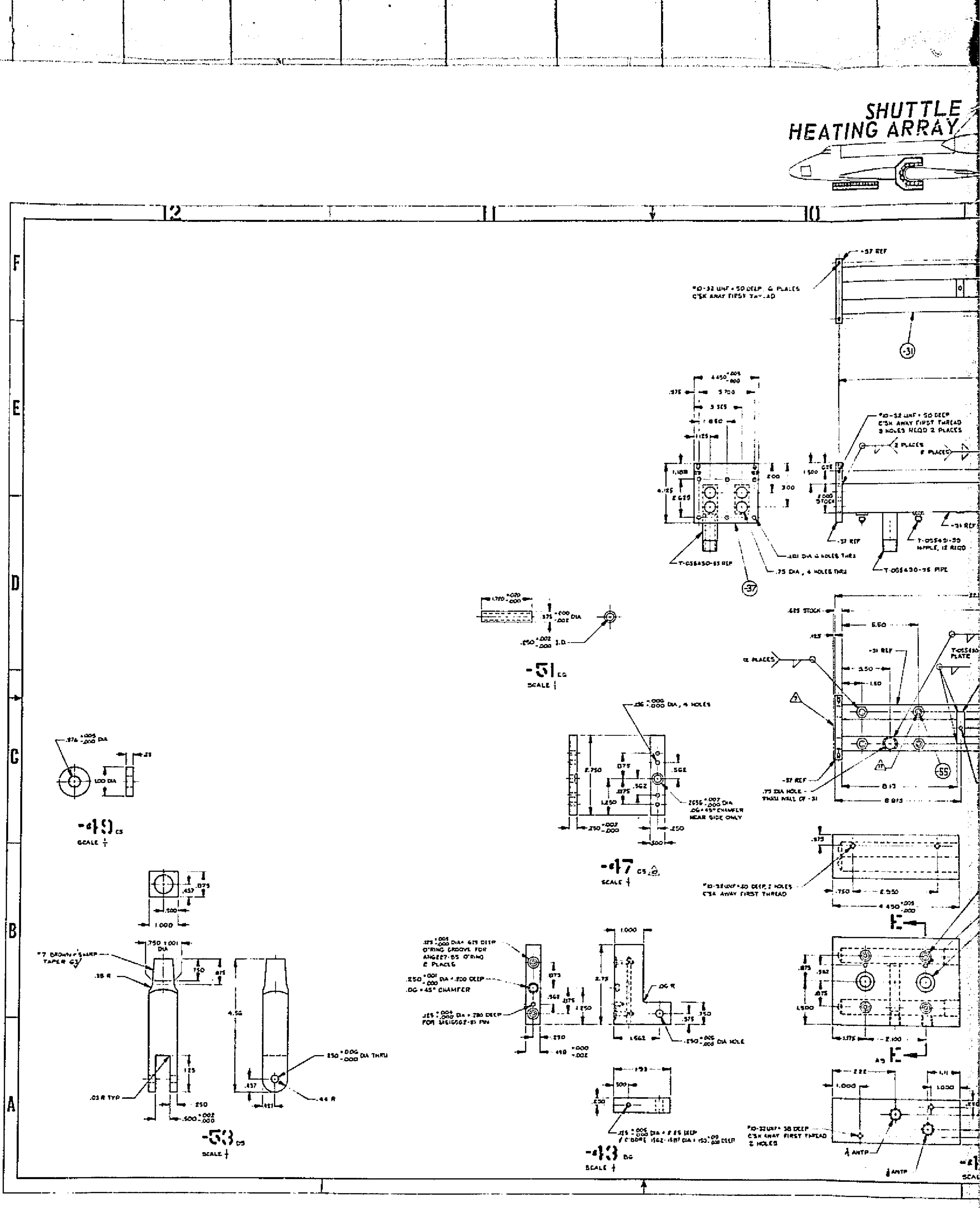
TOLERANCE UNLESS NOTED
.XX ± .03
.XXX ± .010

MCDONNELL AIRCRAFT COMPANY
SAINT LOUIS, MISSOURI
MCDONNELL DOUGLAS CORPORATION

HEATER MODULE, EXPANSION END ASSEMBLY

SIZE J | CODE IDENT NO. 76301 | T-055432

SHEET 1 OF 1



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OF POOR QUALITY

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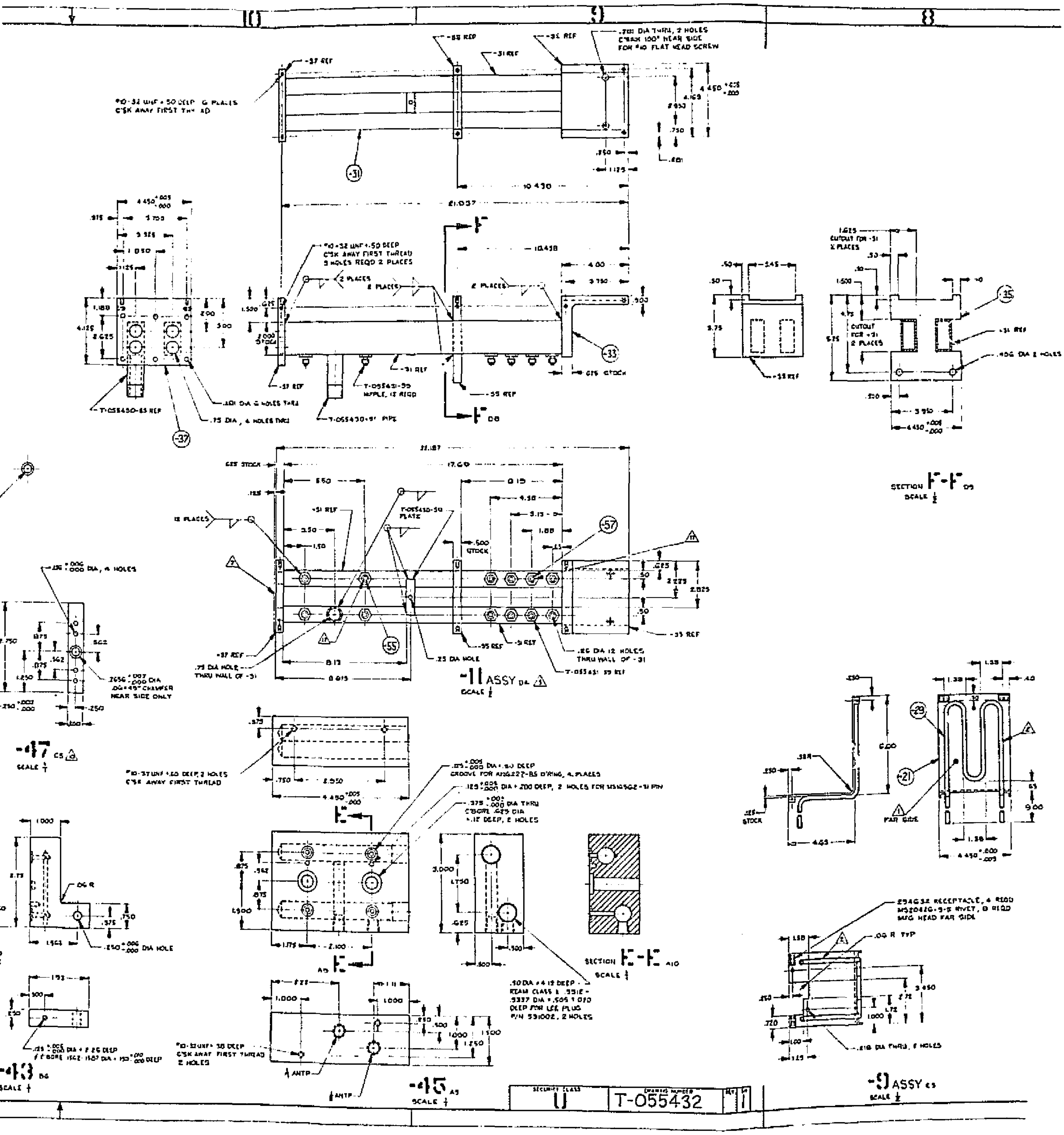
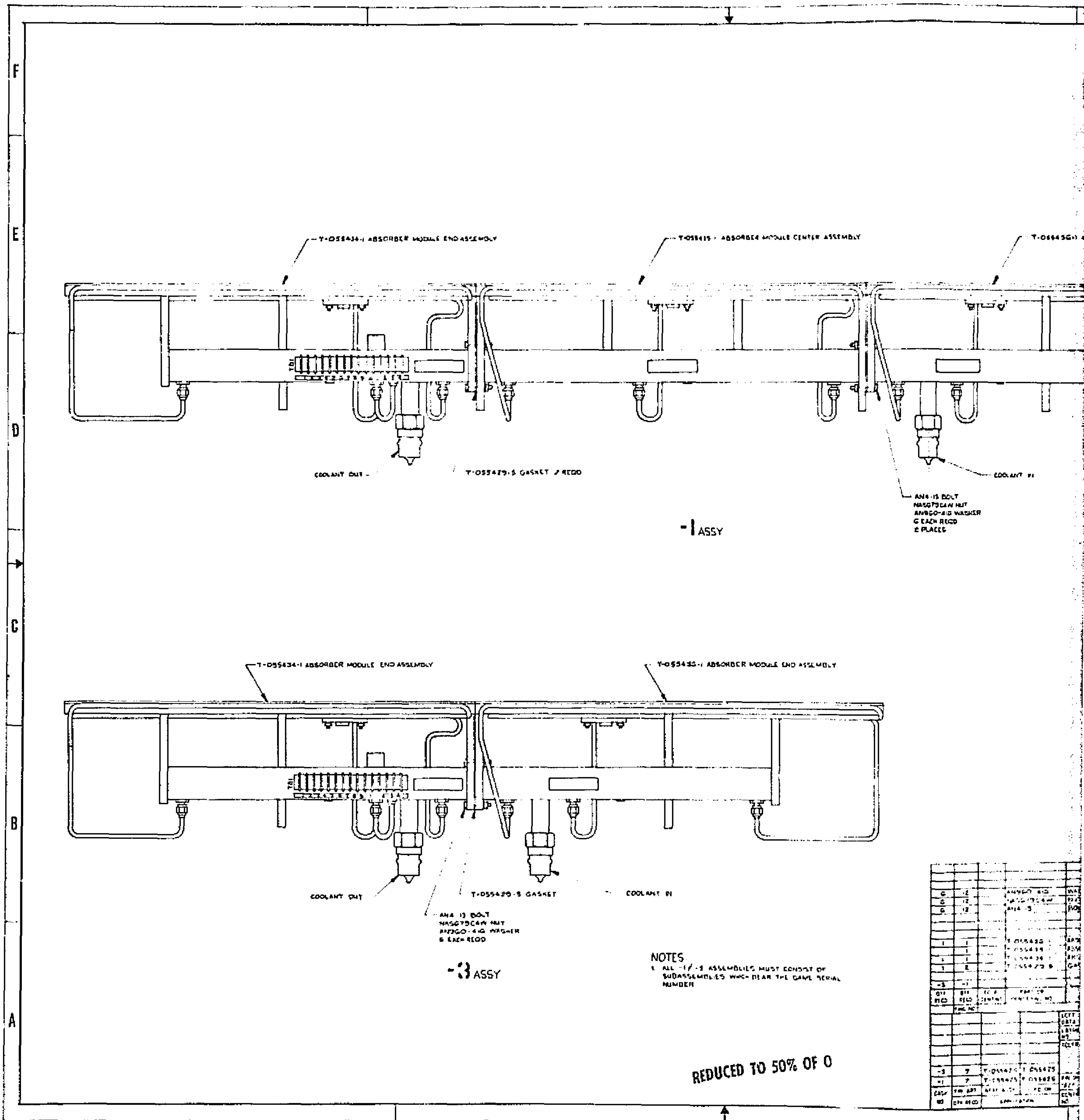


Part 2 of Sheet 1

FOLDOUT FRAME 2



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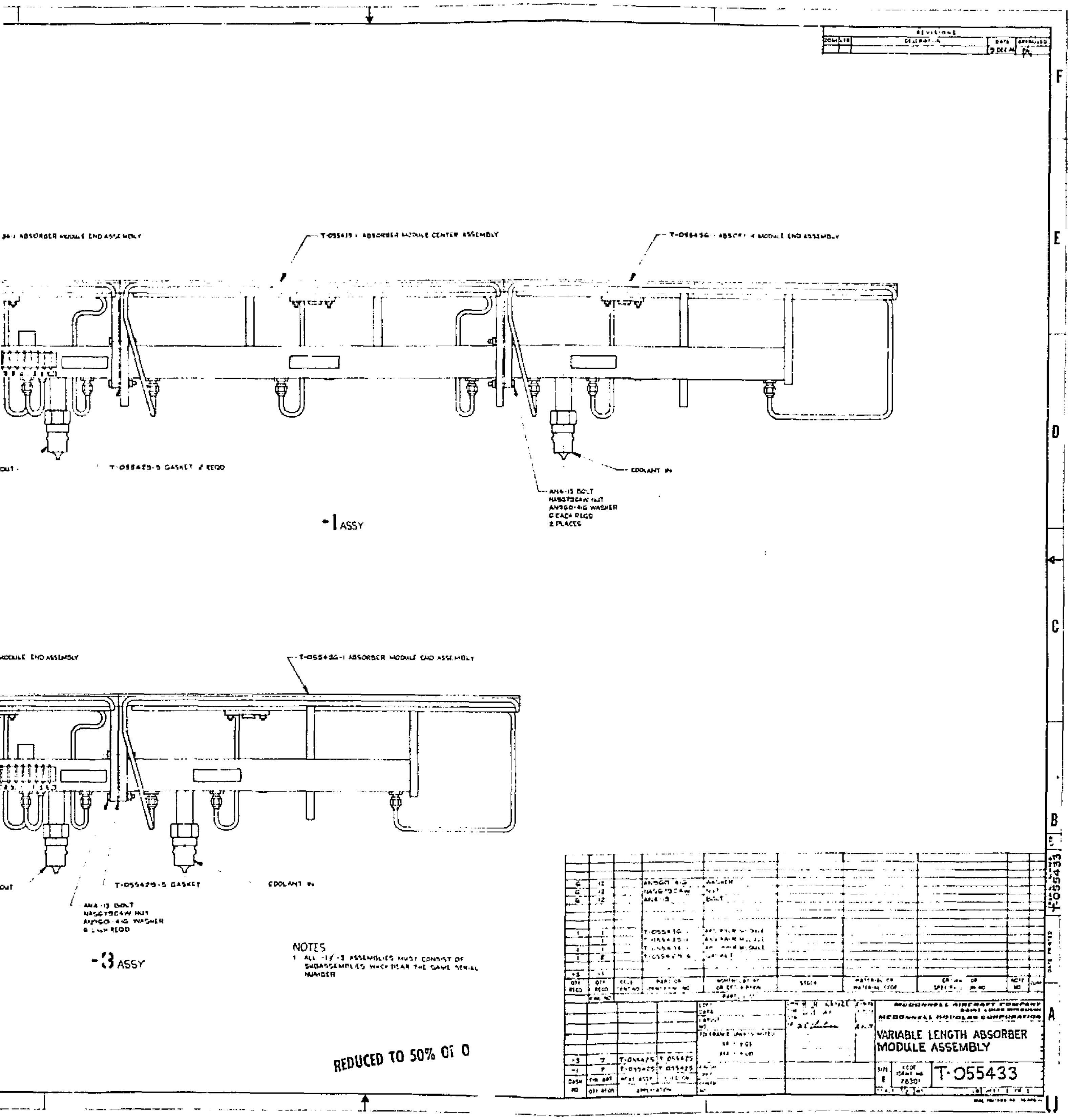
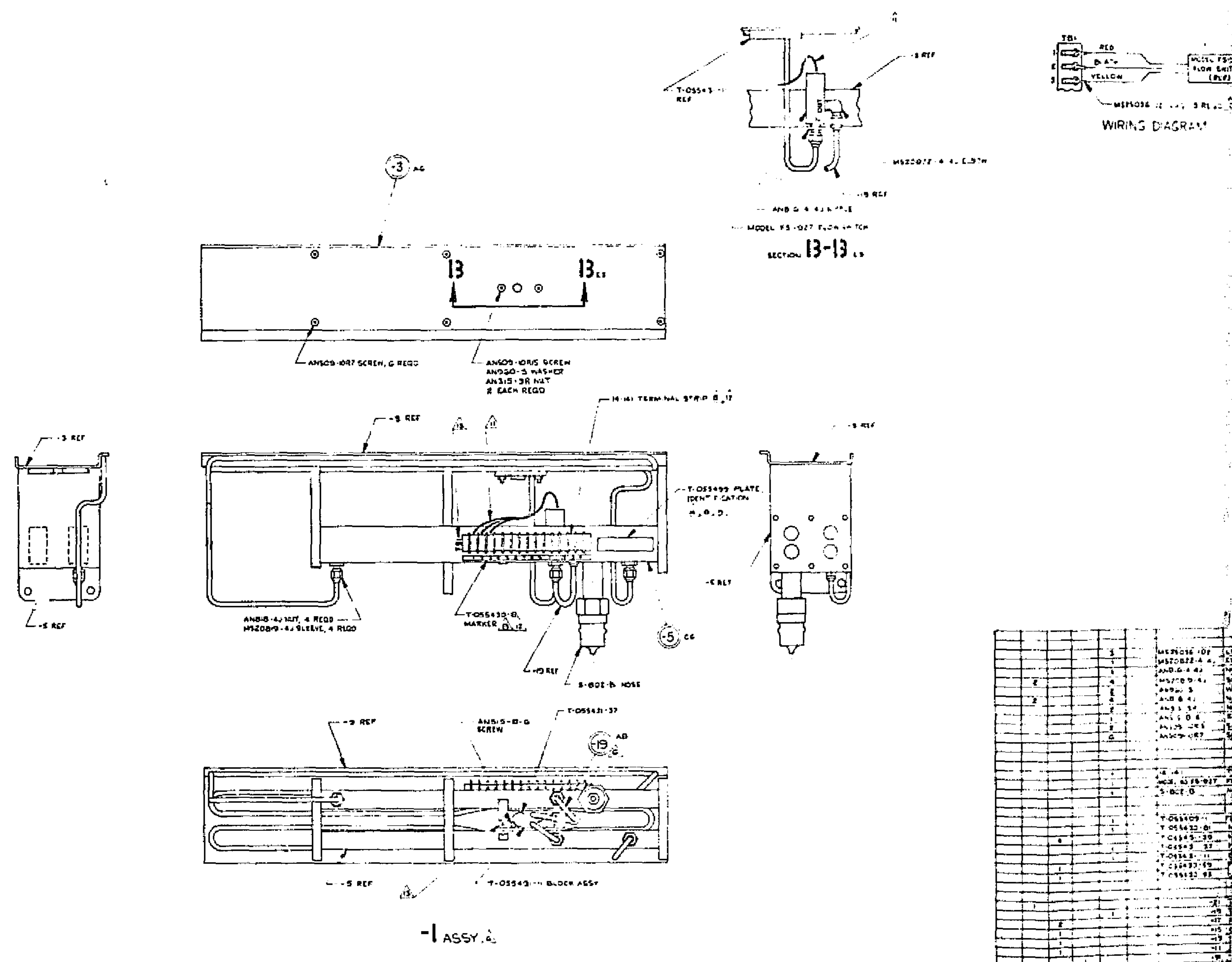
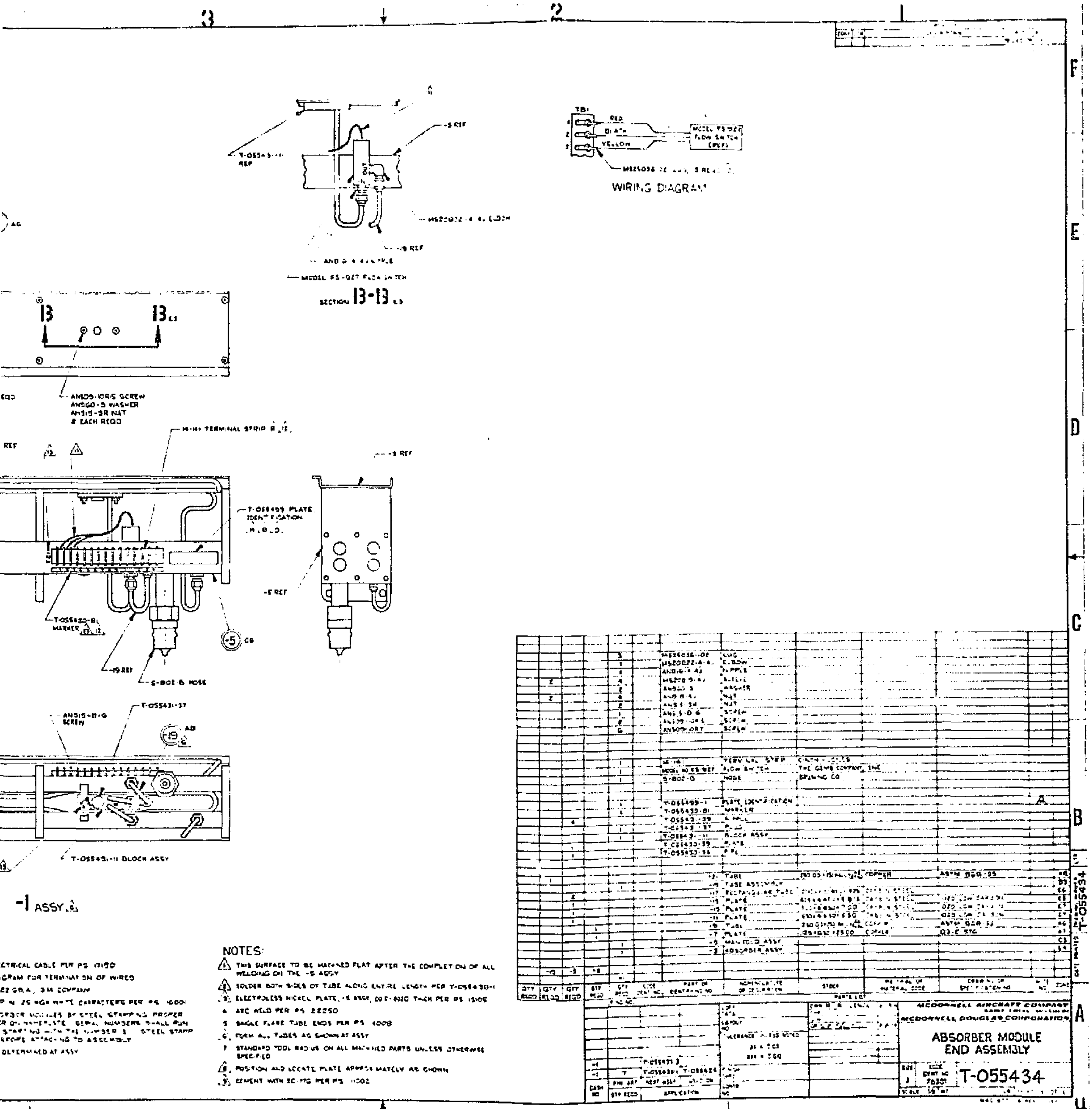

T-055419-1 ABSORBER MODULE CENTER ASSEMBLY
T-055425-5 GASKET 2 REQD
COOLANT IN
AN4-13 BOLT
NAS679C4W NUT
AN960-416 WASHER
6 EACH REQD
2 PLACES
-1 ASSY
T-055434-1 ABSORBER MODULE END ASSEMBLY
T-055429-5 GASKET
-3 ASSY
NOTES
REDUCED TO 50% OF O
VARIABLE LENGTH ABSORBER
MODULE ASSEMBLY
T-055433
78301



NOTES:

1. THIS SURFACE TO BE MACHINED FLAT AFTER THE COMPLETION OF ALL WELDING ON THE -5 ASSY
2. SOLDER BOTH SIDES OF TUBE ALONG ENTIRE LENGTH PER T-055430-1
3. ELECTROLESS NICKEL PLATE, -5 ASSY, .001-.0020 THICK PER PS 13105
4. ARC WELD PER PS 22250
5. SINGLE FLARE TUBE ENDS PER PS 14008
6. FORM ALL TUBES AS SHOWN AT ASSY
7. STANDARD TOOL RADIUS ON ALL MACHINED PARTS UNLESS OTHERWISE SPECIFIED
8. POSITION AND LOCATE PLATE APPROXIMATELY AS SHOWN
9. CEMENT WITH EC PS PER PS 11002
10. ASSEMBLE ELECTRICAL CABLE PER PS 17150
11. SEE WIRING DIAGRAM FOR TERMINATION OF WIRES
12. CEMENT WITH EC GR A, 3M COMPANY
13. RUBBER STAMP W .25 HIGH WHITE CHARACTERS PER PS 16001
14. SERIALIZE ABSORBER MODULES BY STEEL STAMPING PROPER SERIAL NUMBER ON NAMEPLATE. SERIAL NUMBERS SHALL RUN IN SEQUENCE STARTING WITH THE NUMBER 1. STEEL STAMP NAMEPLATE BEFORE ATTACHING TO ASSEMBLY
15. LENGTH TO BE DETERMINED AT ASSY

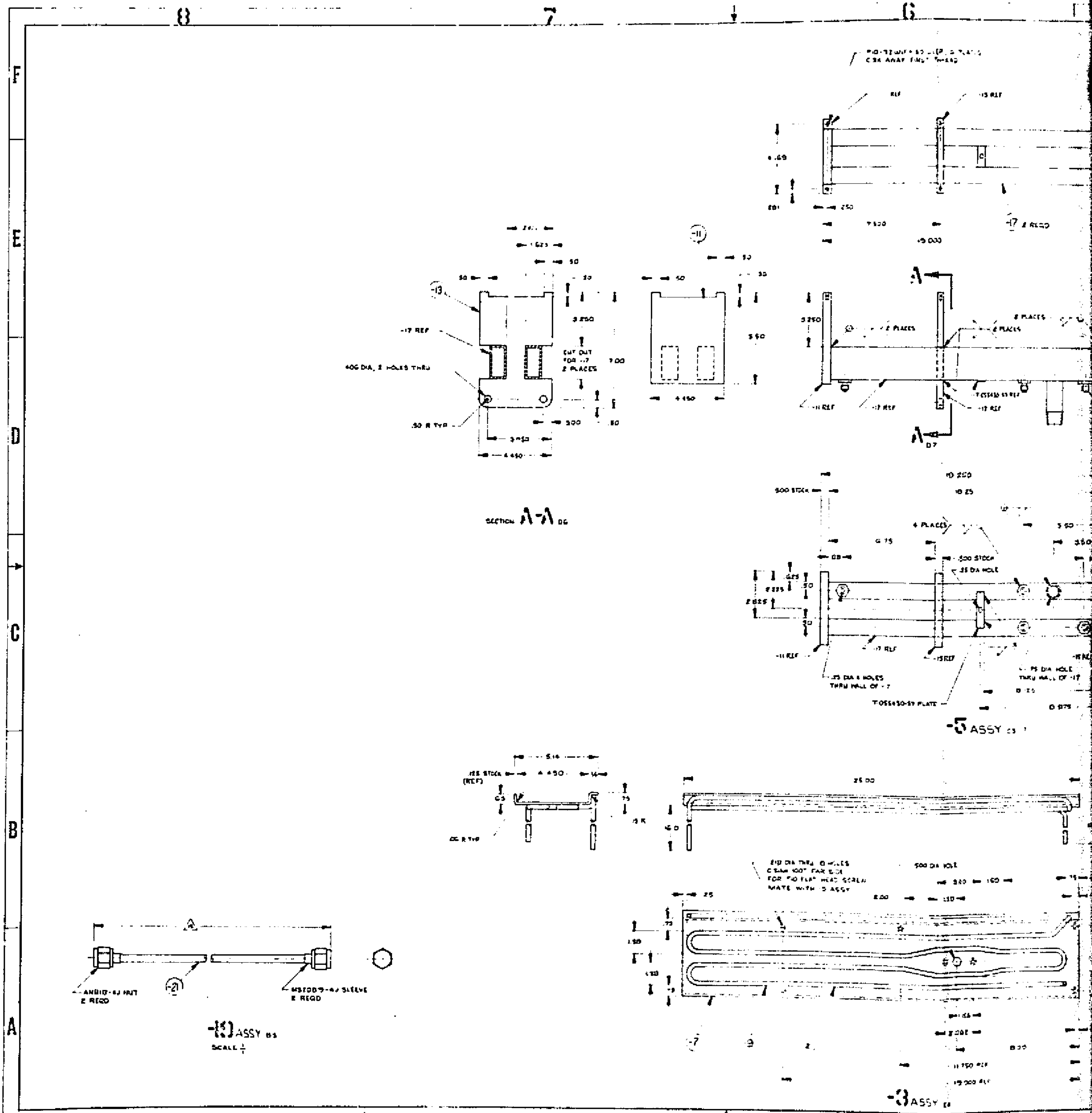


NOTES:

1. THIS SURFACE TO BE MACHINED FLAT AFTER THE COMPLETION OF ALL WELDING ON THE -5 ASSY
2. SOLDER BOTH SIDES OF TUBE ALONG ENTIRE LENGTH PER T-055430-1
3. ELECTROLESS NICKEL PLATE, -5 ASSY, .001-.0010 THICK PER PS 13105
4. ARC WELD PER PS 22250
5. SINGLE FLARE TUBE ENDS PER PS 4008
6. FORM ALL TUBES AS SHOWN AT ASSY
7. STANDARD TOOL RADIUS ON ALL MACHINED PARTS UNLESS OTHERWISE SPECIFIED
8. POSITION AND LOCATE PLATE APPROXIMATELY AS SHOWN
9. CEMENT WITH EC-776 PER PS 11002

Part 1 of Sheet 1

FOLDOUT FRAME 2



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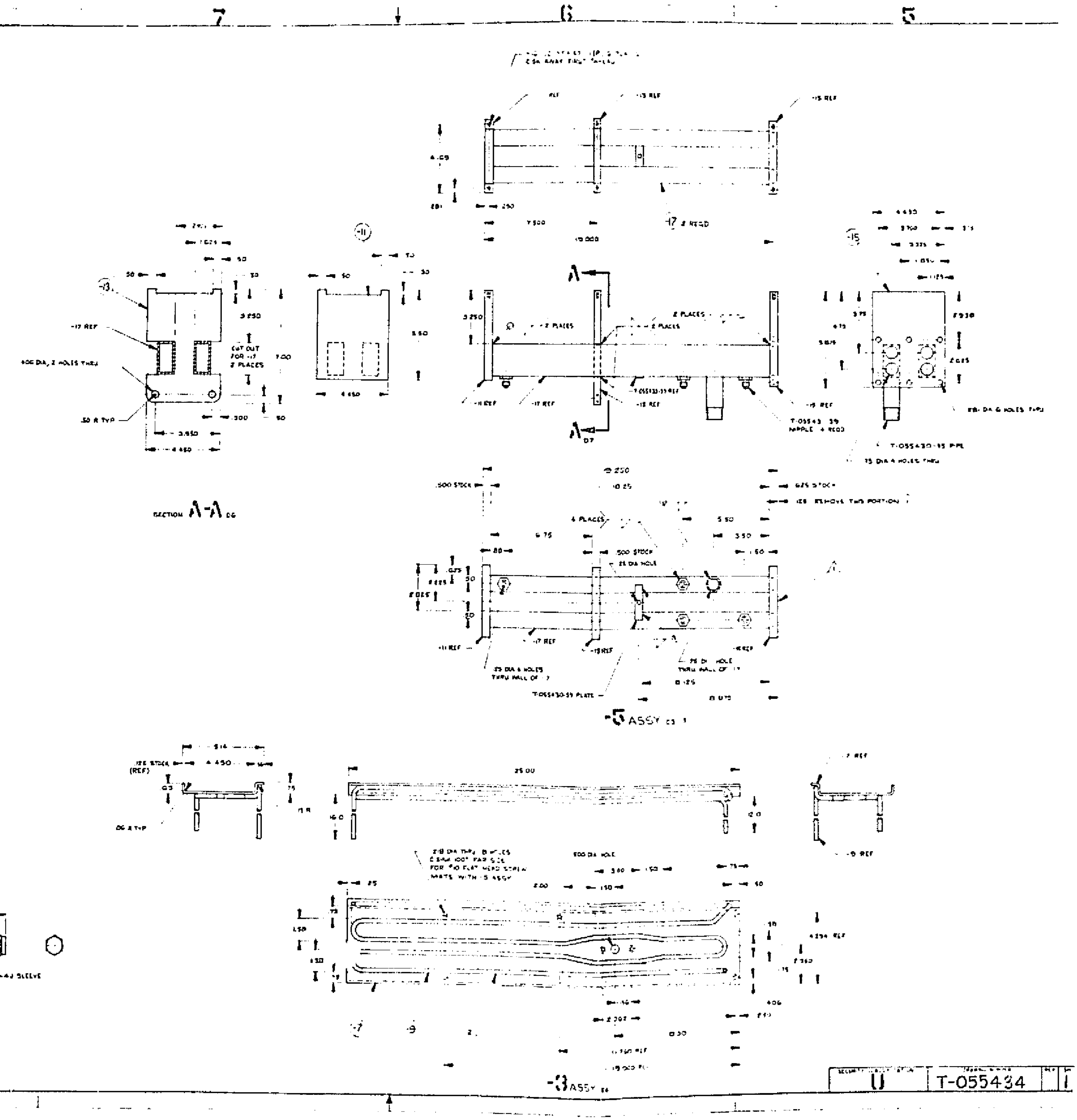
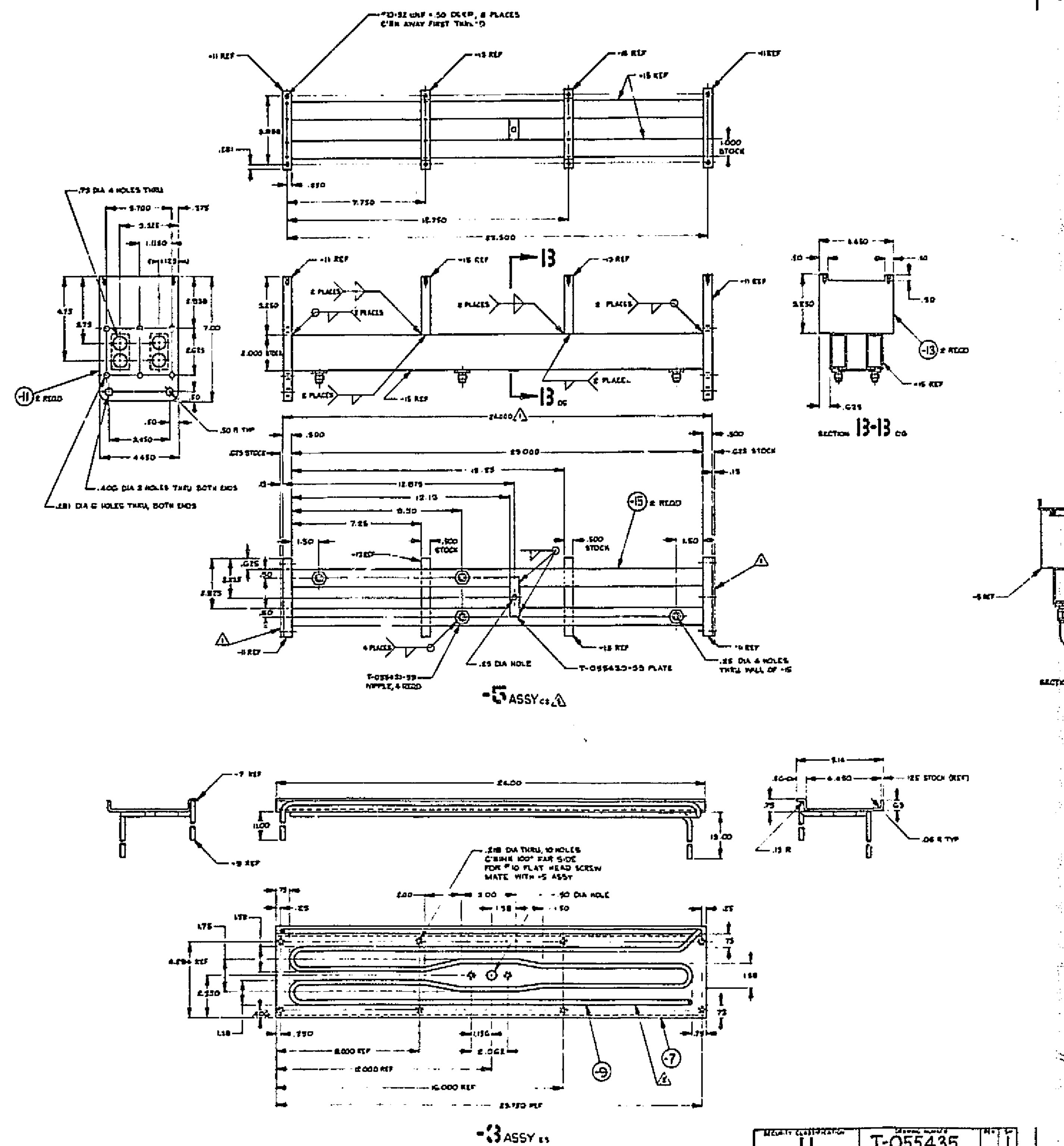


Part 2 of Sheet 1



SECURITY CLASSIFICATION	DRAWING NUMBER	REV	SH
U	T-055435		1

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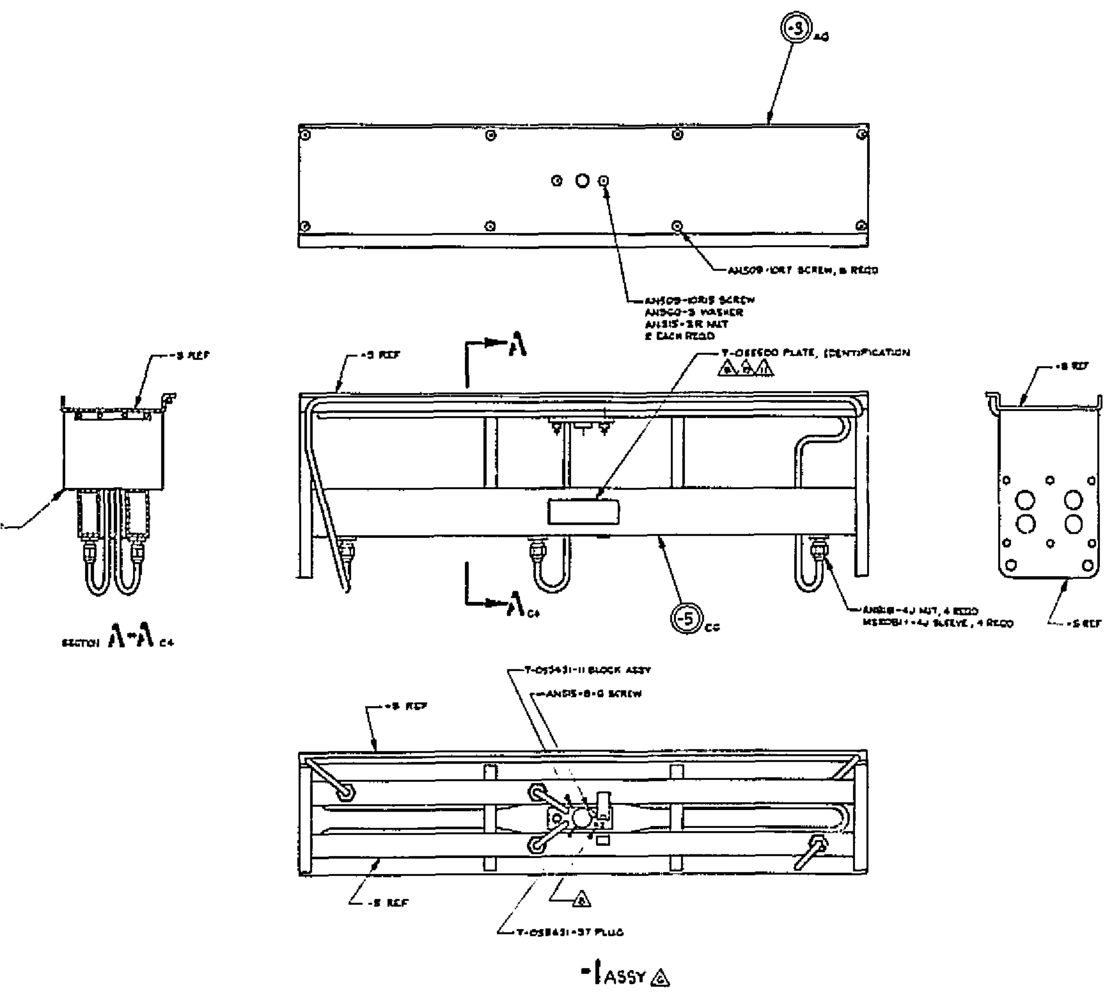


10 POSITION AND LOCATE PLATE APPROXIMATELY AS SHOWN
11 CEMENT WITH EC-776 PER PS 11002

NOTE

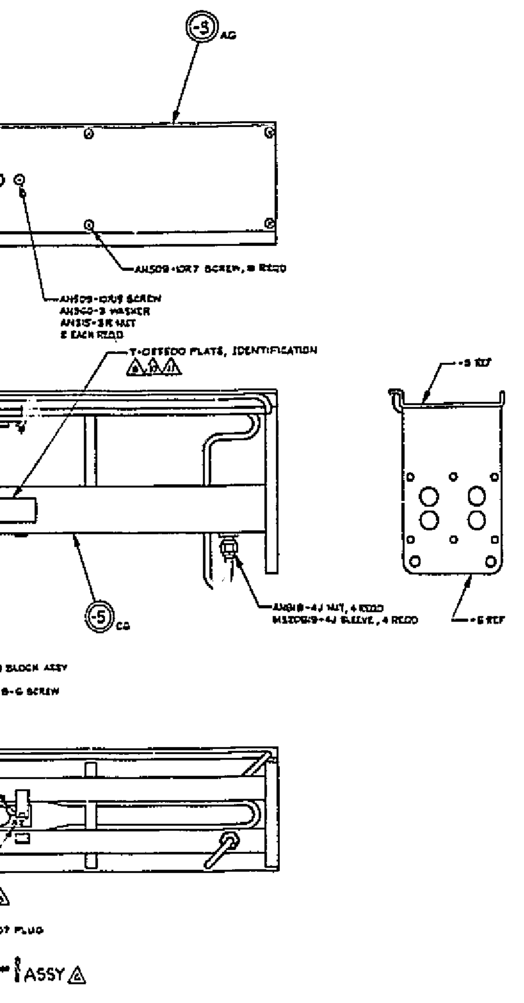
1. THIS SURFACE TO BE MACHINED FLAT AFTER THE COMPLETION OF ALL WELDING ON THE -5 ASSEMBLY
2. SOLDER BOTH SIDES OF TUBE ALONG ENTIRE LENGTH PER T-055438-
3. ELECTROLESS NICKEL PLATE -5 ASSY, .0015-.0020 THICK PER PS 13105
4. ARC WELD PER PS 22290
5. SINGLE FLARE TUBE ENDS PER PS 4008
6. FORM ALL TUBES AS SHOWN AT ASSY
7. STANDARD TOOL RADIUS ON ALL MACHINED PARTS UNLESS OTHERWISE SPECIFIED
8. RUBBER STAMP .25 HIGH WHITE CHARACTERS PER PS 12001
9. SERIALIZE HEATER MODULES BY STEEL STAMPING PROPER SERIAL NUMBER ON NAMEPLATE. SERIAL NUMBERS SHALL RUN IN SEQUENCE STARTING WITH THE NUMBER 1. STEEL STAMP NAMEPLATE BEFORE ATTACHING TO ASSEMBLY

QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	CODE IDENT NO	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION
				4		MS20819-4J	SLEEVE
				2		AN960-3	WASHER
				4		AN818-4J	NUT
				2		AN316-3R	NUT
				1		AN515-8-6	SCREW
				2		AN509-10R15	SCREW
				8		AN509-10R7	SCREW
				1		T-055500-1	PLATE, IDENTIFICATION
		4				T-055431-30	NIPPLE
				1		T-055431-37	PLUG
				1		T-055431-11	BLOCK ASSY
		1				T-055430-59	PLATE
		2				-15	RECTANGULAR TUBE
		2				-13	PLATE
		2				-11	PLATE
			1			-9	TUBE
			1			-7	PLATE
				1		-5	MANIFOLD ASSY
				1		-3	ABSORBER ASSY
		-5	-3	-1			

FIND NO

-1	7	T-055411	T-055425
DASH NO	FIN ASY / QTY REQD	NEXT ASSY	USED ON
		APPLICATION	

LOFT DATA
LAYOUT NO
TOLERANCE UNLESS NOTED
.XX ± .03
.XXX ± .010
FINISH SPEC
CONTR NO



QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	CODE IDENT NO	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	STOCK	MATERIAL OR MATERIAL CODE	DRAWING NO OR SPECIFICATION NO	NOTE NO	ZONE
				4		MS20819-4J	SLEEVE					
				2		AN960-3	WASHER					
				4		AN818-4J	NUT					
				2		AN315-3R	NUT					
				1		AN515-8-6	SCREW					
				2		AN509-10R8	SCREW					
				8		AN509-10R7	SCREW					
				1		T-055800-1	PLATE, IDENTIFICATION				△	
		4				T-055431-39	NIPPLE					
				1		T-055431-37	PLUG					
				1		T-055431-11	BLOCK ASSY					
		1				T-055430-99	PLATE					
		2				-15	RECTANGULAR TUBE	[illegible]	CARBON STEEL			D6
		2				-13	PLATE	.500 × 4.450 × 3.75	CARBON STEEL	1020 LOW CARBON		D8
		2				-11	PLATE	.125 × 4.450 × 7.00	CARBON STEEL	1020 LOW CARBON		D7
			1			-9	TUBE	[illegible]	COPPER	ASTM B88 55		A6
			1			-7	PLATE	.125 × 6.50 × 24.00	COPPER	QQ-C-576		A3
				1		-5	MANIFOLD ASSY					C3
				1		-3	ABSORBER ASSY					C3
		-5	-3									

PARTS LIST

MCDONNELL AIRCRAFT COMPANY
SAINT LOUIS MISSOURI
MCDONNELL DOUGLAS CORPORATION

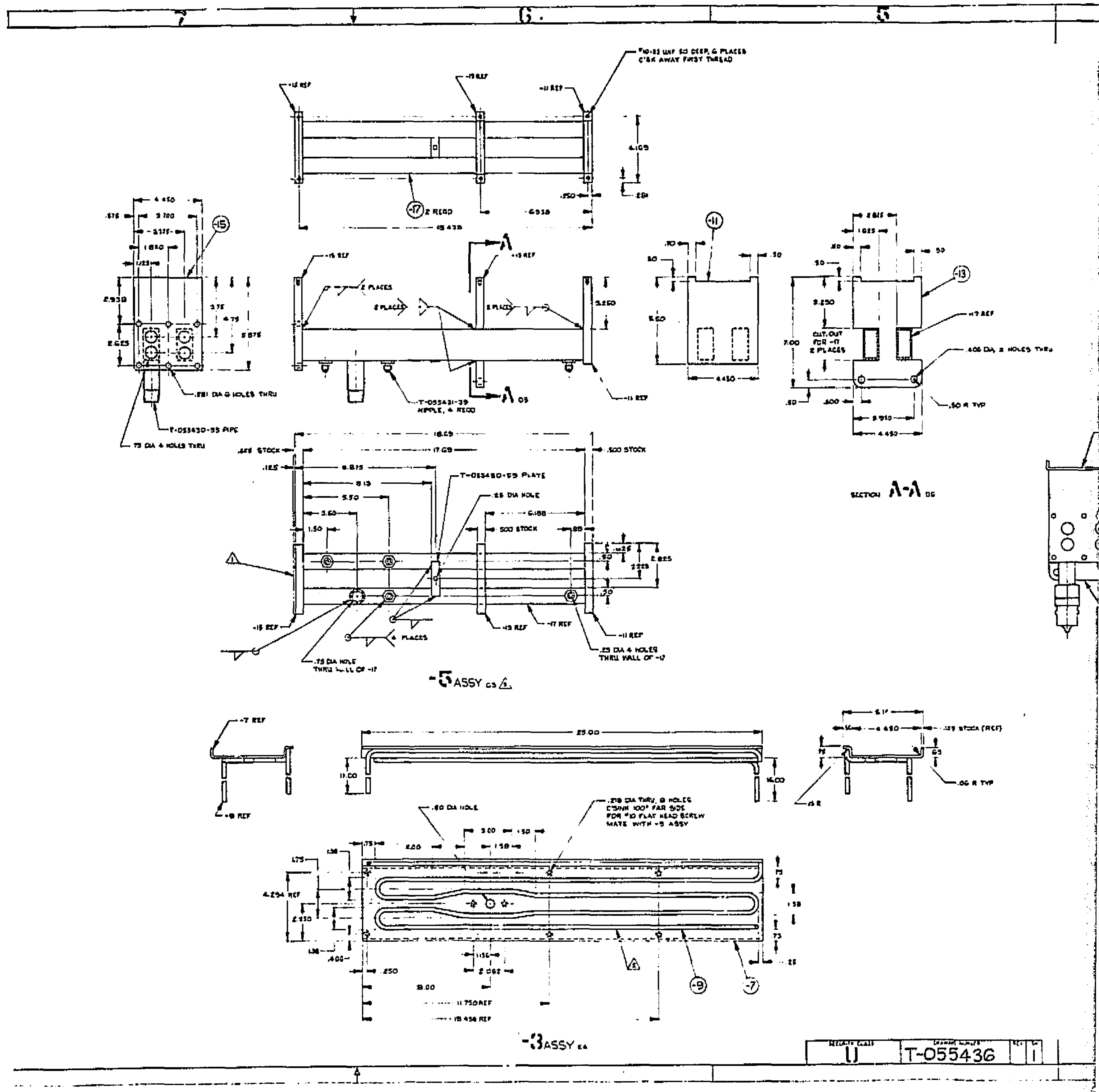
ABSORBER MODULE CENTER ASSEMBLY

SIZE J CODE IDENT NO 76301 T-055435

NEXT ASSY T-055431 / T-055425

NOTE

1. THIS SURFACE TO BE MACHINED FLAT AFTER THE COMPLETION OF ALL WELDING ON THE -3 ASSEMBLY
2. SOLDER BOTH SIDES OF TUBE ALONG ENTIRE LENGTH PER T-055438-1
3. ELECTROLESS NICKEL PLATE -5 ASSY, .0005-.0010 THICK PER P.S. 15105
4. ARC WELD PER P.S. 22250
5. ANGLE FLATE TUBE ENDS PER P.S. 4006
6. FORM ALL TUBES AS SHOWN AT ASSY
7. STANDARD TOOL RADIUS ON ALL MACHINED PARTS UNLESS OTHERWISE SPECIFIED
8. RUBBER STAMP IN .25 HIGH WHITE CHARACTERS PER P.S. 12001
9. SERIALIZE HEATER MODULES BY STEEL STAMPING PROPER SERIAL NUMBER ON NAMEPLATE. SERIAL NUMBERS SHALL RUN IN SEQUENCE, STARTING WITH THE NUMBER 1. STEEL STAMP NAMEPLATE BEFORE ATTACHING TO ASSEMBLY



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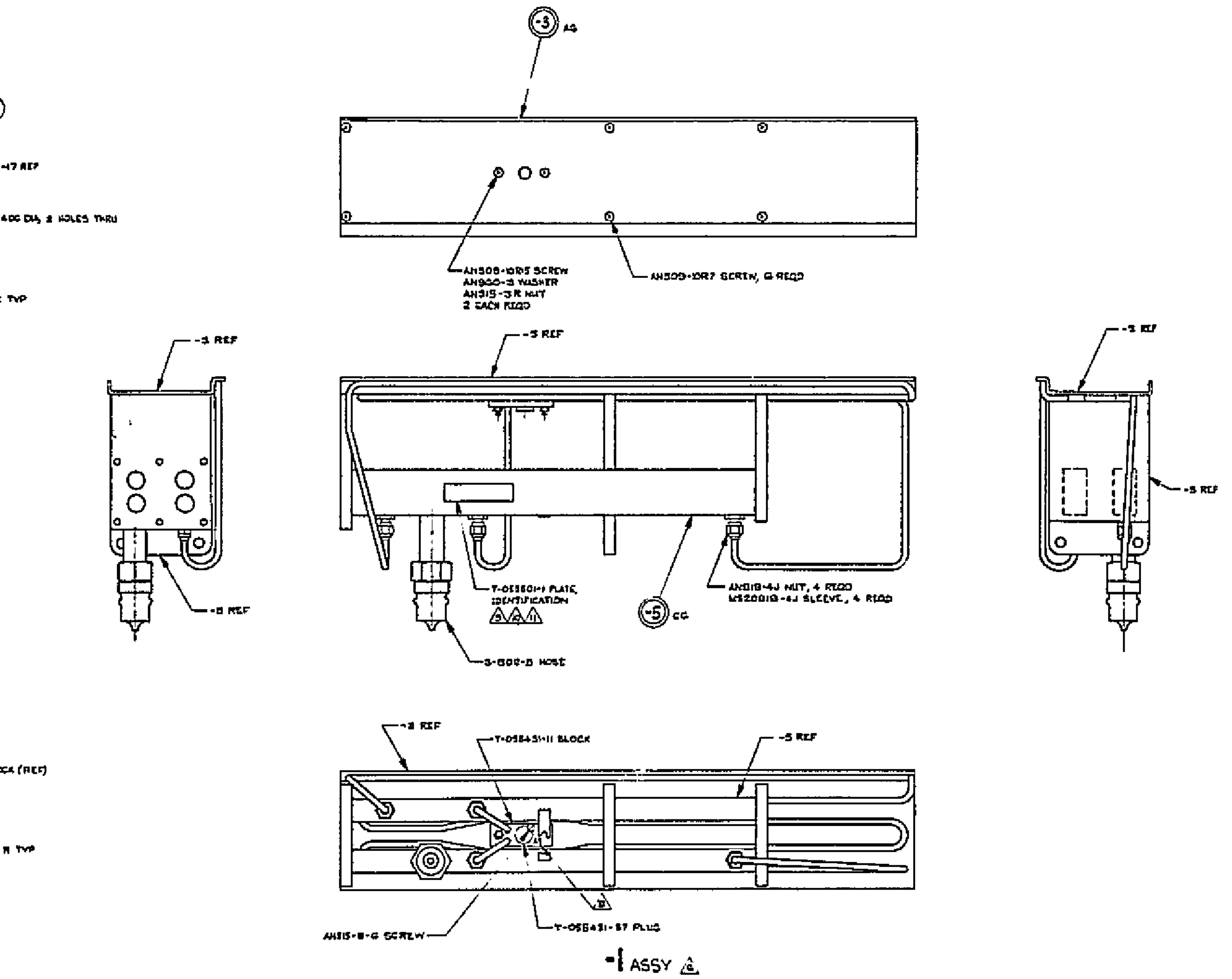
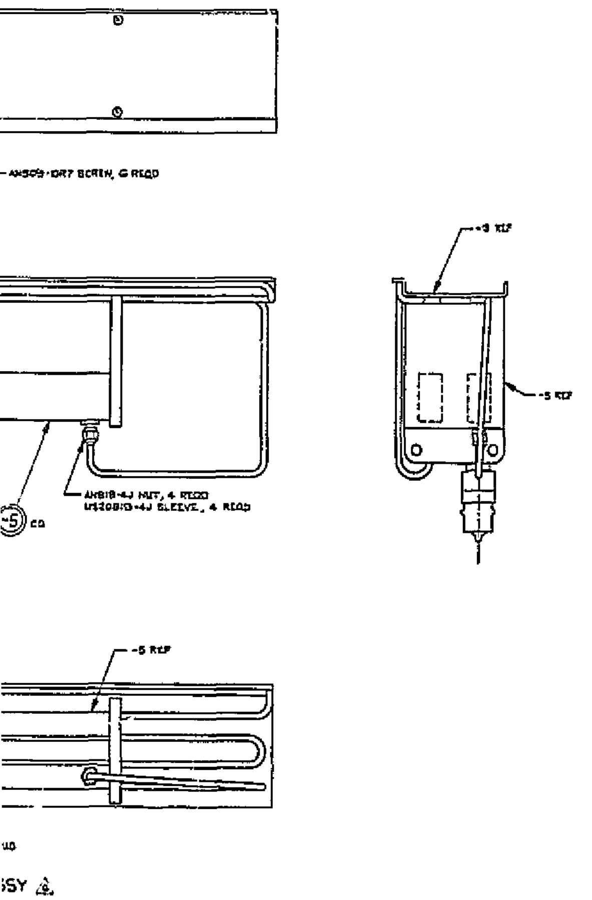


POSITION AND LOCATE PLATE APPROXIMATELY AS SHOWN
CEMENT WITH EC-776 PER PS 11001

NOTE

1. THIS SURFACE TO BE MACHINED FLAT AFTER COMPLETION OF ALL WELDING ON THE -5 ASSEMBLY
2. SOLDER BOTH SIDES OF TUBE ALONG ENTIRE LENGTH PER T-055430-1
3. ELECTROLESS NICKEL PLATE -5 ASSY, .001 - .002 THICK PER PS 13405
4. ARC WELD PER PS 15290
5. SINGLE FLARE TUBE ENDS PER PS 14008
6. FORM ALL TUBES AS SHOWN AT ASSY
7. STANDARD TOOL RADIUS ON ALL MACHINED PARTS UNLESS OTHERWISE SPECIFIED
8. RUBBER STAMP .25 HIGH WHITE CHARACTERS PER PS 16001
9. SERIALIZE ABSORBER MODULES BY STEEL STAMPING PROPER SERIAL NUMBER ON NAMEPLATE. SERIAL NUMBERS SHALL RUN IN SEQUENCE, STARTING WITH THE NUMBER 1. STEEL STAMP NAMEPLATE BEFORE ATTACHING TO ASSEMBLY

QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	CODE IDENT NO	PART OR IDENTIFYING NO	
				4		MS20819-4J	SLE
				2		AN960-8	WAS
				4		AN818-4J	NUT
				2		AN315-3R	NUT
				1		AN515-8-6	SCR
				2		AN509-10R5	SCR
				6		AN509-10R7	SCR
				1		S-800-8	HOS
				1		T-055501-1	PLAT
		6				T-055431-38	NIP
				1		T-055431-37	PLU
				1		T-055431-11	BLO
		1				T-055430-15	PIP
		1				T-055430-19	PLA
		2				-17	RIE
		1				-15	PLA
		1				-13	PLA
		1				-11	PLA
			1			-9	TUB
			1			-7	PLA
				1		-6	MAN
				1		-3	ASS
		-5	-3				
				-1			



REDUCED TO 50% OF ORIGINAL

QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	CODE IDENT NO	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	STOCK	MATERIAL OR MATERIAL SPEC	DRAWING OR SPECIFICATION NO	NOTE NO	ZONE
				4		MS20819-4J	SLEEVE					
				2		AN960-3	WASHER					
				4		AN818-4J	NUT					
				2		AN316-3R	NUT					
				1		AN515-8-6	SCREW					
				2		AN509-10R6	SCREW					
				6		AN509-6R7	SCREW					
				1		S-602-8	NOSE	BRUNING CO.				
				1		T-055501-1	PLATE, IDENTIFICATION				8	
		4				T-055431-39	NIPPLE					
				1		T-055431-37	PLUG					
				1		T-05[illegible]31-1	BLOCK ASSY					
		1				T-[illegible]-35	PIPE					
		1				T-[illegible]-33	PLATE					
		2				-17	RECTANGULAR TUBE	[illegible]	CARBON STEEL			E8
		1				-15	PLATE	.625×4.450×5.875	CARBON STEEL	1020 LOW CARBON		E7
		1				-13	PLATE	.500×4.450×7.00	CARBON STEEL	1020 LOW CARBON		E5
		1				-11	PLATE	.500×4.450×9.50	CARBON STEEL	1020 LOW CARBON		E9
			1			-9	TUBE	[illegible]	COPPER	ASTM B68-58		A6
			1			-7	PLATE	.125×C90×25.00	COPPER	QQ-C-576		A5
				1		-5	MANIFOLD ASSY					C3
				1		-3	ABSORBER ASSY					C4
		-5	-3	-1								

FIND NO — PARTS LIST

NOTE

1. (△) THIS SURFACE TO BE MACHINED FLAT AFTER COMPLETION OF ALL WELDING ON THE -5 ASSEMBLY
2. (△) SOLDER BOTH SIDES OF TUBE ALONG ENTIRE LENGTH PER T-055438-1
3. (△) ELECTROLESS NICKEL PLATE -5 ASSY, .003 - .0010 THICK PER PS 13105
4. ARC WELD PER PS 22250
5. SINGLE FLARE TUBE ENDS PER PS 14000
6. (△) FORM ALL TUBES AS SHOWN AT ASSY
7. STANDARD TOOL RADIUS ON ALL MACHINED PARTS UNLESS OTHERWISE SPECIFIED
8. (△) RUBBER STAMP IN .25 HIGH WHITE CHARACTERS PER PS 16001
9. (△) SERIALIZE ABSORBER MODULES BY STEEL STAMPING PROPER SERIAL NUMBER ON NAMEPLATE. SERIAL NUMBERS SHALL RUN IN SEQUENCE, STARTING WITH THE NUMBER 1. STEEL STAMP NAMEPLATE BEFORE ATTACHING TO ASSEMBLY

DASH NO	QTY REQD	NEXT ASSY	USED ON
-1		T-055433-5	
-1	9	T-055439-1	T-055425
	FIN. ASSY		

APPLICATION

TOLERANCE UNLESS NOTED: .XX ± .03, .XXX ± .010

DWN R. R. LENZE

MCDONNELL AIRCRAFT COMPANY, SAINT LOUIS, MISSOURI

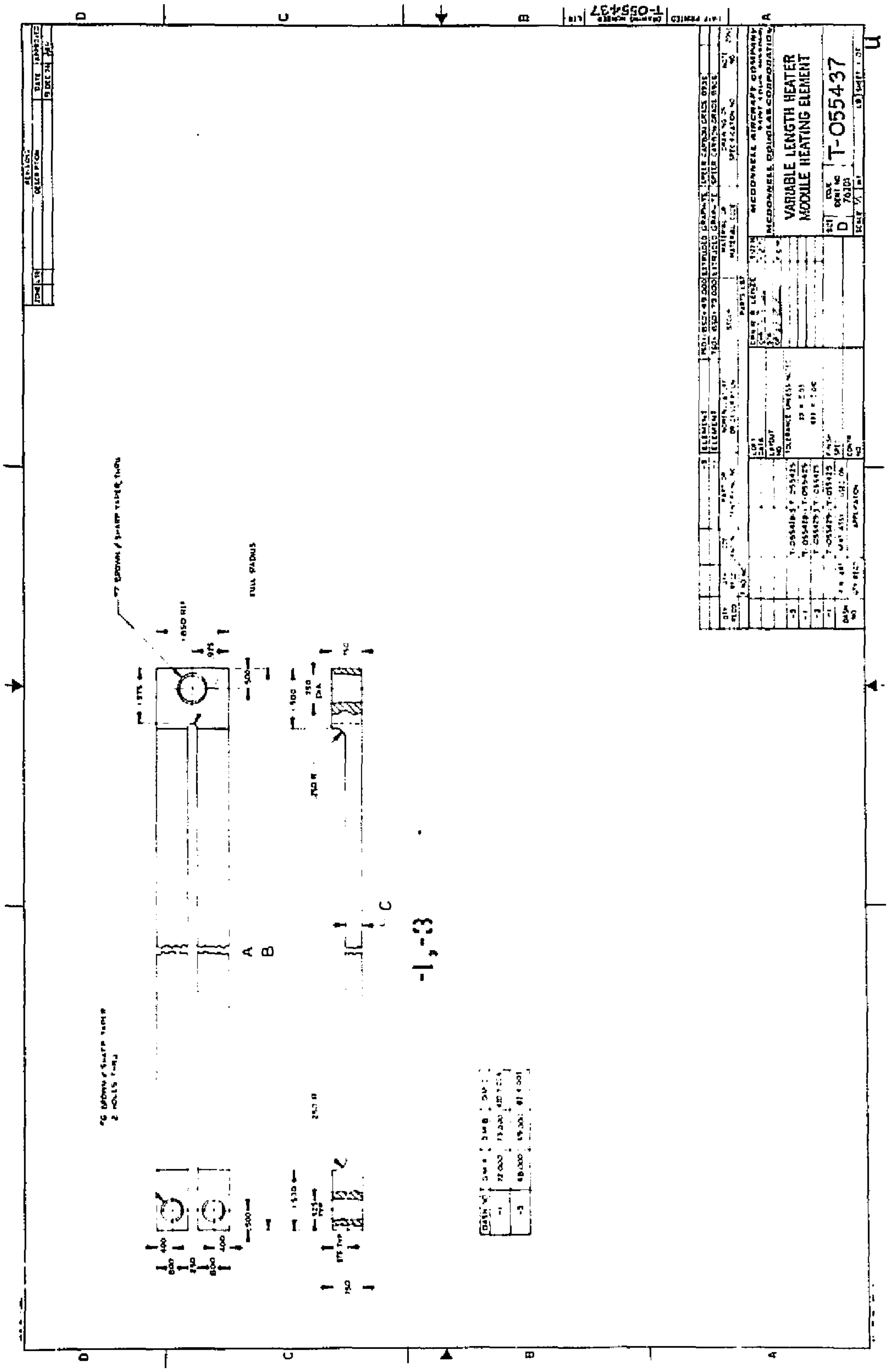
MCDONNELL DOUGLAS CORPORATION

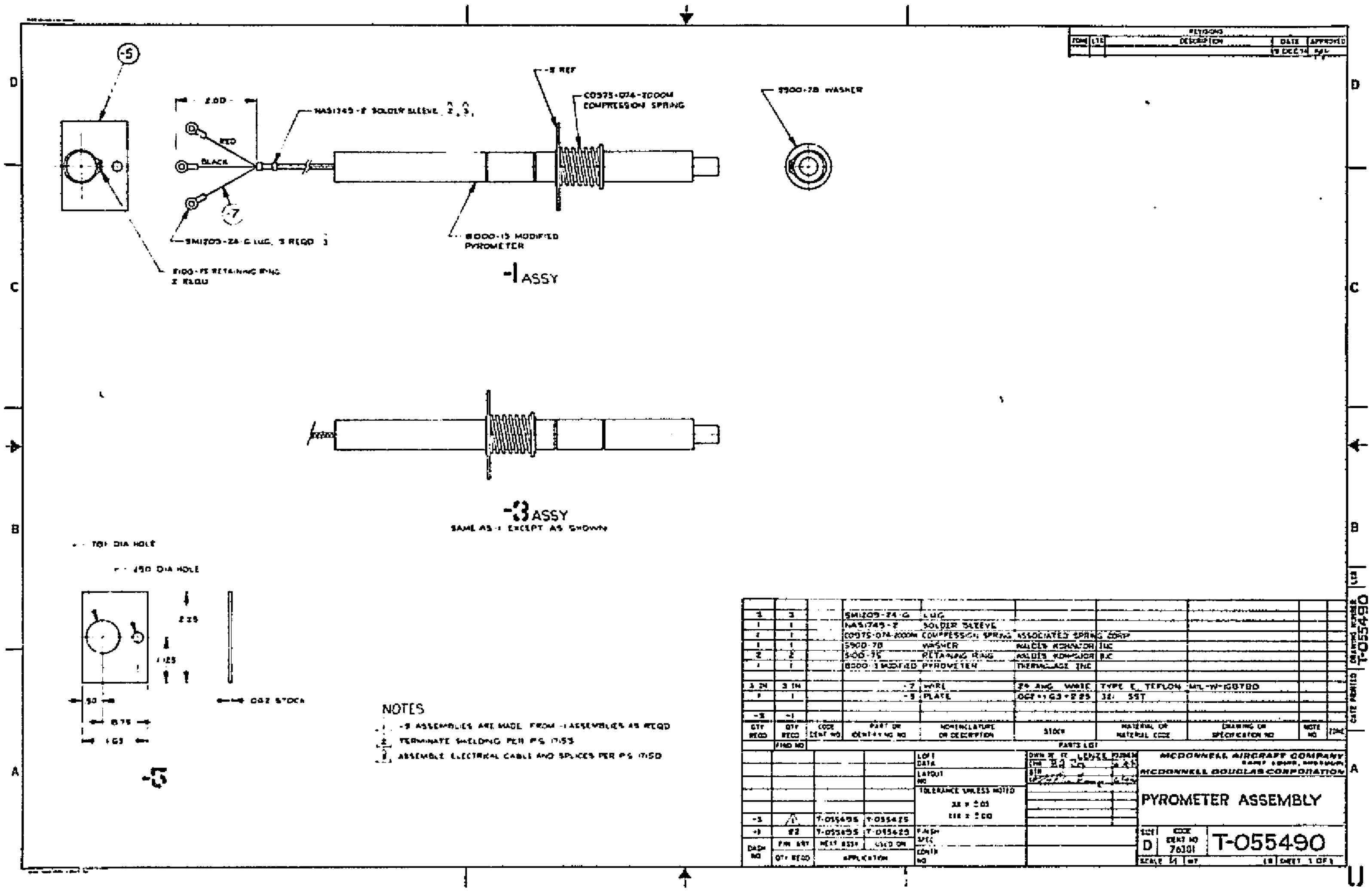
ABSORBER MODULE END ASSEMBLY

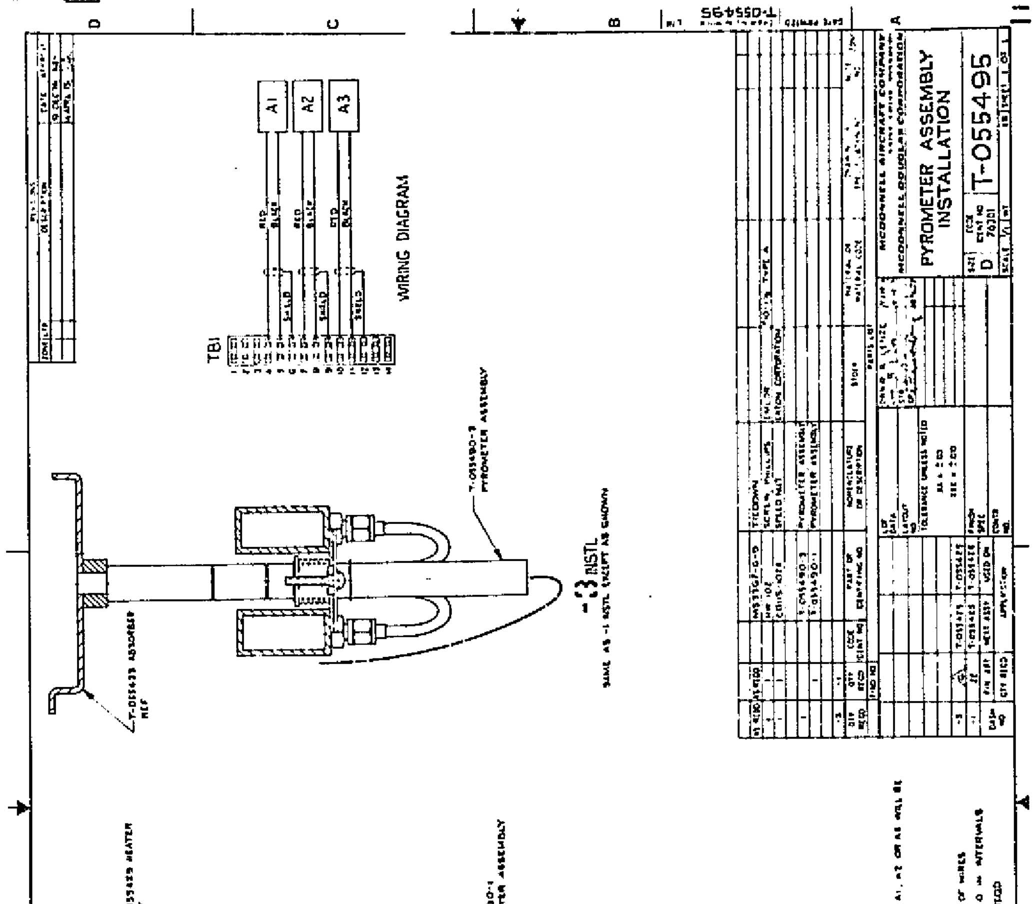
SIZE J — CODE IDENT NO 76301 — T-055436

SCALE 1/2 — SHEET 1 OF 1

FOLDOUT FRAME 3


VARIABLE LENGTH HEATER
MODULE HEATING ELEMENT
T-055437
MCDONNELL AIRCRAFT COMPANY
MCDONNELL DOUGLAS CORPORATION
FULL RADIUS
-1, -3


-5
2.00
NAS1745-2 SOLDER SLEEVE
RED
BLACK
-7
SM1205-24-G LUG, 3 REQD
5100-75 RETAINING RING 2 REQD
-5 REF
C0975-074-2000M COMPRESSION SPRING
8000-15 MODIFIED PYROMETER
5900-78 WASHER
-1 ASSY
-3 ASSY
SAME AS -1 EXCEPT AS SHOWN
.250 DIA HOLE
.50
.875
1.63
.032 STOCK
NOTES
-3 ASSEMBLIES ARE MADE FROM -1 ASSEMBLIES AS REQD
TERMINATE SHIELDING PER P.S. 17153
ASSEMBLE ELECTRICAL CABLE AND SPLICES PER P.S. 17150
SM1205-24-G LUG
NAS1745-2 SOLDER SLEEVE
C0975-074-2000M COMPRESSION SPRING ASSOCIATED SPRING CORP
5900-78 WASHER
5100-75 RETAINING RING
8000-15 MODIFIED PYROMETER THERMOGAGE INC
-7 WIRE 24 AWG WHITE TYPE E TEFLON MIL-W-16878D
-5 PLATE 321 SST
PARTS LIST
MCDONNELL AIRCRAFT COMPANY
MCDONNELL DOUGLAS CORPORATION
PYROMETER ASSEMBLY
T-055495 T-055425
D 76301 T-055490
SHEET 1 OF 1


TB1
A1
A2
A3
WIRING DIAGRAM
-3 INSTL
SAME AS -1 INSTL EXCEPT AS SHOWN
-1 INSTL
NOTES
PYROMETER ASSEMBLY INSTALLATION
T-055495

APPENDIX B
HEATER AND ABSORBER MODULE
LOG SHEETS

This Appendix contains copies of the individual log sheets prepared for each heater and absorber module. The initial functional acceptance test data is entered in column one. Additional columns are provided to collect data at a later date for comparison purposes.

GRAPHITE HEATER LOG SHEET

Contract No.: NAS 9-14041

Heater P/N: T-055429-1

Heater S/N: 01

Item	Date - Month/Year							
	12/74							
1. Internal Resistance (MΩ)	>1000							
2. Breakdown Voltage (kV)	>1.5							
3. Coolant Leak Check	OK							
4. Water Flow Rate - (GPM @ 60 PSI ΔP)	24.78							
5. Operational Checkout								
a. Test Pressure (Torr)	100							
b. Specimen Temperature (°F)	3256							
c. Heater Bus Voltage	65							
d. Heater Amperage	1000							
e. Pyrometer S/N	369							

GRAPHITE HEATER LOG SHEET

Contract No.: NAS 9-14041

Heater P/N: T-055429-1

Heater S/N: 02

Item	Date - Month/Year							
	12/74							
1. Internal Resistance (MΩ)	>1000							
2. Breakdown Voltage (kV)	>1.5K							
3. Coolant Leak Check	OK							
4. Water Flow Rate - (GPM @ 60 PSI ΔP)	24.13							
5. Operational Checkout								
a. Test Pressure (Torr)	100							
b. Specimen Temperature (°F)	3289							
c. Heater Bus Voltage	65							
d. Heater Amperage	990							
e. Pyrometer S/N	370							

GRAPHITE HEATER LOG SHEET

Contract No.: NAS 9-14041

Heater P/N: T-055429-1

Heater S/N: 03

Item	Date - Month/Year							
	1/75							
1. Internal Resistance (MΩ)	>1000							
2. Breakdown Voltage (kV)	>1.5K							
3. Coolant Leak Check	OK							
4. Water Flow Rate - (GPM @ 60 PSI ΔP)	24.22							
5. Operational Checkout								
a. Test Pressure (Torr)	100							
b. Specimen Temperature (°F)	3200							
c. Heater Bus Voltage	70							
d. Heater Amperage	1100							
e. Pyrometer S/N	371							

GRAPHITE HEATER LOG SHEET

Contract No.: NAS 9-14041

Heater P/N: T-055429-1

Heater S/N: 04

Item	Date – Month/Year							
	1/75							
1. Internal Resistance (MΩ)	>1000							
2. Breakdown Voltage (kV)	>1.5							
3. Coolant Leak Check	OK							
4. Water Flow Rate – (GPM @ 60 PSI ΔP)	25.16							
5. Operational Checkout								
a. Test Pressure (Torr)	100							
b. Specimen Temperature (°F)	3200							
c. Heater Bus Voltage	68							
d. Heater Amperage	1060							
e. Pyrometer S/N	372							

GRAPHITE HEATER LOG SHEET

<u>Contract No.:</u> NAS 9-14041

<u>Heater P/N:</u> T-055429-1

<u>Heater S/N:</u> 05

Item	Date - Month/Year							
	1/75							
1. Internal Resistance (MΩ)	>1000							
2. Breakdown Voltage (kV)	>1.5							
3. Coolant Leak Check	OK							
4. Water Flow Rate - (GPM @ 60 PSI ΔP)	24.49							
5. Operational Checkout								
a. Test Pressure (Torr)	100							
b. Specimen Temperature (°F)	3200							
c. Heater Bus Voltage	65							
d. Heater Amperage	100							
e. Pyrometer S/N	373							

GRAPHITE HEATER LOG SHEET

Contract No.: NAS 9-14041

Heater P/N: T-055429-1

Heater S/N: 06

Item	Date - Month/Year							
	1/75							
1. Internal Resistance (MΩ)	>1000							
2. Breakdown Voltage (kV)	>1.5							
3. Coolant Leak Check	OK							
4. Water Flow Rate - (GPM @ 60 PSI ΔP)	24.14							
5. Operational Checkout								
a. Test Pressure (Torr)	100							
b. Specimen Temperature (°F)	3200							
c. Heater Bus Voltage	66							
d. Heater Amperage	1020							
e. Pyrometer S/N	374							

GRAPHITE HEATER LOG SHEET

Contract No.: NAS 9-14041

Heater P/N: T-055429-1

Heater S/N: 07

Item	Date - Month/Year							
	1/75							
1. Internal Resistance (MΩ)	>1000							
2. Breakdown Voltage (kV)	>1.5							
3. Coolant Leak Check	OK							
4. Water Flow Rate - (GPM @ 60 PSI ΔP)	24.51							
5. Operational Checkout								
a. Test Pressure (Torr)	100							
b. Specimen Temperature (°F)	3221							
c. Heater Bus Voltage	66							
d. Heater Amperage	1020							
e. Pyrometer S/N	375							

GRAPHITE HEATER LOG SHEET

Contract No.: NAS 9-14041

Heater P/N: T-055429-1

Heater S/N: 08

Item	Date - Month/Year							
	1/75							
1. Internal Resistance (MΩ)	>1000							
2. Breakdown Voltage (kV)	>1.5							
3. Coolant Leak Check	OK							
4. Water Flow Rate - (GPM @ 60 PSI ΔP)	24.33							
5. Operational Checkout								
a. Test Pressure (Torr)	100							
b. Specimen Temperature (°F)	3214							
c. Heater Bus Voltage	65							
d. Heater Amperage	1010							
e. Pyrometer S/N	376							

GRAPHITE HEATER LOG SHEET

Contract No.: NAS 9-14041

Heater P/N: T-055429-1

Heater S/N: 09

Item	Date - Month/Year							
	1/75							
1. Internal Resistance (MΩ)	>1000							
2. Breakdown Voltage (kV)	>1.5							
3. Coolant Leak Check	OK							
4. Water Flow Rate - (GPM @ 60 PSI ΔP)	24.55							
5. Operational Checkout								
a. Test Pressure (Torr)	100							
b. Specimen Temperature (°F)	3233							
c. Heater Bus Voltage	65							
d. Heater Amperage	1010							
e. Pyrometer S/N	377							

GRAPHITE HEATER LOG SHEET

Contract No.: NAS 9-14041

Heater P/N: T-055429-1

Heater S/N: 10

Item	Date - Month/Year							
	1/75							
1. Internal Resistance (MΩ)	>1000							
2. Breakdown Voltage (kV)	>1.5							
3. Coolant Leak Check	OK							
4. Water Flow Rate - (GPM @ 60 PSI ΔP)	24.60							
5. Operational Checkout								
a. Test Pressure (Torr)	100							
b. Specimen Temperature (°F)	3206							
c. Heater Bus Voltage	67							
d. Heater Amperage	1040							
e. Pyrometer S/N	378							

GRAPHITE HEATER LOG SHEET

Contract No.: NAS 9-14041

Heater P/N: T-055429-1

Heater S/N: 11

Item	Date - Month/Year							
	1/75							
1. Internal Resistance (MΩ)	>1000							
2. Breakdown Voltage (kV)	>1.5							
3. Coolant Leak Check	OK							
4. Water Flow Rate - (GPM @ 60 PSI ΔP)	24.51							
5. Operational Checkout								
a. Test Pressure (Torr)	100							
b. Specimen Temperature (°F)	3200							
c. Heater Bus Voltage	70							
d. Heater Amperage	1100							
e. Pyrometer S/N	379							

GRAPHITE HEATER LOG SHEET

Contract No.: NAS 9-14041

Heater P/N: T-055429-1

Heater S/N: 12

Item	Date - Month/Year							
	1/75							
1. Internal Resistance (MΩ)	>1000							
2. Breakdown Voltage (kV)	>1.5							
3. Coolant Leak Check	OK							
4. Water Flow Rate - (GPM @ 60 PSI ΔP)	24.82							
5. Operational Checkout								
a. Test Pressure (Torr)	100							
b. Specimen Temperature (°F)	3207							
c. Heater Bus Voltage	70							
d. Heater Amperage	1100							
e. Pyrometer S/N	380							

GRAPHITE HEATER LOG SHEET

Contract No.: NAS 9-14041

Heater P/N: T-055429-3

Heater S/N: 13

Item	Date - Month/Year							
	2/75							
1. Internal Resistance (MΩ)	>1000							
2. Breakdown Voltage (kV)	>1.5							
3. Coolant Leak Check	OK							
4. Water Flow Rate - (GPM @ 60 PSI ΔP)	17.80							
5. Operational Checkout								
a. Test Pressure (Torr)	100							
b. Specimen Temperature (°F)	3224							
c. Heater Bus Voltage	70							
d. Heater Amperage	790							
e. Pyrometer S/N	382							

GRAPHITE HEATER LOG SHEET

Contract No.: NAS 9-14041

Heater P/N: T-055429-3

Heater S/N: 14

Item	Date - Month/Year							
	2/75							
1. Internal Resistance (MΩ)	>1000							
2. Breakdown Voltage (kV)	>1.5							
3. Coolant Leak Check	OK							
4. Water Flow Rate - (GPM @ 60 PSI ΔP)	17.92							
5. Operational Checkout								
a. Test Pressure (Torr)	100							
b. Specimen Temperature (°F)	3226							
c. Heater Bus Voltage	66							
d. Heater Amperage	760							
e. Pyrometer S/N	383							

GRAPHITE HEATER LOG SHEET

Contract No.: NAS 9-14041

Heater P/N: T-055429-3

Heater S/N: 15

Item	Date - Month/Year							
	2/75							
1. Internal Resistance (MΩ)	>1000							
2. Breakdown Voltage (kV)	>1.5							
3. Coolant Leak Check	OK							
4. Water Flow Rate - (GPM @ 60 PSI ΔP)	18.19							
5. Operational Checkout								
a. Test Pressure (Torr)	100							
b. Specimen Temperature (°F)	3249							
c. Heater Bus Voltage	65							
d. Heater Amperage	750							
e. Pyrometer S/N	384							

GRAPHITE HEATER LOG SHEET

Contract No.: NAS 9-14041

Heater P/N: T-055429-3

Heater S/N: 16

Item	Date - Month/Year							
	2/75							
1. Internal Resistance (MΩ)	>1000							
2. Breakdown Voltage (kV)	>1.5							
3. Coolant Leak Check	OK							
4. Water Flow Rate - (GPM @ 60 PSI ΔP)	18.04							
5. Operational Checkout								
a. Test Pressure (Torr)	100							
b. Specimen Temperature (°F)	3241							
c. Heater Bus Voltage	65							
d. Heater Amperage	750							
e. Pyrometer S/N	385							

GRAPHITE HEATER LOG SHEET

Contract No.: NAS 9-14041

Heater P/N: T-055429-3

Heater S/N: 17

Item	Date - Month/Year							
	2/75							
1. Internal Resistance (MΩ)	> 1000							
2. Breakdown Voltage (kV)	>1.5							
3. Coolant Leak Check	OK							
4. Water Flow Rate - (GPM @ 60 PSI ΔP)	17.94							
5. Operational Checkout								
a. Test Pressure (Torr)	100							
b. Specimen Temperature (°F)	3216							
c. Heater Bus Voltage	65							
d. Heater Amperage	750							
e. Pyrometer S/N	386							

GRAPHITE HEATER LOG SHEET

Contract No.: NAS 9-14041

Heater P/N: T-055429-3

Heater S/N: 18

Item	Date - Month/Year							
	2/75							
1. Internal Resistance (MΩ)	>1000							
2. Breakdown Voltage (kV)	>1.5							
3. Coolant Leak Check	OK							
4. Water Flow Rate - (GPM @ 60 PSI ΔP)	18.19							
5. Operational Checkout								
a. Test Pressure (Torr)	100							
b. Specimen Temperature (°F)	3267							
c. Heater Bus Voltage	65							
d. Heater Amperage	750							
e. Pyrometer S/N	387							

GRAPHITE HEATER LOG SHEET

Contract No.: NAS 9-14041

Heater P/N: T-055429-3

Heater S/N: 19

Item	Date - Month/Year							
	2/75							
1. Internal Resistance (MΩ)	>1000							
2. Breakdown Voltage (kV)	>1.5							
3. Coolant Leak Check	OK							
4. Water Flow Rate - (GPM @ 60 PSI ΔP)	17.88							
5. Operational Checkout								
a. Test Pressure (Torr)	100							
b. Specimen Temperature (°F)	3244							
c. Heater Bus Voltage	65							
d. Heater Amperage	740							
e. Pyrometer S/N	388							

GRAPHITE HEATER LOG SHEET

Contract No.: NAS 9-14041

Heater P/N: T-055429-3

Heater S/N: 20

Item	Date - Month/Year							
	2/75							
1. Internal Resistance (MΩ)	>1000							
2. Breakdown Voltage (kV)	>1.5							
3. Coolant Leak Check	OK							
4. Water Flow Rate - (GPM @ 60 PSI ΔP)	18.04							
5. Operational Checkout								
a. Test Pressure (Torr)	100							
b. Specimen Temperature (°F)	3248							
c. Heater Bus Voltage	65							
d. Heater Amperage	740							
e. Pyrometer S/N	389							

GRAPHITE HEATER LOG SHEET

Contract No.: NAS 9-14041

Heater P/N: T-055429-3

Heater S/N: 21

Item	Date - Month/Year							
	2/75							
1. Internal Resistance (MΩ)	>1000							
2. Breakdown Voltage (kV)	>1.5							
3. Coolant Leak Check	OK							
4. Water Flow Rate - (GPM @ 60 PSI ΔP)	18.42							
5. Operational Checkout								
a. Test Pressure (Torr)	100							
b. Specimen Temperature (°F)	3284							
c. Heater Bus Voltage	65							
d. Heater Amperage	740							
e. Pyrometer S/N	389							

GRAPHITE HEATER LOG SHEET

Contract No.: NAS 9-14041

Heater P/N: T-055429-3

Heater S/N: 22

Item	Date - Month/Year							
	2/75							
1. Internal Resistance (MΩ)	>1000							
2. Breakdown Voltage (kV)	>1.5							
3. Coolant Leak Check	OK							
4. Water Flow Rate - (GPM @ 60 PSI ΔP)	17.78							
5. Operational Checkout								
a. Test Pressure (Torr)	100							
b. Specimen Temperature (°F)	3228							
c. Heater Bus Voltage	65							
d. Heater Amperage	740							
e. Pyrometer S/N	381							

ABSORBER LOG SHEET

Contract No.: NAS 9-14041

Absorber P/N: T-055433-1

Absorber S/N: 01

Item	Date - Month/Year							
	3/75							
1. Coolant Leak Check	OK							
2. Water Flow Rate - (GPM @ 60 PSI ΔP)	6.75							

ABSORBER LOG SHEET

Contract No.: NAS 9-14041

Absorber P/N: T-055433-1

Absorber S/N: 02

Item	Date - Month/Year							
	3/75							
1. Coolant Leak Check	OK							
2. Water Flow Rate - (GPM @ 60 PSI ΔP)	6.63							

ABSORBER LOG SHEET

Contract No.: NAS 9-14041

Absorber P/N: T-055433-1

Absorber S/N: 03

Item	Date - Month/Year							
	3/75							
1. Coolant Leak Check	OK							
2. Water Flow Rate - (GPM @ 60 PSI ΔP)	6.75							

ABSORBER LOG SHEET

Contract No.: NAS 9-14041

Absorber P/N: T-055433-1

Absorber S/N: 04

Item	Date - Month/Year							
	3/75							
1. Coolant Leak Check	OK							
2. Water Flow Rate - (GPM @ 60 PSI ΔP)	6.63							

ABSORBER LOG SHEET

Contract No.: NAS 9-14041

Absorber P/N: T-055433-1

Absorber S/N: 05

Item	Date - Month/Year							
	3/75							
1. Coolant Leak Check	OK							
2. Water Flow Rate - (GPM @ 60 PSI ΔP)	6.82							

ABSORBER LOG SHEET

Contract No.: NAS 9-14041

Absorber P/N: T-055433-1

Absorber S/N: 06

Item	Date - Month/Year							
	3/75							
1. Coolant Leak Check	OK							
2. Water Flow Rate - (GPM @ 60 PSI ΔP)	7.01							

ABSORBER LOG SHEET

Contract No.: NAS 9-14041

Absorber P/N: T-055433-1

Absorber S/N: 07

Item	Date - Month/Year							
	3/75							
1. Coolant Leak Check	OK							
2. Water Flow Rate - (GPM @ 60 PSI ΔP)	7.01							

INDEX