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DESIGN OF AIRDROP CONTROLLED EXIT SYSTEM (ACES)

BY
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Individual airdrop platforms are coupled to form assemblies consisting of two, three or four platforms. These assemblies are extracted from the aircraft and recovered as a unit, thereby eliminating dispersion of the airdropped materials on the drop zone. The platforms are modified by adding reinforcing truss structures along each side and incorporating hydraulic devices to control the attitude of the individual platforms relative to each other during the recovery process. Long suspension lines are employed to regulate the attitude of the elongated assemblies at touchdown. The airdropped materials are attached

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20. ABSTRACT (continued)

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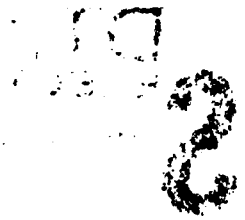

PREFACE

The U.S. Army Natick Research and Development Laboratories, Natick, Massachusetts has sponsored the technical effort to investigate, conceptionalize, and develop an airdrop technique which will materially reduce extraction time from the aircraft and dispersion of the airdropped materials on the drop zone. The AAI Corporation under contract DAAK60-77-C-0076, performed conceptual studies and analyses of various approaches which culminated in conception of a system where the platforms are connected and extracted from the aircraft in tandem and landed as a unit with a set of recovery parachutes. This system has been designated the Aircraft Controlled Exit System (ACES). Design services were performed, equipment fabricated, and laboratory and field testing performed that established the feasibility of the approach and demonstrated that the system was highly effective in reducing aircraft extraction time and dispersion on the drop zone.

Under this current contract DAAK-80-C-0082, the AAI Corporation has provided services for redesign of the system and fabrication of hardware to support DT-1 and OT-1 tests of the system. The capabilities of the system were also expanded to include platforms up to 24-feet in length, up to four platforms in an airdrop assembly, and airdrop of multiple assemblies from the same aircraft.

This ACES program has been performed under the direction of George Chakoian and Bruce Bonaceto of the U.S. Army Natick R&D Laboratories, Natick, Massachusetts.

Note: The terms used in this report are U.S. customary to conform with measurements used by the contractor.

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TABLE OF CONTENTS

		PAGE
PREFACE		1
LIST OF FIGURES		4
1.	INTRODUCTION	9
2.	PROGRAM OBJECTIVES	10
3.	ACES OPERATIONAL CONCEPT	12
4.	DESCRIPTION OF THE EQUIPMENT	25
5.	DESIGN	36
	A. Structural Design	36
	B. Interchangeability	40
	C. Expanded Platform Capability	40
	D. Expanded System Capability	41
	E. Investigation of Load Limiting Devices	41
	F. Improved Handling Provisions Aboard Aircraft	43
	G. Stacking Provisions	44
	H. Line Bag Provisions	44
	I. System Weights	44
6.	TEST PROGRAM PLANS	45
7.	CONCLUSIONS	45
APPENDICES		
	A. Design Drawings	47
	B. Structural Analyses	95
	C. Investigation of a Pressure Relief Valve as a Load Limiting Device	109

LIST OF FIGURES

		PAGE
Figure 1	Rotation Geometry ACES System	13
Figure 2	Sequence of Events in an ACES Airdrop	15
Figure 3	Details of ACES Equipment	16
Figure 4	Arrangement of Components at Hinge Line	17
Figure 5	Extration of ACES Assembly From Aircraft	18
Figure 6	Recovery Parachutes Deployed	19
Figure 7	Start of Recovery Parachute Inflation	20
Figure 8	Control of ACES Assembly Completed	21
Figure 9	ACES Assembly in Vertical Descent	22
Figure 10	ACES Assembly at Touchdown	23
Figure 11	ACES Airdrop Operation Completed	24
Figure 12	View of 12-foot Platform Assembly	26
Figure 13	View of 16-foot Platform Assembly	27
Figure 14	View of 20-foot Platform Assembly	28
Figure 15	View of 24-foot Platform Assembly	29
Figure 16	View of Lateral Brace-Truss End	30
Figure 17	View of Lateral Brace Members-Hydraulic Truss End	31
Figure 18	View of 35,000-Pound Extraction Force Transfer Coupler and Mounting Bracket	33
Figure 19	View of Release Mechanism for 35,000-Pound Extraction Force Transfer Coupling	34
Figure 20	Applied Loads - End Platform	38
Figure 21	Applied Loads - Center Platform	39

LIST OF FIGURES
(Continued)

		PAGE
Figure A-1	Extraction Coupling, 35 K Platform Extraction, Metric Platform	49
Figure A-2	Reinforcement Bar, 35 K Platform Extraction, Metric Platform	50
Figure A-3	Mounting Bracket, 35 K Release Actuator, Metric Platform	51
Figure A-4	Universdal Aft Truss End	52
Figure A-5	Universal Aft Truss End	53
Figure A-6	Interior Truss Member	54
Figure A-7	Interior Truss Member	55
Figure A-8	Strut Fwd. End	56
Figure A-9	Strut Fwd. End	57
Figure A-10	Strut Aft End	58
Figure A-11	Support Strut, Hydraulic Cylinder	59
Figure A-12	Support Strut, Hydraulic Cylinder	60
Figure A-13	Forward Truss End	61
Figure A-14	Forward Truss End	62
Figure A-15	Lateral Restraint Connector - Aft End	63
Figure A-16	Lateral Restraint Connector - Fwd. End	64
Figure A-17	Lateral Restraint Brace, Rail Extension	65
Figure A-18	Lateral Restraint Brace	66
Figure A-19	Upper Truss Member	67
Figure A-20	Upper Truss Member	68
Figure A-21	Upper Truss Member	69

LIST OF FIGURES
(Continued)

		PAGE
Figure A-22	Connecting Link	70
Figure A-23	Rail Extension	71
Figure A-24	Rod Eye	72
Figure A-25	Hydraulic Cylinder Assembly	73
Figure A-26	Aft Rail, Alum.	74
Figure A-27	Fwd Rail, Alum.	75
Figure A-28	Outer Aft Rail, Steel	76
Figure A-29	Inner Aft Rail, Steel	77
Figure A-30	Outer Fwd Rail, Steel	78
Figure A-31	Slide	79
Figure A-32	Sleeve	80
Figure A-33	Restrictor Valve	81
Figure A-34	Hydraulic Cylinder	82
Figure A-35	ACES Platform Assemblies	83
Figure A-36	ACES Platform Assemblies	84
Figure A-37	ACES Platform Assemblies	85
Figure A-38	Panel Assembly, Platform Extraction	86
Figure A-39	Rail, Side, Modified for ACES	87
Figure A-40	Pin	88
Figure A-41	Pin, Platform Connecting	89
Figure A-42	Sleeved Bolt	90

LIST OF FIGURES
(Continued)

		PAGE
Figure A-43	Rigging Assembly, ACES	91
Figure A-44	Rigging Assembly, ACES	92
Figure A-45	Pin, Platform Extraction Coupling	93
Figure A-46	Load Coupler, 4 Spool	94

DESIGN OF AIRDROP CONTROLLED EXIT SYTEM (ACES)

1. INTRODUCTION

A primary function of airdrop in the U.S. Army mission is surprise assault by aircraft. To enhance surprise assault, there is a need to reduce heavy airdrop extraction time during the airdrop of multiple platform loads from single aircraft and thereby reduce the dispersion pattern of the loads on the ground and exposure time of the aircraft. As a part of a continuing program to address this need the U.S. Army Natick Research and Development Laboratories, Natick, Massachusetts, sponsored an investigative effort to determine the best method of reducing extraction time and controlling dispersion. This contractor, under contract DAAK60-77-C-0076, contributed to these investigations by performing conceptual studies and analyses wherein various approaches were synthesized and analyzed. This culminated in conception of a system where the platforms are connected and extracted from the aircraft in tandem and landed as a unit with a set of recovery parachutes. Design services were performed, equipment fabricated, and laboratory and field testing of the system accomplished. The system has been designated the Airdrop Controlled Exit System (ACES). A summary of the investigative effort and the test experience is presented in engineering reports references 1 and 2, respectively, prepared by the AAI Corporation, Cockeysville, Maryland.

These conceptual investigations and the Engineering Development Tests (EDT) established the feasibility of the tandem method of extraction. It was further demonstrated that the system was highly effective in reducing

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1. A. L. Farinacci, Airdrop Controlled Exit System (ACES) Advanced Development Investigation. AAI Corporation, Contract DAAK60-77-C-0076 (1978), NATICK/TR-82/028 (1982) - (AD A119 348)

2. W. L. Black, Test Report Engineering Development Tests Airdrop Controlled Exit System (ACES). AAI Corporation, Contract DAAK60-77-C-0076 (1980), NATICK/TR-82/017 (1982) - (AD A118 737)

aircraft extraction time and eliminating dispersion in the drop zone. Based upon this experience the Army administered plans for continuing the development of the system by sponsoring programs which provided for improvement of the design, expansion of system capabilities and conduct of the required development (DT-1) and operational (OT-1) test programs.

Under contract DAAK60-80-C-0082 and under the direction of George Chakoian and Bruce Bonaceto of the U.S. Army Natick R&D Laboratories this contractor provided services for redesign of the system and fabrication of the hardware needed to conduct the test programs. Technical assistance was also provided as needed during the test programs. This report provides a summary of the services furnished under this contract.

2. PROGRAM OBJECTIVES

The equipment used in the engineering development tests was extensively instrumented to obtain data to guide future design activity. The data acquired during these tests was generally of good quality and adequate for its intended purpose. These data, which are presented in reference 2, were used in the redesign of the equipment. Using the data and experience of the EDT program, the following objectives were established for this program.

- o Conduct analyses and redesign the structures using the experience and data obtained in the EDT program.
- o Explore the possibility of achieving interchangeability of parts.
- o Expand the capability of the system to include a 24-foot platform.
- o Expand the system operational capability to accommodate four or more platforms in an ACES assembly and the airdrop of multiple assemblies from a single aircraft.
- o Investigate the possible use of load limiting devices which would modify peak loads and reduce structural weight.
- o Incorporate modifications that will improve handling aboard the aircraft.

- Design the truss members to permit vertical stacking of the platforms.
- Modify the design of the line bags that had been found useful in simplifying the rigging of the suspension lines.

3. ACES OPERATIONAL CONCEPT

In the ACES mode of operation, the individual platforms are connected so that they are simultaneously extracted from the aircraft in tandem order. The platforms are connected at hinge lines that run parallel to the platform ends and are located in a space between the platforms. Structure has been added to create these hinge line connections. As each platform clears the ramp, it is allowed to rotate in a nearly normal tip-off mode. This produces rotation about the hinge lines and an angle between the platforms. This angle caused by tip-off has been arbitrarily defined as a negative displacement angle. Any tendency to reduce this negative angle or rotate in the positive direction is resisted by a hydraulic control device that permits regulated rotation in this direction. The purpose of this constraint is to delay large positive displacements long enough for the main recovery parachutes to deploy and gain control of the assembly. Early experiments conducted by the Air Force with platforms connected but unconstrained resulted in large, rapid displacements of sufficient magnitude to destroy the equipment loaded on the platforms. This geometry is illustrated in Figure 1.

The recovery parachutes are deployed as soon as possible in the ACES system. The force transfer actuator is usually installed on the aftmost platform to enable early deployment. Tip-off rotations of the assembly ranging from 30 to 150 degrees results in good performance. Usually the suspension lines attached to the forward end of the assembly are the first to become taut. This pull accelerates tip-off rotation, the suspension lines become mostly slack, and the assembly rotates until the suspension lines to the aft end become taut. This accelerated tip-off rotation lasts for a period of one to two seconds during which time the recovery parachutes have reached an advanced state of deployment. When the aft suspension lines become taut, tip-off rotation is quickly terminated. All of the suspension lines then begin picking up load and the assembly swings down toward a vertical attitude and quickly stabilizes into vertical descent.

The initial pull of the end suspension lines during the above recovery sequence sometimes are of considerable magnitude. Also, because long

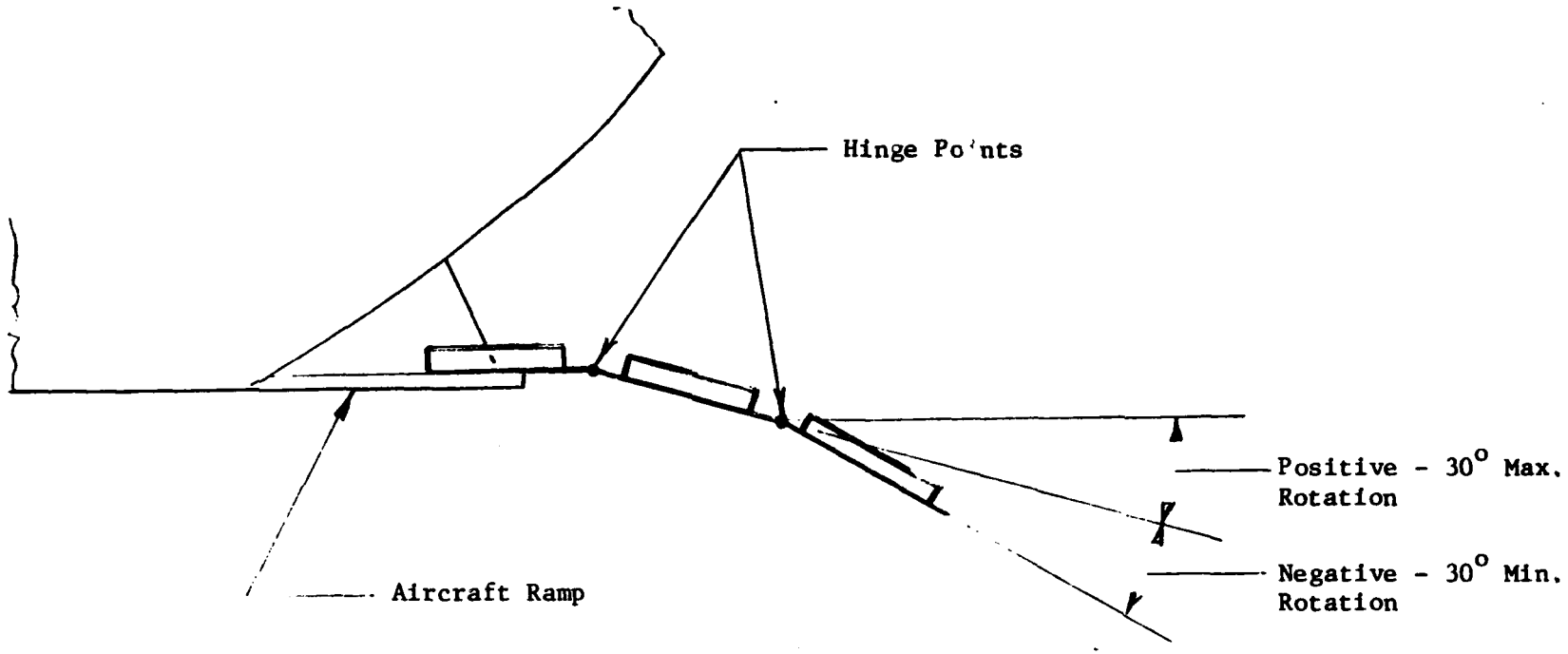


Figure 1. Rotation Geometry in ACES System

moment arms are involved, very large bending moments are created that the platform rails are incapable of carrying. Truss style reinforcement structures have been added to the rails to react these moments. The current truss structure has been designed to fit the metric type platform, but with some moderate modification they can also be installed on the Army's developmental Type V platform. The hydraulic components that provide rotational constraint in the positive direction have been incorporated in these reinforcing structures. Figures 2 and 3 are conceptual drawings that illustrate ACES operational procedures and details of the equipment.

The ability of the ACES system to function properly is dependent upon control of platform rotation about the hinge line that is created when a set of platforms is coupled. The hinge line is located in the plane of the platform rails and is created by connecting the triangular fittings of one platform to the rail extensions of the adjacent platform with a set of 1-1/4" diameter pins. This is shown in Figure 4. Twelve inches above these rail extensions is a bar designated the "compression link" which is attached to the truss at one end and to the hydraulic cylinder through a fitting at the other end. This arrangement allows $\pm$30 degrees of rotation about the hinge line. The cylinder has a rod in both ends so that oil displaced in one end of the cylinder can flow into the other end of the cylinder. The two ends of the cylinder have been connected by a line which contains a check valve. The check valve opens and permits uninhibited rotation of the platforms in the tip-off or negative direction, but during rotation in the opposite or positive direction the check valve closes forcing the oil to flow through an orifice. This orifice has been sized to limit the positive rate of rotation about the hinge line. Experience has shown that an orifice diameter of 0.013-inches functions satisfactorily. Under adverse conditions positive rotation has been limited to 25-degrees which is within the 30-degree physical limit built into the equipment. Figures 5 through 11 illustrate the various stages of a two-platform airdrop. The aircraft in this operation was a C-141B. In this assembly two 24-foot platforms were coupled and loaded to produce a total assembly weight of 35,000 pounds, which is the maximum permissible airdrop weight.

Figure 2. Sequence of Events in an ACES Airdrop

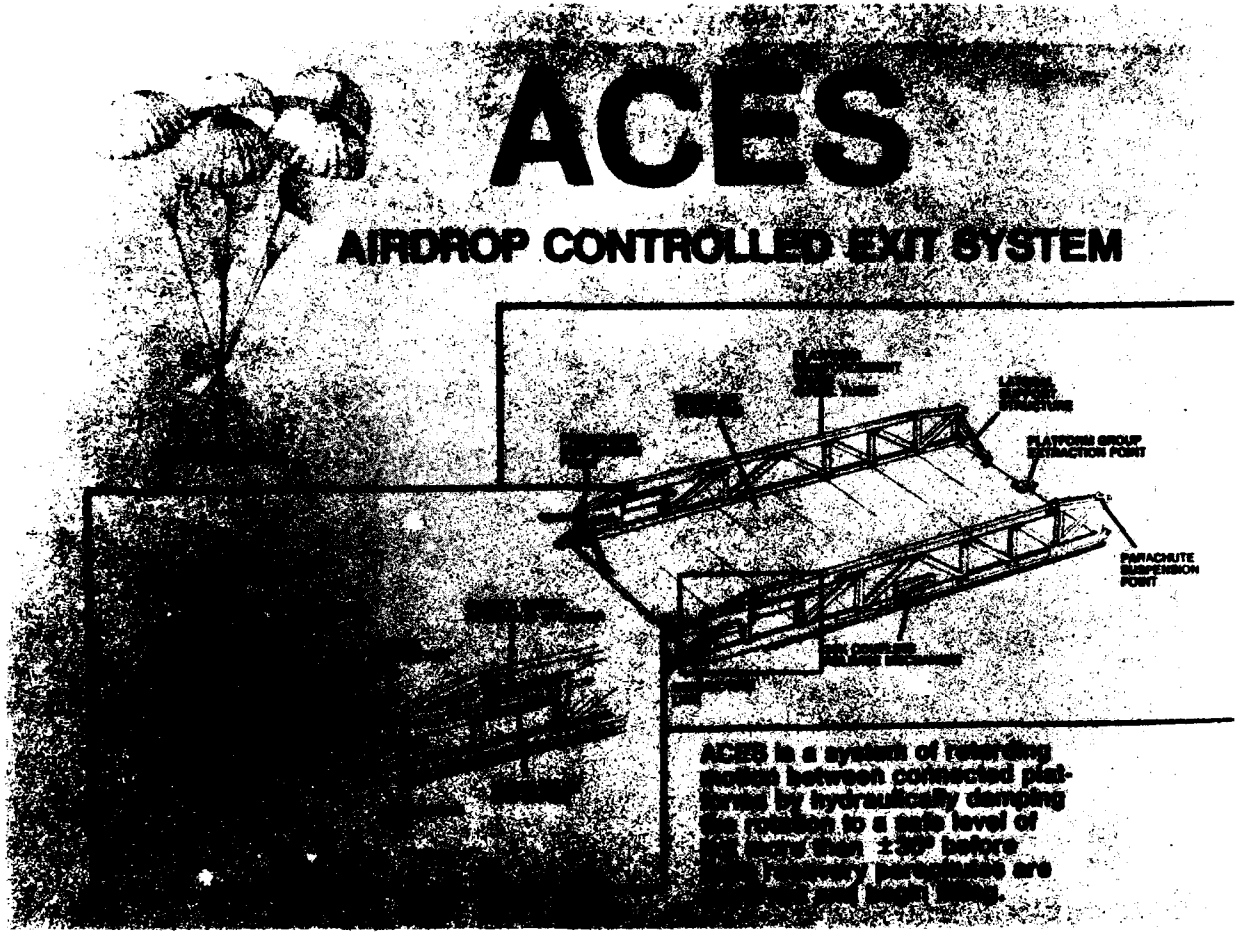


Figure 3. Details of ACES Equipment

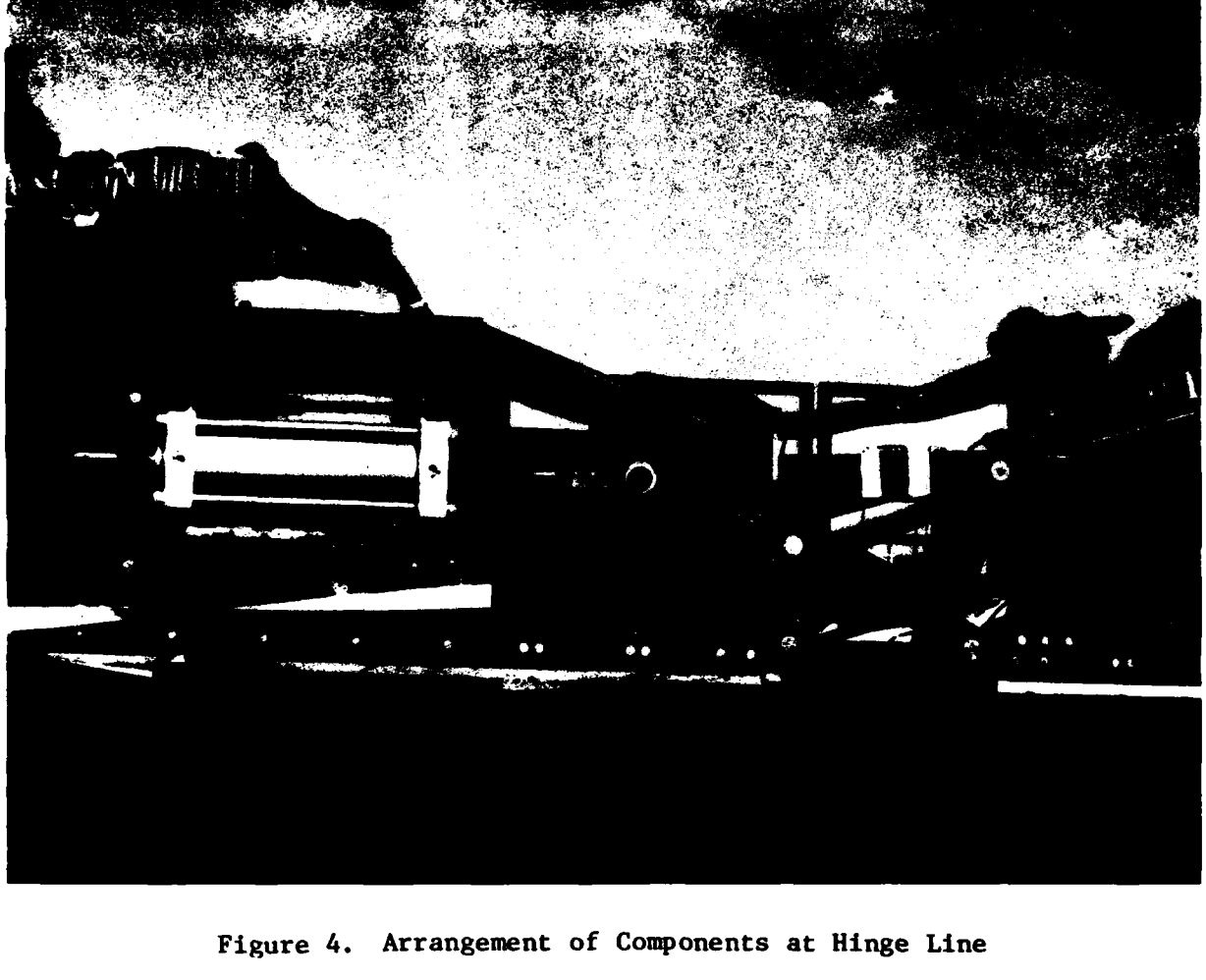


Figure 4. Arrangement of Components at Hinge Line

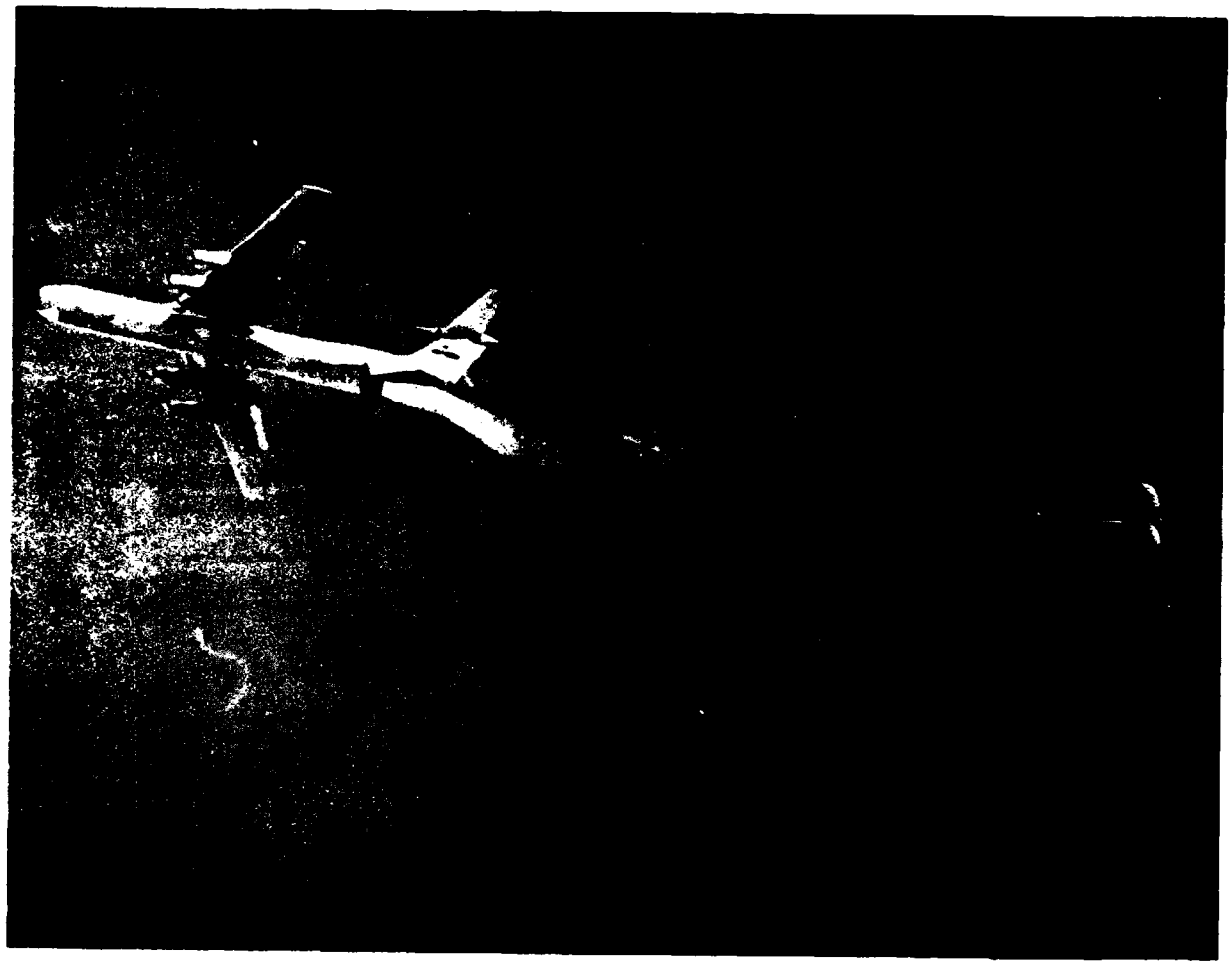


Figure 5. Extraction of ACES Assembly from the Aircraft

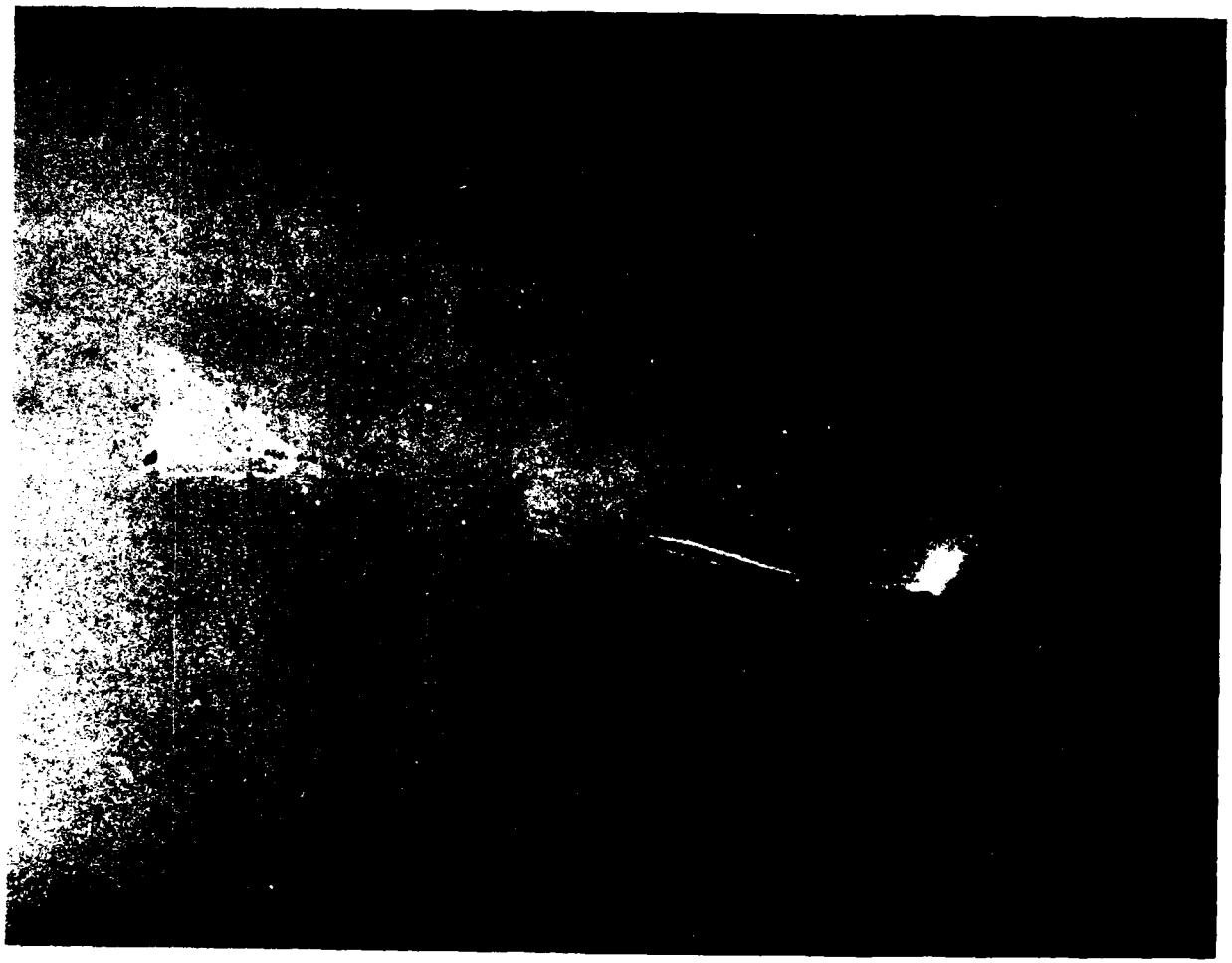


Figure 6. Recovery Parachutes Deployed

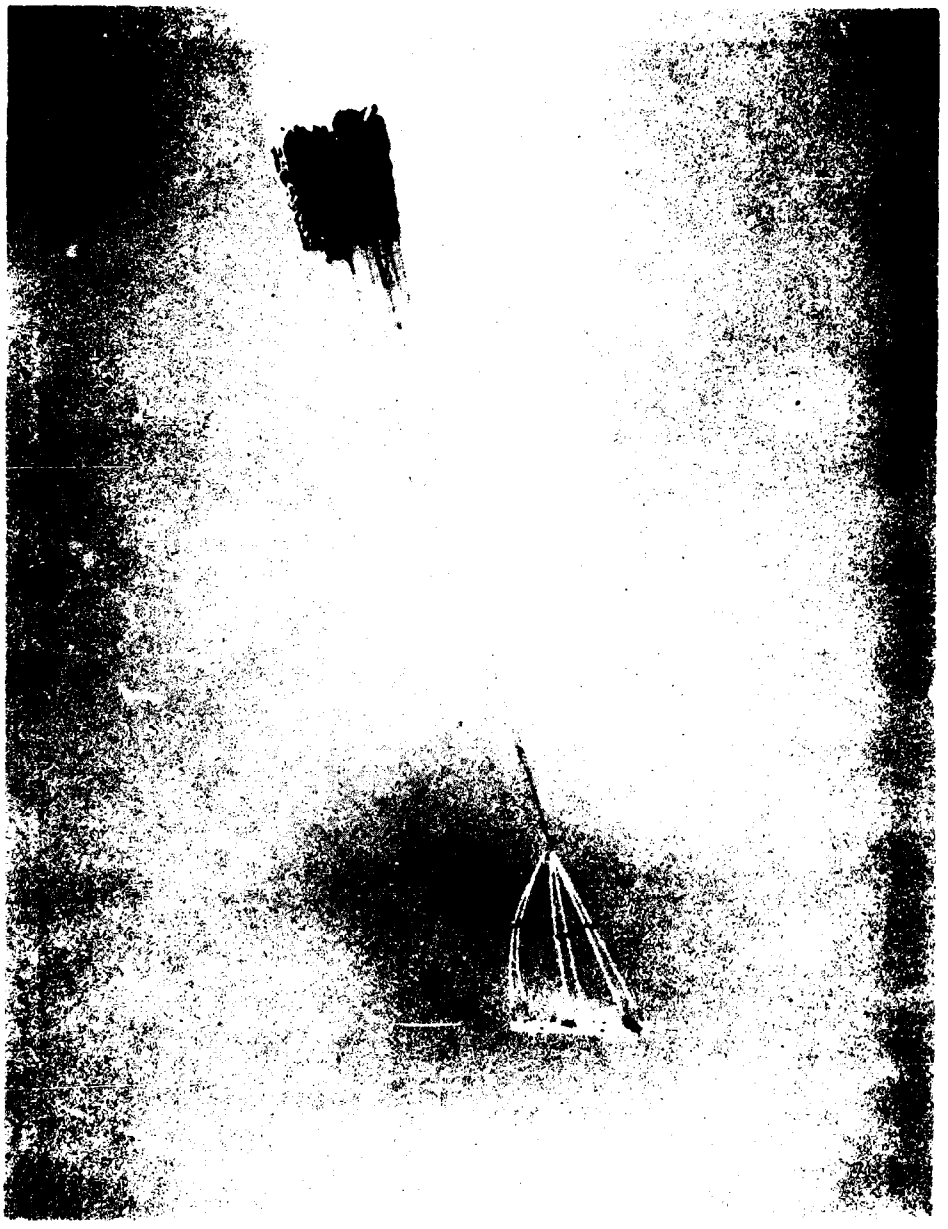


Figure 7. Start of Recovery Parachute Inflation

Figure 8. Control of ACES Assembly Complete

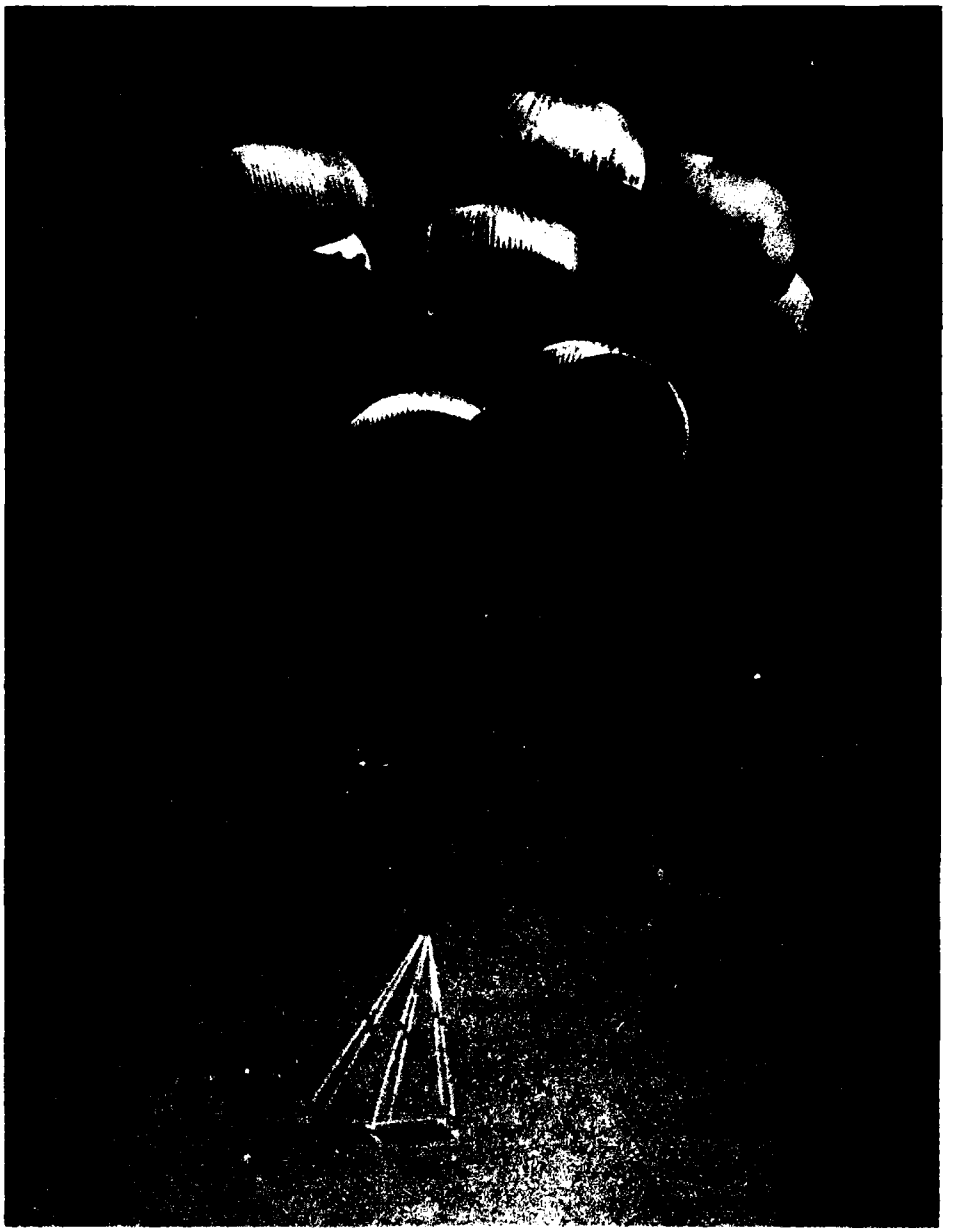


Figure 9. ACES Assembly in Vertical Descent

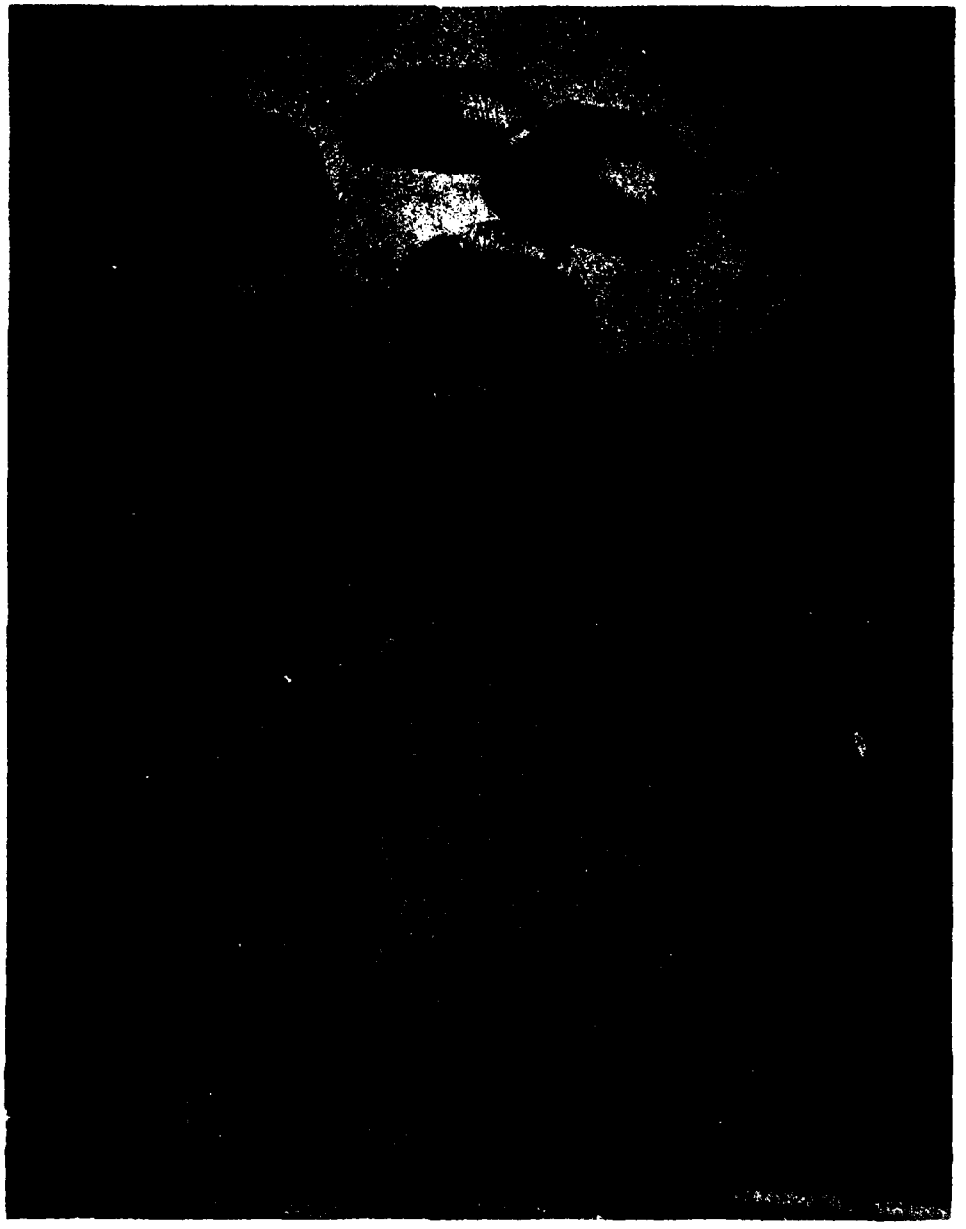


Figure 10. ACES Assembly at Touchdown

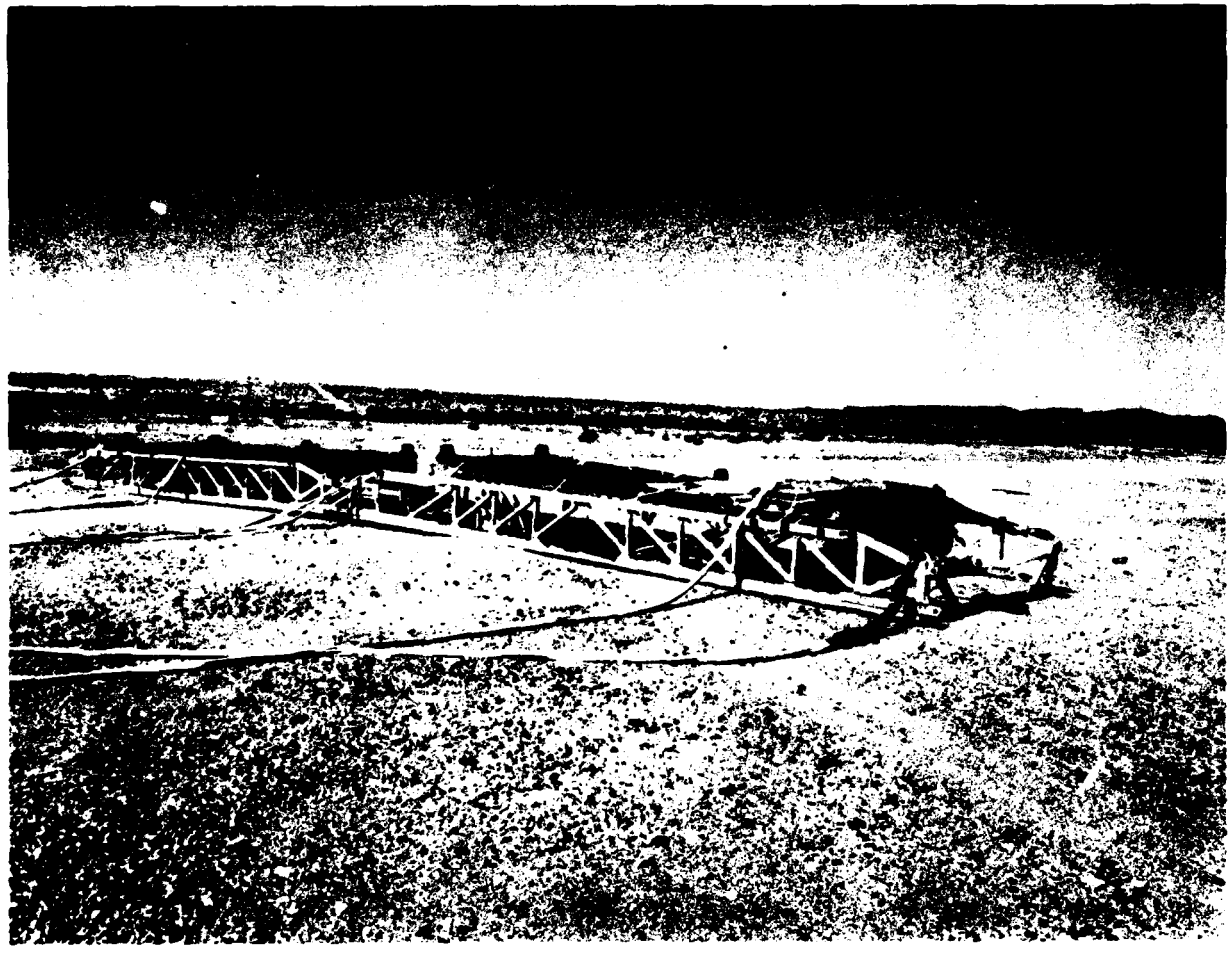


Figure 11. ACES Airdrop Operation Completed

4. DESCRIPTION OF THE EQUIPMENT

The ACES system equipment has been adapted to the 12-, 16-, 20-, and 24-foot standard metric platforms. The rails of these platforms were modified slightly by adding a few holes to aid the attachment of reinforcing members. These reinforcing members serve three purposes; first, they provide the means of securing the truss assembly to the rail; second, they assist in reacting the bending moments that occur in the area of the hydraulic cylinder; and third, they are extended beyond the platform on the trussed end of the platform to create one-half of the hinge line arrangement. The installation of these reinforcement members on the 12-foot platform shows clearly in Figure 12.

The primary structural members in the ACES equipment are the truss assemblies which are added to the rails to react the large bending moments imposed during the early stages of the recovery operation. These truss assemblies are fabricated of steel tubing and plate. They are built up by bolting together components that are largely interchangeable. Five components plus attachment hardware are required to fabricate a truss assembly. They are: a hydraulic cylinder end, a truss end, a top rail, a number of intermediate braces and the special vertical brace in the area of the hydraulic cylinder. The quantity of intermediate braces required depends upon the length of the platform. Views of the 16-, 20-, and 24-foot platform assemblies are provided in Figures 13, 14, and 15.

The truss assemblies require lateral restraint. This is provided by installation of lateral diagonal braces which can be readily installed and removed by the insertion of two pins. This feature is included to permit drive on/off of vehicular loads. The lateral restraint on the truss end is shown in Figure 16. A similar restraint for the hydraulic end is shown in Figure 17. An additional brace is shown in Figure 17 which is located in the plane of the platform. This brace stabilizes the triangular rail extension against lateral loads.

A triangular rail extension is shown in Figure 17. These rail extensions are attached to the hydraulic truss ends and provide one half of the hinge line arrangement. A view of two platforms coupled at the hinge line

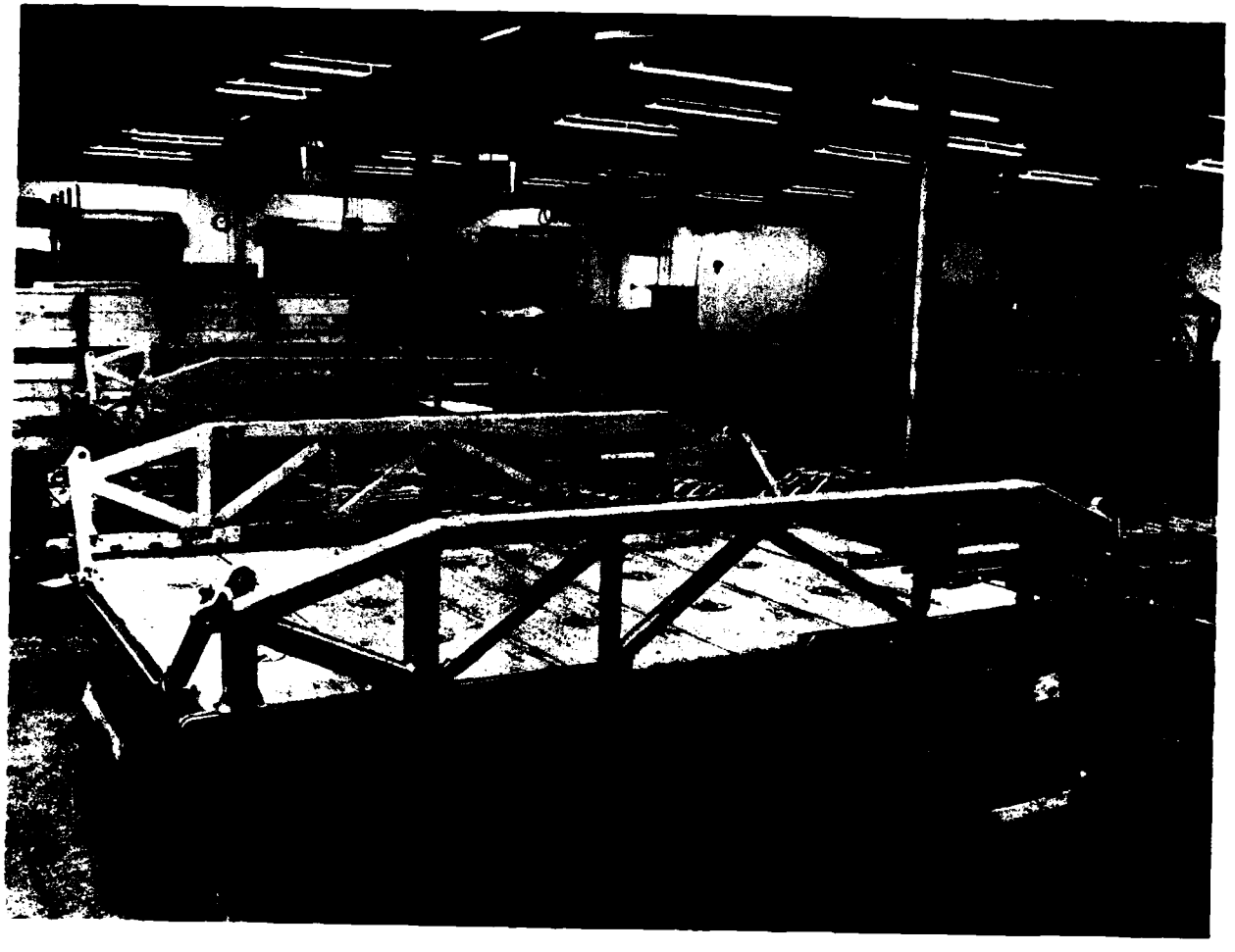


Figure 12. View of 12-foot Platform Assembly

Figure 13. View of 16-foot Platform Assembly

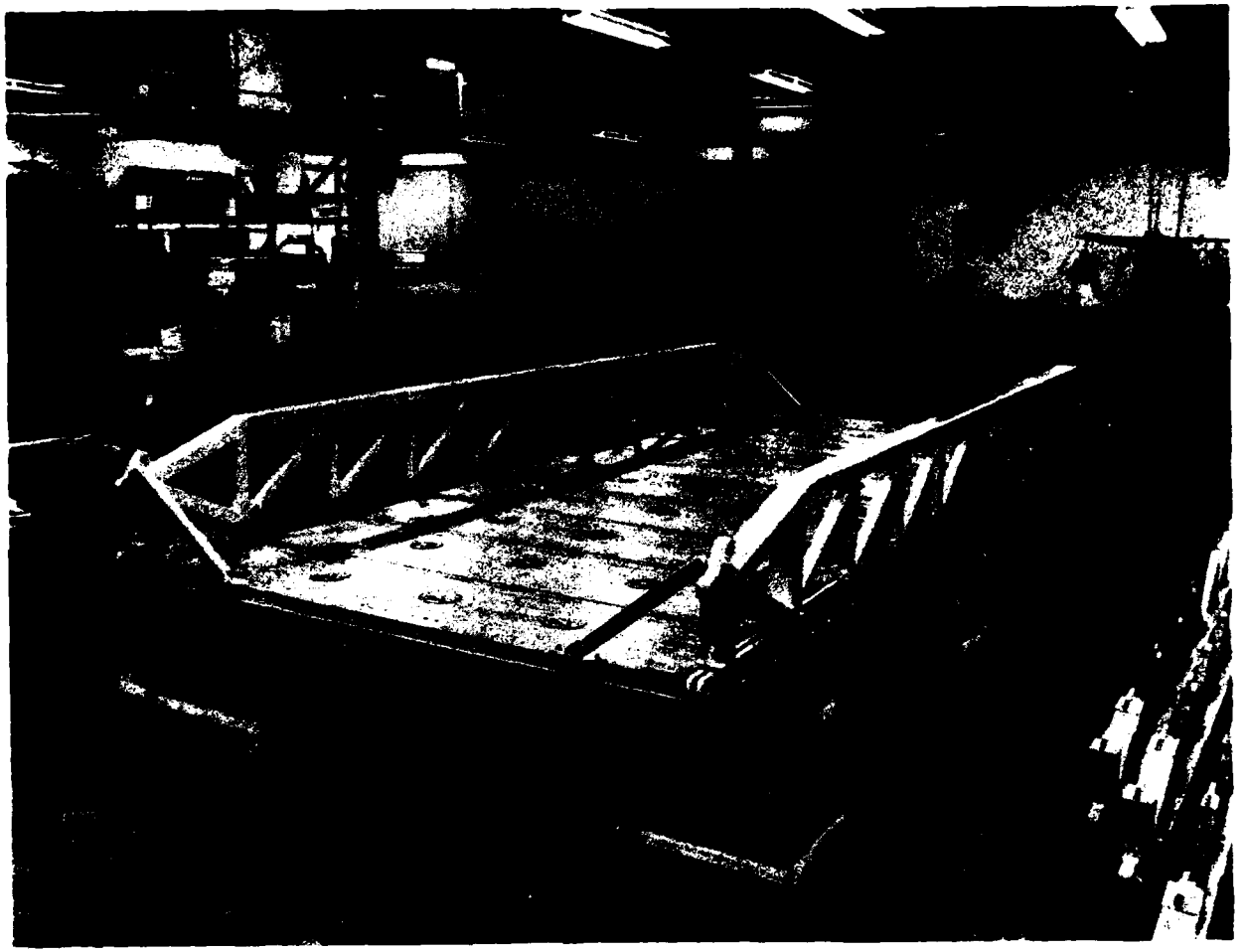


Figure 14. View of 20-foot Platform Assembly

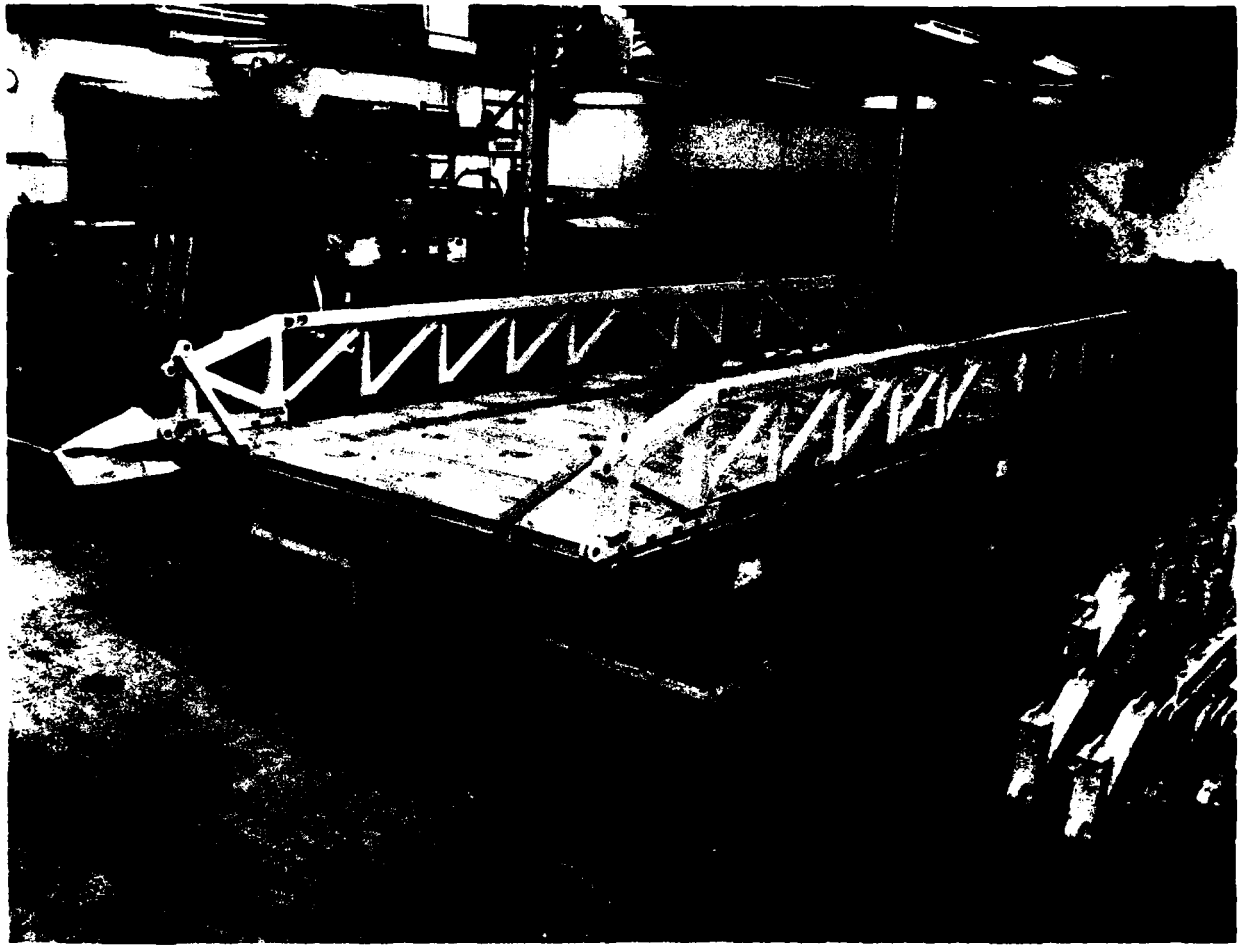


Figure 15. View of 24-foot Platform Assembly

Figure 16. View of Lateral Brace - Truss End

Figure 17. View of Lateral Brace Members - Hydraulic Truss End

is presented in Figure 4. Also illustrated in these two figures is the compression link. This link is located 12 inches above the hinge line and connects the hydraulic cylinder to the adjacent platform. The hydraulic cylinder that appears in these two views is the control device that regulates the rate of positive rotation about the hinge line. This is a five-inch-diameter cylinder with a two-inch-diameter rod extension at both ends to allow oil to flow from one side of the piston to the other. It is rated to operate at 5000 psi. This cylinder has operated in ACES at pressures up to 6300 psi without damage. This risk was taken to limit the size and weight of the cylinder. The design of this hydraulic control system was a critical matter and had considerable impact on the configuration of the ACES equipment.

Platform extraction is employed in the ACES system; i.e., the extraction parachute is attached to the platform rather than the load. Reinforcement bars have been added inside the platform and a bracket added that allows two degrees of rotational freedom for the standard 35,000-pound force transfer coupler. The bracket with the coupler installed is shown in Figure 18. This coupler is used to transfer the pull of the extraction parachutes to the deployment bags of the recovery parachutes and cause the parachutes to deploy. Timing of this transfer is accomplished with a release mechanism that is installed along the left-hand rail of one of the platforms. A special fitting adapts this release mechanism to the metric platform. This release mechanism and the load transfer coupler are connected through a push-pull cable. The release mechanism installed on a platform is shown in Figure 19. The arm being manually restrained in the illustration rests on top of the aircraft structure when installed in the aircraft. This restraint ends when this arm clears the end of the ramp, and the arm rotates about 180 degrees causing the coupler to release the extraction parachute and transfer its pull to the deployment bags of the recovery parachutes. In the ACES operation, early deployment of the recovery parachutes aids in limiting tip-off rotation, therefore, the release mechanism is usually installed on the aft platform.

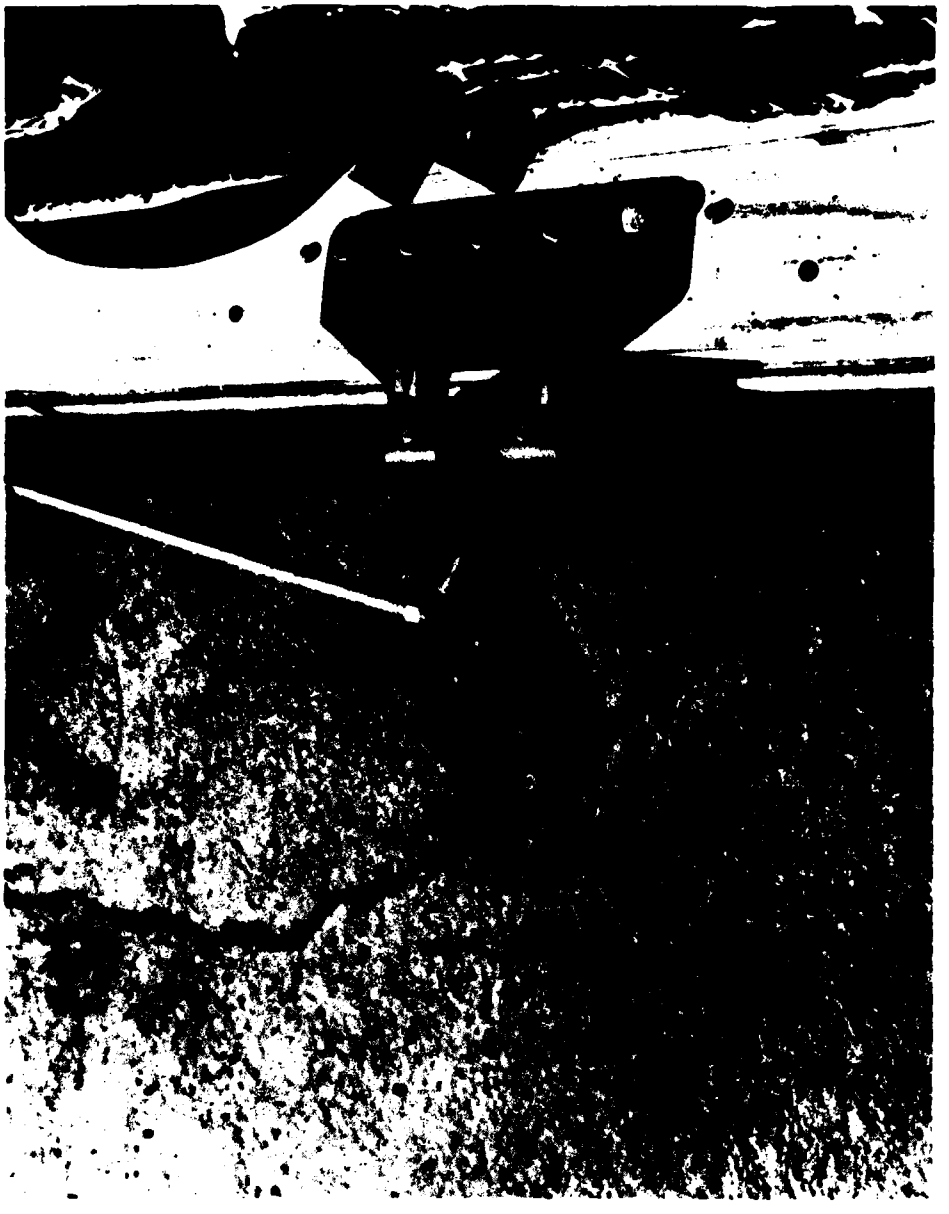


Figure 18. View of 35,000-Pound Extraction Force Transfer Coupler and Mounting Bracket

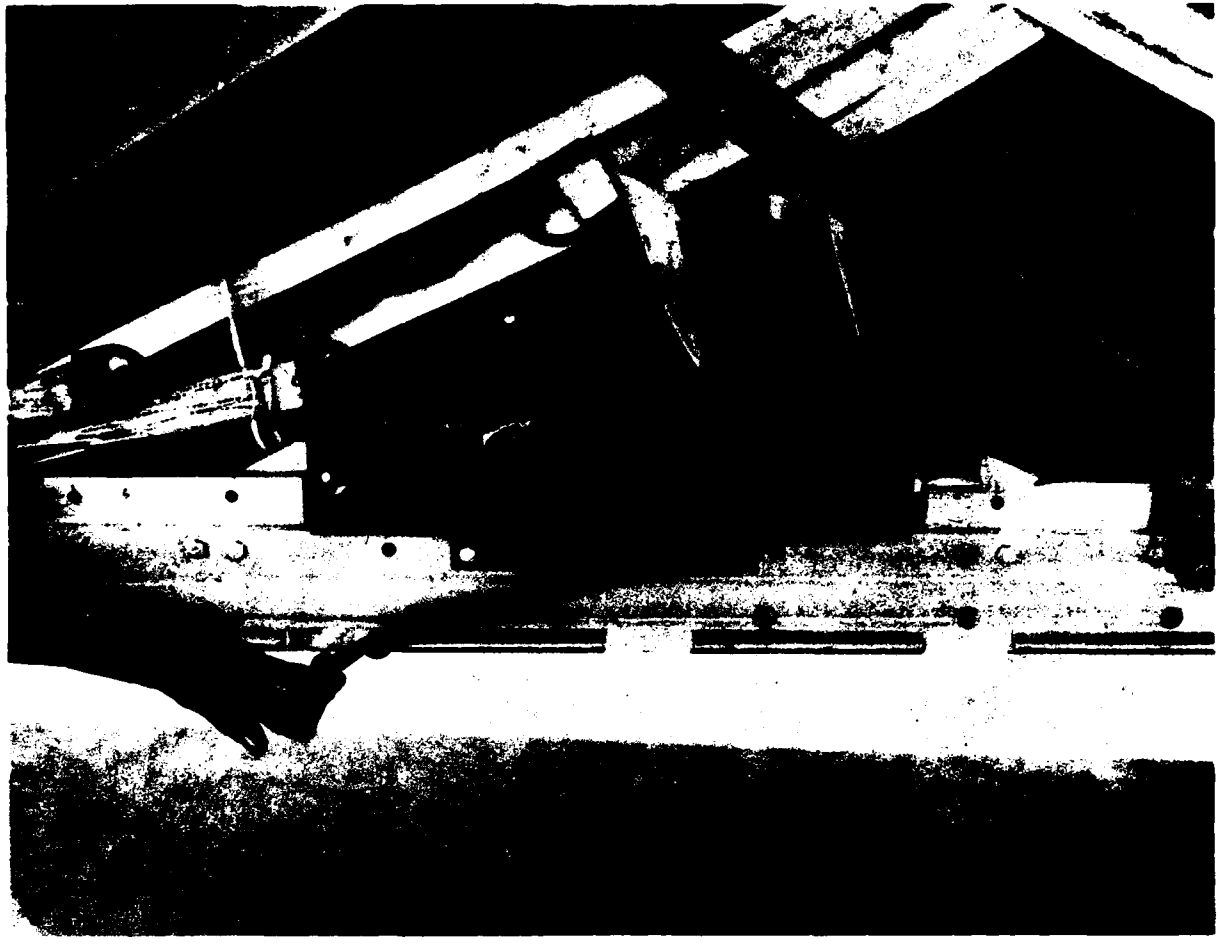


Figure 19. View of Release Mechanism for 35,000-Pound Extraction Force Transfer Coupling

The ACES system employs a platform suspension system; i.e., the suspension lines are attached to the platform rather than the load. Attachment points have been provided in the truss structure. The ACES suspension system is unique in two respects. First, additional suspension lines are required to control the articulated character of the assembly; and second, they are considerably longer than those employed in individual platform airdrop.

The suspension lines have been designed so that the confluence point is about 60 feet above the plane of the platforms. The purpose of this is to enable the use of suspension lines of approximately the same length regardless of the combination of platform lengths in the assembly and the position of the composite center of gravity. The 60-foot distance to the confluence point allows the attitude of the load at touchdown to be near enough to horizontal to produce a safe landing. A line bag is provided for each suspension line. The lines are packed in these bags which helps significantly in deploying the lines without entanglement. The line bags also reduce the time and difficulty of the rigging.

5. DESIGN

The performance of the equipment during the Engineering Development Testing program (EDT) indicated the ACES procedure of connecting a group of platforms and controlling their positions relative to each other during airdrop with hydraulic cylinders was a sound concept. Also, it was conclusively demonstrated that this technique provided the ultimate solution to rapid extraction from the aircraft and elimination of dispersion of airdropped materials on the drop zone. Instrumentation was used during the EDT program to acquire an extensive quantity of data on the performance of the equipment and the loads imposed on the structure throughout the airdrop operation. This provided a valuable bank of factual information to guide redesign of the equipment. Using these data and experience, the design effort was directed toward satisfying the program objectives listed in Section 2. Drawings of the ACES equipment are provided in Appendix A.

A. Structural Design

The truss style structure added to the platform rails in the EDT program equipment was an integral weldment. Experience showed that the concept of using a truss to reinforce the rails was good. The design loads in the EDT program had been empirically determined by computer simulation which proved to be lower than those actually experienced. Consequently, on some of the tests the structure yielded slightly at the attachment bolts and an occasional weld failed and had to be repaired. The redesigned structure was proportioned to react to the measured loads obtained during the EDT tests.

The basic configuration of the truss structure was not changed. It consists of top and bottom longitudinal members located 20.75 inches apart. Due to the uniqueness of the hydraulic control system, the principal loads are compression in the top member and tension in the lower member. These longitudinal elements are secured by vertical members located at 2.0-foot intervals with diagonal members located in each bay to react shear loads. This pattern is interrupted in the hydraulic cylinder end of the truss in order to provide space for installation of the cylinder. Special

provisions are necessary in this area to provide an adequate structure. The two-foot bay spacing was used for compatibility with the two-foot width of the platform panels.

The truss in this design is a bolted structure. This approach was adopted to satisfy a goal of maximizing the interchangeability of parts. Interchangeability is discussed in detail in section 5B. A bolted design was achieved at a very slight increase in weight, but the advantages interchangeable parts offer in manufacture and servicing in the field far outweigh this small weight penalty.

The data acquired in the EDT program were searched and analyzed to obtain typical loads that the structure experienced during an airdrop. The loads can be categorized into two types. One category is the peak loads that are of short duration of 250 to 500 milliseconds. The other category is the steady-state loads. The magnitudes of the steady-state loads are significantly lower than the pulse type loads and have no bearing on the design. The pulse loads are generated when the recovery parachutes begin to inflate and pull on the suspension lines running to an end of the ACES assembly. Typically, the lines to the forward end of the assembly might be the first to become taut. This accelerates tip-off rotation of the assembly. The next load imposed is through the suspension lines attached to the aft end of the assembly. This pull rapidly arrests tip-off rotation and a few milliseconds later all the suspension lines begin to take on loads as the recovery parachutes gain full control of the assembly. The magnitude and direction of these pulse loads is the product of several factors and varies from drop to drop. A careful review of the available information led to the adaption of the loading shown in Figues 20 and 21 as being characteristic of the loads applied to the structure. Figure 20 shows the typical loading on an end platform. Figure 21 shows typical loading of a center platform. Classical procedures were employed to compute the loads produced in the truss members. These member loads were multiplied by a factor of 1.50 and the product compared to the load-carrying capacity of the member. The capacity of the

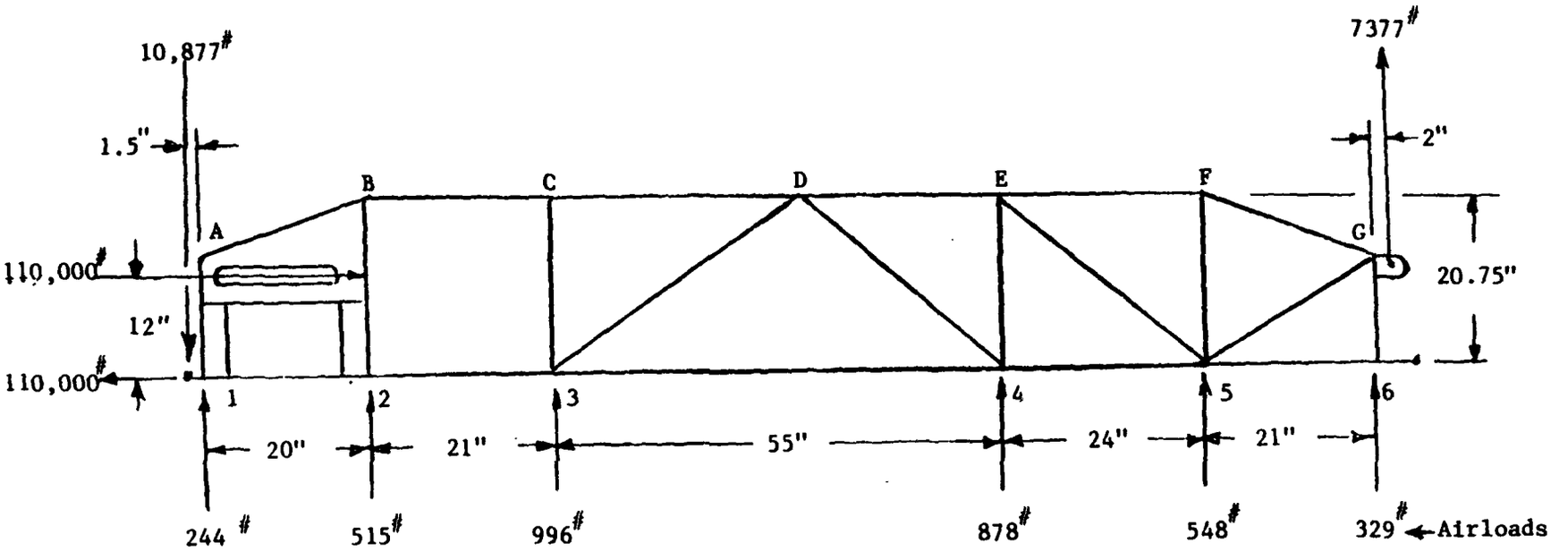


Figure 20. Applied Loads - End Platform

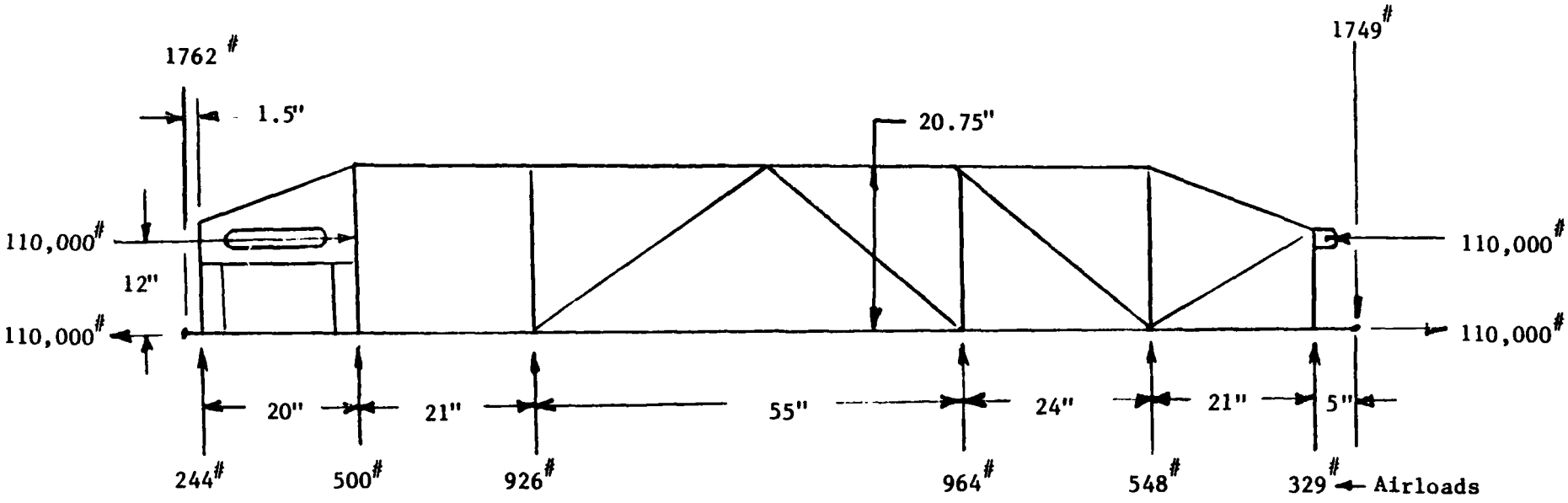


Figure 21. Applied Loads - Center Platform

members were determined by multiplying the allowable yield stress by the area of the member. A capacity greater than the applied loads multiplied by the 1.50 factor was the acceptance criterion.

Other loading conditions were analyzed, but the conditions shown in Figures 20 and 21 produced maximum stress levels, and consequently, governed the design. Detailed analyses of the 12-foot platform subject to these loads are provided in Appendix B. Similar analyses were performed for each of the four platform designs.

B. Interchangeability

A considerable effort was expended to achieve a large measure of interchangeability of parts. This was considered desirable for two reasons. First, it is envisioned that maintenance in the field will be simplified to a significant extent if the parts are interchangeable. Second, it is anticipated that manufacturing costs will be substantially lower if the truss assemblies can be fabricated from a small number of standard parts.

The effort to achieve interchangeability of parts was quite successful and every part in an ACES assembly is interchangeable to some degree. The parts separate into two classifications with respect to interchangeability. One class has universal interchangeability and the part can be used on any size platform and on either side of the platform. The other classification is limited interchangeability where the part is interchangeable on a certain size platform only. All parts in the ACES system have universal interchangeability except the following:

- The top rail members
- The lower rail reinforcements
- The compression links
- The triangular rail extensions

C. Expanded Platform Capability

A 24-foot platform was added to the ACES capability. No special problems were encountered in designing this unit except that the stability of the upper rail becomes precarious due to the long unsupported column span in the lateral direction. This member was reinforced by adding

plates to the 3 x 4 tube. With these added plate the design does not satisfy the 1.50 safety factor used as an acceptance criterion. However, the design was considered an acceptable risk because this size platform is rarely used as the middle platform in a three-platform configuration where maximum design loads occur. Also, any yielding during service results in a bent rail which can be readily repaired.

D. Expanded System Capability

The EDT program employed only two and three platform assemblies. It is envisioned as being desirable to employ four platforms in an assembly and plans were made to test assemblies containing four platforms during the test program. No particular problems with this expanded system are anticipated. Provisions have been made to attach the additional suspension lines to the parachute release mechanism. Any expansion beyond four platforms in an assembly would require the design of special equipment to accommodate the additional suspension lines.

It was also envisioned that it might be desirable to drop two ACES assemblies from a single aircraft. This would be possible only from the C-141B airplane because of the limited space in the C-130. Procedures for accomplishing this were established and multiple ACES drops are included in the test plans. The procedure will be nearly identical with the methods employed in multiple airdrop of individual platforms.

E. Investigation of Load Limiting Devices

The maximum loads imposed on the structure are pulse type loads having a duration of 250 to 500 milliseconds. These loads are generated by the pull of the recovery parachutes acting at one of the ends of the assembly during the period when the parachutes are deploying and acquiring control of the assembly. The pull is applied at one end and is usually of sufficient magnitude to reverse rotation of the assembly. This pull generates large moments at the hinge lines and the platforms would rapidly fold upon each other if the hydraulic cylinders were not in place to resist this motion. The loads measured in the compression links correlate very well in time and magnitude with the moment generated at the hinge lines by the pull of the

parachutes. The compression link load creates large pressures in the hydraulic cylinders, and it was reasoned that if this pressure could be limited in some manner, the loads on the structure would be correspondingly reduced.

The hydraulic cylinders are rated to operate at a maximum pressure of 5000 pounds per square inch. A relief valve set to open at 5000 psi is capable of limiting the peak pressure to this value provided it has sufficient flow capacity. The load applied to the structure will be correspondingly limited. The duration of the load pulse modified in this manner is a critical matter. The duration of the unmodified load pulses vary from 250 to 500 milliseconds; therefore, it is reasonable to assume that the modified load pulse will last at least 500 milliseconds. This value was used to investigate the feasibility of limiting the peak loads with a pressure relief valve. The function of the hydraulic cylinder is to limit positive rotation between the platforms to 30 degrees. The object of the analysis, therefore, is to determine whether or not this rotational constraint is exceeded when a relief valve is installed in the system.

In the investigation a three-platform configuration was used and it was assumed that the end platform where the parachute pull was applied was a 12-foot platform and carried a light load of 4200 pounds. The other platforms carried heavy loads which made them difficult to rotate. The applied parachute load was sufficient to generate a torque of 220,000 foot-pounds at the hinge line. This is the load measured in EDT test No. 13 and was used to design the truss structure. Analyses for systems equipped with both a 4.0-inch and a 5.0-inch diameter control cylinder having relief valves set at 5000 psi were performed. These analyses are presented in Appendix C. For the 4.0-inch-diameter cylinder, platform rotation during the 500-millisecond pulse would be 106 degrees, and the flow rate through the valve would be 218 gallons per minute (GPM). For the 5.0-inch-diameter cylinder platform rotation would be 47 degrees and the flow rate through the valve 167 GPM. All of these values are excessive; therefore, this approach was assessed as being unsatisfactory. The duration of the load pulse is critical, and if it did not exceed 400 milliseconds, the use of a relief valve with a 5.0-inch-diameter

cylinder would be acceptable. A review of the test information indicates that a pulse of this short duration is unrealistic; therefore, this approach was not adopted.

An alternate approach that provides a measure of load control is to use a large diameter orifice in the check valve by-pass. The system is designed so that the check valve closes when positive rotation between a set of platforms begins. This forces the oil to flow through an orifice and the rate of positive rotation is controlled. This orifice can be enlarged to permit increased oil flow which will limit the system oil pressure and the associated loads. Rotation must be limited, however, to the +30-degree limit built into the system. Sizing of the orifice can best be determined experimentally, and this is the approach that is planned for the test program. Rotation between the platforms is measured in all tests. The orifice size will be increased gradually from test to test until rotations approaching the 30-degree limit are obtained. The orifice size will be held constant during the remainder of the program and the measured loads obtained under these conditions can be used in any subsequent design effort.

F. Improved Handling Provisions Aboard Aircraft

During the EDT test program problems were sometimes encountered in joining the platforms and achieving engagement with the detent locks in the aircraft. These two operations are somewhat interdependent. To improve this situation triangular rail extensions were added and an elongated hole was made at one of the attachment points so that vertical alignment of the holes at the hinge line is possible. To obtain alignment in the horizontal direction, the holes in the fixed aft rail extensions were elongated. In addition, the pins used to accomplish the connections were formed with long tapered noses to aid installation as well as disassembly.

Many of the pins used to join removable parts of the assembly were quick-action of the "pip" pin variety. Also, retainers for straight pins were of the snap-on variety. This approach was pursued to the extent that no bolted connections are involved in the assembly or disassembly of an ACES assembly. Bolts are used, however, where parts are permanently connected.

G. Stacking Provisions

In the initial equipment design, attachment provisions for the suspension slings protruded above the level of the top rail and prevented stacking of the platform assemblies. In the modified equipment the suspension sling attachment points have been relocated and the top rails designed so that no protrusions are present to interfere with vertical stacking of the assembled platforms.

H. Line Bag Provisions

In the three- and four-platform ACES assemblies there are a considerable number of suspension slings, and management of these slings during the rigging operation can be a problem. During the EDT program the riggers at the proving ground devised a line bag in which the slings are packed. These line bags did not interfere with the operation of the slings and were of considerable help in managing the rigging operation.

The line bags used in the EDT program functioned well but no attempt had been made to optimize their design and minimize their weight. The task of improving the design was pursued at the Natick Laboratories and a bag was developed that was simpler and much lighter than the earlier improvised units. Natick tested these line bags and fabricated sufficient quantities to support the test program.

I. System Weights

Control of the equipment weight was a prime factor during design. The applied loads measured during the EDT tests and used in the redesign effort were 70 percent higher than those used in the design of the initial equipment. The larger loads and some compromising of the design to achieve interchangeability caused an increase of about 35 percent in the weight of the EDT equipment.

A major portion of the weight is in the truss ends. These items are identical on all platform assemblies. They weigh 1160 pounds. The center truss structure weighs approximately 44 pounds per foot. The following is a listing of the weights of the ACES equipment for the various length platforms.

Platform Length-Ft	System Weight-lbs
12.0	1510
16.0	1693
20.0	1862
24.0	2049

6. TEST PROGRAM PLANS

Plans were developed for conducting a test program at the Army's Yuma Proving Ground in Arizona. The plan provides for 24 system tests. Events, loads, and motions will be monitored by onboard instruments and the measurements telemetered and recorded on the ground. Extensive photographic coverage is planned to monitor and record performance throughout the airdrop operation. The tests have been designed to provide performance data on the numerous ACES configurations that are expected to be used in service. The information obtained from this program will be used to guide effort leading to a final design for the ACES equipment.

7. CONCLUSIONS

The design goals established for the program have been fully satisfied except for a completely satisfactory means for limiting or modifying the pulse type loads that dictate structural requirements. Partial success in this area is anticipated by increasing the size of the orifice that controls the rate of positive rotation between the platforms. The degree of success in this area will be determined during the test program. A major design accomplishment is achievement of full interchangeability of parts. It is anticipated that this will produce significant benefits both in the manufacture and in the use and maintenance of the equipment.

APPENDIX A

DESIGN DRAWINGS

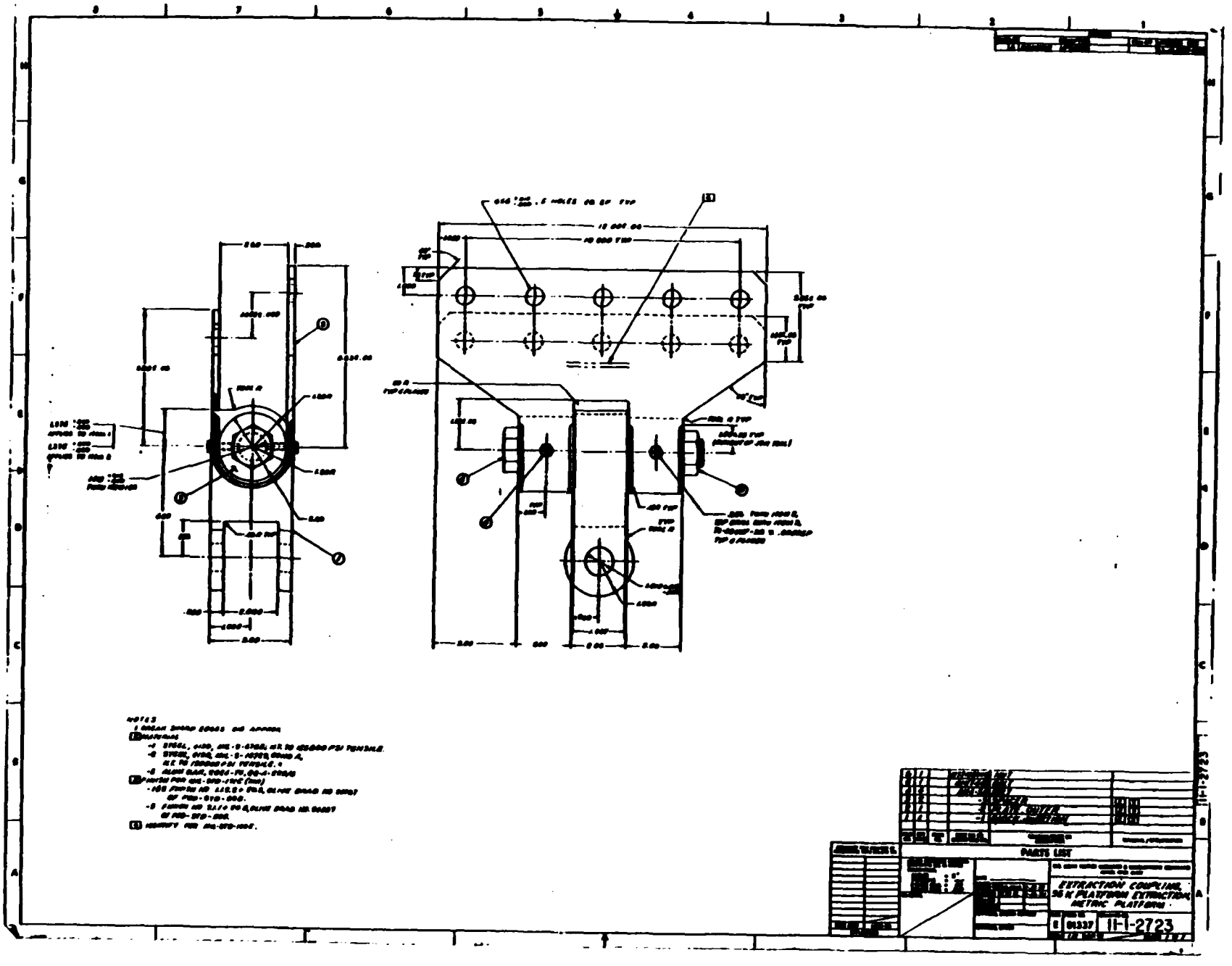

PARTS LIST
EXTRACTION COUPLING,
36 K PLATFORM EXTRACTION
METRIC PLATFORM
11-1-2723

Figure A-1

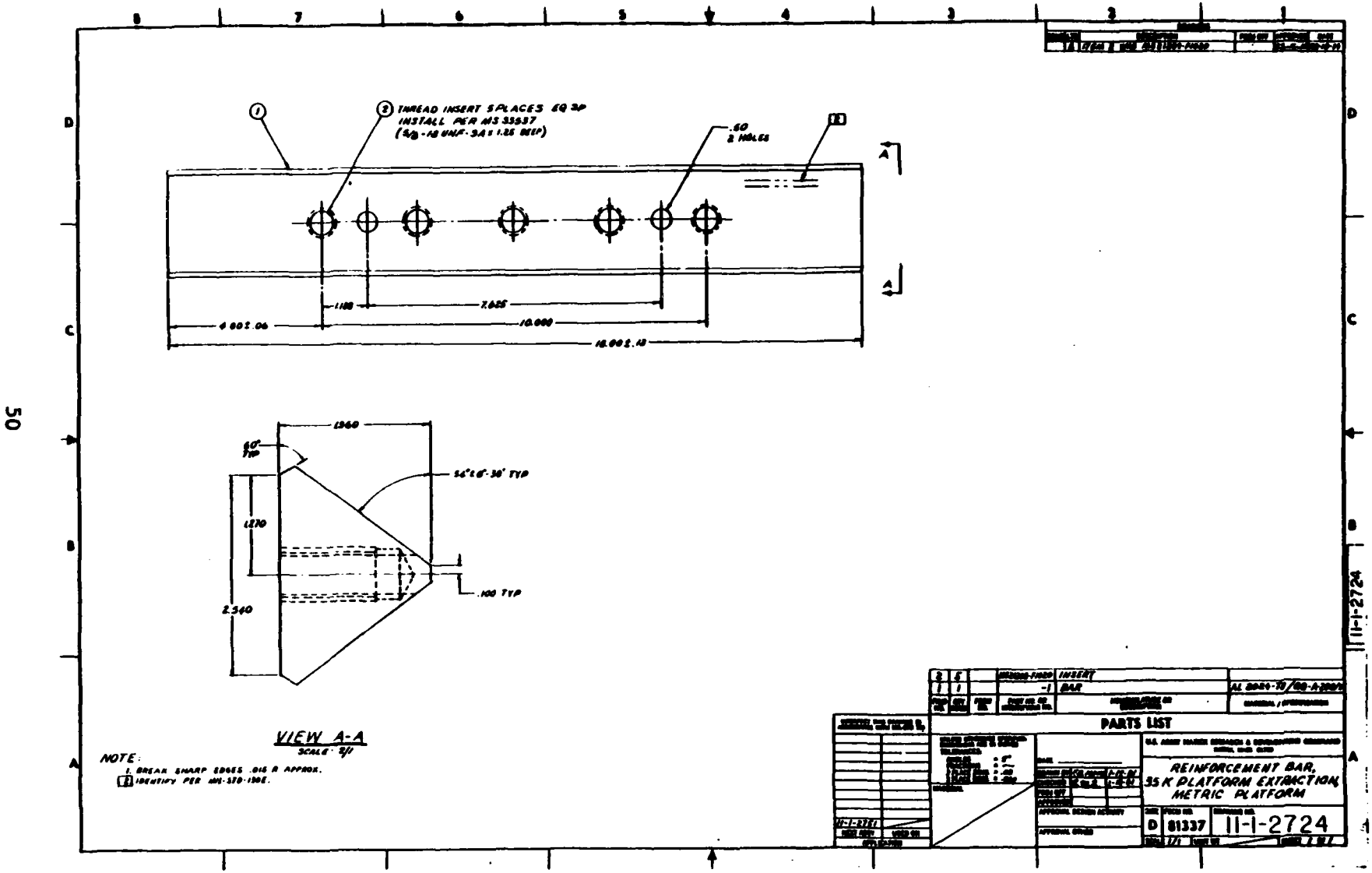

2 THREAD INSERT 5 PLACES EQ SP
INSTALL PER MS 33537
(5/8-18 UNF-3A x 1.25 DEEP)
.60
2 HOLES
1.188
7.625
10.000
4.812.06
10.062.13
1.960
60°
54°±6°-30' TYP
1.270
2.340
.100 TYP
VIEW A-A
SCALE 2/1
NOTE:
1. BREAK SHARP EDGES .015 R APPROX.
2 IDENTIFY PER MIL-STD-130E.
PARTS LIST
REINFORCEMENT BAR,
35 K PLATFORM EXTRACTION,
METRIC PLATFORM
D 81337 11-1-2724
11-1-2724

Figure A-2

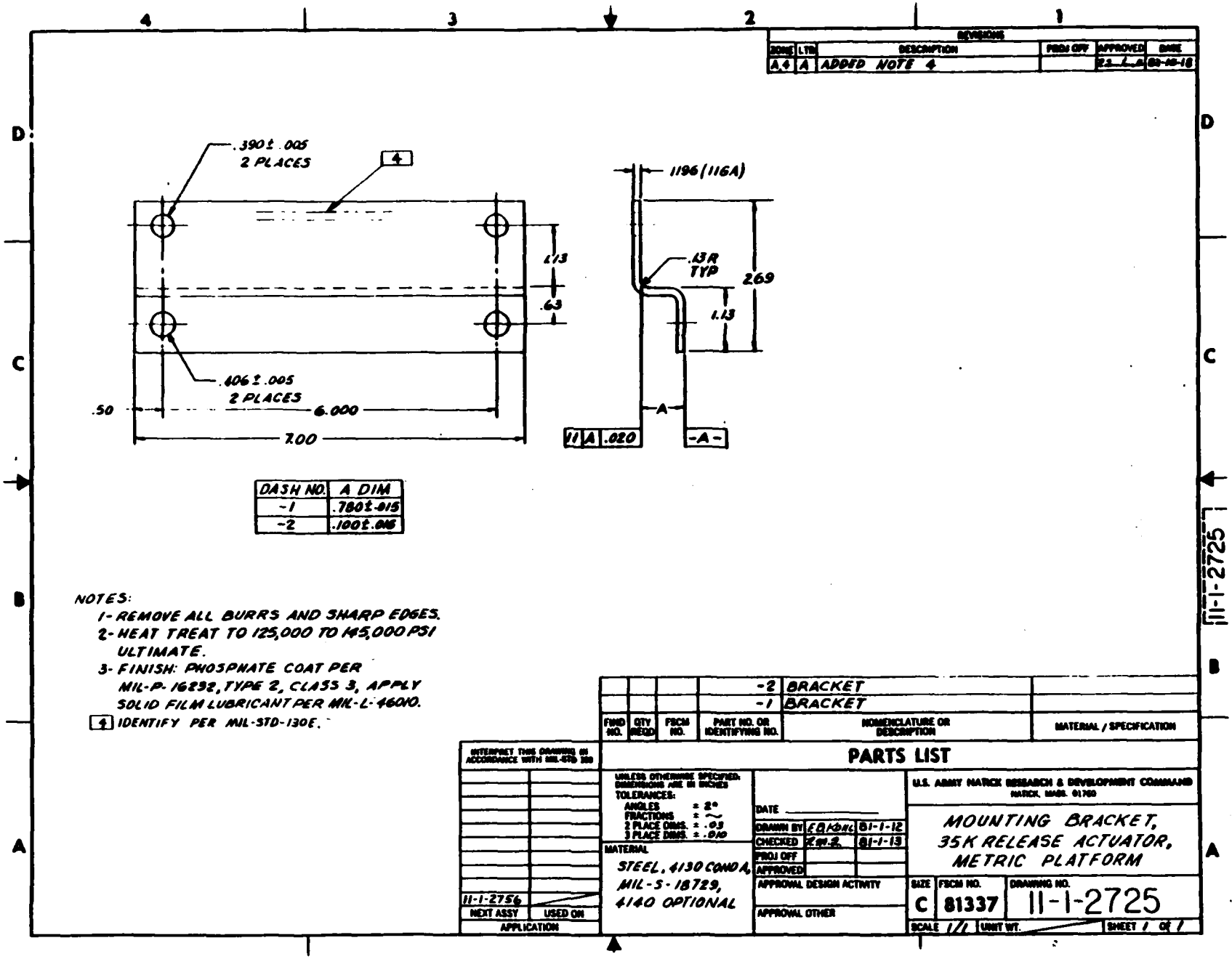

REVISIONS
ZONE | LTR | DESCRIPTION | PROJ OFF | APPROVED | DATE
A.4 | A | ADDED NOTE 4 | | | 80-10-16
.390 ± .005
2 PLACES
4
.13
.63
.106 ± .005
2 PLACES
.50
6.000
7.00
1196 (116A)
.13R
TYP
269
1.13
A
11 A .020
-A-
DASH NO. | A DIM
-1 | .780 ± .015
-2 | .100 ± .005
NOTES:
1- REMOVE ALL BURRS AND SHARP EDGES.
2- HEAT TREAT TO 125,000 TO 145,000 PSI ULTIMATE.
3- FINISH: PHOSPHATE COAT PER MIL-P-16232, TYPE 2, CLASS 3, APPLY SOLID FILM LUBRICANT PER MIL-L-46010.
4 IDENTIFY PER MIL-STD-130E.
-2 BRACKET
-1 BRACKET
FIND NO. | QTY REQD | FSCM NO. | PART NO. OR IDENTIFYING NO. | NOMENCLATURE OR DESCRIPTION | MATERIAL / SPECIFICATION
PARTS LIST
INTERPRET THIS DRAWING IN ACCORDANCE WITH MIL-STD 100
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES
TOLERANCES:
ANGLES ± 2°
FRACTIONS ± ~
2 PLACE DIMS. ± .03
3 PLACE DIMS. ± .010
MATERIAL
STEEL, 4130 COND A, MIL-S-18729, 4140 OPTIONAL
DATE
DRAWN EBKohl 81-1-12
CHECKED Kent S. 81-1-13
PROJ OFF
APPROVED
APPROVAL DESIGN ACTIVITY
APPROVAL OTHER
U.S. ARMY NATICK RESEARCH & DEVELOPMENT COMMAND
NATICK, MASS. 01760
MOUNTING BRACKET, 35K RELEASE ACTUATOR, METRIC PLATFORM
SIZE C | FSCM NO. 81337 | DRAWING NO. 11-1-2725
SCALE 1/1 | UNIT WT. | SHEET 1 OF 1
11-1-2756
NEXT ASSY | USED ON
APPLICATION
11-1-2725

Figure A-3

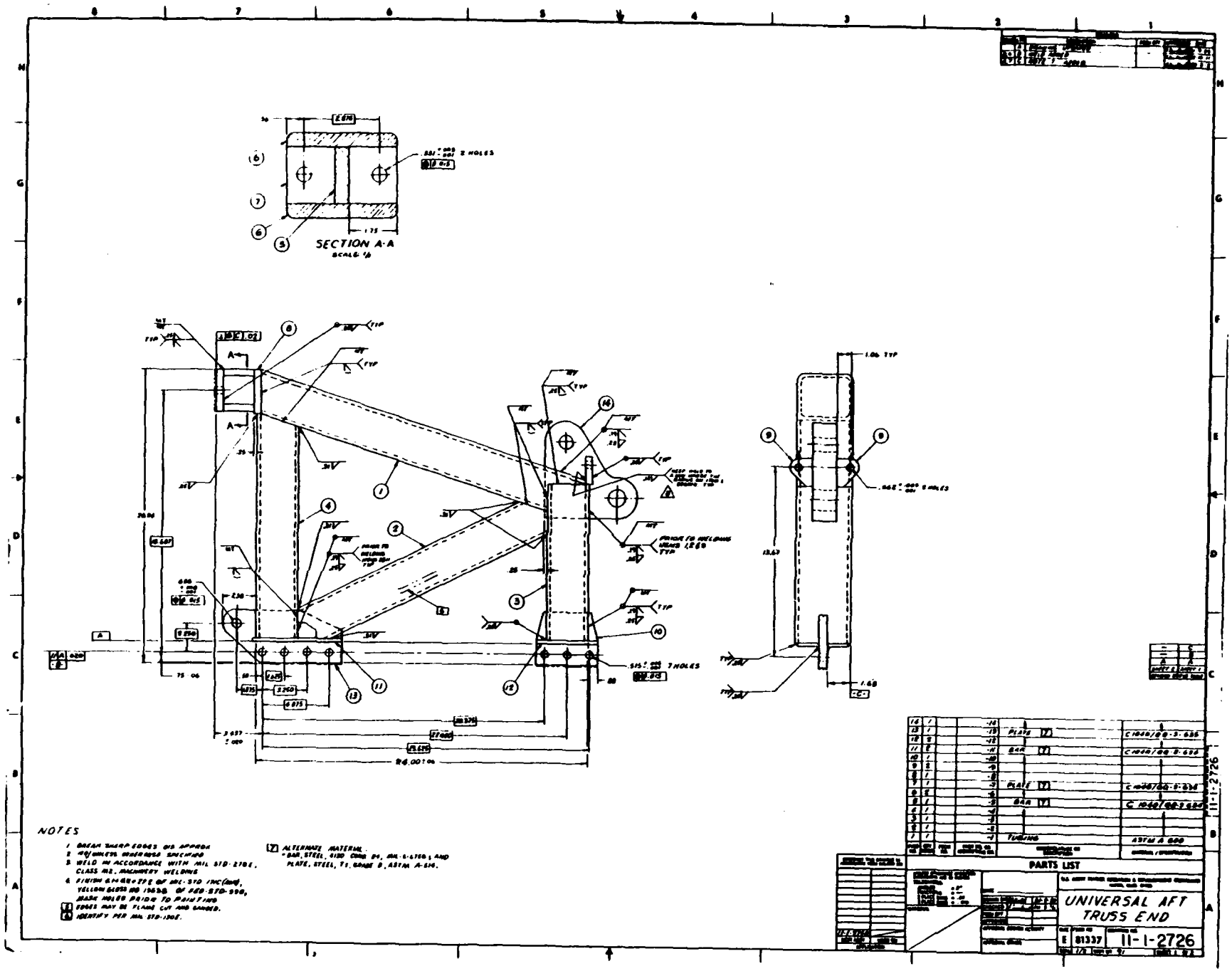

SECTION A-A
SCALE 1/2
NOTES
PARTS LIST
UNIVERSAL AFT TRUSS END
11-1-2726

Figure 4

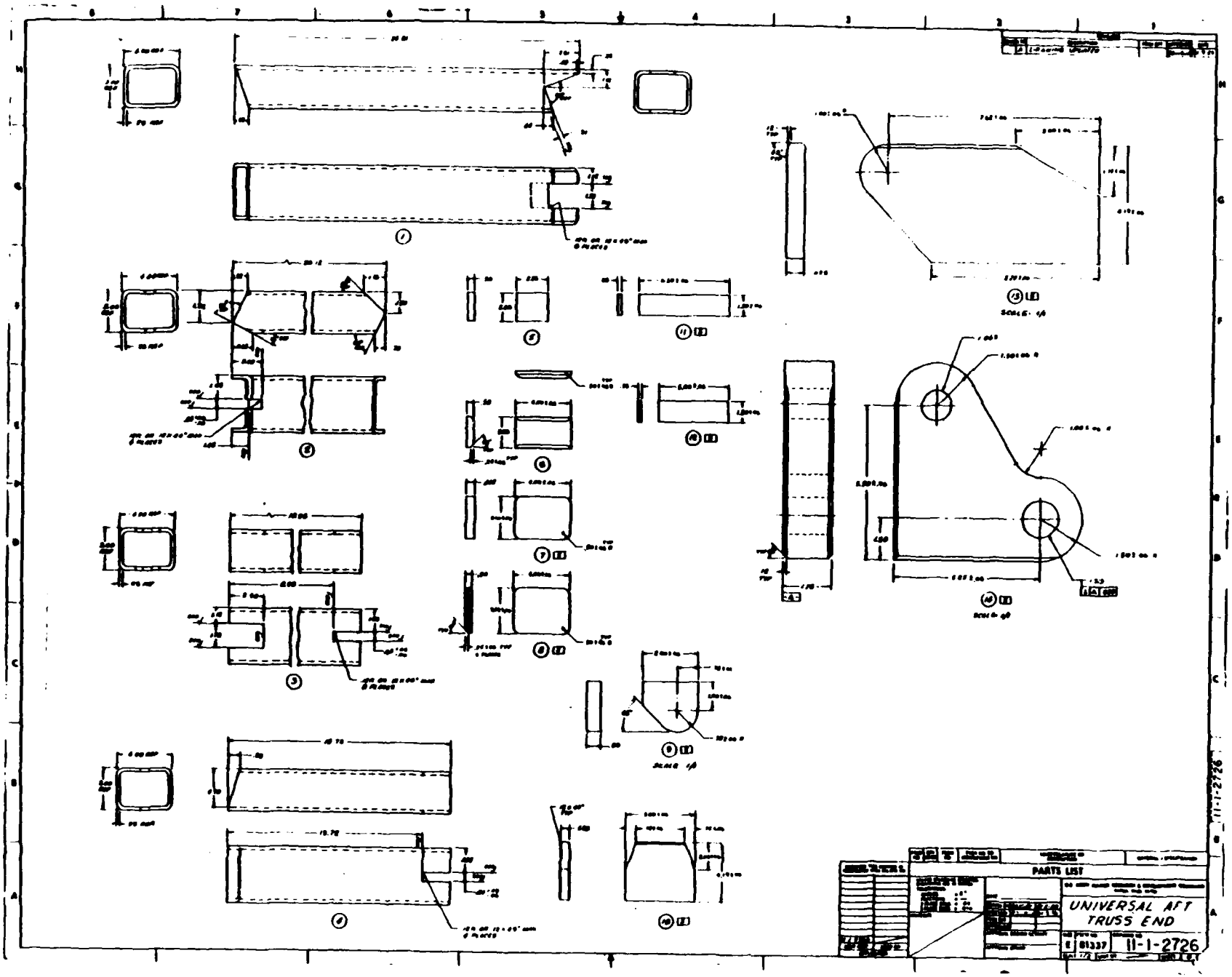
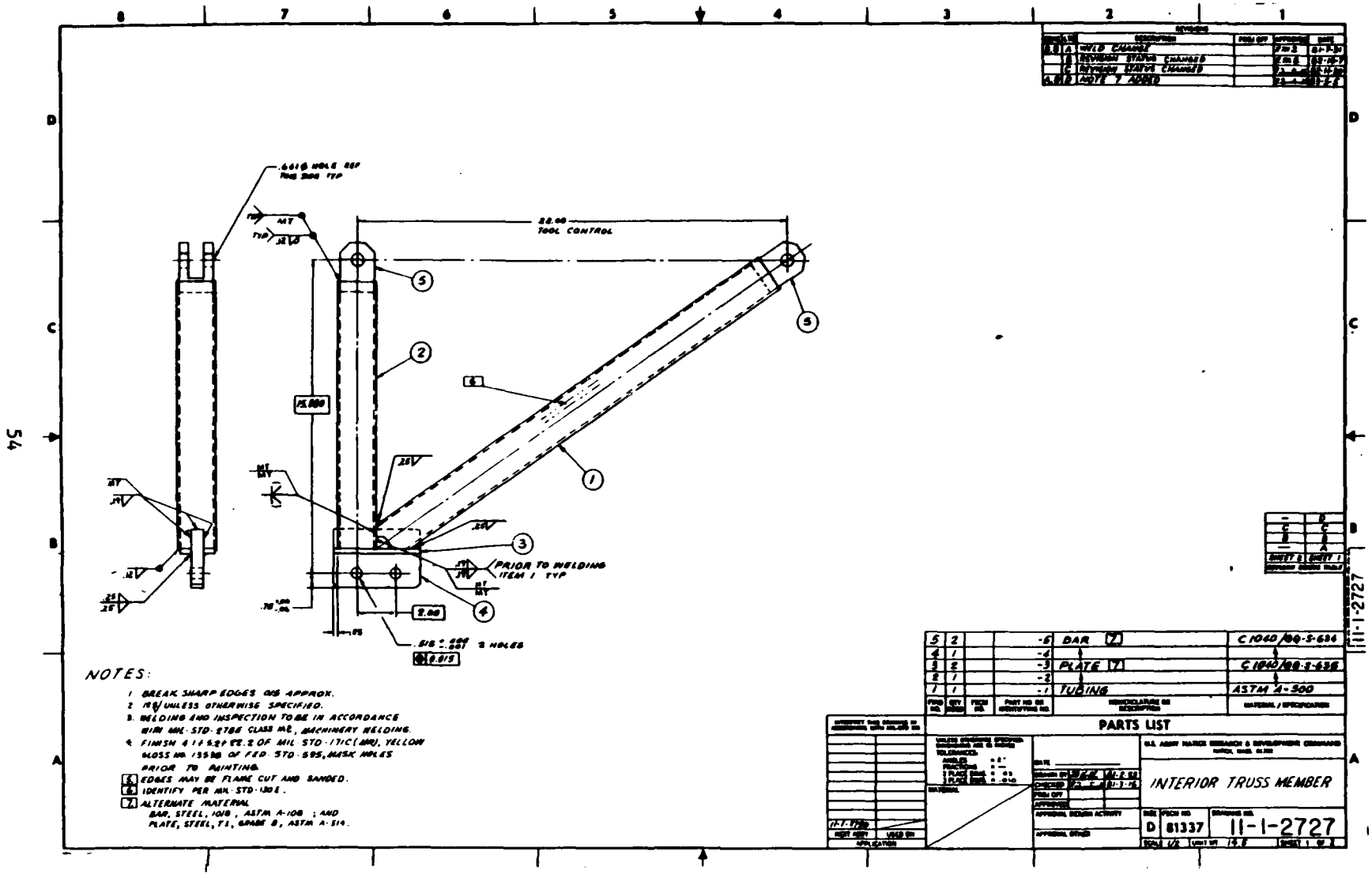


Figure A-5


22.00
TOOL CONTROL
PRIOR TO WELDING ITEM 1 TYP
2.00
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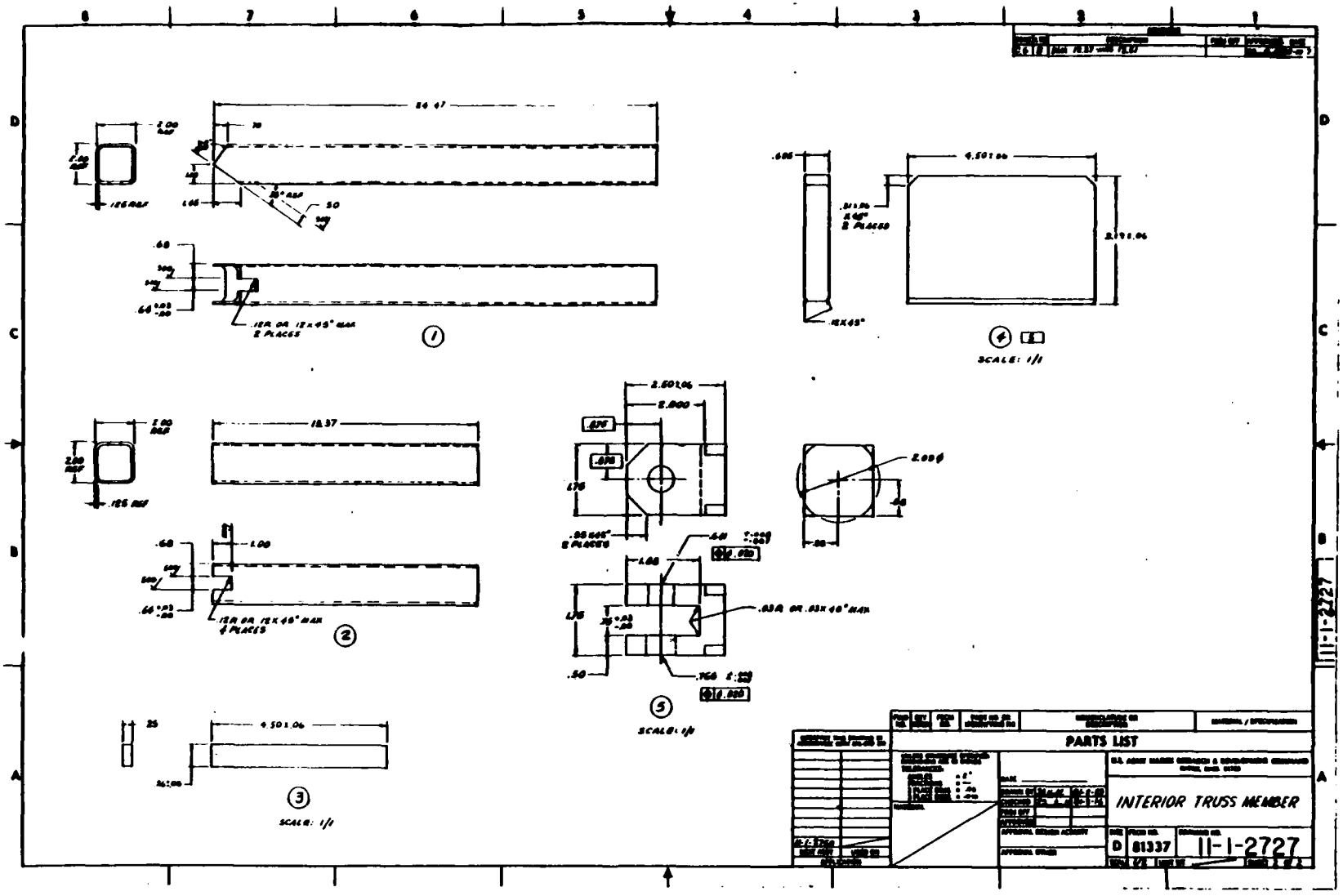
1 BREAK SHARP EDGES .015 APPROX.
2 125 UNLESS OTHERWISE SPECIFIED.
3 WELDING AND INSPECTION TO BE IN ACCORDANCE WITH MIL-STD-278E CLASS WE, MACHINERY WELDING.
4 FINISH 4 1/4 5.2# 52.2 OF MIL STD-171C(AMD), YELLOW GLOSS NO. 13538 OF FED STD-595, MASK HOLES PRIOR TO PAINTING.
5 EDGES MAY BE FLAME CUT AND SANDED.
6 IDENTIFY PER MIL-STD-130E.
7 ALTERNATE MATERIAL
BAR, STEEL, 1018, ASTM A-108 ; AND
PLATE, STEEL, T1, GRADE B, ASTM A-514.
-6 BAR 7 C1040 QQ-S-634
-4
-3 PLATE 7 C1040 QQ-S-636
-2
-1 TUBING ASTM A-500
PARTS LIST
INTERIOR TRUSS MEMBER
D 81337
11-1-2727

Figure A-6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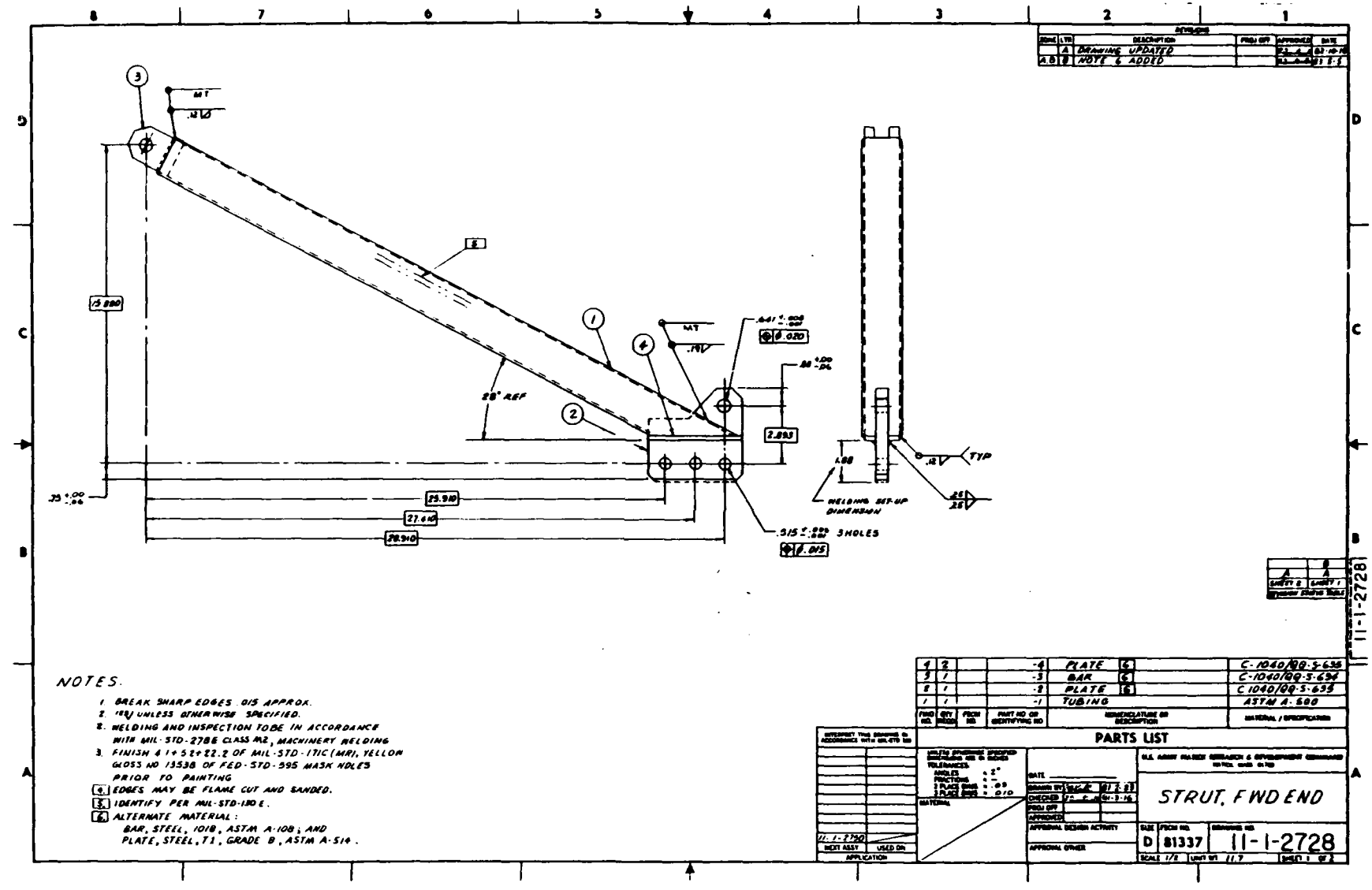
INTERIOR TRUSS MEMBER
D
81337
11-1-2727
SCALE: 1/1
SCALE: 1/1
SCALE: 1/1

Figure A-7


STRUT, FWD END
D 81337
11-1-2728
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3. WELDING AND INSPECTION TO BE IN ACCORDANCE WITH MIL-STD-2788 CLASS M2, MACHINERY WELDING
3. FINISH 4 1 5 2 2.2 OF MIL-STD-171C (MR), YELLOW GLOSS NO 13538 OF FED-STD-595 MASK HOLES PRIOR TO PAINTING
4. EDGES MAY BE FLAME CUT AND SANDED.
5. IDENTIFY PER MIL-STD-130 E.
6. ALTERNATE MATERIAL: BAR, STEEL, 1018, ASTM A-108; AND PLATE, STEEL, T1, GRADE B, ASTM A-514.
PARTS LIST
C-1040/QQ-S-636
C-1040/QQ-S-634
C 1040/QQ-S-699
ASTM A-500
28° REF
TYP
3 HOLES

Figure A-8

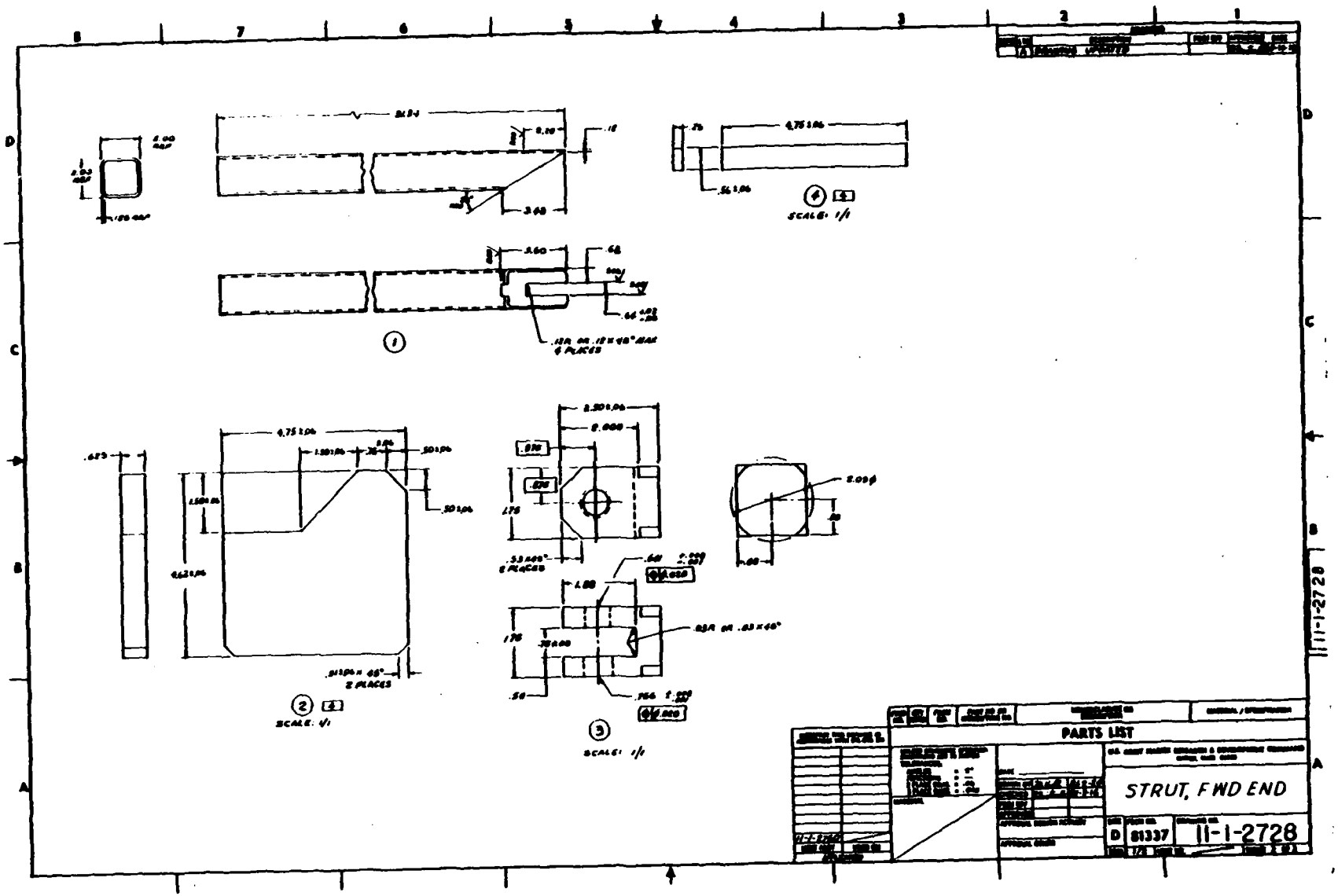
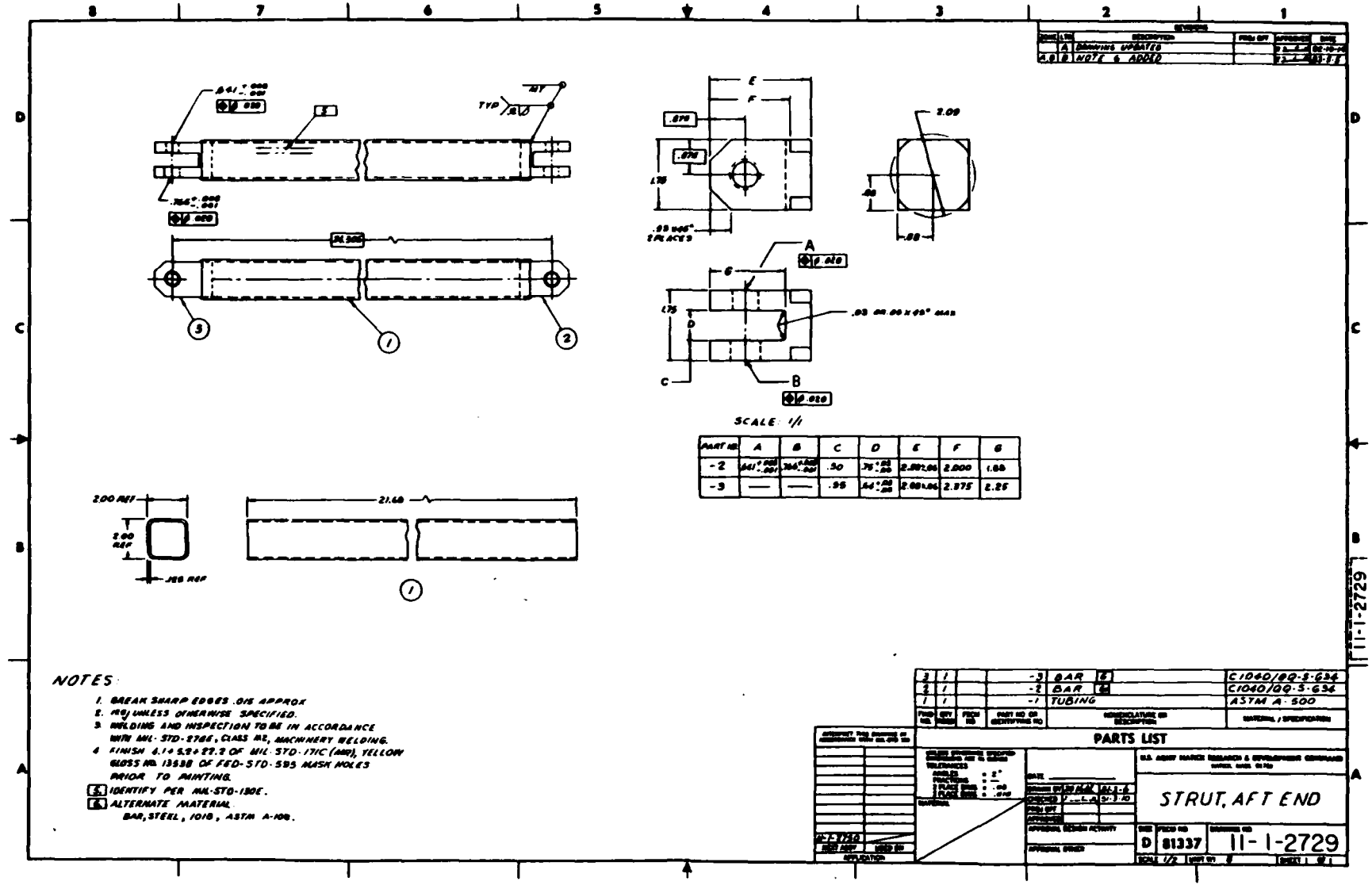


Figure A-9


SCALE 1/1
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4. FINISH 4.1+5.2+22.2 OF MIL-STD-171C (AMD), YELLOW GLOSS NO. 13538 OF FED-STD-595 ALASH HOLES PRIOR TO PAINTING.
5. IDENTIFY PER MIL-STD-130E.
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PARTS LIST
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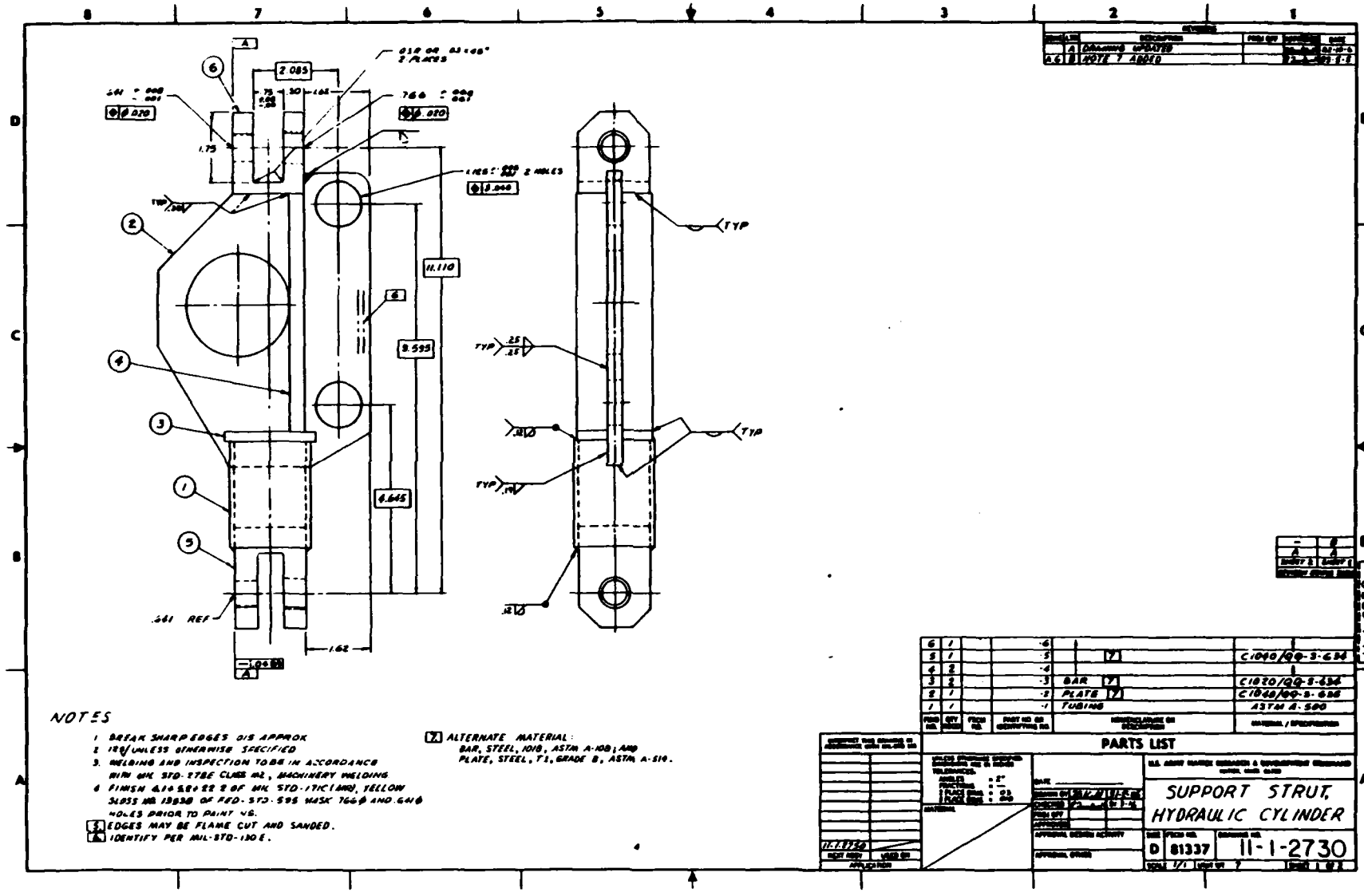
D 81337 11-1-2729
11-1-2729

Figure A-10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6. IDENTIFY PER MIL-STD-130E.
7. ALTERNATE MATERIAL: BAR, STEEL, 1018, ASTM A-108; AND PLATE, STEEL, T1, GRADE B, ASTM A-514.
PARTS LIST
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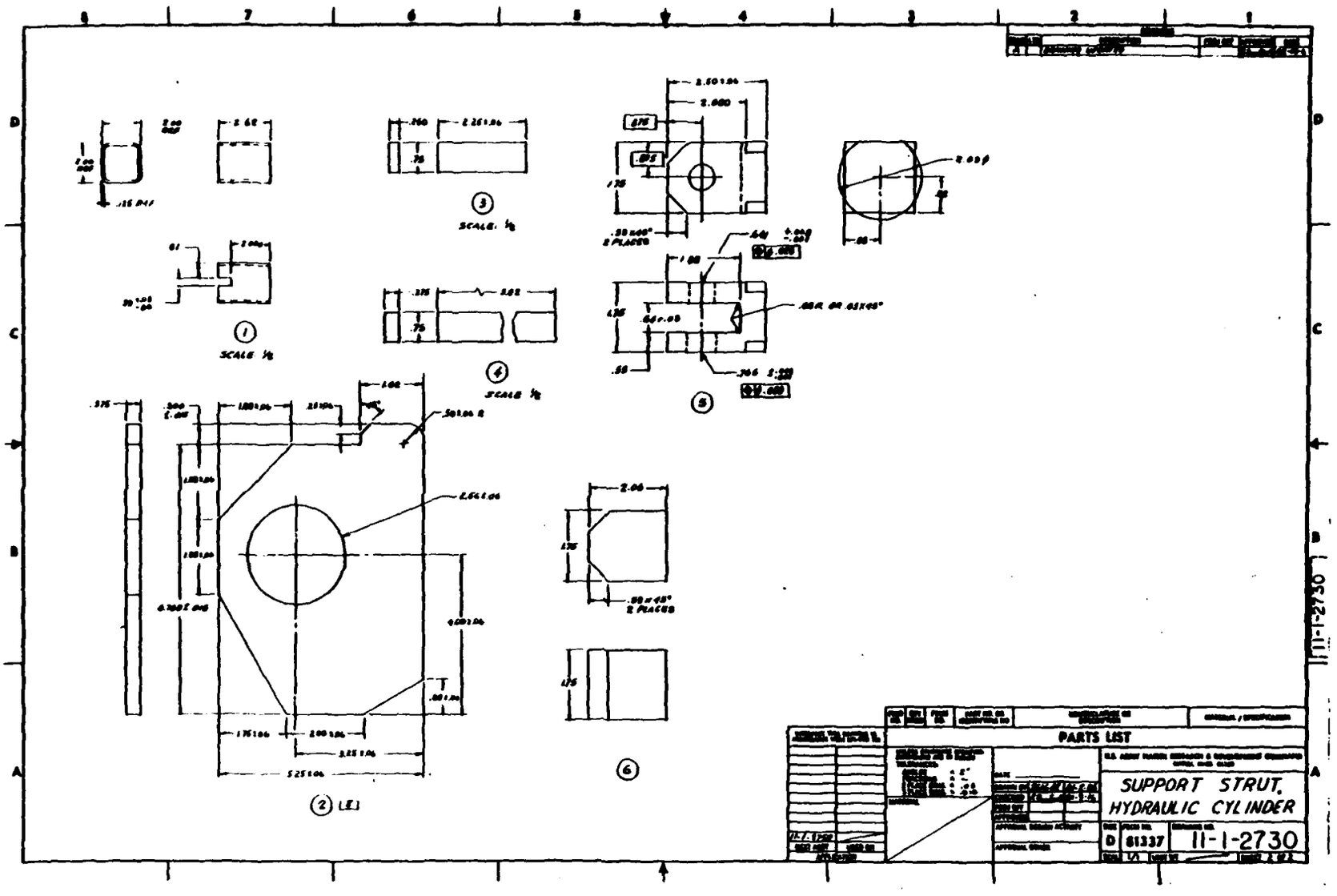
D 81337 11-1-2730
11-1-2730

Figure A-11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D
81337
11-1-2730
11-1-2730

Figure A-12

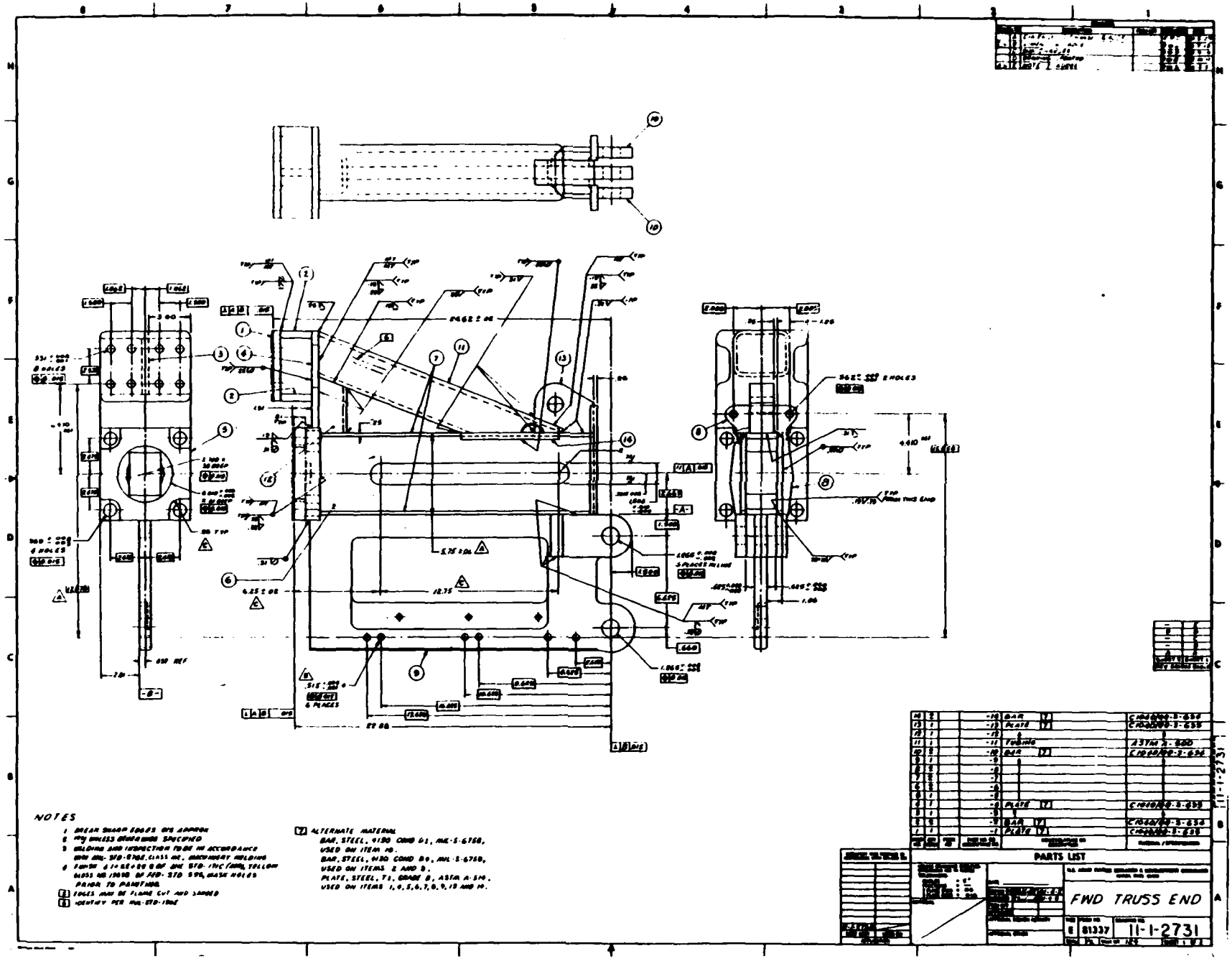


Figure A-13

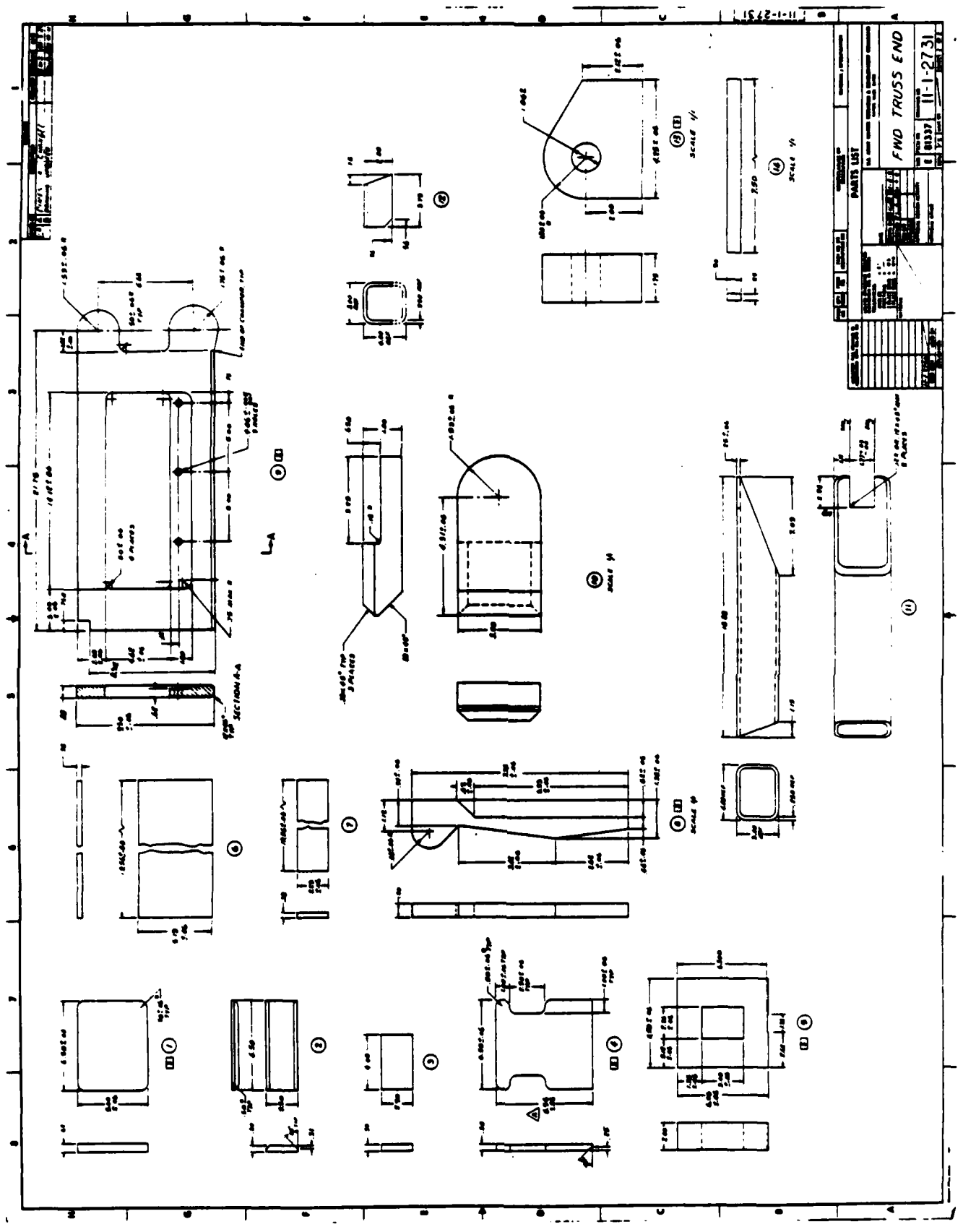
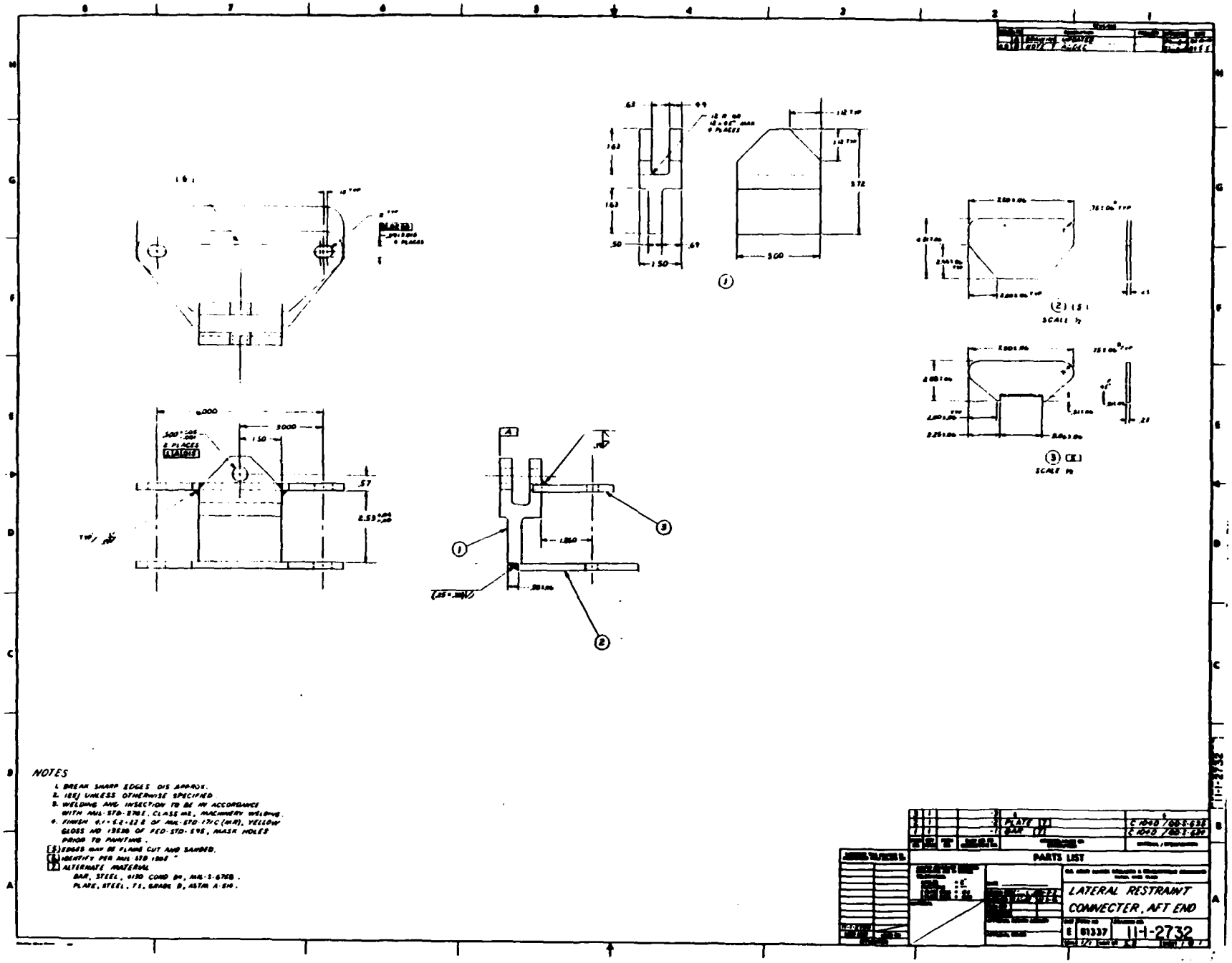


Figure A-14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(6) IDENTIFY PER MIL-STD-1968
(7) ALTERNATE MATERIAL
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PLATE, STEEL, FT, GRADE B, ASTM A-514.
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LATERAL RESTRAINT
CONNECTER, AFT END
11-1-2732

Figure A-15

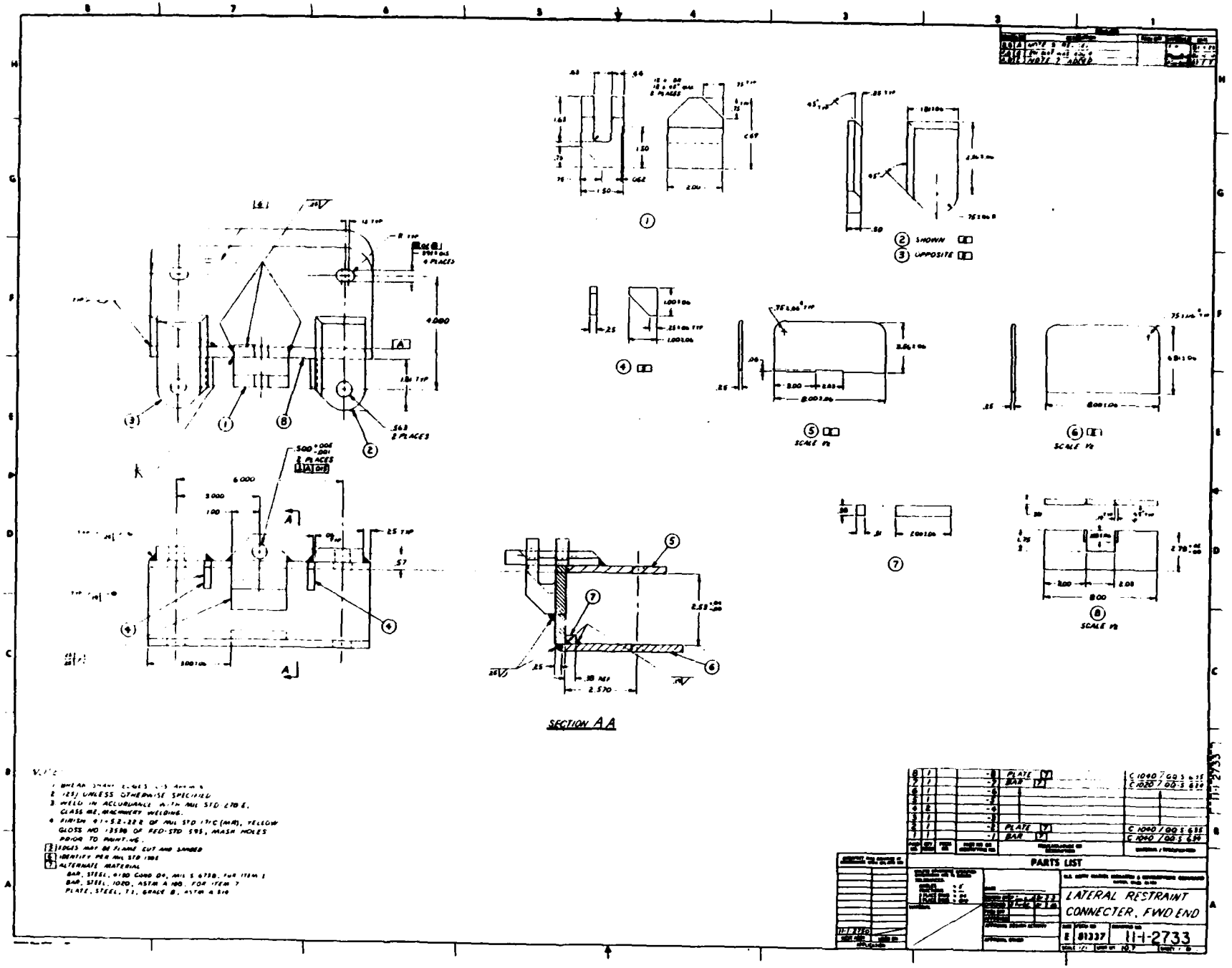

SECTION AA
PARTS LIST
LATERAL RESTRAINT CONNECTER, FWD END
81337
114-2733

Figure A-16

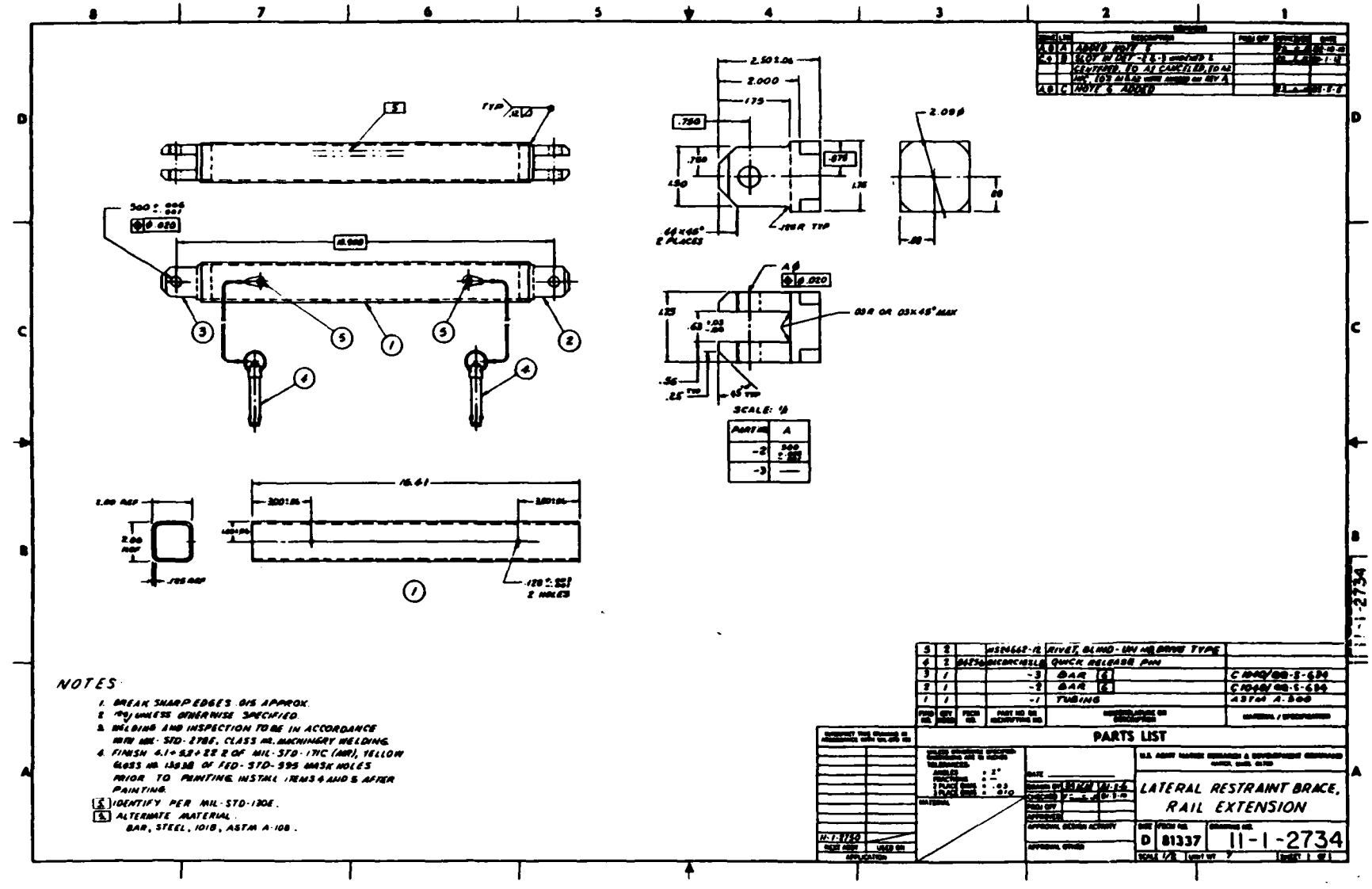

NOTES
1. BREAK SHARP EDGES .015 APPROX.
2. [illegible] UNLESS OTHERWISE SPECIFIED.
3. WELDING AND INSPECTION TO BE IN ACCORDANCE WITH MIL-STD-2788, CLASS MR, MACHINERY WELDING.
4. FINISH 4.1÷5.2÷2.2 2 OF MIL-STD-171C (AMR), YELLOW GLOSS NO 13538 OF FED-STD-595 MASK HOLES PRIOR TO PAINTING. INSTALL ITEMS 4 AND 5 AFTER PAINTING.
5 IDENTIFY PER MIL-STD-130E.
5 ALTERNATE MATERIAL
BAR, STEEL, 1018, ASTM A-108.
SCALE: ½
PARTS LIST
LATERAL RESTRAINT BRACE, RAIL EXTENSION
D 81337
11-1-2734

Figure A-17

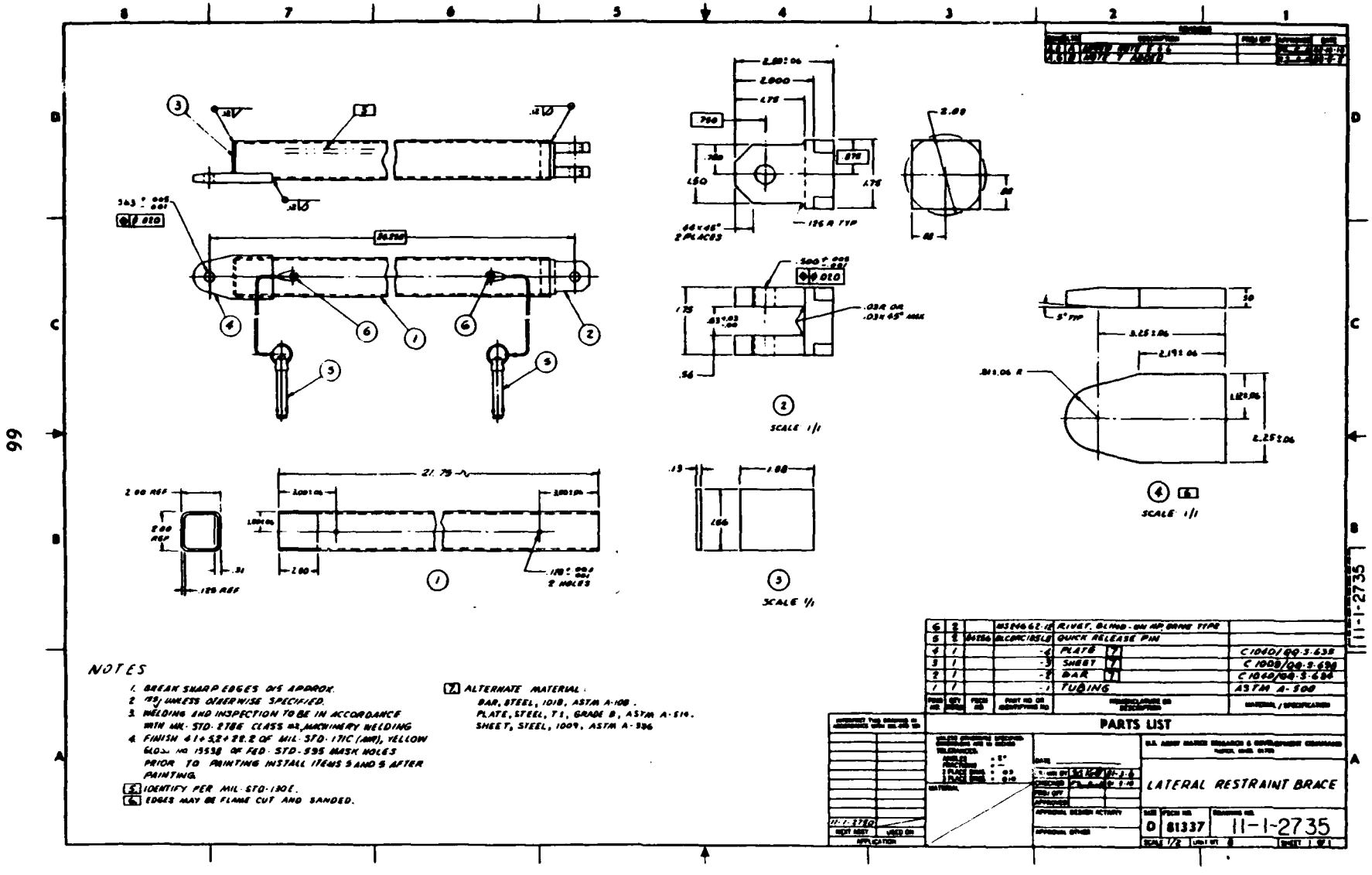

NOTES
1. BREAK SHARP EDGES .015 APPROX.
2. ± 1/64 UNLESS OTHERWISE SPECIFIED.
3. WELDING AND INSPECTION TO BE IN ACCORDANCE WITH MIL-STD-278E CLASS 2 MACHINERY WELDING
4. FINISH 41 ± 5.2 ± 22.2 OF MIL-STD-171C (AMY), YELLOW GLOSS NO 13538 OF FED-STD-595 MASK HOLES PRIOR TO PAINTING INSTALL ITEMS 5 AND 6 AFTER PAINTING.
5. IDENTIFY PER MIL-STD-130E.
6. EDGES MAY BE FLAME CUT AND SANDED.
7. ALTERNATE MATERIAL:
BAR, STEEL, 1018, ASTM A-108.
PLATE, STEEL, T1, GRADE B, ASTM A-514.
SHEET, STEEL, 1009, ASTM A-336
SCALE 1/1
SCALE 1/1
SCALE 1/1
PARTS LIST
LATERAL RESTRAINT BRACE
D 81337
11-1-2735

Figure A-18

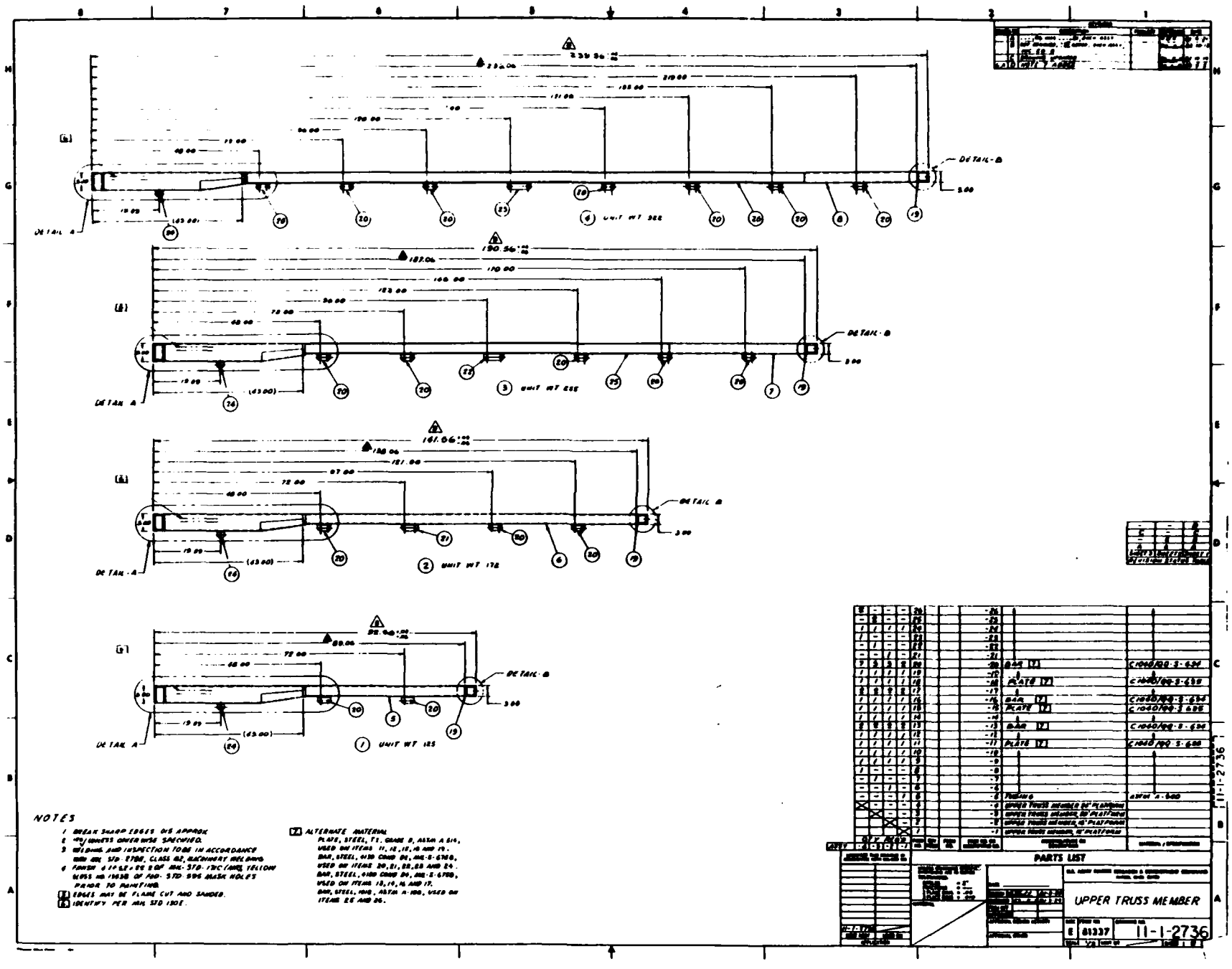


Figure A-19

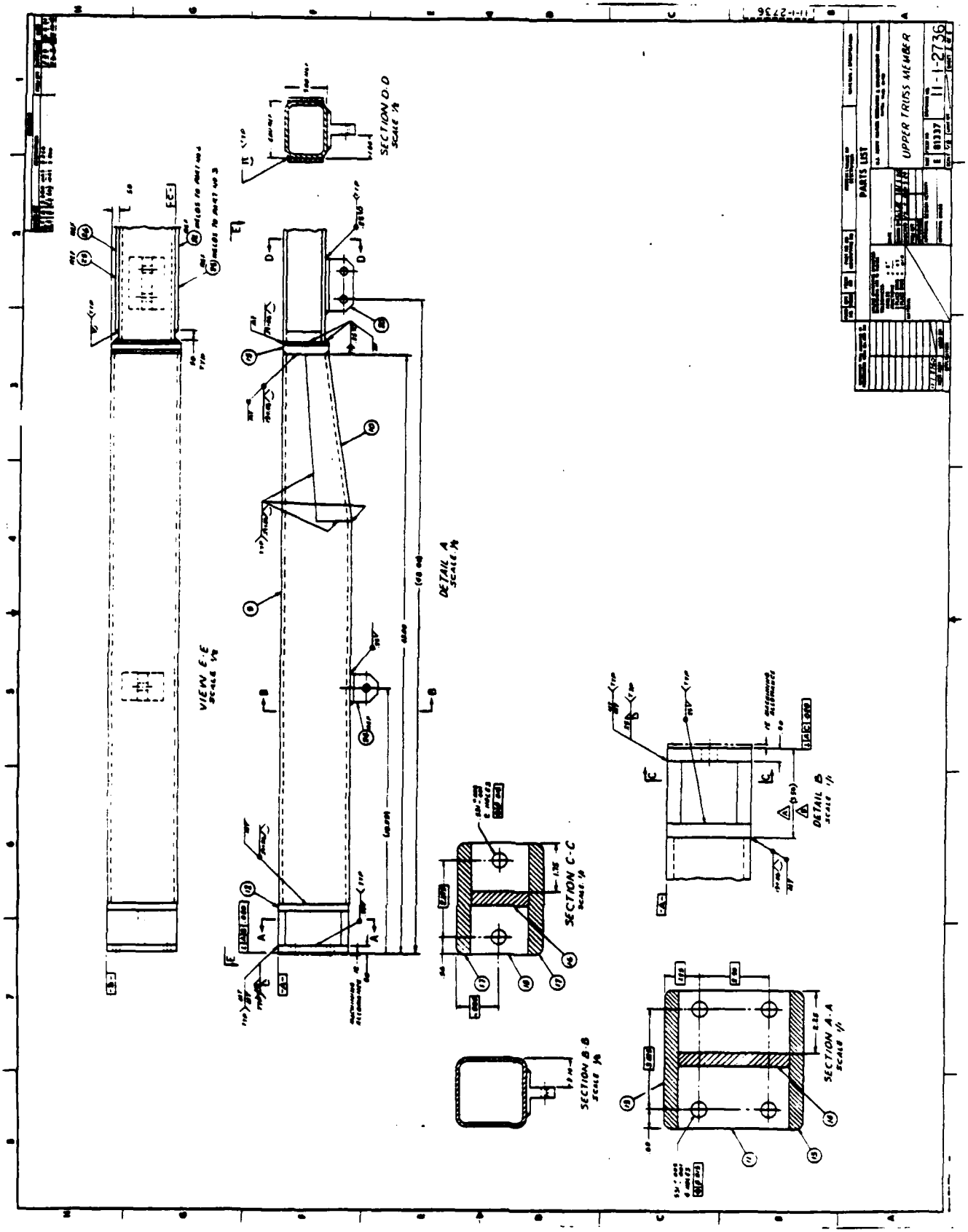

UPPER TRUSS MEMBER
11-1-2736
PARTS LIST
VIEW E-E
SCALE 1/8
SECTION D-D
SCALE 1/4
DETAIL A
SCALE 1/4
SECTION C-C
SCALE 1/2
SECTION B-B
SCALE 1/4
DETAIL B
SCALE 1/2
SECTION A-A
SCALE 1/2

Figure A-20

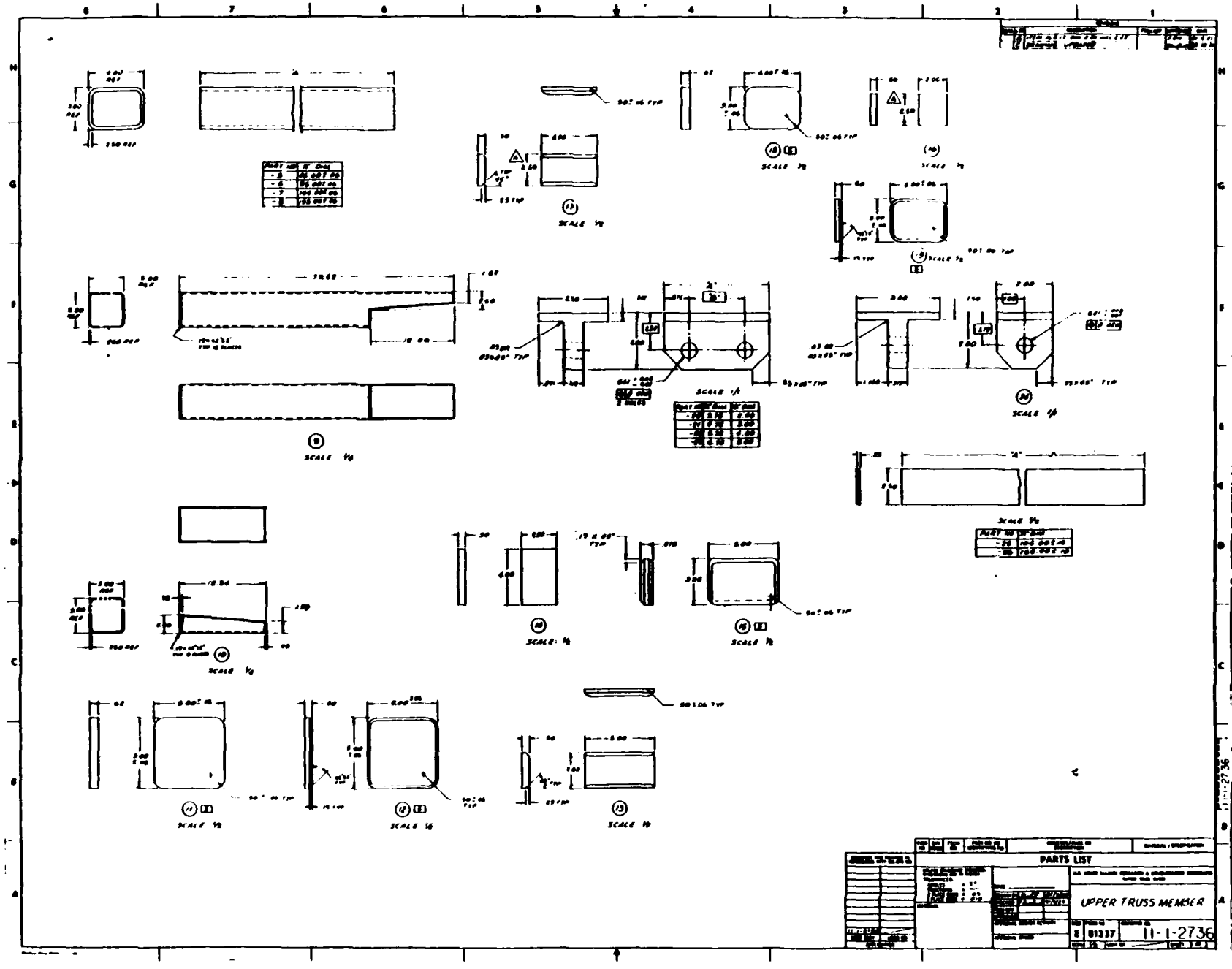


Figure A-21

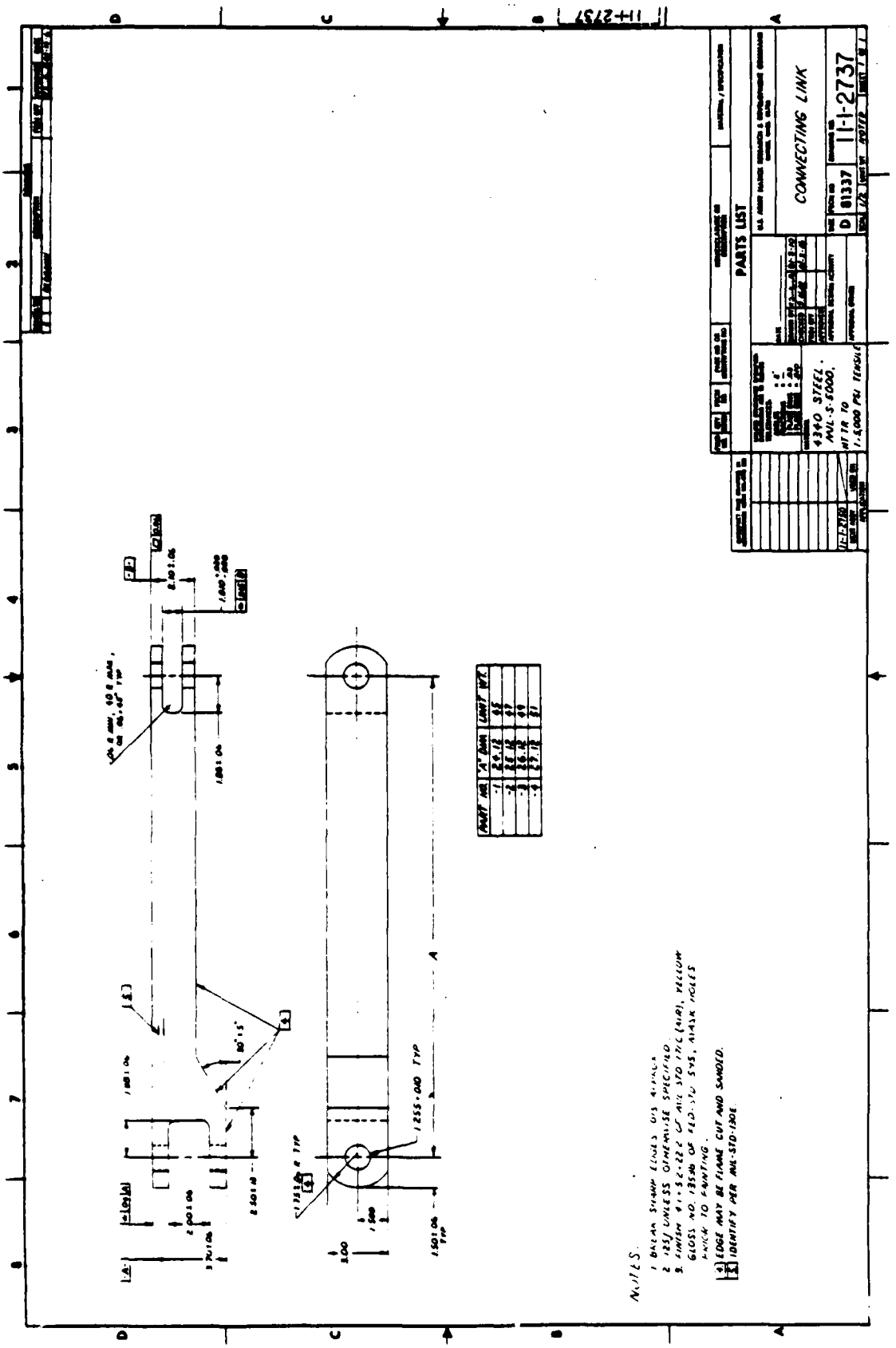

PARTS LIST
CONNECTING LINK
11-1-2737
D 81337
4340 STEEL, MIL-S-5000, HT TO 180,000 PSI TENSILE
NOTES
1 BREAK SHARP EDGES AS SHOWN
2 .125 UNLESS OTHERWISE SPECIFIED
3 FINISH 63 RMS EXCEPT AS STD FOR THREADS, FILLETS AND HOLES NO FINISH OF MACHINED SURFACES, MASK HOLES PRIOR TO PAINTING.
EDGE MAY BE FLAME CUT AND SANDED.
IDENTIFY PER MIL-STD-130E

Figure A-22

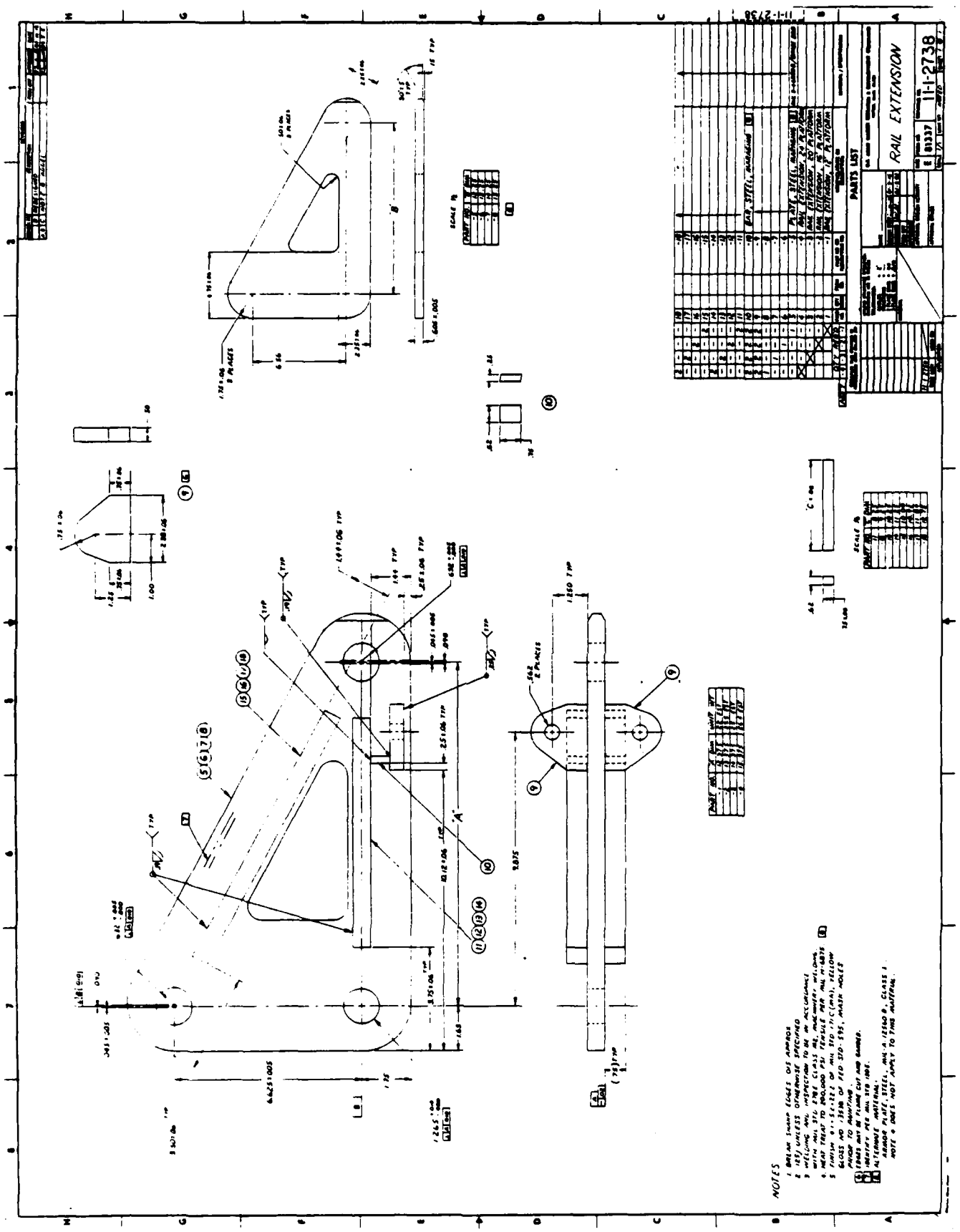


Figure A-23

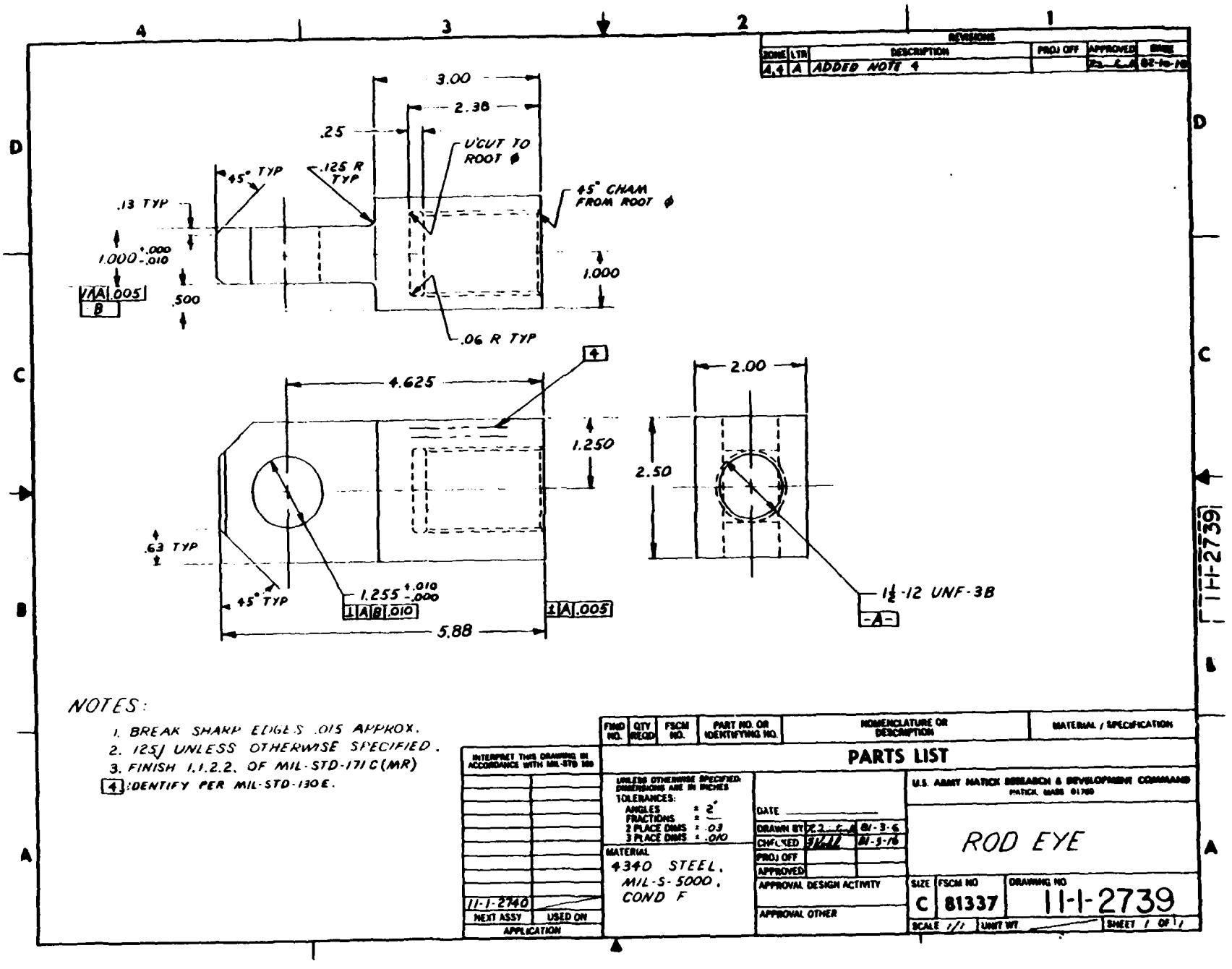

REVISIONS
ZONE LTR DESCRIPTION PROJ OFF APPROVED DATE
4,4 A ADDED NOTE 4
3.00
2.38
.25
U'CUT TO ROOT ⌀
.125 R TYP
45° TYP
45° CHAM FROM ROOT ⌀
.13 TYP
1.000 +.000 -.010
.500
1.000
.06 R TYP
4.625
1.250
2.00
2.50
.63 TYP
45° TYP
1.255 +.010 -.000
5.88
1½-12 UNF-3B
-A-
NOTES:
1. BREAK SHARP EDGES .015 APPROX.
2. 125 UNLESS OTHERWISE SPECIFIED.
3. FINISH 1.1.2.2. OF MIL-STD-171C(MR)
4 :IDENTIFY PER MIL-STD-130E.
FIND NO. QTY REQ'D FSCM NO. PART NO. OR IDENTIFYING NO. NOMENCLATURE OR DESCRIPTION MATERIAL / SPECIFICATION
PARTS LIST
INTERPRET THIS DRAWING IN ACCORDANCE WITH MIL-STD 100
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES
TOLERANCES:
ANGLES ± 2°
FRACTIONS ±
2 PLACE DIMS ± .03
3 PLACE DIMS ± .010
MATERIAL
4340 STEEL, MIL-S-5000, COND F
DATE
DRAWN 8/-3-6
CHECKED 8/-3-76
PROJ OFF
APPROVED
APPROVAL DESIGN ACTIVITY
APPROVAL OTHER
11-1-2740
NEXT ASSY USED ON
APPLICATION
U.S. ARMY NATICK RESEARCH & DEVELOPMENT COMMAND
NATICK, MASS 01760
ROD EYE
SIZE C
FSCM NO 81337
DRAWING NO 11-1-2739
SCALE 1/1
UNIT WT
SHEET 1 OF 1
11-1-2739

Figure A-24

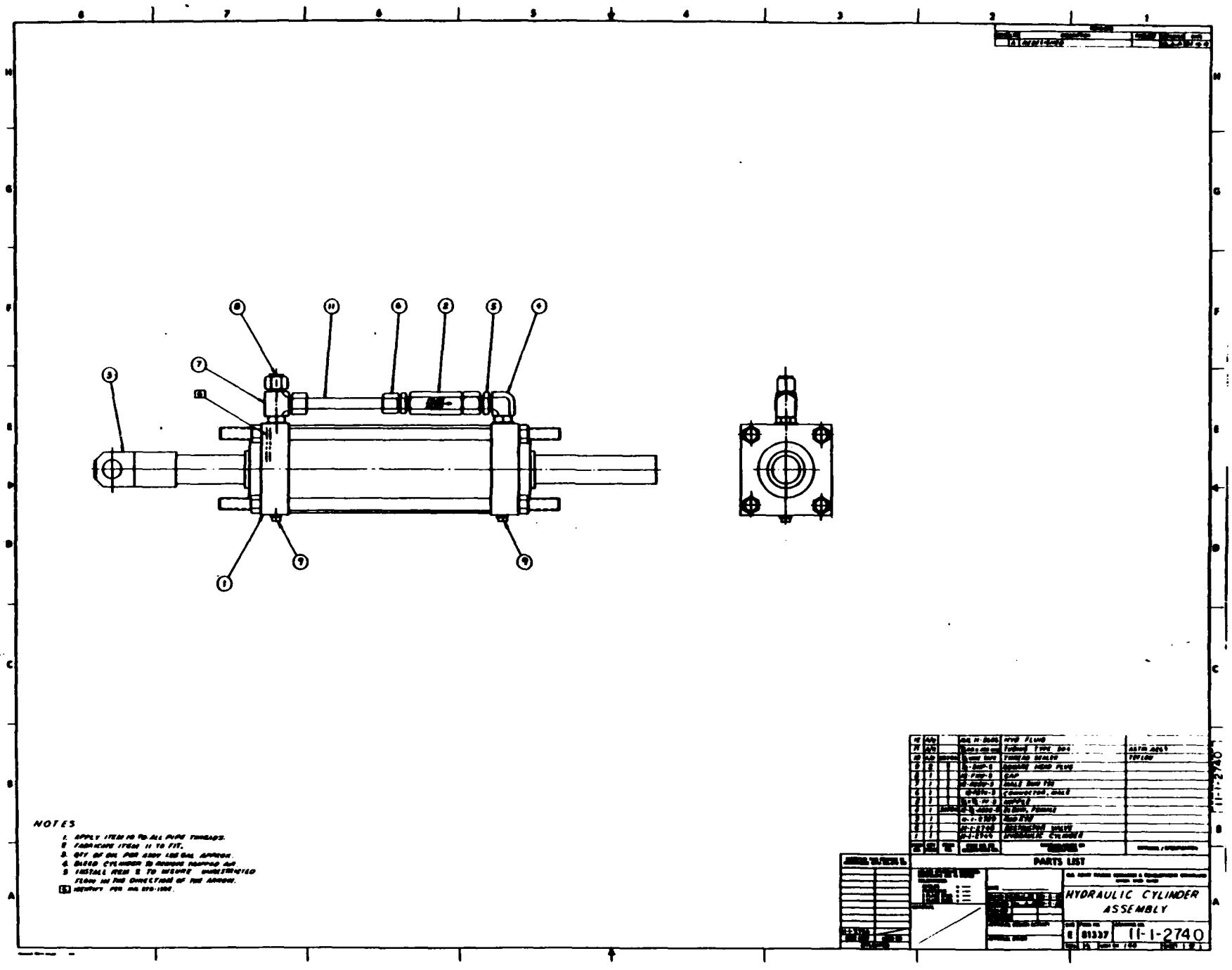


Figure A-25

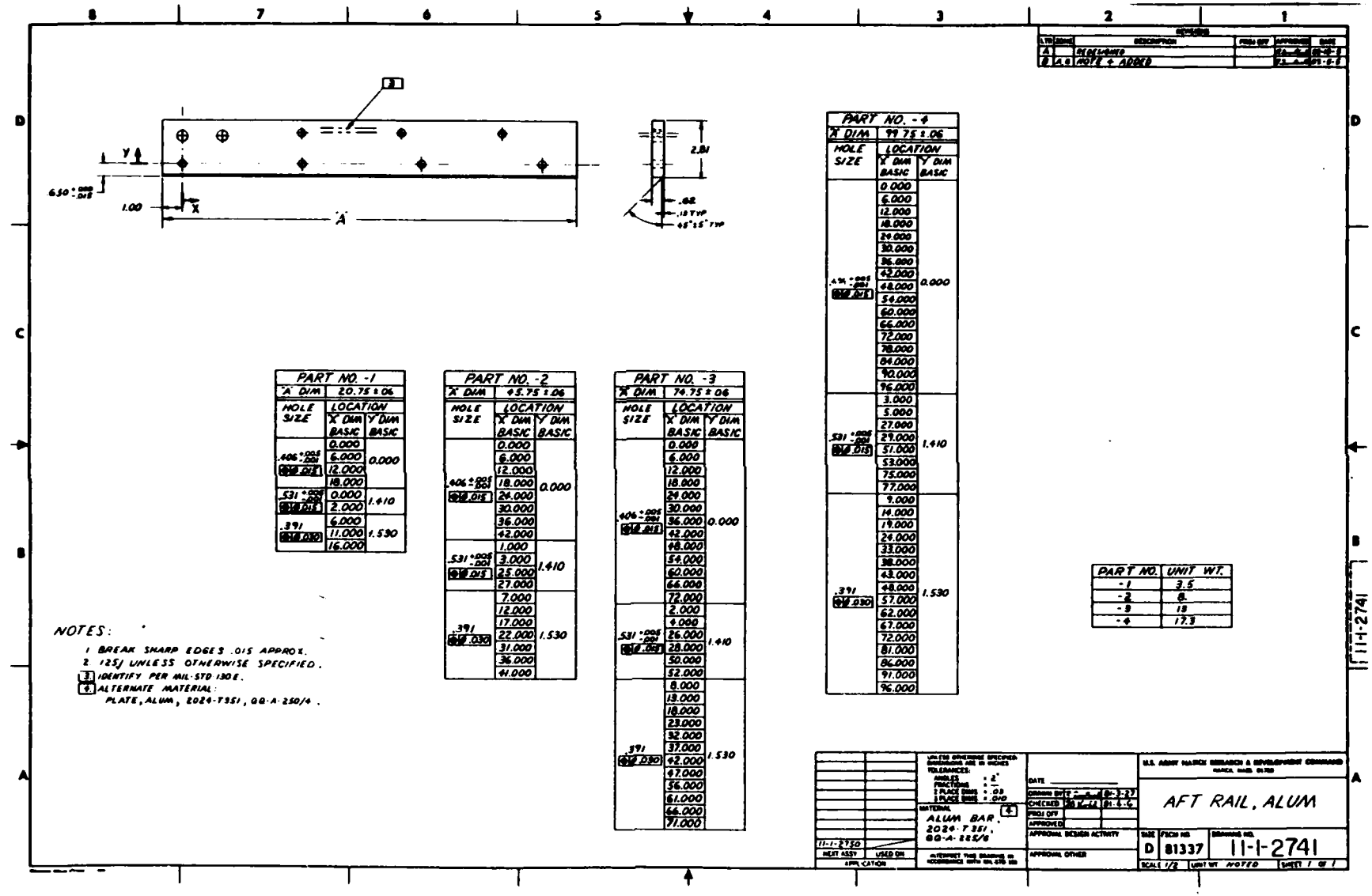

PART NO. -1
'A' DIM 20.75 ± .06
PART NO. -2
'A' DIM 45.75 ± .06
PART NO. -3
'A' DIM 74.75 ± .06
PART NO. -4
'A' DIM 99.75 ± .06
NOTES:
1 BREAK SHARP EDGES .015 APPROX.
2. 125/ UNLESS OTHERWISE SPECIFIED.
3 IDENTIFY PER MIL-STD 130E.
4 ALTERNATE MATERIAL:
PLATE, ALUM, 2024-T351, QQ-A-250/4.
PART NO. | UNIT WT.
-1 | 3.5
-2 | 8.
-3 | 13
-4 | 17.3
AFT RAIL, ALUM
11-1-2741

Figure A-26

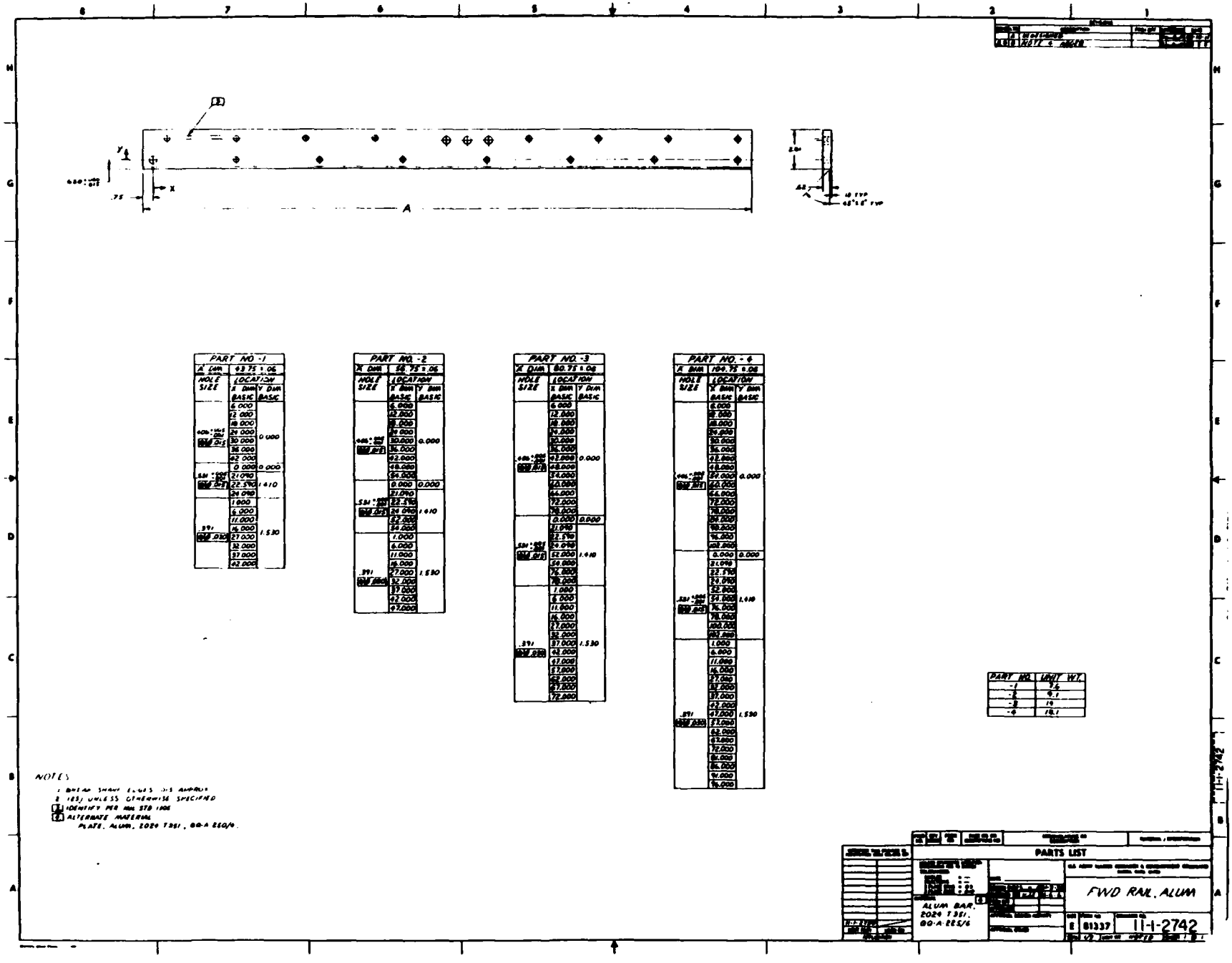

PART NO. -1
PART NO. -2
PART NO. -3
PART NO. -4
PARTS LIST
FWD RAIL, ALUM
ALUM BAR, 2024 T351, QQ-A-225/6
11-1-2742

Figure A-27

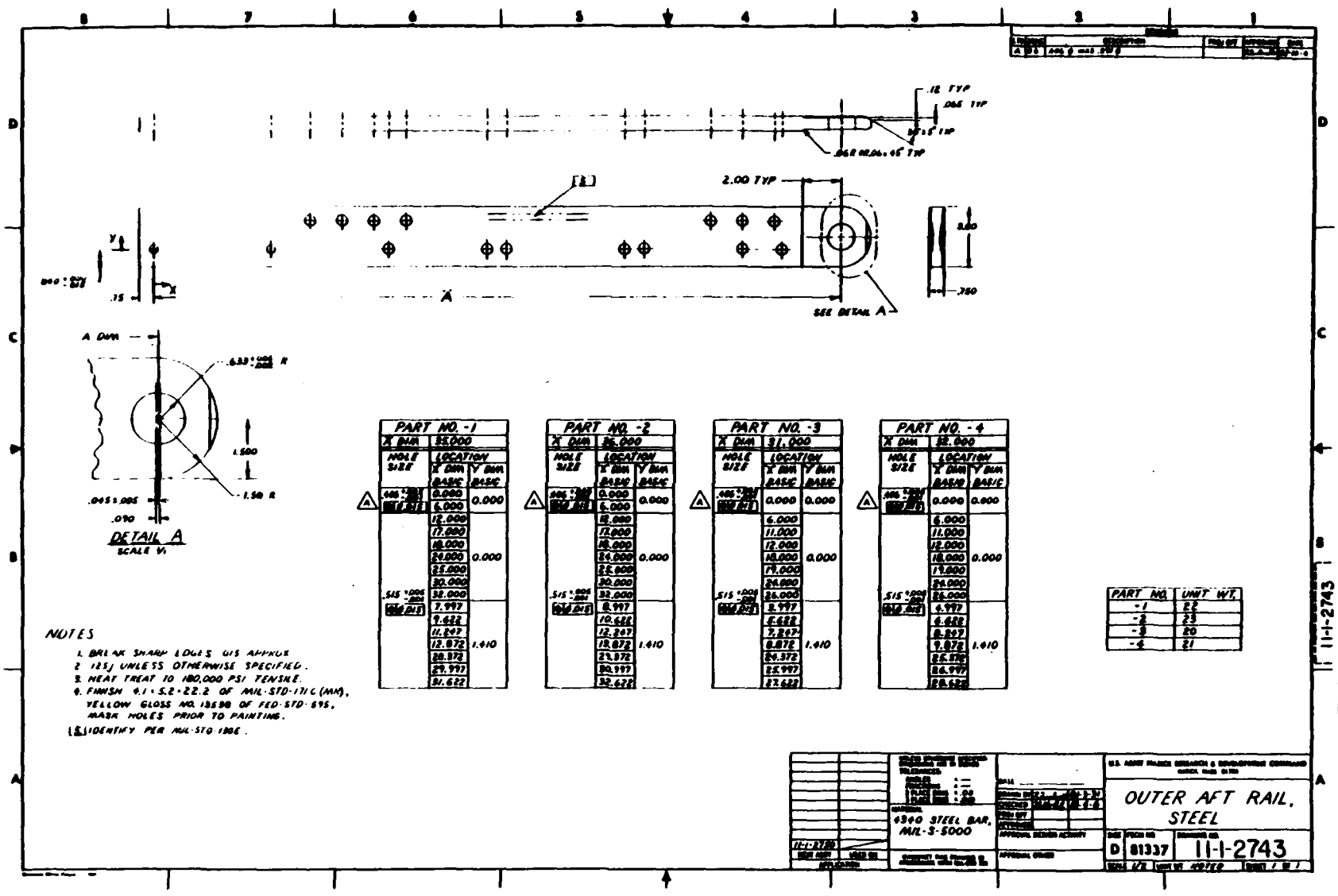

2.00 TYP
SEE DETAIL A
DETAIL A
SCALE 4/1
PART NO. -1
PART NO. -2
PART NO. -3
PART NO. -4
NOTES
1. BREAK SHARP EDGES .015 APPROX.
2. 125 UNLESS OTHERWISE SPECIFIED.
3. HEAT TREAT TO 180,000 PSI TENSILE.
4. FINISH 4.1-5.2-22.2 OF MIL-STD-171C (MM), YELLOW GLOSS NO. 13538 OF FED-STD-595, MASK HOLES PRIOR TO PAINTING.
5. IDENTIFY PER MIL-STD-130C.
4340 STEEL BAR, MIL-S-5000
OUTER AFT RAIL, STEEL
D 81337
11-1-2743

Figure A-28

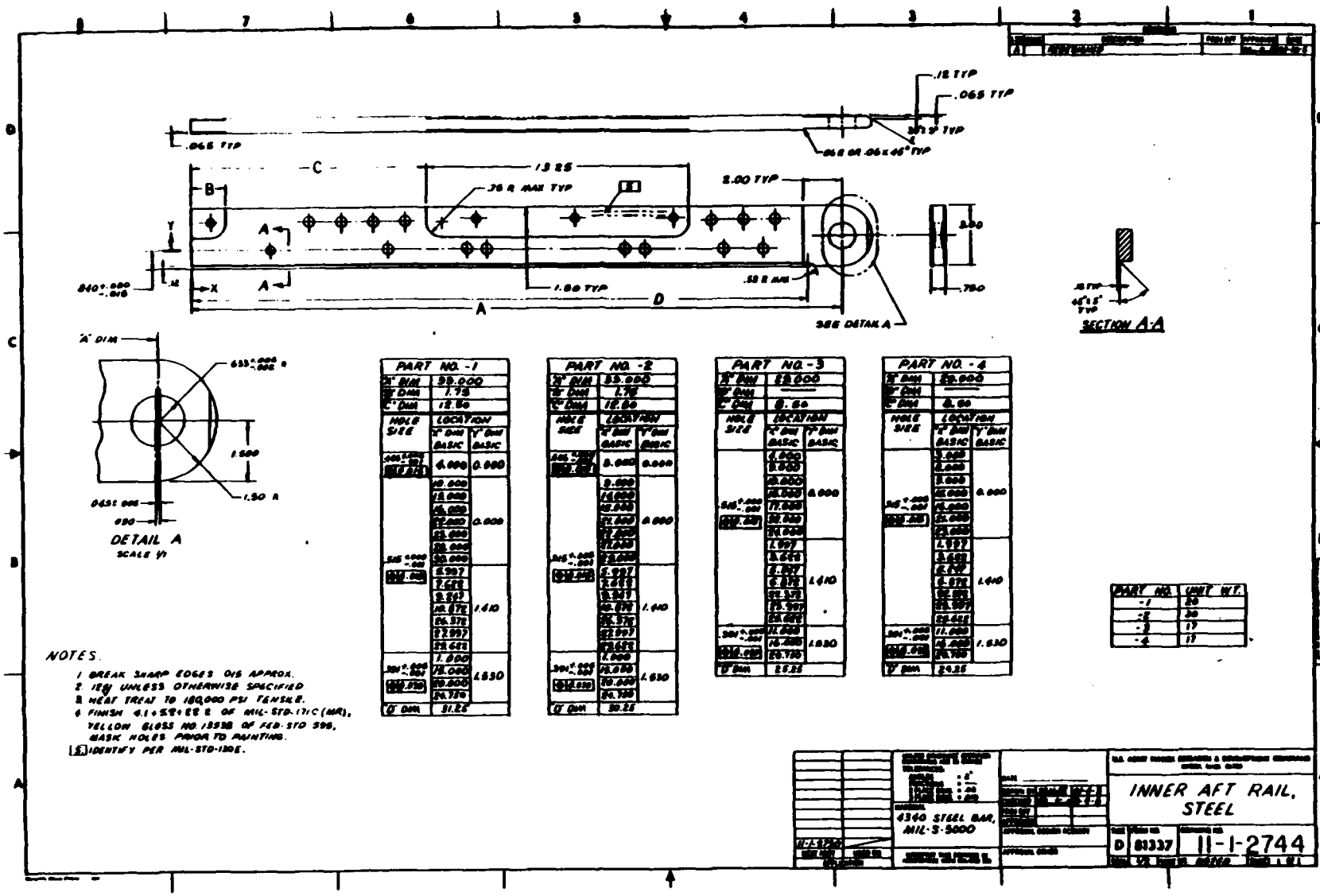

.18 TYP
.065 TYP
.065 TYP
.06 x 45° TYP
13.25
.75 R MAX TYP
2.00 TYP
1.50 TYP
.50 R MAX
SEE DETAIL A
SECTION A-A
DETAIL A
SCALE 1/1
1.50 R
PART NO. -1
PART NO. -2
PART NO. -3
PART NO. -4
NOTES.
1 BREAK SHARP EDGES .015 APPROX.
2 IEG UNLESS OTHERWISE SPECIFIED
3 HEAT TREAT TO 180,000 PSI TENSILE.
4 FINISH ... OF MIL-STD-171C (MR), YELLOW GLOSS NO. 13538 OF FED-STD 595, MASK HOLES PRIOR TO PAINTING.
5 IDENTIFY PER MIL-STD-130E.
4340 STEEL BAR, AMS-S-5000
INNER AFT RAIL, STEEL
D 81337
11-1-2744

Figure A-29

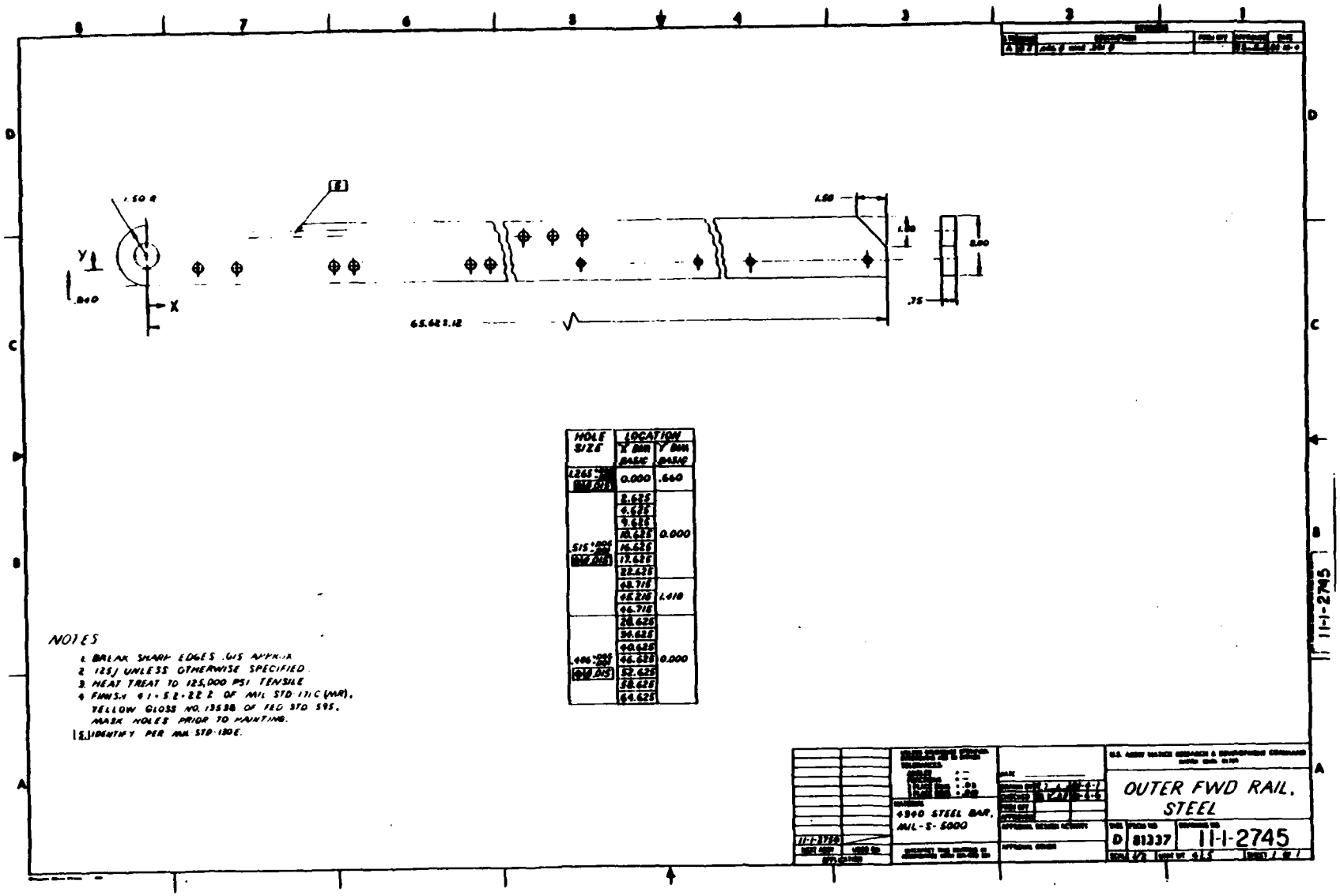

NOTES
1. BREAK SHARP EDGES .015 MAX.
2. 125 UNLESS OTHERWISE SPECIFIED.
3. HEAT TREAT TO 125,000 PSI TENSILE
4. FINISH 91-52-22 OF MIL STD 171C (MR), YELLOW GLOSS NO. 13538 OF FED STD 595. MASK HOLES PRIOR TO PAINTING.
5. IDENTIFY PER MIL STD-130E.
HOLE SIZE
LOCATION
X BAR BASIC
Y BAR BASIC
0.000
.640
2.625
4.625
6.625
8.625
10.625
12.625
14.625
16.625
18.625
20.625
22.625
24.625
26.625
28.625
30.625
32.625
34.625
0.000
1.410
0.000
4340 STEEL BAR, MIL-S-5000
OUTER FWD RAIL, STEEL
D 81337
11-1-2745

Figure A-30

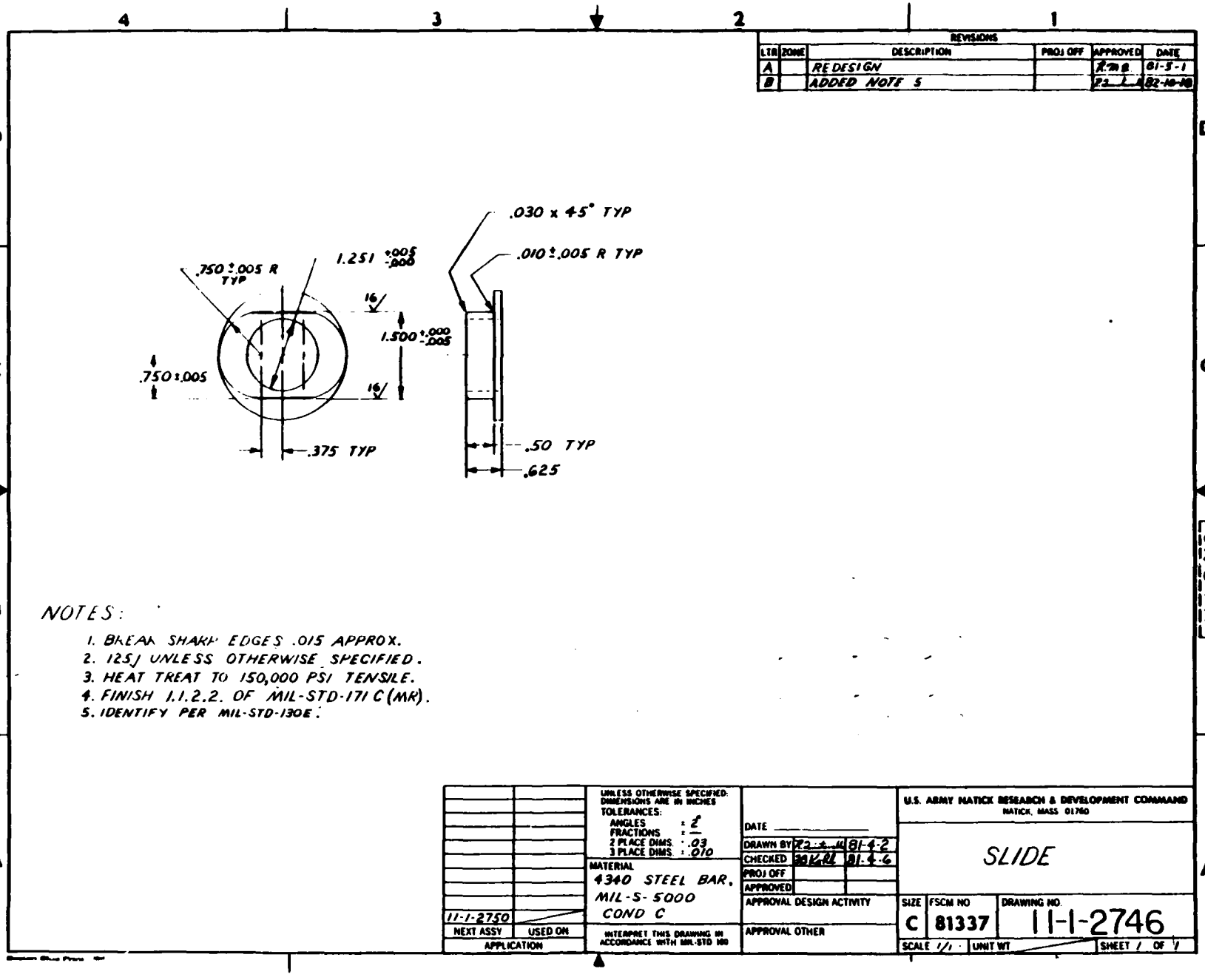

4
3
2
1
D
C
B
A
REVISIONS
LTR | ZONE | DESCRIPTION | PROJ OFF | APPROVED | DATE
A | | RE DESIGN | | | 81-5-1
B | | ADDED NOTE 5 | | | 82-10-18
.030 x 45° TYP
.010 ± .005 R TYP
.750 ± .005 R TYP
1.251 +.005 -.000
16
1.500 +.000 -.005
16
.750 ± .005
.375 TYP
.50 TYP
.625
NOTES:
1. BREAK SHARP EDGES .015 APPROX.
2. 125 UNLESS OTHERWISE SPECIFIED.
3. HEAT TREAT TO 150,000 PSI TENSILE.
4. FINISH 1.1.2.2. OF MIL-STD-171 C (MR).
5. IDENTIFY PER MIL-STD-130E.
11-1-2746
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES
TOLERANCES:
ANGLES ± 2°
FRACTIONS ± —
2 PLACE DIMS. ± .03
3 PLACE DIMS. ± .010
MATERIAL
4340 STEEL BAR, MIL-S-5000 COND C
INTERPRET THIS DRAWING IN ACCORDANCE WITH MIL-STD 100
DATE
DRAWN BY 81-4-2
CHECKED 81-4-6
PROJ OFF
APPROVED
APPROVAL DESIGN ACTIVITY
APPROVAL OTHER
11-1-2750
NEXT ASSY
USED ON
APPLICATION
U.S. ARMY NATICK RESEARCH & DEVELOPMENT COMMAND
NATICK, MASS 01760
SLIDE
SIZE C
FSCM NO 81337
DRAWING NO. 11-1-2746
SCALE 1/1
UNIT WT
SHEET 1 OF 1
79

Figure A-31

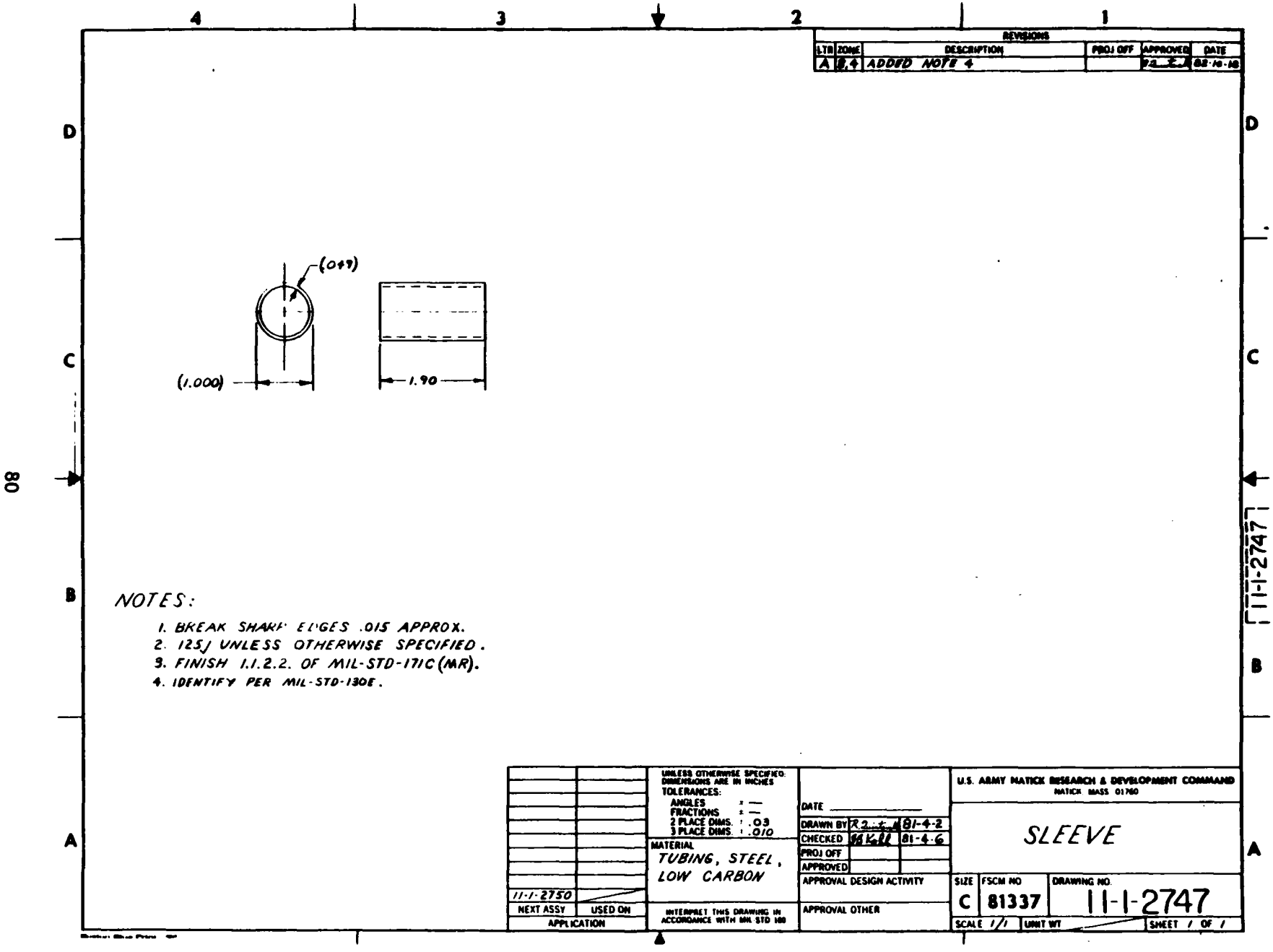

4
3
2
1
D
C
B
A
REVISIONS
LTR ZONE DESCRIPTION PROJ OFF APPROVED DATE
A B,4 ADDED NOTE 4 82-10-18
(.049)
(1.000)
1.90
NOTES:
1. BREAK SHARP EDGES .015 APPROX.
2. 125/ UNLESS OTHERWISE SPECIFIED.
3. FINISH 1.1.2.2. OF MIL-STD-171C(MR).
4. IDENTIFY PER MIL-STD-130E.
11-1-2747
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES:
ANGLES ± —
FRACTIONS ± —
2 PLACE DIMS. ± .03
3 PLACE DIMS. ± .010
MATERIAL
TUBING, STEEL, LOW CARBON
11-1-2750
NEXT ASSY
USED ON
APPLICATION
INTERPRET THIS DRAWING IN ACCORDANCE WITH MIL STD 100
DATE
DRAWN BY R.J. 81-4-2
CHECKED 81-4-6
PROJ OFF
APPROVED
APPROVAL DESIGN ACTIVITY
APPROVAL OTHER
U.S. ARMY NATICK RESEARCH & DEVELOPMENT COMMAND
NATICK MASS 01760
SLEEVE
SIZE C
FSCM NO 81337
DRAWING NO. 11-1-2747
SCALE 1/1
UNIT WT
SHEET 1 OF 1

Figure A-32

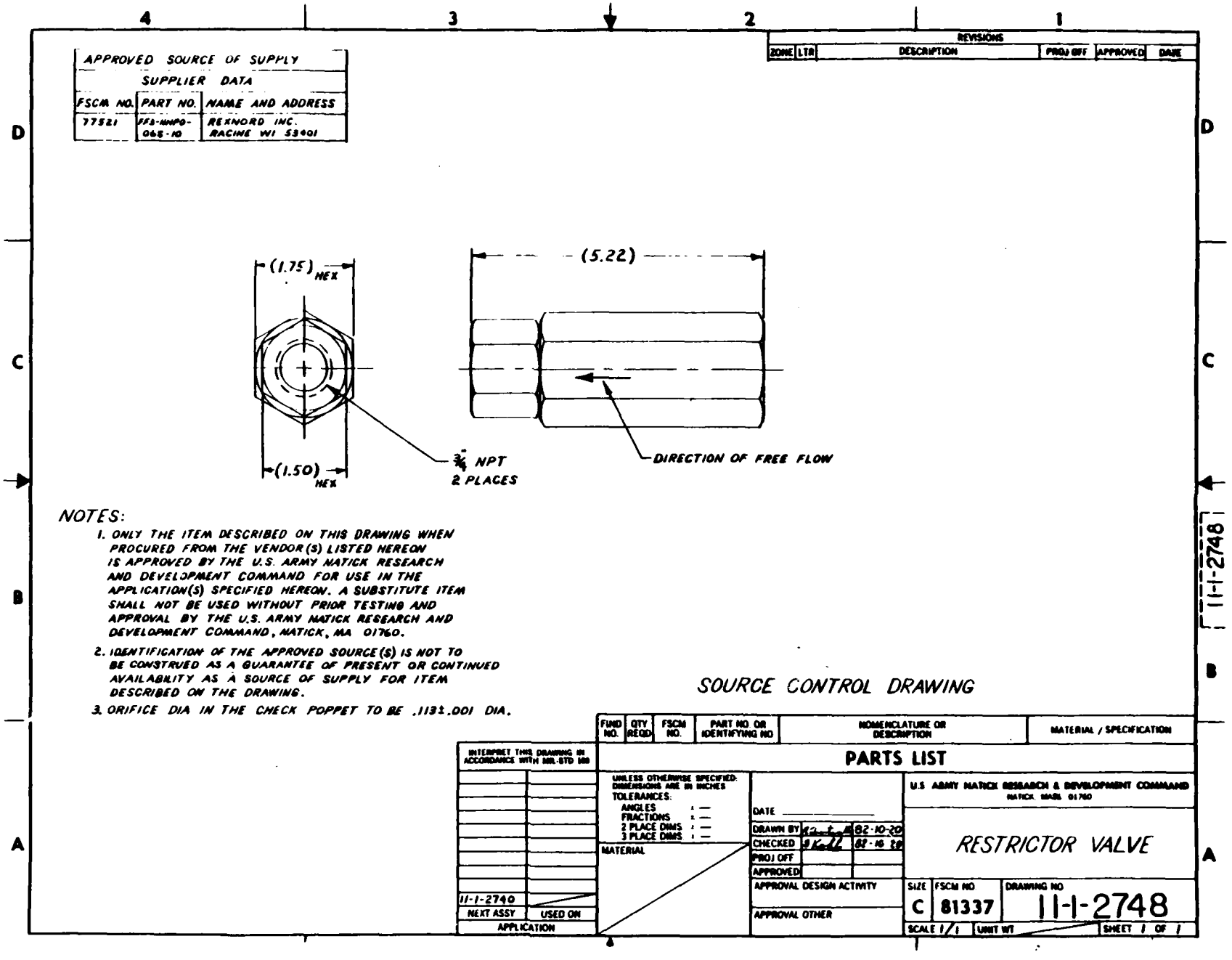

4
3
2
1
D
C
B
A
REVISIONS
ZONE | LTR | DESCRIPTION | PROJ OFF | APPROVED | DATE
APPROVED SOURCE OF SUPPLY
SUPPLIER DATA
FSCM NO. | PART NO. | NAME AND ADDRESS
77521 | FF3-HNPO-065-10 | REXNORD INC. RACINE WI 53401
(1.75) HEX
(1.50) HEX
(5.22)
¾" NPT 2 PLACES
DIRECTION OF FREE FLOW
NOTES:
1. ONLY THE ITEM DESCRIBED ON THIS DRAWING WHEN PROCURED FROM THE VENDOR(S) LISTED HEREON IS APPROVED BY THE U.S. ARMY NATICK RESEARCH AND DEVELOPMENT COMMAND FOR USE IN THE APPLICATION(S) SPECIFIED HEREON. A SUBSTITUTE ITEM SHALL NOT BE USED WITHOUT PRIOR TESTING AND APPROVAL BY THE U.S. ARMY NATICK RESEARCH AND DEVELOPMENT COMMAND, NATICK, MA 01760.
2. IDENTIFICATION OF THE APPROVED SOURCE(S) IS NOT TO BE CONSTRUED AS A GUARANTEE OF PRESENT OR CONTINUED AVAILABILITY AS A SOURCE OF SUPPLY FOR ITEM DESCRIBED ON THE DRAWING.
3. ORIFICE DIA IN THE CHECK POPPET TO BE .113±.001 DIA.
SOURCE CONTROL DRAWING
FUNC NO. | QTY REQD | FSCM NO. | PART NO. OR IDENTIFYING NO | NOMENCLATURE OR DESCRIPTION | MATERIAL / SPECIFICATION
PARTS LIST
INTERPRET THIS DRAWING IN ACCORDANCE WITH MIL-STD 100
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES
TOLERANCES:
ANGLES :—
FRACTIONS :—
2 PLACE DIMS :—
3 PLACE DIMS :—
MATERIAL
DATE
DRAWN BY 82-10-20
CHECKED 82-10-20
PROJ OFF
APPROVED
APPROVAL DESIGN ACTIVITY
APPROVAL OTHER
U.S ARMY NATICK RESEARCH & DEVELOPMENT COMMAND
NATICK, MASS 01760
RESTRICTOR VALVE
SIZE C | FSCM NO 81337 | DRAWING NO 11-1-2748
SCALE 1/1 | UNIT WT | SHEET 1 OF 1
11-1-2740
NEXT ASSY | USED ON
APPLICATION
11-1-2748

Figure A-33

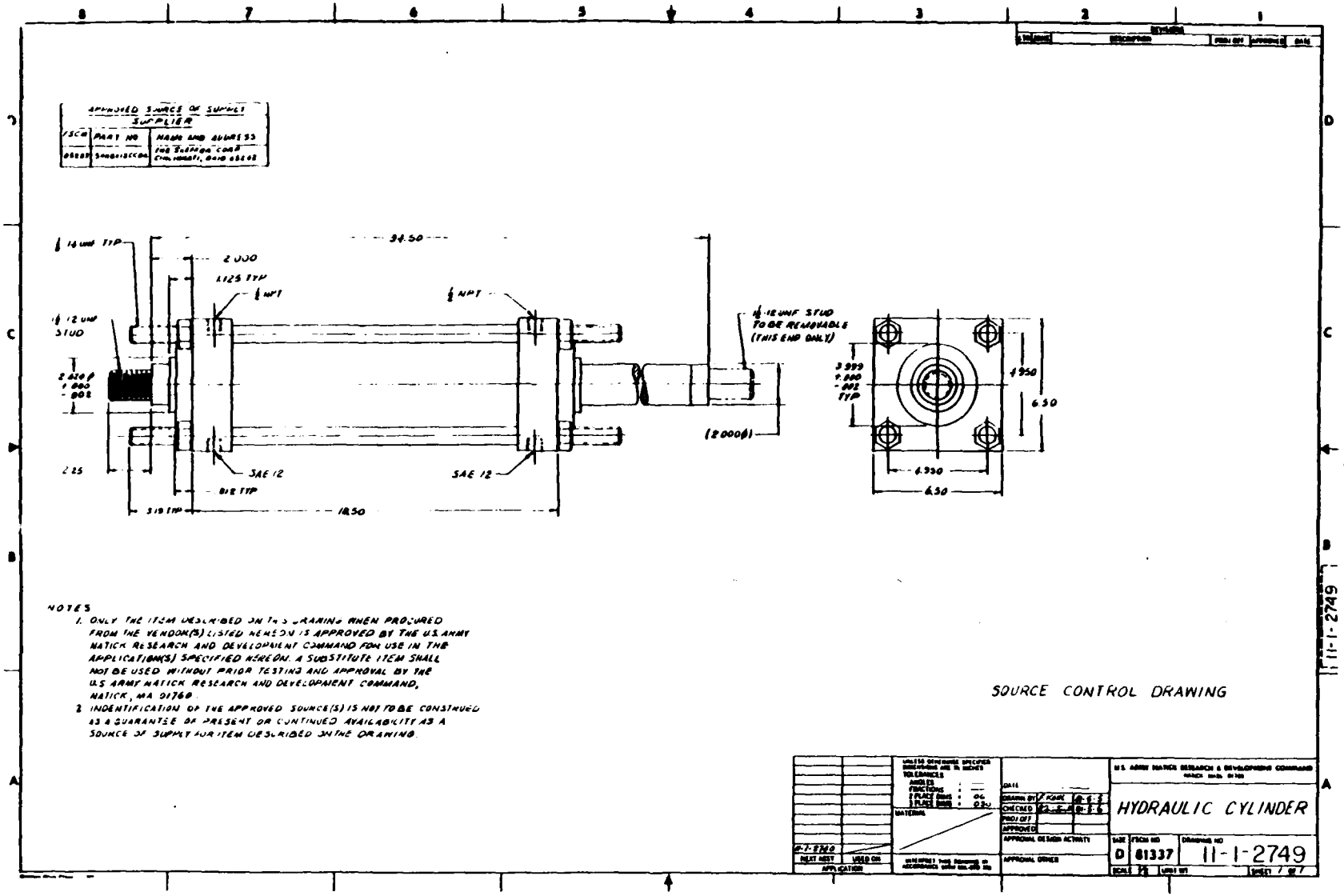

APPROVED SOURCE OF SUPPLY
SUPPLIER
FSCM
PART NO
NAME AND ADDRESS
SOURCE CONTROL DRAWING
HYDRAULIC CYLINDER
11-1-2749
D 81337
NOTES
1. ONLY THE ITEM DESCRIBED ON THIS DRAWING WHEN PROCURED FROM THE VENDOR(S) LISTED HEREON IS APPROVED BY THE U.S. ARMY NATICK RESEARCH AND DEVELOPMENT COMMAND FOR USE IN THE APPLICATION(S) SPECIFIED HEREON. A SUBSTITUTE ITEM SHALL NOT BE USED WITHOUT PRIOR TESTING AND APPROVAL BY THE U.S. ARMY NATICK RESEARCH AND DEVELOPMENT COMMAND, NATICK, MA 01760.
2. INDENTIFICATION OF THE APPROVED SOURCE(S) IS NOT TO BE CONSTRUED AS A GUARANTEE OF PRESENT OR CONTINUED AVAILABILITY AS A SOURCE OF SUPPLY FOR ITEM DESCRIBED ON THE DRAWING.

Figure A-34

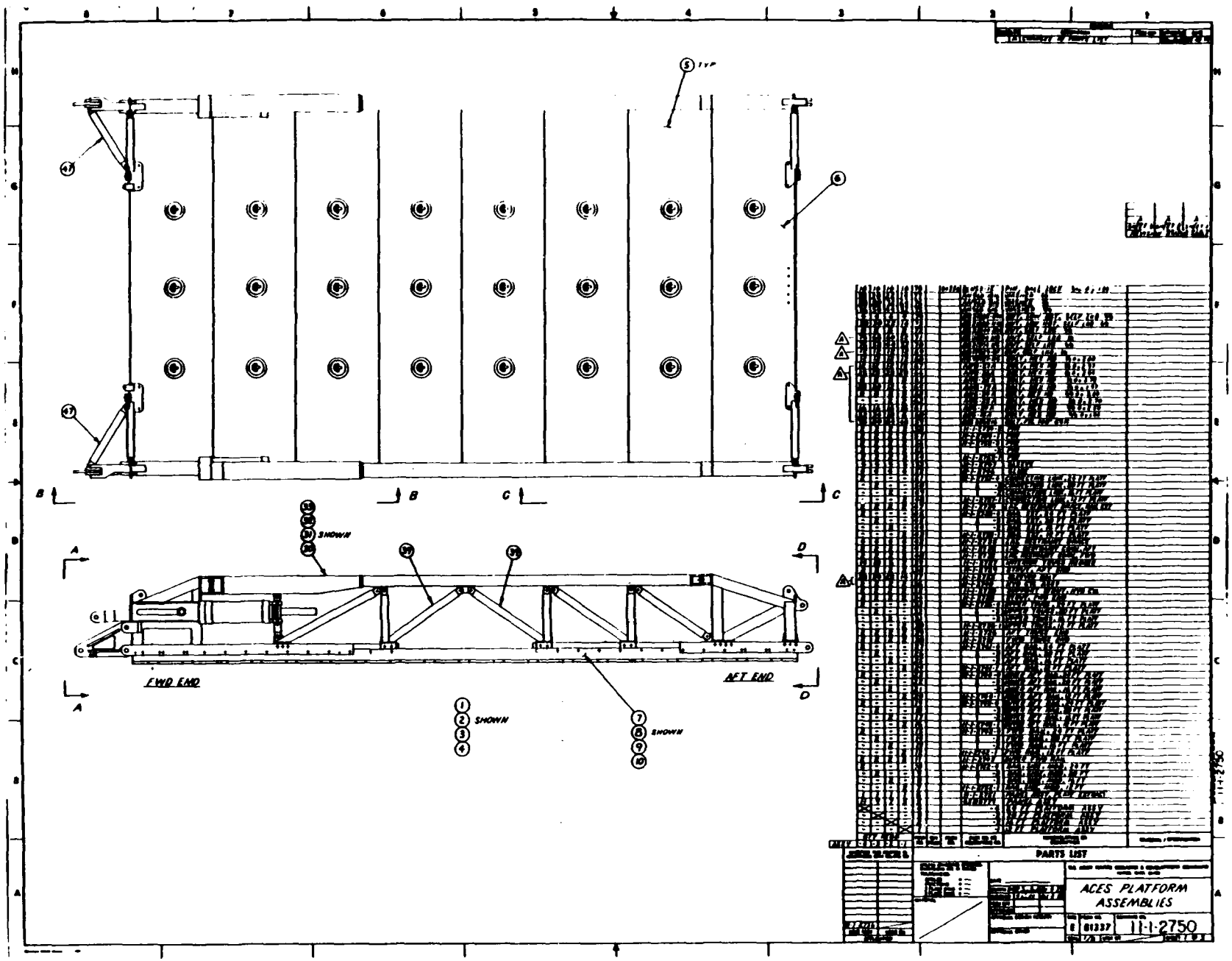

PARTS LIST
ACES PLATFORM ASSEMBLIES
11-1-2750
FWD END
AFT END
SHOWN
SHOWN
SHOWN

Figure A-35

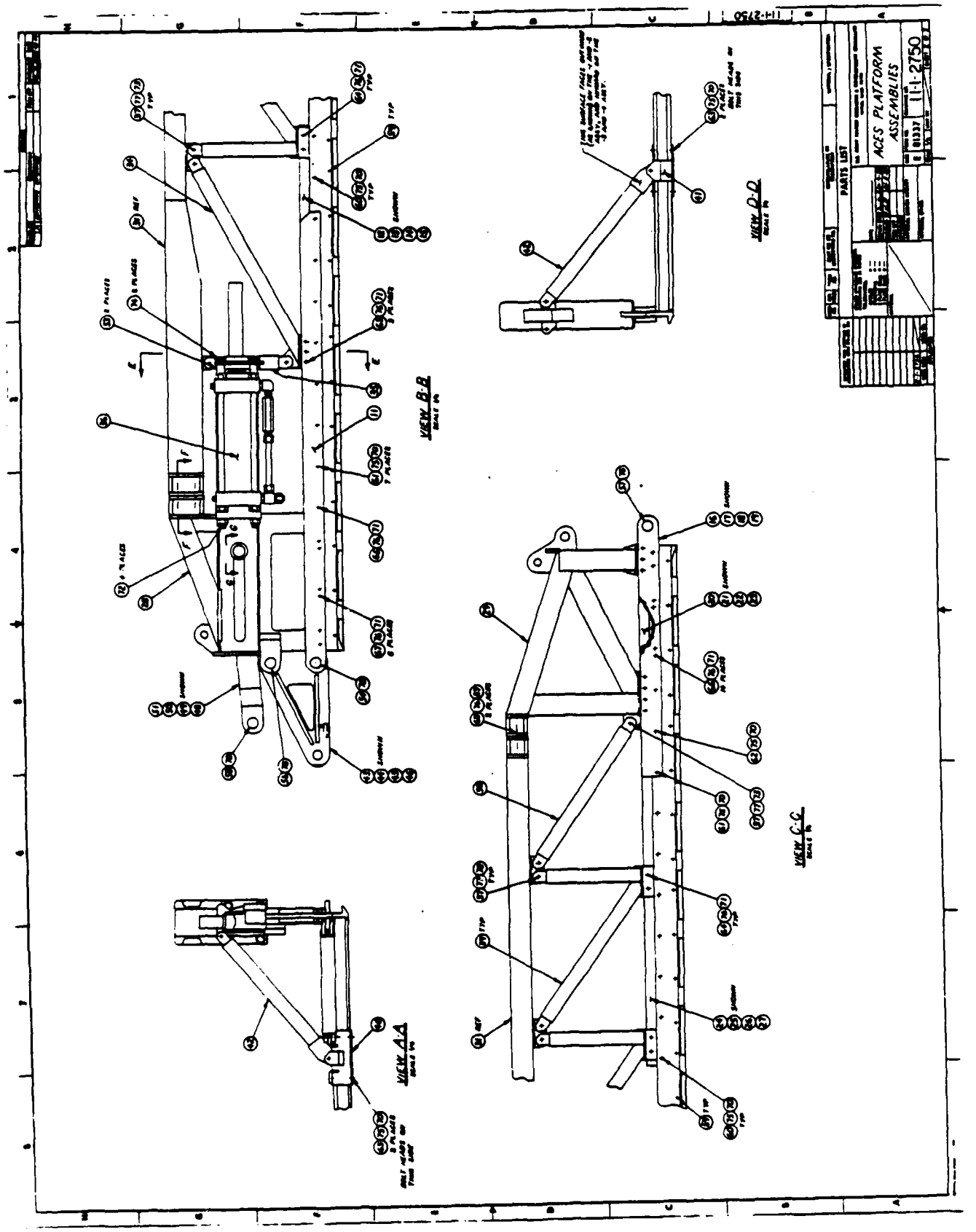

ACES PLATFORM
ASSEMBLIES
111-2750
PARTS LIST
VIEW B-B
VIEW D-D
VIEW C-C
VIEW A-A

Figure A-36

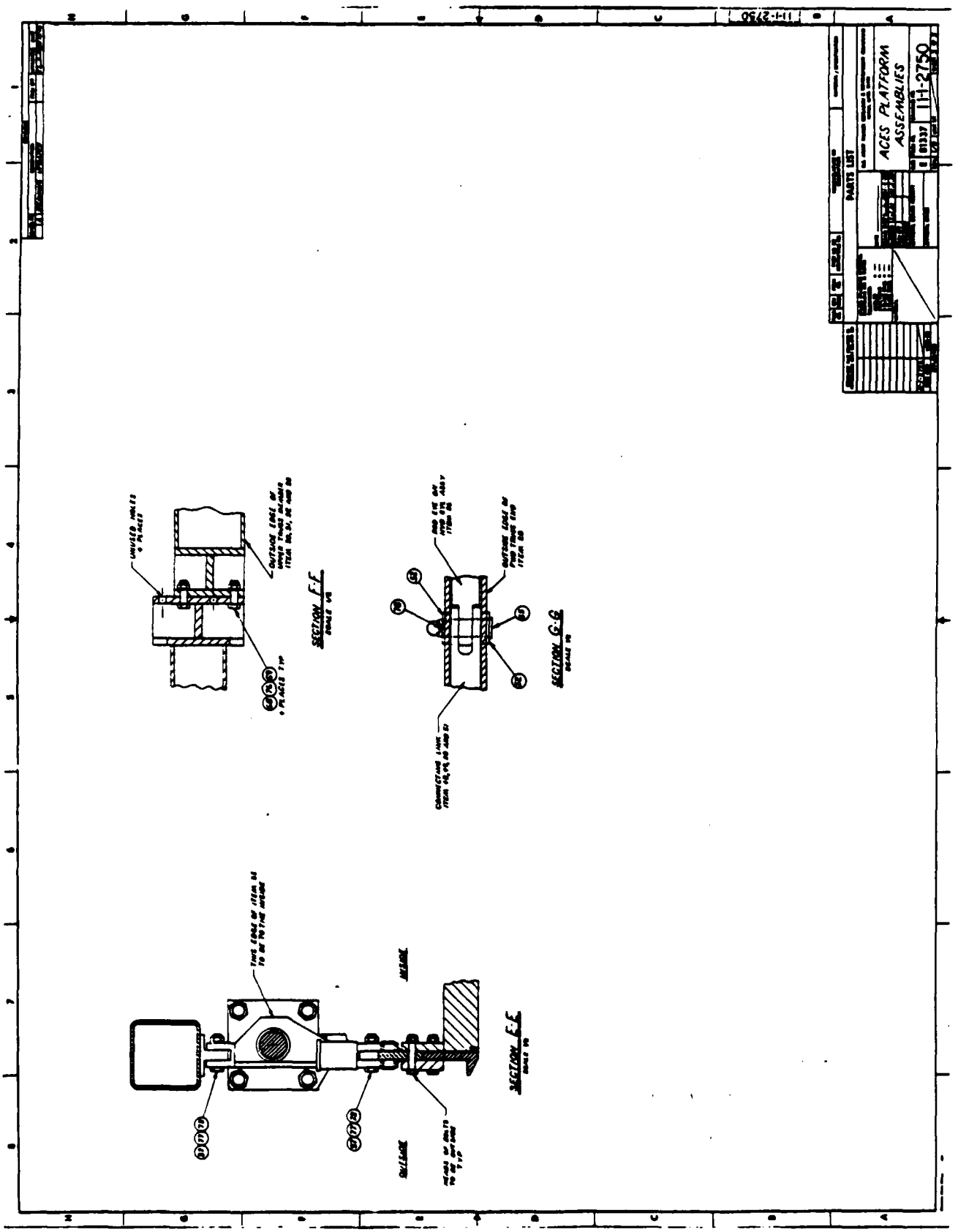

ACES PLATFORM ASSEMBLIES
11-1-2750
PARTS LIST
SECTION E-E
SECTION G-G
SECTION E-E

Figure A-37

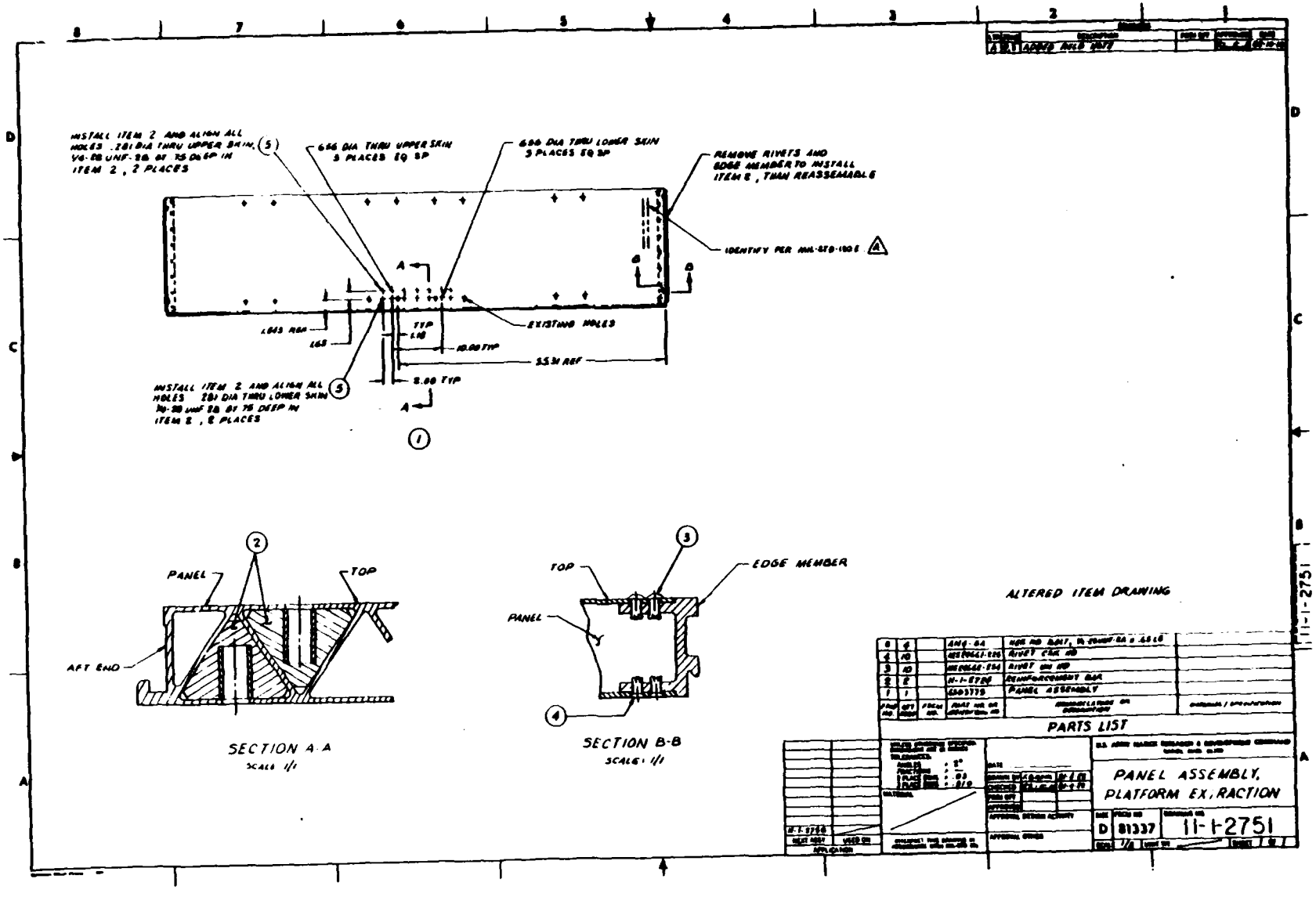

INSTALL ITEM 2 AND ALIGN ALL HOLES .281 DIA THRU UPPER SKIN, 1/4-28 UNF-2B AT 75 DEEP IN ITEM 2, 2 PLACES
.656 DIA THRU UPPER SKIN 3 PLACES EQ SP
.656 DIA THRU LOWER SKIN 3 PLACES EQ SP
REMOVE RIVETS AND EDGE MEMBER TO INSTALL ITEM 2, THEN REASSEMBLE
IDENTIFY PER MIL-STD-130 6
EXISTING HOLES
TYP LH
10.00 TYP
55.31 REF
5.00 TYP
INSTALL ITEM 2 AND ALIGN ALL HOLES .281 DIA THRU LOWER SKIN 1/4-28 UNF-2B AT 75 DEEP IN ITEM 2, 2 PLACES
PANEL
TOP
AFT END
SECTION A-A
SCALE 1/1
EDGE MEMBER
SECTION B-B
SCALE 1/1
ALTERED ITEM DRAWING
PARTS LIST
PANEL ASSEMBLY, PLATFORM EX, RACTION
D 81337
11-1-2751

Figure A-38

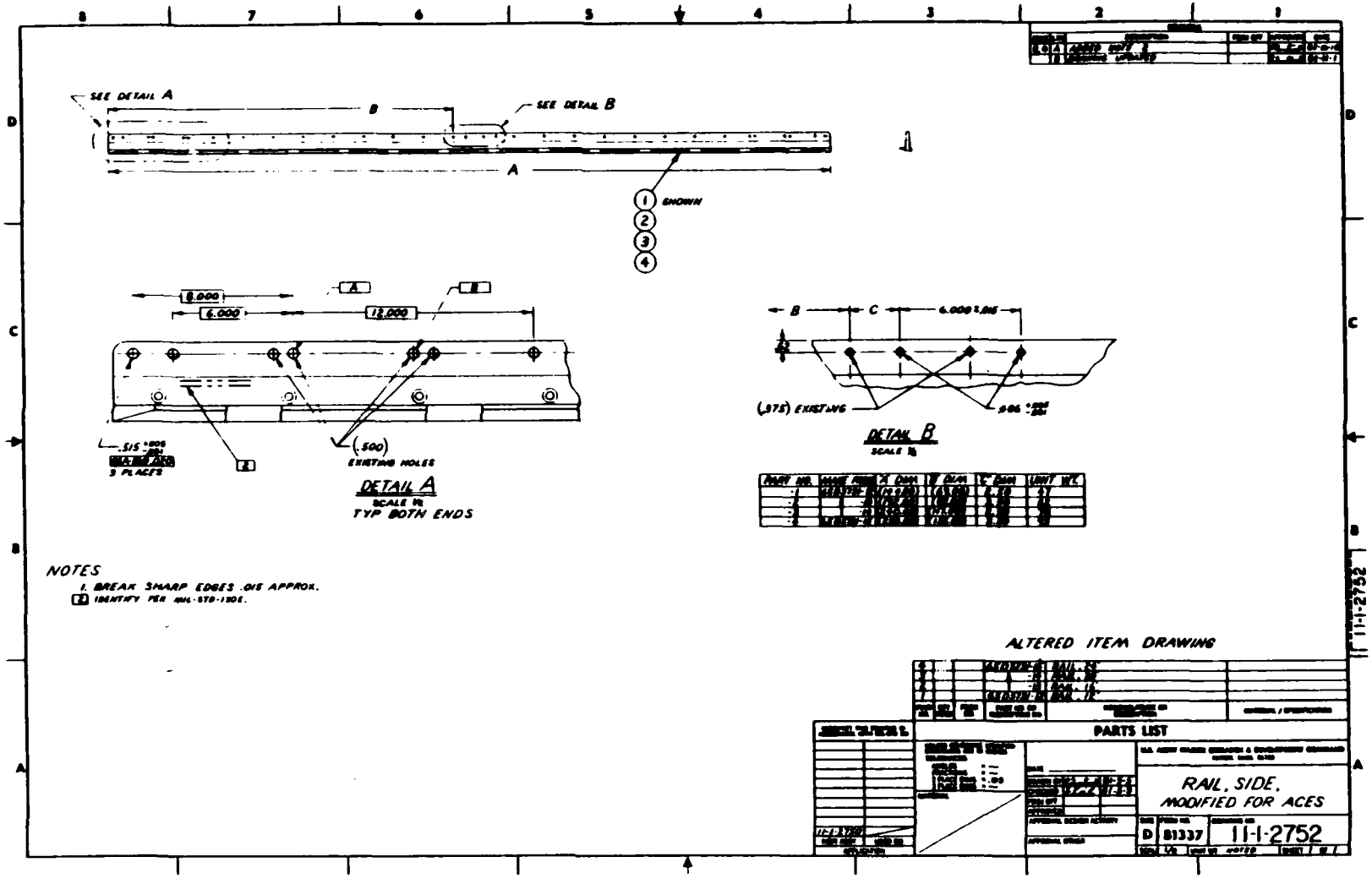

SEE DETAIL A
SEE DETAIL B
A
B
SHOWN
DETAIL A
SCALE 1½
TYP BOTH ENDS
EXISTING HOLES
DETAIL B
SCALE 1½
(.375) EXISTING
NOTES
1. BREAK SHARP EDGES .015 APPROX.
ALTERED ITEM DRAWING
PARTS LIST
RAIL, SIDE, MODIFIED FOR ACES
D 81337
11-1-2752

Figure A-39

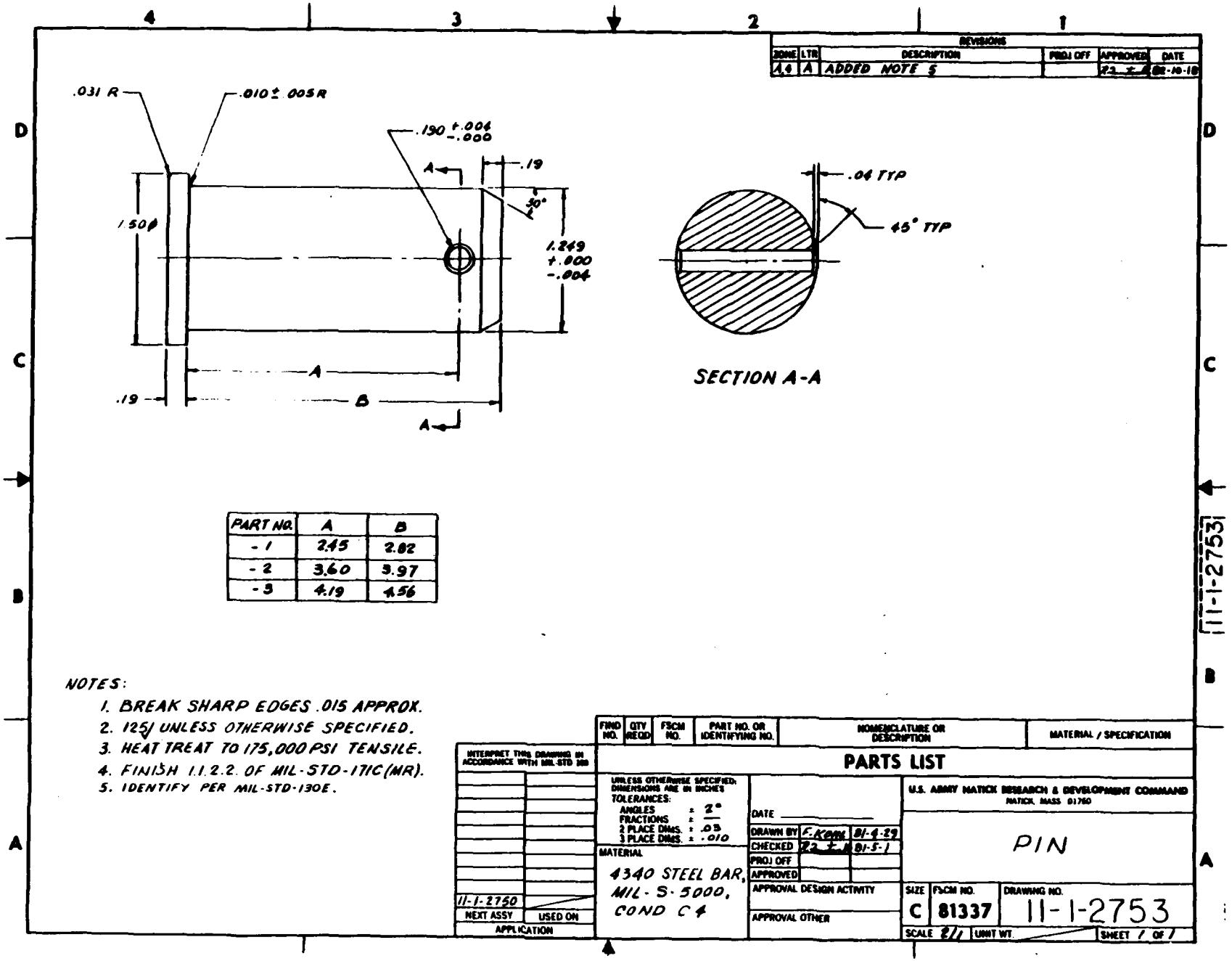

REVISIONS
ZONE LTR DESCRIPTION PROJ OFF APPROVED DATE
A.1 A ADDED NOTE 5
.031 R
.010 ± .005 R
.190 +.004 -.000
.19
A
30°
1.50 Ø
1.249 +.000 -.004
A
.19
B
A
.04 TYP
45° TYP
SECTION A-A
PART NO. A B
-1 2.45 2.82
-2 3.60 3.97
-3 4.19 4.56
NOTES:
1. BREAK SHARP EDGES .015 APPROX.
2. 125/ UNLESS OTHERWISE SPECIFIED.
3. HEAT TREAT TO 175,000 PSI TENSILE.
4. FINISH 1.1.2.2. OF MIL-STD-171C(MR).
5. IDENTIFY PER MIL-STD-130E.
FIND NO. QTY REQD FSCM NO. PART NO. OR IDENTIFYING NO. NOMENCLATURE OR DESCRIPTION MATERIAL / SPECIFICATION
PARTS LIST
INTERPRET THIS DRAWING IN ACCORDANCE WITH MIL-STD 100
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES
TOLERANCES:
ANGLES ± 2°
FRACTIONS ± —
2 PLACE DIMS. ± .03
3 PLACE DIMS. ± .010
MATERIAL
4340 STEEL BAR, MIL-S-5000, COND C4
DATE
DRAWN BY F. KOPK 81-4-29
CHECKED 81-5-1
PROJ OFF
APPROVED
APPROVAL DESIGN ACTIVITY
APPROVAL OTHER
U.S. ARMY NATICK RESEARCH & DEVELOPMENT COMMAND
NATICK, MASS 01760
PIN
SIZE C FSCM NO. 81337 DRAWING NO. 11-1-2753
SCALE 2/1 UNIT WT. SHEET 1 OF 1
11-1-2750
NEXT ASSY USED ON
APPLICATION
11-1-2753
88

Figure A-40

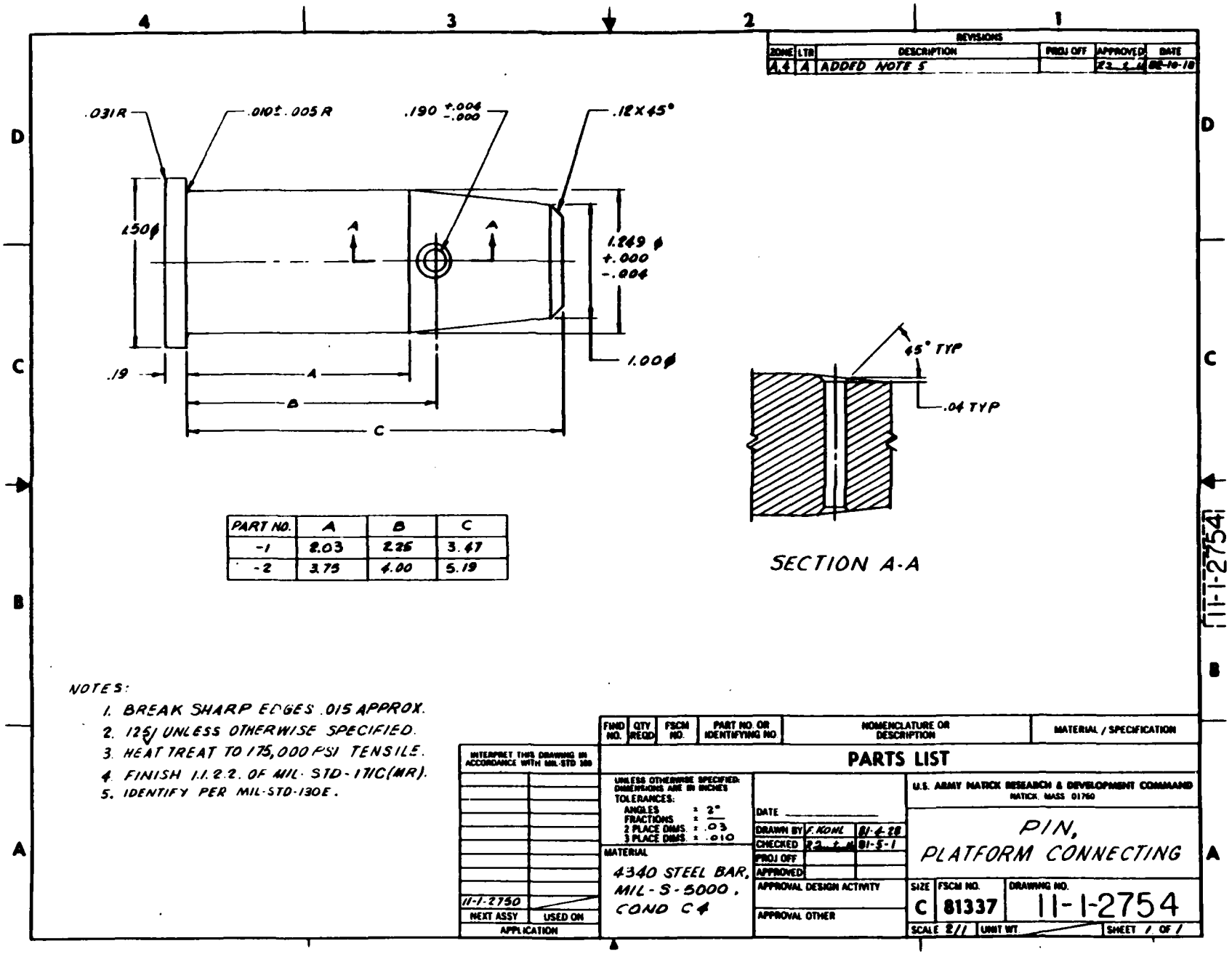

4
3
2
1
D
C
B
A
REVISIONS
ZONE | LTR | DESCRIPTION | PROJ OFF | APPROVED | DATE
A,4 | A | ADDED NOTE 5 | | | 80-10-16
.031R
.010±.005R
.190 +.004 -.000
.12X45°
1.50ϕ
1.249ϕ +.000 -.004
1.00ϕ
.19
A
B
C
45° TYP
.04 TYP
SECTION A-A
PART NO. | A | B | C
-1 | 2.03 | 2.26 | 3.47
-2 | 3.75 | 4.00 | 5.19
NOTES:
1. BREAK SHARP EDGES .015 APPROX.
2. 125/ UNLESS OTHERWISE SPECIFIED.
3. HEAT TREAT TO 175,000 PSI TENSILE.
4. FINISH 1.1.2.2. OF MIL-STD-171C(MR).
5. IDENTIFY PER MIL-STD-130E.
FIND NO. | QTY REQD | FSCM NO. | PART NO. OR IDENTIFYING NO | NOMENCLATURE OR DESCRIPTION | MATERIAL / SPECIFICATION
PARTS LIST
INTERPRET THIS DRAWING IN ACCORDANCE WITH MIL-STD 100
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES
TOLERANCES:
ANGLES ± 2°
FRACTIONS ± 1/64
2 PLACE DIMS. ± .03
3 PLACE DIMS. ± .010
MATERIAL
4340 STEEL BAR, MIL-S-5000, COND C4
DATE
DRAWN BY F. KOHL 81-4-28
CHECKED R.J. 81-5-1
PROJ OFF
APPROVED
APPROVAL DESIGN ACTIVITY
APPROVAL OTHER
U.S. ARMY NATICK RESEARCH & DEVELOPMENT COMMAND
NATICK, MASS 01760
PIN, PLATFORM CONNECTING
SIZE C | FSCM NO. 81337 | DRAWING NO. 11-1-2754
SCALE 2/1 | UNIT WT | SHEET 1 OF 1
11-1-2750
NEXT ASSY | USED ON
APPLICATION
11-1-2754

Figure A-41

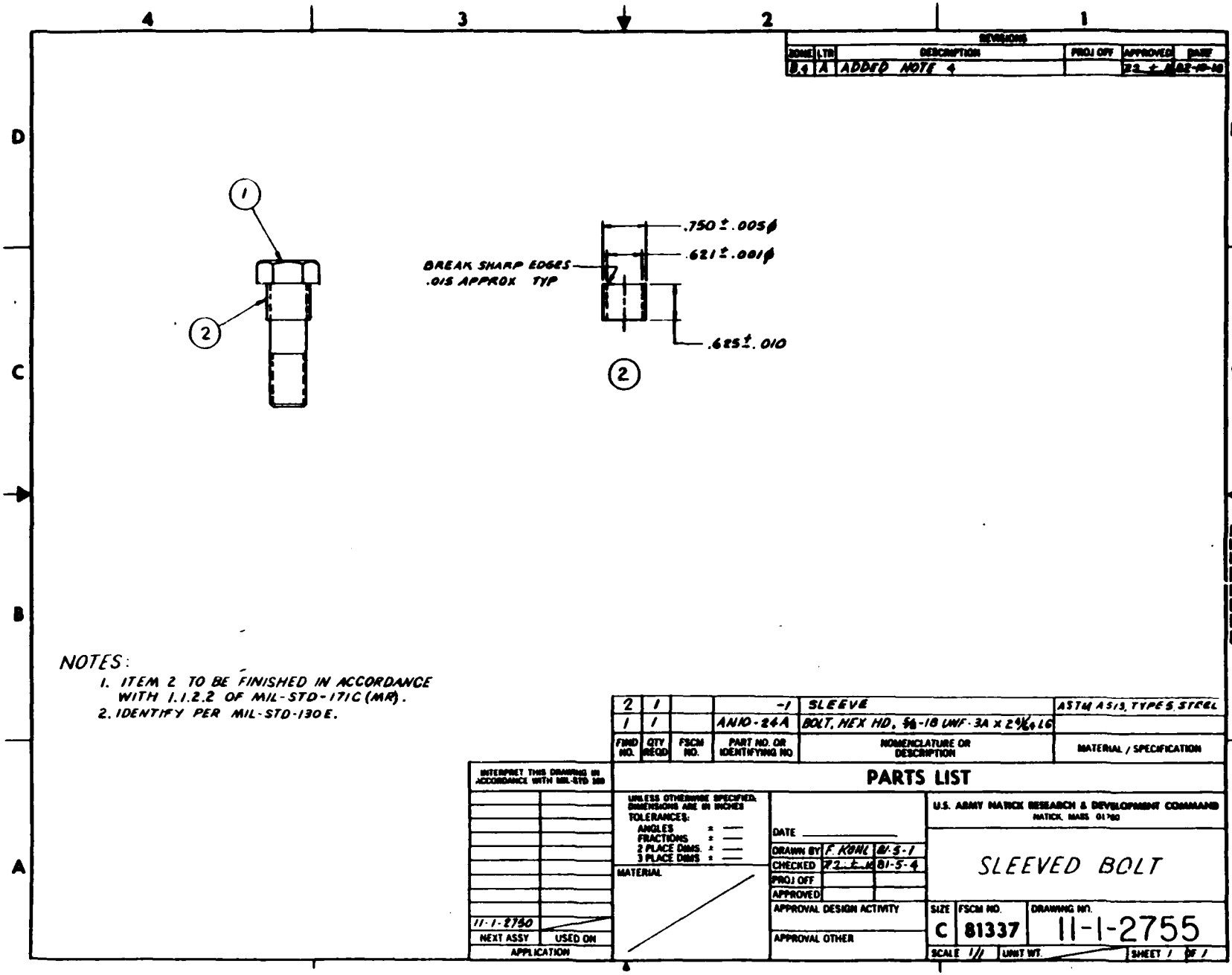

4
3
2
1
D
C
B
A
DESIGNATION
ZONE | LTR | DESCRIPTION | PROJ OFF | APPROVED | DATE
B,1 | A | ADDED NOTE 4 | | 72 L K | 82-10-18
1
2
.750 ± .005ϕ
.621 ± .001ϕ
BREAK SHARP EDGES .015 APPROX TYP
.625 ± .010
2
NOTES:
1. ITEM 2 TO BE FINISHED IN ACCORDANCE WITH 1.1.2.2 OF MIL-STD-171C (MR).
2. IDENTIFY PER MIL-STD-130E.
FIND NO. | QTY REQD | FSCM NO. | PART NO. OR IDENTIFYING NO | NOMENCLATURE OR DESCRIPTION | MATERIAL / SPECIFICATION
2 | 1 | | -1 | SLEEVE | ASTM A513, TYPE 5 STEEL
1 | 1 | | AN10-24A | BOLT, HEX HD, 5/8-18 UNF-3A x 2 9/16 LG |
PARTS LIST
INTERPRET THIS DRAWING IN ACCORDANCE WITH MIL-STD 100
UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES
TOLERANCES:
ANGLES ± —
FRACTIONS ± —
2 PLACE DIMS. ± —
3 PLACE DIMS ± —
MATERIAL
DATE
DRAWN BY F. KOHL 81-5-1
CHECKED 72 L K 81-5-4
PROJ OFF
APPROVED
APPROVAL DESIGN ACTIVITY
APPROVAL OTHER
11-1-2750
NEXT ASSY | USED ON
APPLICATION
U.S. ARMY NATICK RESEARCH & DEVELOPMENT COMMAND
NATICK, MASS 01760
SLEEVED BOLT
SIZE C | FSCM NO. 81337 | DRAWING NO. 11-1-2755
SCALE 1/1 | UNIT WT. | SHEET 1 OF 1
06
11-1-2755

Figure A-42

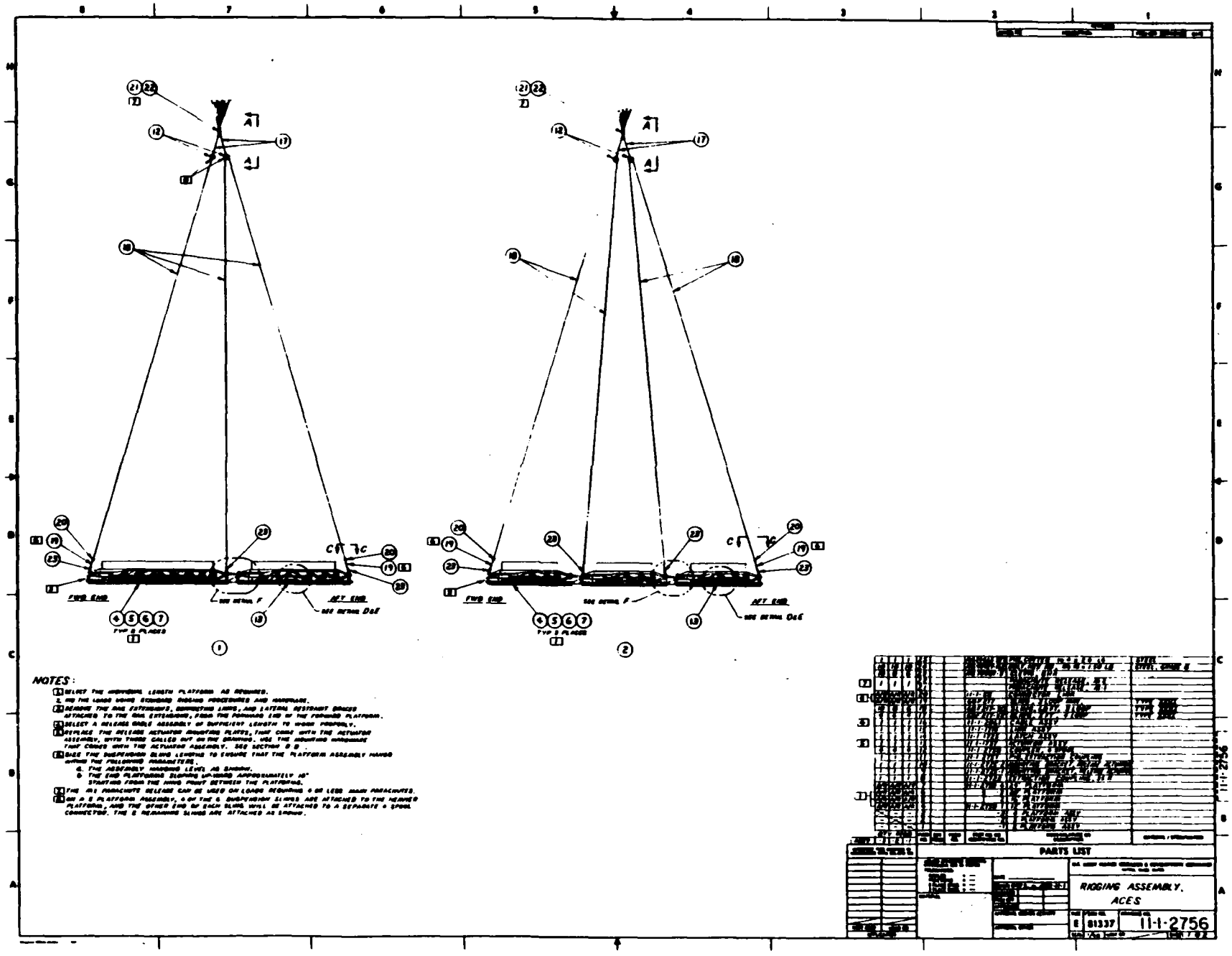


Figure A-43

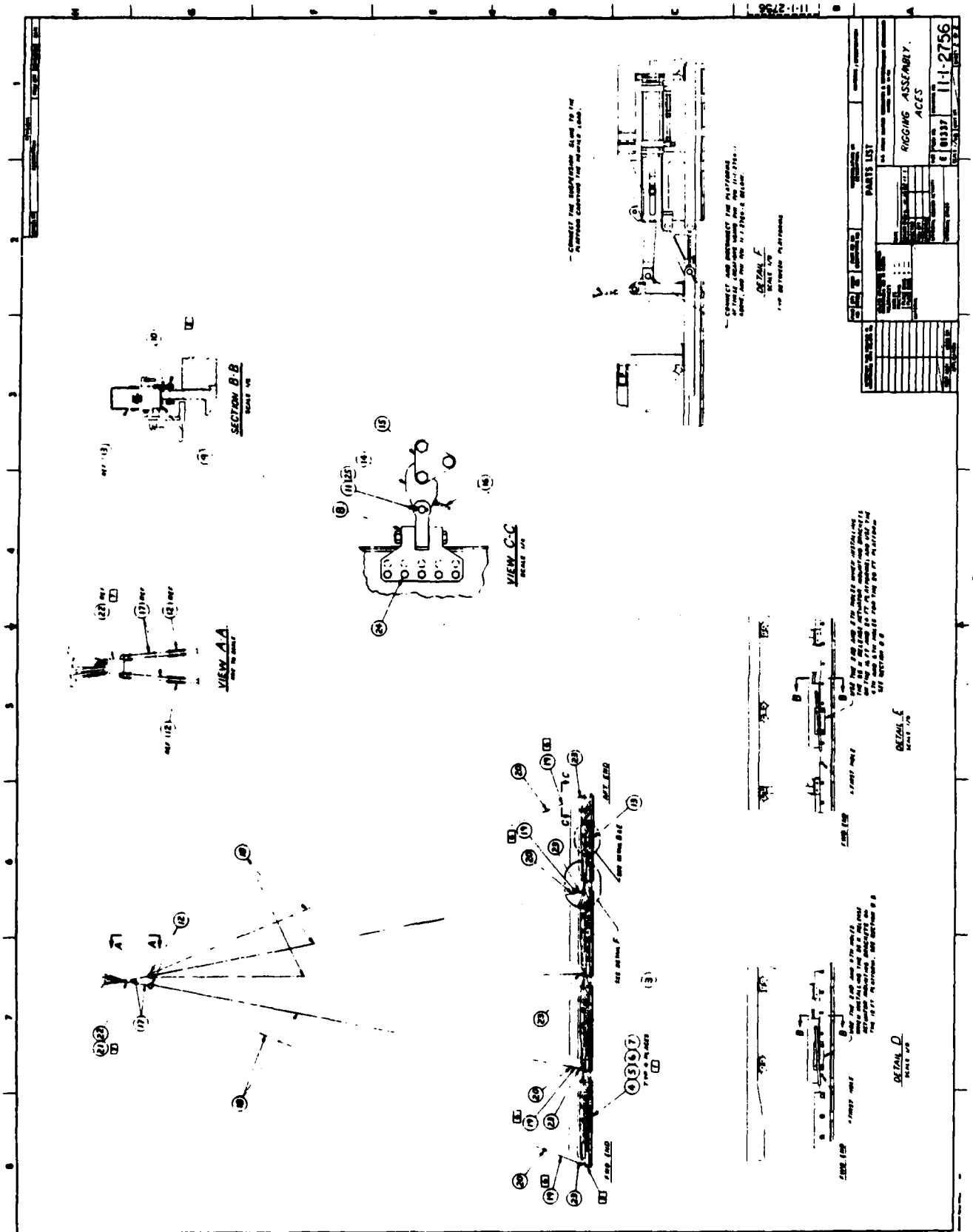

RIGGING ASSEMBLY, ACES
11-1-2756
PARTS LIST
SECTION B-B
VIEW A-A
VIEW C-C
DETAIL D
DETAIL E
DETAIL F

Figure A-44

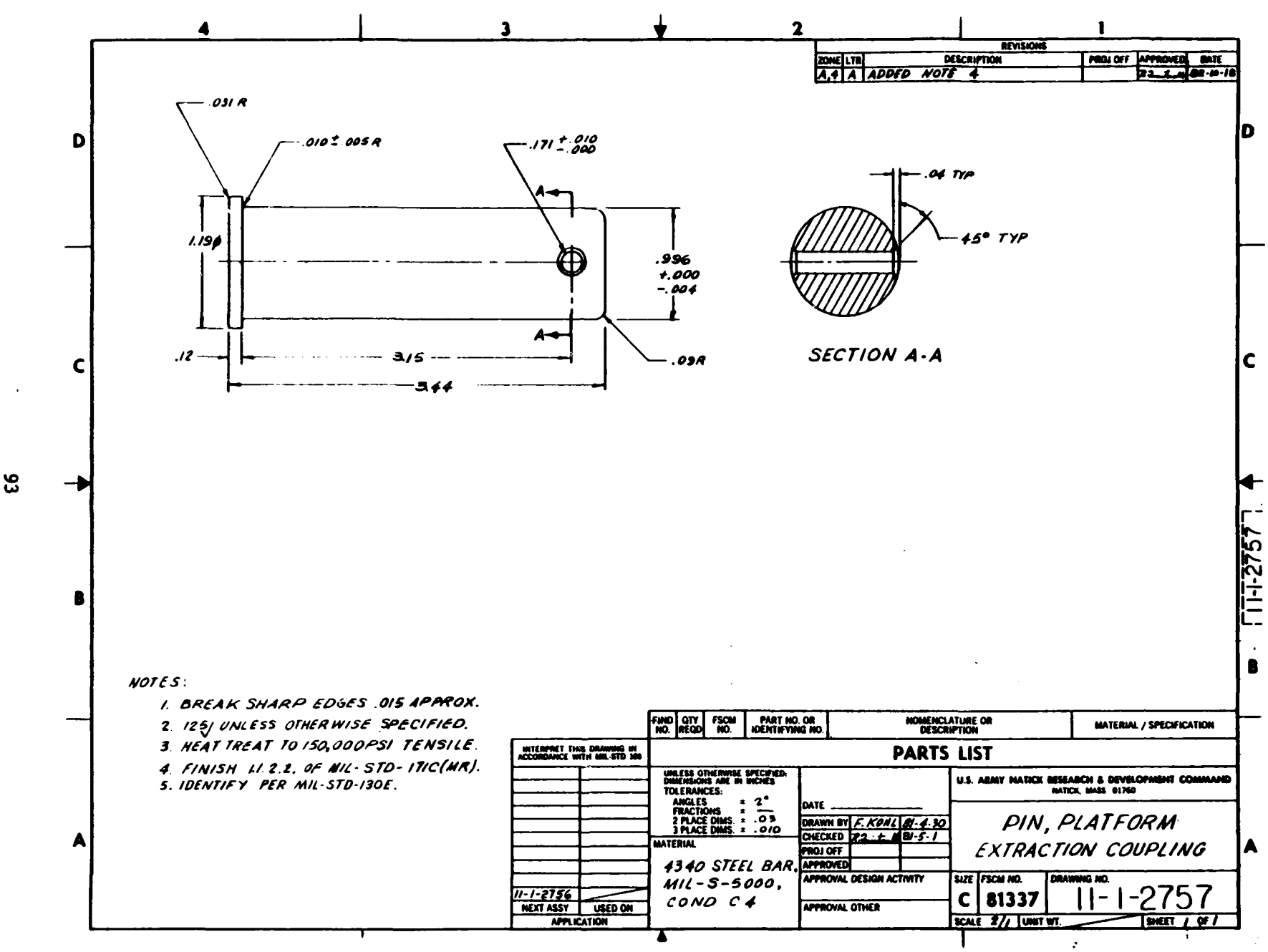

REVISIONS
ZONE | LTR | DESCRIPTION | PROJ OFF | APPROVED | DATE
A,4 | A | ADDED NOTE 4 | | | 82-10-18
.031 R
.010 ± .005 R
.171 +.010 -.000
1.190
.996 +.000 -.004
.12
3.15
3.44
.09R
.04 TYP
45° TYP
SECTION A-A
NOTES:
1. BREAK SHARP EDGES .015 APPROX.
2. 125 UNLESS OTHERWISE SPECIFIED.
3. HEAT TREAT TO 150,000PSI TENSILE.
4. FINISH I.I 2.2. OF MIL-STD-17IC(MR).
5. IDENTIFY PER MIL-STD-130E.
FIND NO. | QTY REQD | FSCM NO. | PART NO. OR IDENTIFYING NO. | NOMENCLATURE OR DESCRIPTION | MATERIAL / SPECIFICATION
PARTS LIST
INTERPRET THIS DRAWING IN ACCORDANCE WITH MIL-STD 100
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES
TOLERANCES:
ANGLES ± 2°
FRACTIONS ± —
2 PLACE DIMS. ± .03
3 PLACE DIMS. ± .010
MATERIAL
4340 STEEL BAR, MIL-S-5000, COND C4
DATE
DRAWN BY F. KOHL 81-4-30
CHECKED 81-5-1
PROJ OFF
APPROVED
APPROVAL DESIGN ACTIVITY
APPROVAL OTHER
11-1-2756
NEXT ASSY | USED ON
APPLICATION
U.S. ARMY NATICK RESEARCH & DEVELOPMENT COMMAND
NATICK, MASS 01760
PIN, PLATFORM EXTRACTION COUPLING
SIZE C | FSCM NO. 81337 | DRAWING NO. 11-1-2757
SCALE 2/1 | UNIT WT. | SHEET 1 OF 1
11-1-2757
93

Figure A-45

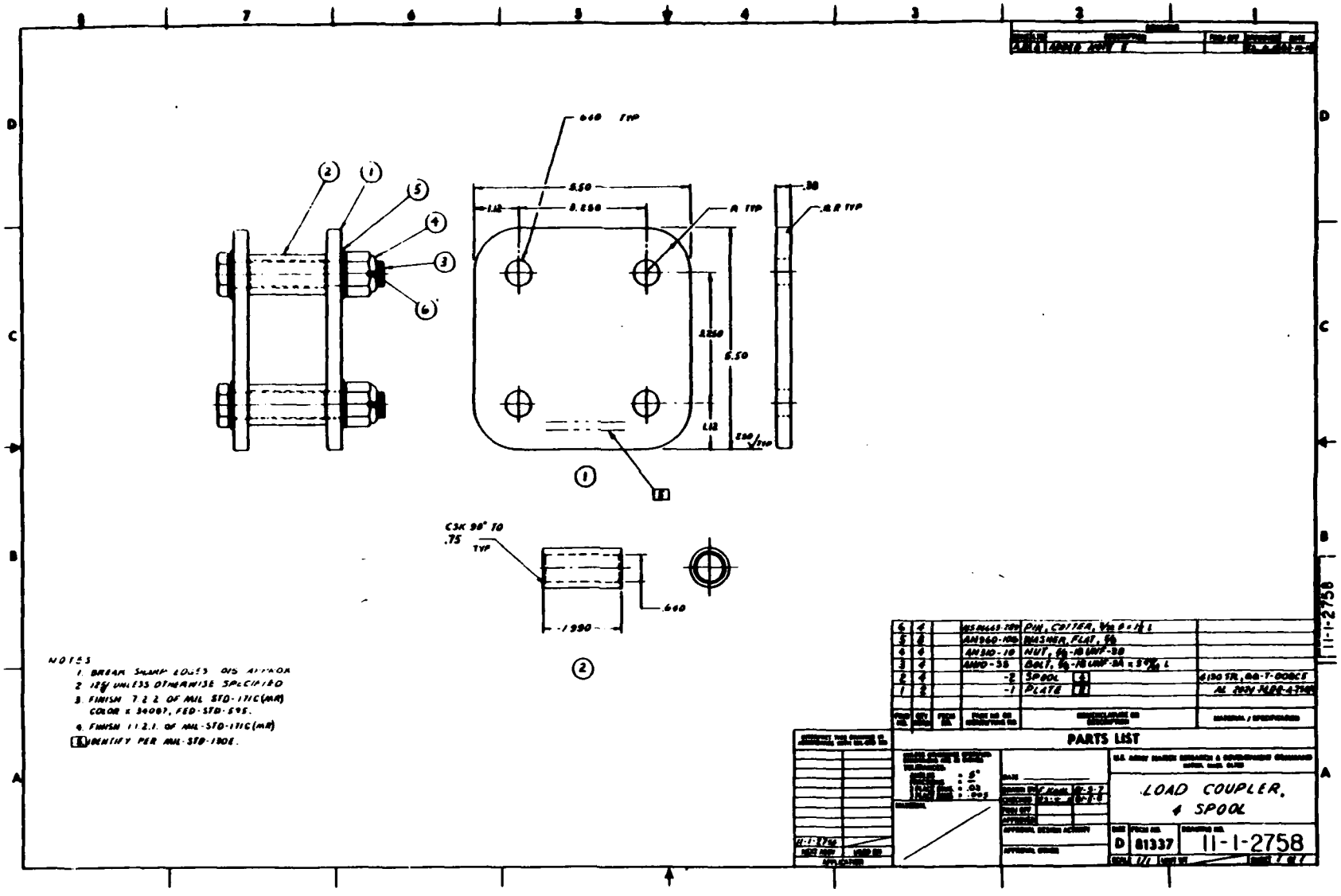

.640 TYP
8.50
8.250
1.12
.38
.12 R TYP
R TYP
2.250
6.50
1.12
.250 TYP
CSK 90° TO .75 TYP
.640
1.990
NOTES
1. BREAK SHARP EDGES .015 MAXIMUM
2. ±1/64 UNLESS OTHERWISE SPECIFIED
3. FINISH 7.2.2 OF MIL STD-171C(MR) COLOR # 34087, FED-STD-595.
4. FINISH 11.2.1. OF MIL-STD-171C(MR)
5. IDENTIFY PER MIL-STD-130E.
PARTS LIST
LOAD COUPLER, 4 SPOOL
D 81337 11-1-2758

Figure A-46

APPENDIX B

STRUCTURAL ANALYSES

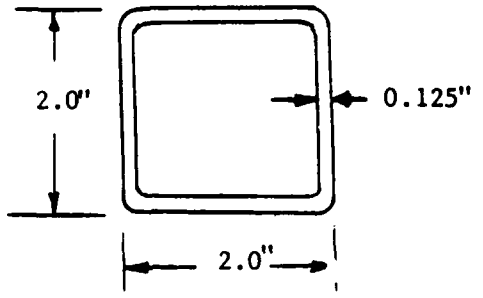
INTRODUCTION

The ACES structures were analyzed for the various load conditions expected during an airdrop. The analyses for the two conditions presented here controlled the basic structure design. Analyses are included for the 12-foot platform. Similar analyses were performed for the other size platforms.

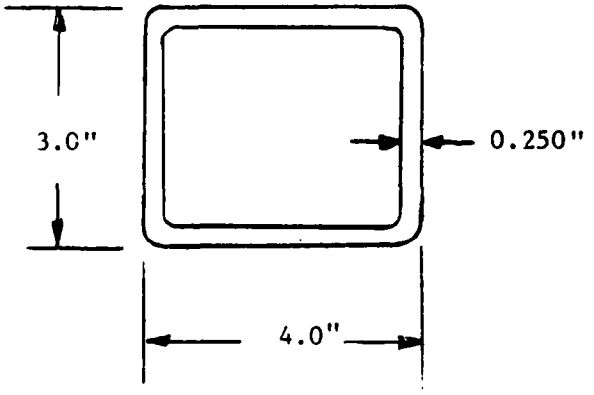
PROCEDURE:

The load in the individual truss members was computed from the applied system loads. These member loads were increased by a factor of 1.50 and this value compared to the load carrying capacity of the member for acceptability. Load carrying capacities were based upon the yield strength of the material.

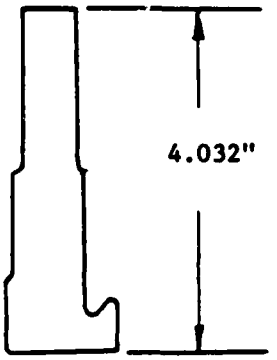
The basic structural members are:



Mat'l - Steel
Area - 0.917 $in.^2$
I = 0.533 $in.^4$
σ_y = 46,000 psi
Cap. = 0.917 x 46,000 = 42,182 lb



Mat'l - Steel
Area - 3.18
I_{x-x} = 6.82 $in.^4$
I_{y-y} = 4.30 $in.^4$
σ_y = 46,000 psi
Cap. = 3.18 x 46,000 = 146,280 lb

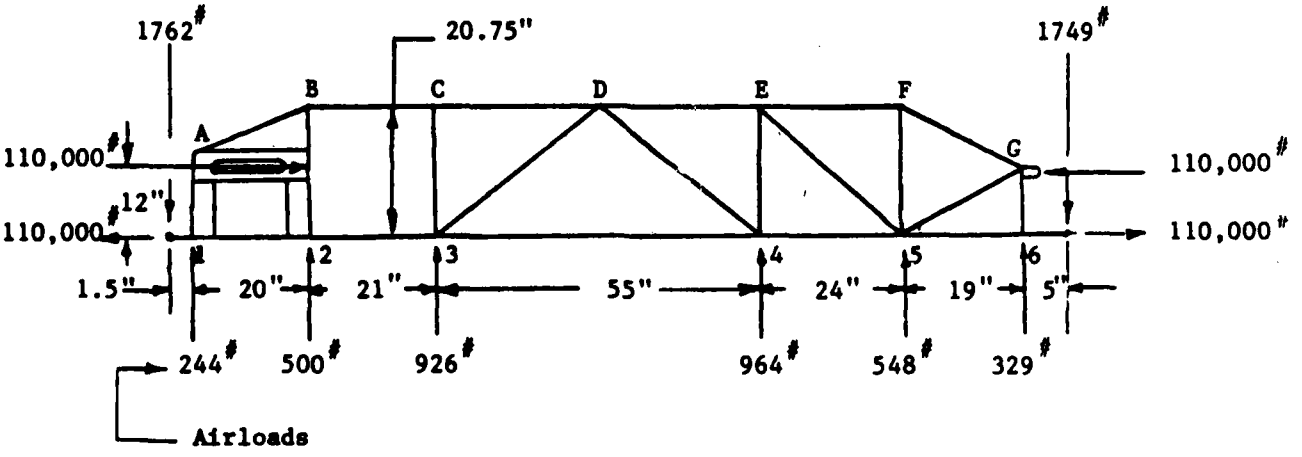


Mat'l - 2024-T4
Area - 2.28 $in.^2$
I = 3.22 $in.^4$
σ_y = 44,000 psi
Cap. = 2.28 x 44,000 = 100,320 lb

CONDITION 1

Platform is Center Unit in a Three-Platform ACES Configuration

Truss Geometry and Loading



C-D, B-C and 2-3

$$\Sigma M_3 = 0$$

$$C\text{-}D = \frac{(110{,}000 \times 12) + (244 \times 41) + (500 \times 21) - (1762 \times 42.5)}{20.75}$$

$$= 60{,}994 \quad (C)$$

$$60{,}994 \times 1.5 = 91{,}491$$

4-5, D-E

$$\Sigma M_4 = 0$$

$$D\text{-}E = \frac{(926 \times 55) + (500 \times 76) + (244 \times 96) + (110{,}000 \times 12) - (1762 \times 97.5)}{20.75}$$

$$= 60{,}750 \ (C)$$

$$60{,}750 \times 1.5 = 91{,}125$$

3-4

$$\Sigma M_D = 0$$

$$3\text{-}4 = \frac{(926 \times 27.5) + (500 \times 48.5) + (244 \times 68.5) + (110{,}000 \times 20.75)}{20.75}$$

$$\underline{- (110{,}000 \times 8.75) - (1762 \times 70)}$$

$$= 60{,}872 \ (T)$$

$$60{,}872 \times 1.5 = 91{,}308$$

D-3

$$\Sigma F_H \ @ \ 3 = 0$$

$$D\text{-}3 = \frac{34.45}{27.5} \ (60{,}994 - 60{,}872)$$

$$= 153 \ (T)$$

$$153 \times 1.5 = 230$$

D-4

ΣF_H @ 4 = 0

$D\text{-}4 = \frac{34.45}{27.5}$ (60,872 - 60,750)

= 153 (C)

153 x 1.5 = 230

E-4

ΣF_V @ E

E-4 = 1749 - 548 - 329

= 872 (C)

872 x 1.5 = 1308

E-5

ΣF_V @ 5

$E\text{-}5 = \frac{31.72}{20.75}$ (1749 - 548 - 329)

1333 (T)

1333 x 1.5 = 2000

E-F

$\Sigma M_5 = 0$

$E\text{-}F = \frac{(110{,}000 \times 12)-(1749 \times 26)+(329 \times 21)}{20.75}$

= 61,756 (C)

61,756 x 1.5 = 92,634

F-G

ΣF_H @ 5 = 0

$F\text{-}G = \frac{22.75}{21}$ (61,756)

= 66,902 (C)

66,902 x 1.5 = 100,353

F-5

ΣF_V @ 5 = 0

$F\text{-}5 = \frac{8.75}{22.75}$ (66,902)

= 25,732 (T)

25,732 x 1.5 = 38,598

G-6

$\Sigma M_5 = 0$

$G\text{-}6 = \frac{(1749 \times 26)-(329 \times 21)}{21}$

= 1836 (T)

= 1836 x 1.5 = 2754

G-5

ΣF_V @ G = 0

$G\text{-}5 = \frac{24.19}{12} \left[(66,902 \times \frac{8.75}{22.75}) + 1836\right]$

= 55,572 (C)

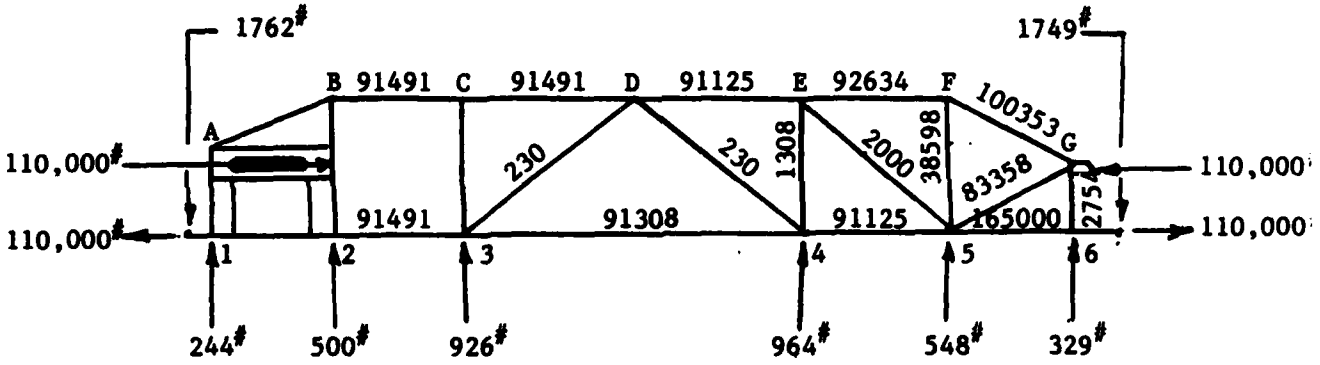
55,572 x 1.5 = 83,358

5-6

ΣF_H @ 6 = 0

5-6 = 110,000 (T)

110,000 x 1.5 = 165,000



Note: Values along truss members indicate stress in psi.

Check Lateral Buckling of Upper Rail Member:

$$P_c = \frac{\pi^2 E I}{L^2}$$

Where:

P_c = critical load

E = Young's Nodulus

= 30×10^6 psi

I = Moment of inertia

= 6.82 $in.^4$

L = Column length

= 100 inches

$$P_{CR} = \frac{\pi^2 (30 \times 10^6)(6.82)}{(100)^2}$$

= 201,932

$$M.S. = \frac{(201,932 - 91,491)}{91,492} \times 100$$

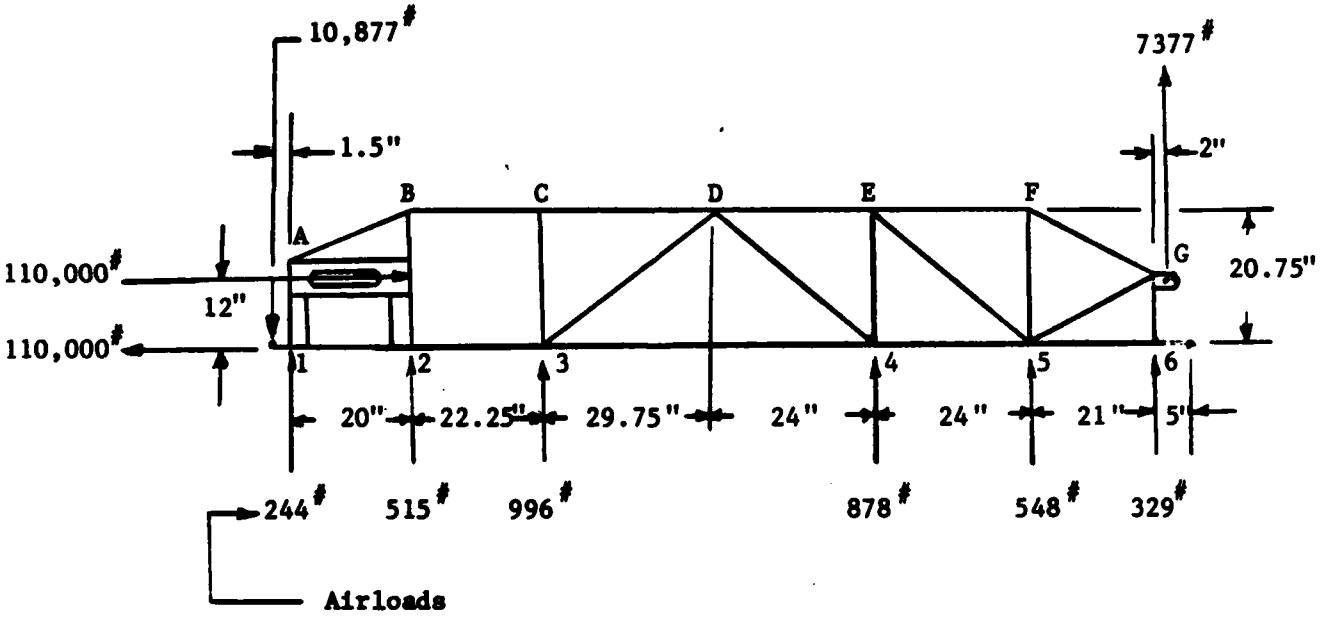
= 120 percent*

* This margin is sensitive to the column length (L). On the 16-foot platform this margin is reduced to zero and on the 20- and 24-foot platforms the top rail is reinforced to obtain acceptability.

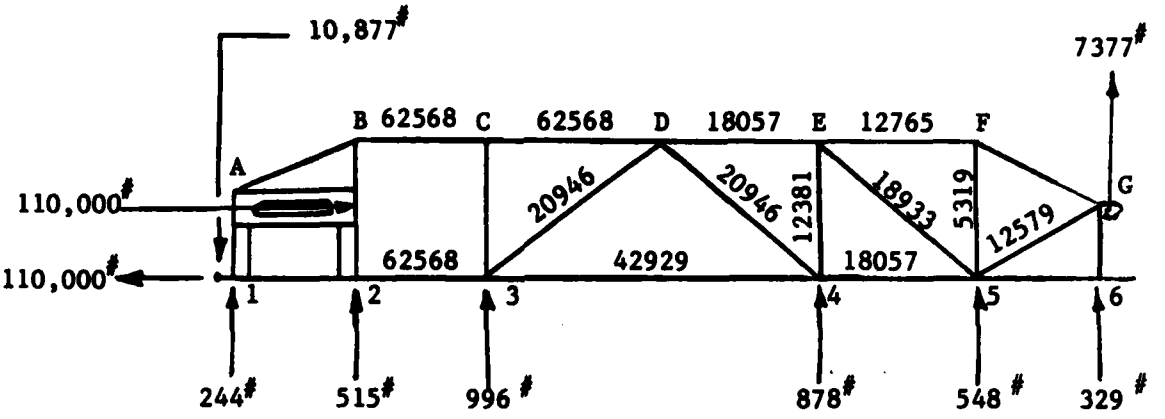
CONDITION 2

Platform is Located at the End of an ACES Assembly

Truss Geometry and Loading



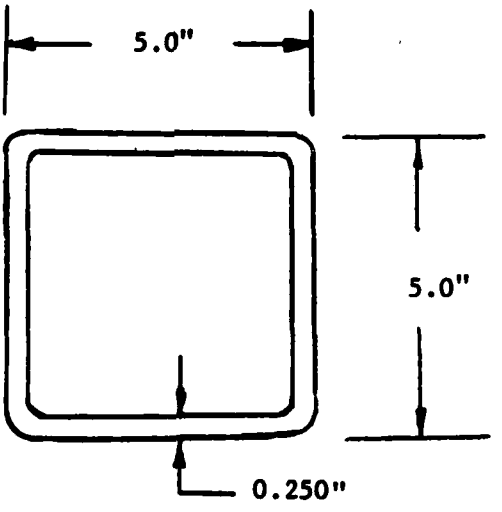
The loads in the members were computed as per procedures shown for Condition 1. The member loads are as follows:



Note: Values along truss members indicate stress in psi.

The diagonal member C-2 is missing in order to provide room for installation of the hydraulic cylinder. This makes it necessary for members B-C and 2-3 to carry the large shear loads at Section B-2 in bending.

The section properties of B-C are the following:

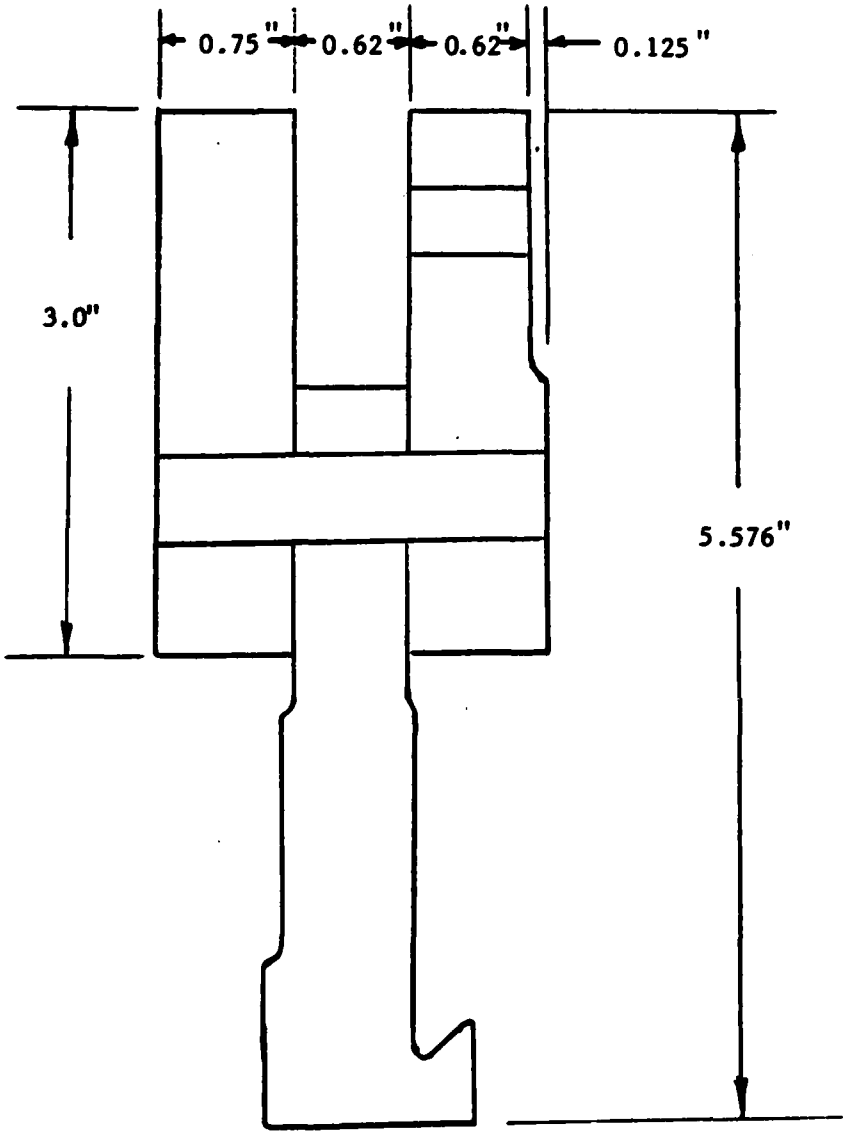


Mat'l - Steel

Area = 4.68 in^2.

I = 17.50 in^4.

The section properties of 2-3 are the following:



Mat'l - 2024-T4 Aluminum

Area - 4.22 in^2.

I_{X-X} = 7.83 in^4.

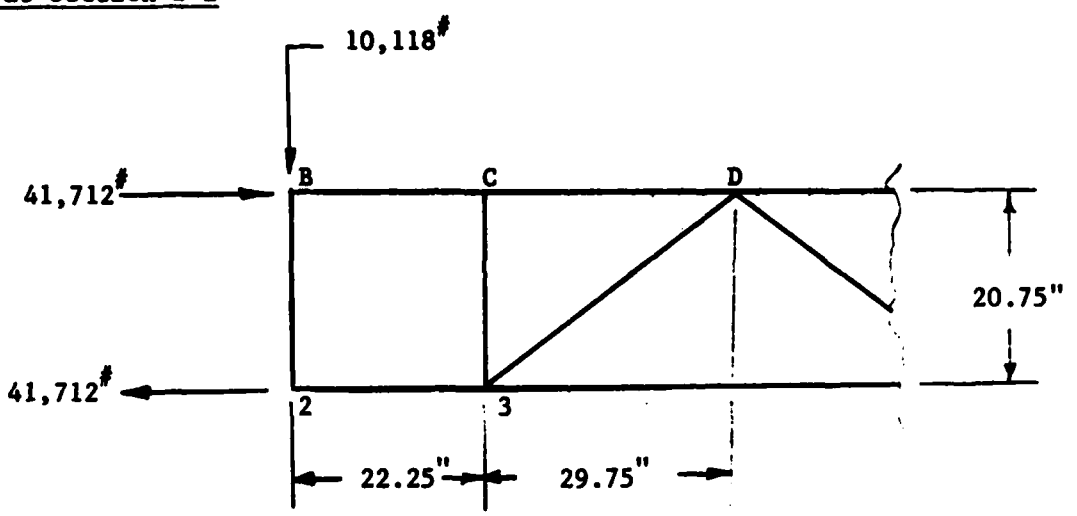
$\overline{X}$ = 3.75 in^6.

Shear at Sect. B-2

B-2 = 10,877 - (244 + 515)

= 10,118 lb

Loads at Section B-2



Loads divide in proportion to inertia

$$\text{Load at B} = \frac{17.50}{25.33} \times 10{,}118 = 6990$$

$$\text{Load at } (2) = 10{,}118 - 6990$$

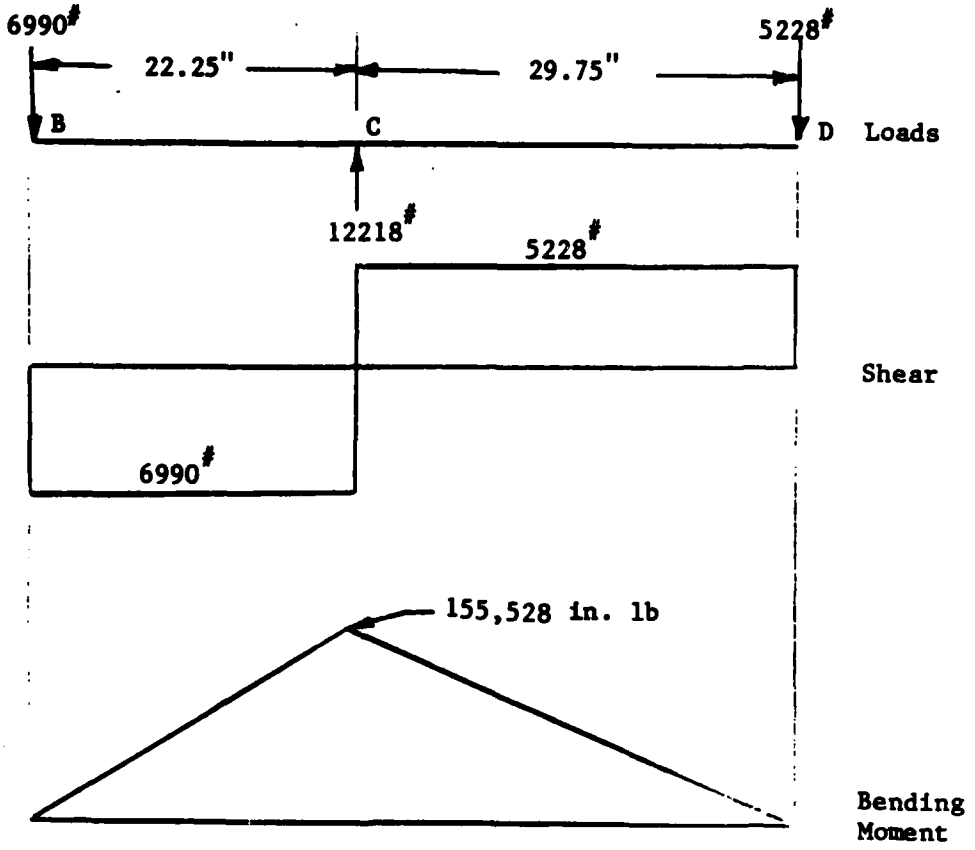
$$= 3128$$

Load in C-3

$$\text{C-3} = \frac{6990 \times 52}{29.75}$$

$$= 12{,}218$$

Shear and Bending B-D



$$\sigma_{Bending} = \frac{155,528 \times 2.5}{17.50} = 22,218 \text{ psi}$$

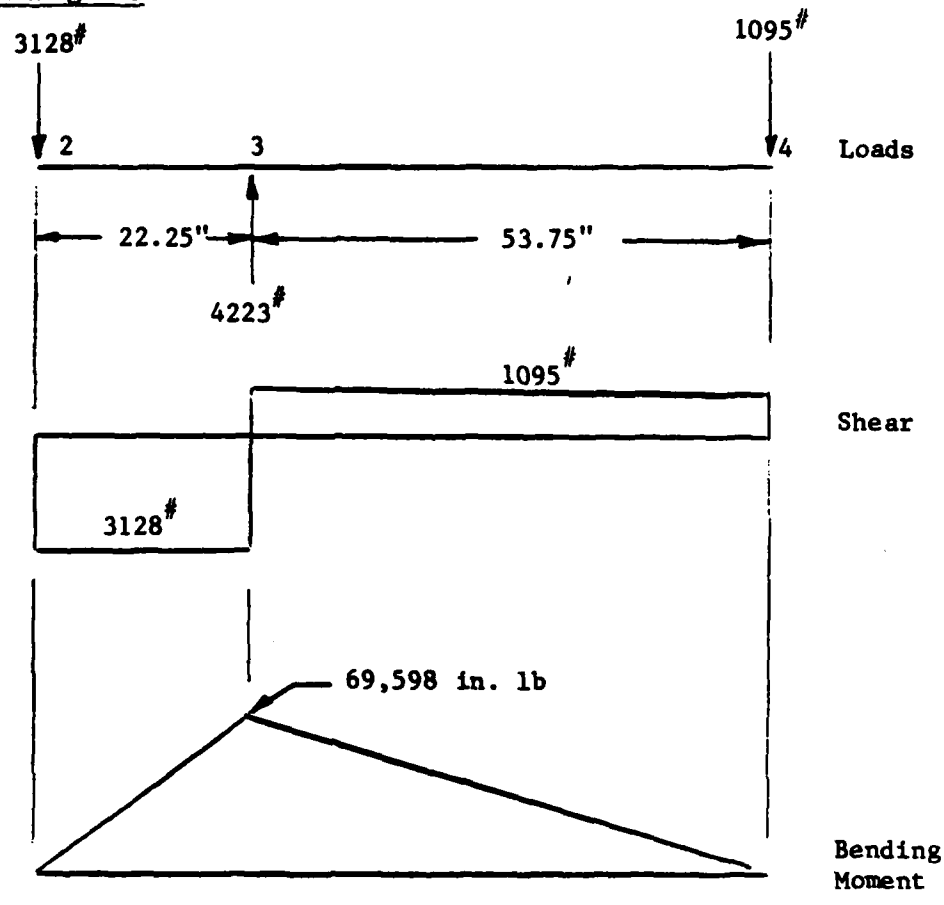
$$\sigma_{Comp} = \frac{41,712}{4.68} = 8,913 \text{ psi}$$

$$\sigma_{Tot} = 22,218 + 8913 = 31,131$$

$$\text{M.S.} = \left[\frac{46,000 - (31,131 \times 1.5)}{46,000}\right] 100$$

$$= -1.51 \text{ percent}$$

Shear and Bending 2-3



$$\sigma_{Bending} = \frac{69,589 \times 1.826}{7.83} = 16,230 \text{ psi}$$

$$\sigma_{Tension} = \frac{41,712}{4.22} = 9,884 \text{ psi}$$

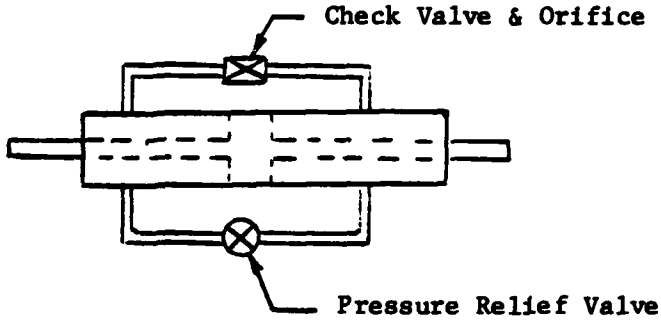
$$\sigma_{Tot} = 16,230 + 9884 = 26,114 \text{ psi}$$

$$\text{M.S.} = \left[\frac{44,000 - (26,114 \times 1.5)}{44,000} \right] 100 = + 10.9\%$$

APPENDIX C

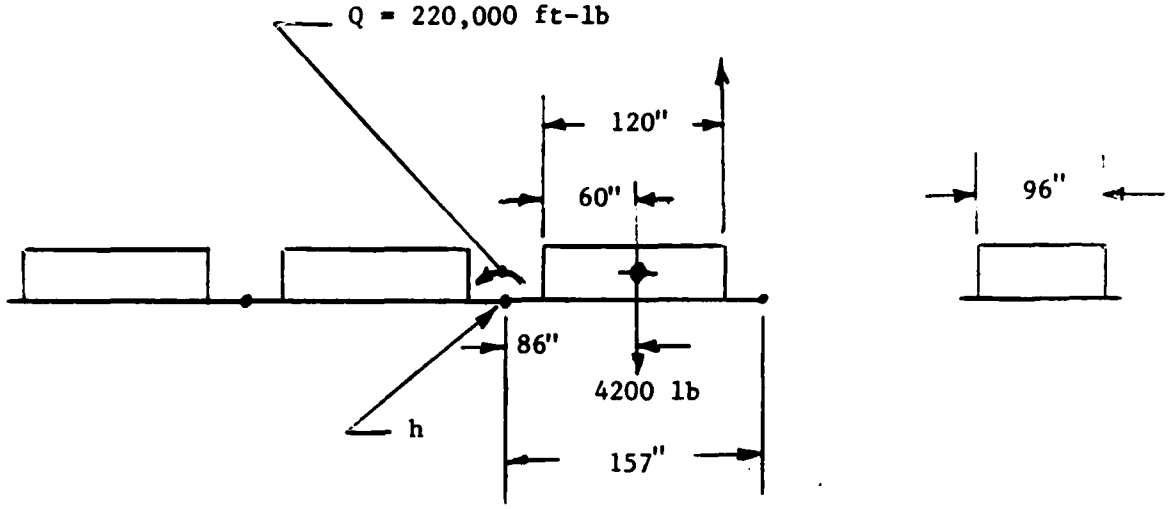
INVESTIGATION OF A PRESSURE RELIEF VALVE AS A LOAD LIMITING DEVICE

Approach: A pressure relief valve is located so that it allows the oil to bypass the control orifice if the pressure exceeds 5000 psi.



Assume:

1. A three-platform configuration having a 12-foot end platform that is lightly loaded at 4200 pounds. The parachute pull is applied to this platform. The other platforms carry heavy loads making them difficult to rotate.
2. The parachute load is sufficient to generate a torque at the hinge line of 220,000 foot-pounds (maximum torque measured in test No. 13 of EDT series).
3. The parachute load duration is 500 milliseconds.



Analysis:

Inertia at "h"

$$I_h = I_o + MR^2$$

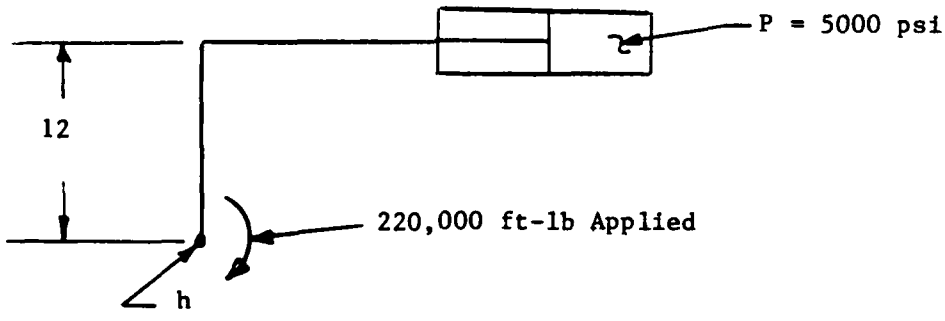
$$= \frac{4200}{12 \times 32.2} \left[(120)^2 + (96)^2\right] + \frac{4200}{32.2}(86)^2$$

$$= 1{,}221{,}391 \text{ slug in}^2$$

$$= 8482 \text{ slug ft}^2$$

Look at 4.0 inch Cylinder

The net piston area (A) of this cylinder is 9.42 in^2. The moment arm about the hinge line is 12 inches. Pressure is 5000 psi.



The torque (Q_p) developed by the two cylinders at the hinge line to resist the 220,000 ft-lbs of applied torque is:

$$Q_p = \frac{9.42 \times 5000 \times 12 \times 2}{12}$$

$$= 94,200 \text{ ft-lb}$$

The residual torque available to rotate the platform about the hinge line is:

$$Q_R = 220,000 - 94,200$$

$$= 125,800 \text{ ft-lb}$$

The platform acceleration (α_p) about the hinge line is:

$$\alpha_p = Q_R/I$$

$$\alpha_p = \frac{125,800}{8482}$$

$$= 14.82 \text{ rad/sec}^2$$

Platform rotation about the hinge line in 500 milliseconds is:

$$\theta = 1/2 \ \alpha t^2$$

$$= 1/2 \ (14.82)(0.50)^2$$

$$= 1.85 \text{ radians}$$

$$= 106 \text{ degrees}$$

The rotational velocity (ω) about the hinge line attained in 0.500 seconds is

$$\omega = \alpha t$$

$$= 14.82 \times (0.50)$$

$$= 7.41 \text{ rad/sec}$$

The peak piston velocity is:

$V = r\,\omega$

$= 12 \times 7.41$

$= 88.92$ in/sec

The flow rate (F) through the relief valve is:

$$F = \frac{V\,A\,60}{231}$$

$$= \frac{88.92 \times 9.42 \times 60}{231}$$

$= 218$ GPM

Look at 5.0 inch Cylinder

The net piston area (A) of this cylinder is 16.49 in^2.

$$Q_p = \frac{16.49 \times 5000 \times 12 \times 2}{12}$$

$= 164{,}900$ ft-lbs

$Q_R = 220{,}000 - 164{,}900$

$= 55{,}100$ ft-lbs

$$\alpha_p = \frac{55{,}100}{8482}$$

$= 6.50$ rad/sec^2

$\theta = 1/2\ (6.50)(0.50)^2$

$= 0.815$ rad

$=$ 47 degrees

$$\omega = \alpha\, t$$

$$= 6.50 \times 0.50$$

$$= 3.25 \text{ rad/sec}$$

$$V = r\, \omega$$

$$= 12 \times 3.25$$

$$= 39 \text{ in/sec}$$

$$F = \frac{39 \times 16.49 \times 60}{231}$$

$$= 167 \text{ GPM}$$

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