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NASA CONTRACTOR REPORT

NASA CR-61397

HIGH INTENSITY PORTABLE FLUORESCENT LIGHT

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Prepared for

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16. ABSTRACT

Eight (8) High Intensity Portable Fluorescent Lights were produced under Contract NAS8-24527. Three prototype lights were produced, two of which were subsequently updated to the physical and operational configuration of the qualification and flight units. Also furnished were 17 spare lamp assemblies and a number of spare mechanical and electrical components.

Positioning of lamp apertures and reflectors in these lights is such that the light is concentrated and intensified in a specific pattern rather than widely diffused. Indium amalgam control of mercury vapor pressure in the lamp gives high output at lamp ambient temperatures up to 105°C. A small amount of amalgam applied to each electrode stem helps to obtain fast warm-up. Shrinking a Teflon sleeve on the tube and potting metal caps on each end of the lamp minimizes dispersion of mercury vapor and glass particles in the event of accidental lamp breakage. Operation at 20 kHz allows the lamps to consume more power than at low frequency, thus increasing their light output and raising their efficiency. When used to expose color photographic film, light from the lamps produces results approximately equal to sunlight.

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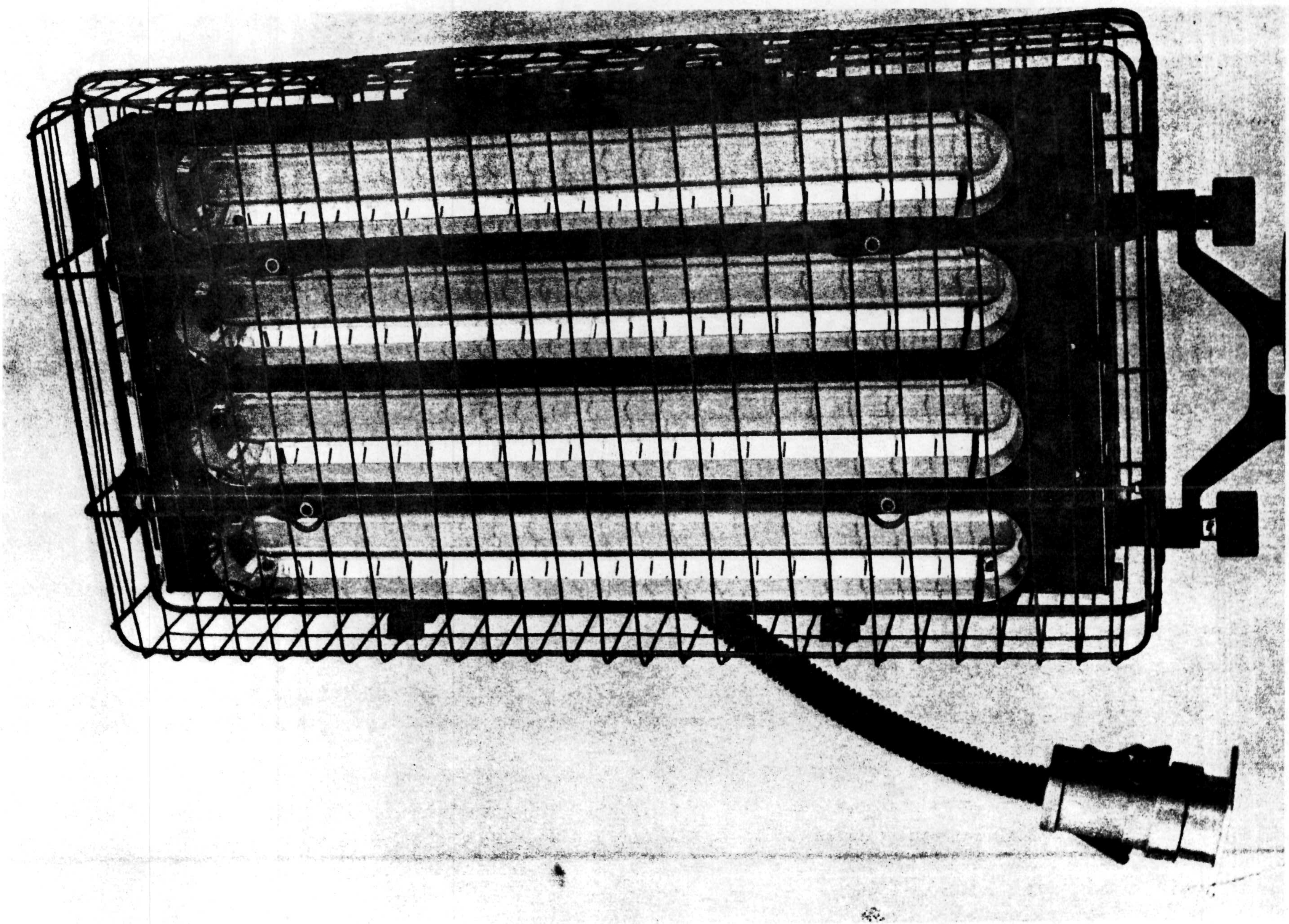
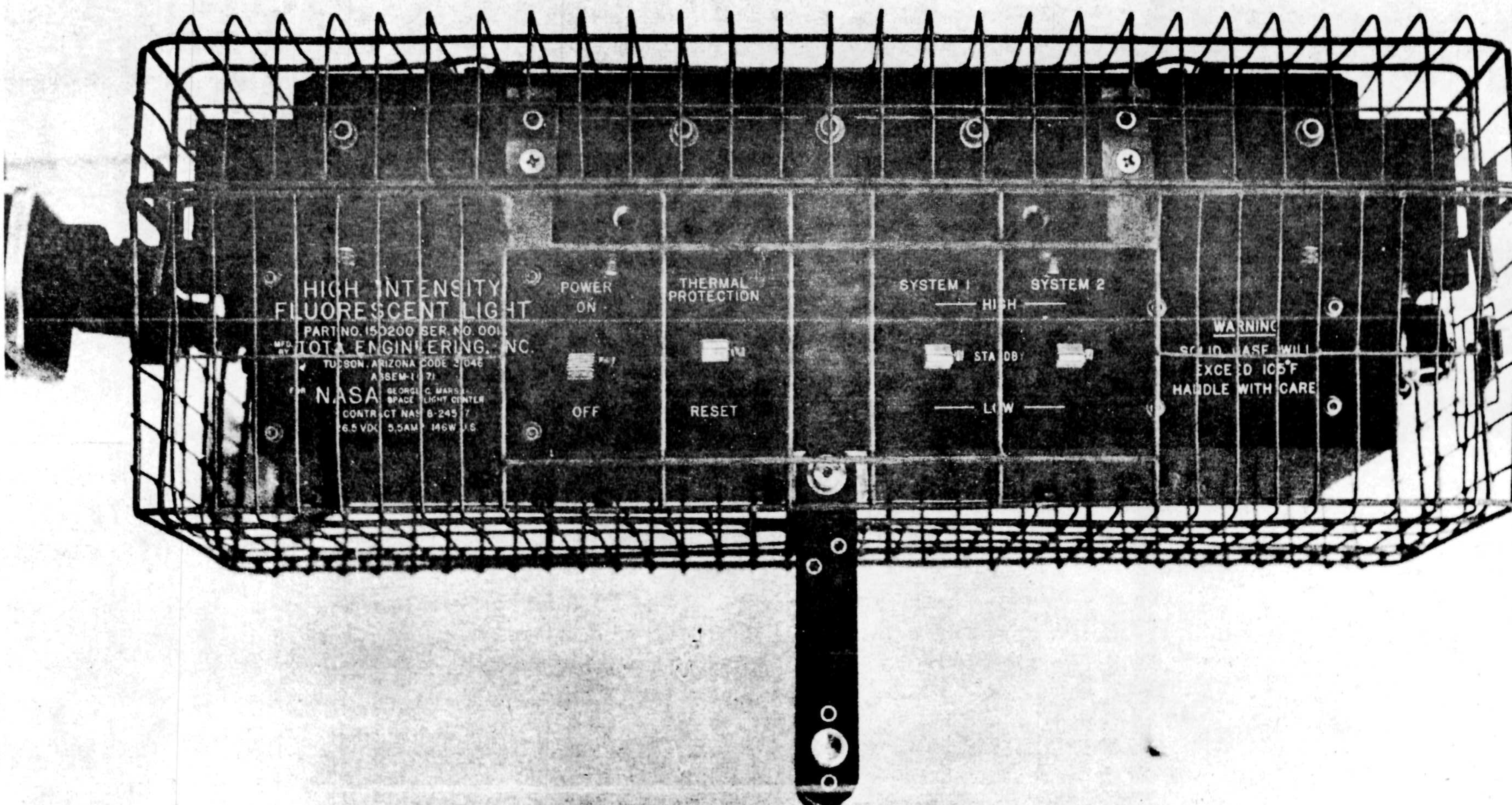


FRONT VIEW — HIGH INTENSITY FLUORESCENT PORTABLE LIGHT



TOP VIEW — HIGH INTENSITY FLUORESCENT PORTABLE LIGHT

1.0 SUMMARY AND ILLUSTRATIONS

Eight (8) High Intensity Portable Fluorescent Lights were produced under Contract NAS8-24527. Units Serial Numbers 006 and 007 were specified as Qualification units, S/N's 001 through 005 and 008 were specified as flight units.

Three prototype lights were produced of which S/N's X1 and X2 were subsequently updated to the physical and operational configuration of the qualification and flight units. These two units were not required to meet the functional characteristics of the qualification and flight units, nor to undergo the same tests, nor to meet the same cleanliness requirements, as they were for use as training units. However, the lamps in S/N's X1 and X2 are of flight quality. S/N X3 was used by the contractor for evaluation, tests, studies, and the trial incorporation of modifications and changes.

Also furnished were 17 spare lamp assemblies, P/N 150189, and a number of spare mechanical and electrical components.

Light Units S/N's 003, 004, and 005 were shipped direct to McDonnell-Douglas Astronautics Co. All other shipments were to NASA, Marshall Space Flight Center, Huntsville, Alabama.

Positioning of lamp apertures and reflectors is such that the light is concentrated and intensified in a specific pattern rather than widely diffused.

Indium amalgam control of mercury vapor pressure in the lamp gives high output at lamp ambient temperatures up to 105°C. A small amount of amalgam applied to each electrode stem helps to obtain fast warm-up.

Shrinking a Teflon sleeve on the tube and potting metal caps on each end of the lamp minimizes dispersion of mercury vapor and glass particles in event of accidental lamp breakage.

Operation at 20 KHz allows the lamps to consume more power than at low frequency, thus increasing their light output and raising their efficiency.

When used to expose color photographic film, light from the lamps produces results approximately equal to sunlight

2.0 GENERAL

The contractor produced eight (8) High Intensity Portable Fluorescent Lights, P/N 150200, Serial Numbers 001 through 008, of which S/N's 006 and 007 were assigned as qualification units, and the remainder as flight units. Three prototype or experimental lights, identified as S/N X1, X2 and X3, were produced for the developmental program. Two of these (S/N's X1 and X2) were subsequently updated to be physically and operationally the same as the flight units so that they might be

2.0 GENERAL (Continued)

used for operational and handling training. The lamps used in S/N's X1 and X2 are of flight quality.

Each light is composed of two independent lighting subsystems, each capable of two levels of intensity, and controlled by independent 3-position toggle switches.

Safety, reliability, ease of operation and of handling were paramount considerations in the design of the lights.

With the exception of the fluorescent lamps themselves, parts and assemblies were designed by the contractor. Since he was not equipped or staffed to fabricate or finish the mechanical, structural, or electrical components, these parts were subcontracted to approved vendors who were capable of producing the specific item, or performing the specific function to the quality required. Subsequently, IOTA assembled the parts and components into the finished product which was then tested, packaged, and shipped.

Tests were performed on all units to verify proper continuity, and on the flight and qualification units to assure required insulation resistance, freedom from corona discharge, and to determine power consumption, light distribution and intensity.

Lights S/N's 003, 004 and 005 were shipped direct to McDonnel-Douglas Astronautics Co., Huntington Beach, California. All other lights were shipped to NASA, Marshall Space Flight Center, Huntsville, Alabama.

3.0 DELEGATION

NASA Delegation No. PR-M-24527 assigned to Defense Contract Administration Services, Phoenix, the authority for contract administration, quality and reliability assurance, and production, engineering support and transportation management.

4.0 QUALITY

Quality requirements for the contract were specified by NASA Quality Publication NPC200-3, "Inspection System Provisions for Suppliers of Space Materials, Parts, Components, and Services," (April, 1962 Edition), also by subsections 4.1 and 4.2.1 of NASA Quality Publication NPC200-2, "Quality Program Provisions for Space System Contractors," (April, 1962 Edition), and also by NASA Reliability and Quality Assurance Publication NHB 5300.4(3A), "Requirements for Soldered Electrical Connections," (May, 1968 Edition).

The contract office approved an IOTA-prepared "Quality Control Plan for Contract NAS8-24527" based on, and complying with, the above documents.

4.0 QUALITY (Continued)

After notification of approval, quality operations at IOTA complied with this plan, and assembly of the two qualification units and the six flight units, as well as modification of S/N's X1 and X2, was accomplished in accordance with it.

4.1 Certifications and Test Data

For Electrical components, the IOTA purchase order specified that the vendors would furnish certifications as well as any applicable test data.

For mechanical and structural components, the IOTA purchase order specified that certifications of materials, processes, and other applicable features be furnished.

4.2 Inspection

One hundred percent inspection by the subcontractor, and also IOTA source inspection was applied to all parts made and services rendered by a subcontractor. Government source inspection applied to any parts or services where it was so specified by the DCAS Quality Assurance Representative. IOTA purchase orders specified these requirements when they applied.

4.3 Calibration

Periodic calibration, traceable to the National Bureau of Standards, was required at IOTA and at all subcontractor's facilities for all measuring tools and equipment and for all test control equipment. Calibrated equipment was marked with the date of calibration, and the date on which recalibration was due. When certificates were furnished by the calibrating organization, they were retained as part of the calibration records.

4.4 In House-Inspection

No IOTA-owned or employees' personal measuring tools or equipment were used for inspection. These functions were all performed at the subcontractor's facilities. Inspections made at IOTA were confined to assembly operations and process, the electrical tests of purchased components, and tests performed on the end items. Inspection instruction sheets were prepared for subcontractor use for parts and non-standard, non-proprietary services, as well as those applicable at IOTA. Test instruction sheets were prepared for use at IOTA.

5.0 VENDORS

The nature of the end item, the large number of components involved, and the necessity of depending on subcontractors made mandatory the careful selection of vendors. To this end, an Approved Vendor List was established, based largely on a history of reliability and quality of their products, and on their ability to meet delivery schedules at reasonable prices. Where such history was not readily available, quality surveys of the facilities of the prospective vendor were performed. The records of these surveys are part of the contract historical records.

5.1 Electrical and Mechanical Components

Wherever possible, high reliability electrical components were chosen. Often such parts were available from only one vendor. Where standard off-the-shelf items were used the choice of vendors widened. However, in all cases IOTA purchase orders specified that certifications be furnished, and where test data was available, it, too, was required. Receiving inspection tests were performed on electrical components to verify their conformance with vendor specified characteristics.

Mechanical or structural components were subcontracted to the vendor considered best equipped to produce the part and provide the necessary associated services. Where two or more subcontractors were available, capability of meeting the delivery schedule at reasonable cost became a deciding factor. Purchase orders specified that the vendor must supply certification of all materials and processes applicable to the part.

Certifications received from the vendors of electrical and mechanical components are part of the contract historical records.

5.2 Lamps

Lamps used in the High Intensity Portable Fluorescent Light are unique. A search for lamps with the desired characteristics established that the supply must come from a single vendor; the Westinghouse Electric Corporation in Bloomfield, New Jersey. This vendor was able to furnish lamps of small size and weight to the specified power rating. The lamps also incorporated a phosphor producing light whose spectral energy distribution was such that its effect on photographic color film very closely approximates the effect of sunlight. A clear aperture the length of the glass tube and nominally 60° of its circumference was left in the phosphor to provide a window of increased light intensity. The lamps contain a small quantity of indium amalgam to assist in control of the mercury in the glass envelope. A problem arose wherein vendor test results did not correspond with IOTA values of light measurement. IOTA personnel carried lamps and test equipment in use at IOTA to the vendors laboratory and were able to resolve the difficulty to the satisfaction of all involved. Improved processes and controls by the vendor ultimately resulted in replacement of the lamps originally supplied with improved items for the 10 light assemblies and for spare lamps furnished under the contract.

5.3 Transformers and Inductors

Fabrication and tests of inductor and transformer assemblies was subcontracted to a single vendor. His deliveries to the original design showed erratic and inconsistent operating characteristics. X-rays and sectioning of assemblies indicated cracks in the cores, which were felt to be causing the difficulties. The cracks were believed to occur during the thermal shock tests. A minor change was introduced creating a .020 inch gap between the ends of the center posts of the two core halves, the method of internal support was revised, a different type of potting compound was used, and the potting procedures were changed to leave a small air bubble inside the housing. Assemblies incorporating these changes did not exhibit the erratic and inconsistent performance characteristics. The vendor performed all inspections and tests on the assemblies, and furnished data on all items accomplished, as required by the purchase order.

Inductors and transformers used in the 10 light assemblies are of this latter improved configuration, as are the spare transformers.

6.0 END ITEM OBJECTIVES

Design of the light to provide the maximum reliability and efficiency, at the same time sought to satisfy the following specific requirements:

A. Minimize the cost.

B. Minimize the weight.

C. Minimize the size.

D. Use of minimum number of electrical and electronic components.

E. Simplified package design.

F. Provide fail-safe ballast design.

G. Closely approach the specified power input.

H. Provide maximum light output for size and power input.

I. Offer minimum EMI and RFI.

J. Operate the inverter at 20 KHz or higher.

K. Provide maximum touch temperature of 105°F.

L. Provide ease of operation and handling.

7.0 END ITEM DESCRIPTION

The High Intensity Portable Fluorescent Light consists of a single package, approximately a rectangular box in shape, containing two independent lighting subsystems, each with a high and a low (bright and dim) operational mode, controlled by a three position toggle switch.

The structural housing is completely surrounded by a wire cage (or thermal barrier) to prevent the operator inadvertently touching the moderately warm case. At the rear of the top of the thermal barrier is access for operating the control switches. At the back of the light unit a folding handle protrudes through the barrier. This handle is locked in the open operating position, or in the folded stowed position by a rod seating in detents and actuated by a thumb push button. The power connector lead comes out the lower side of the electronics housing and terminates in a Zero-G connector.

The electronic housing which forms the back section of the light unit contains the electronic components mounted on metal chassis held in place with screws. The housing is a rectangular pan with two long sides converging slightly toward the bottom of the pan (the back of the light unit). The open side of the pan attaches to the back of the lamp housing with screws.

The lamp housing is a shallow rectangular pan at whose front, or open side, are mounted the four lamps and the reflector frame. Lamps are mounted so that their aperture coincides with the four slots in the reflector frame. Ends of the slots are rounded and highly polished. Sides of the slots are flat surfaces which have a wide included angle of taper at the bottom adjacent the lamps, changing to a narrow included angle of taper less than half the distance from the lamp to the edge of the slot. Highly polished and optically coated reflector strips are bonded to these tapered surfaces. Except for the reflector slots all external surfaces of the structure are black anodized to assist in heat dissipation.

To prevent free release of mercury vapor and of glass particles in event of accidental lamp breakage, a tubular Teflon sleeve is shrunk over the entire length of the glass tube. The shrinking process is very carefully controlled in order to minimize detrimental effects on optical and light emission properties of the lamps. Metal end caps are mounted on each end of the lamp; the leads passing through hollow terminals in the cap, and are soldered to them on the outside. To contain mercury vapor and glass particles, the end caps are filled around the end of the glass tube with a resilient potting compound.

The thermal barrier is of welded wire construction, divided into a forward and rear unit joined by screws. The barrier is secured by screws to stand-offs to the light unit. Wire and sheet surfaces on the inside of the barrier are gold plated to reflect heat back to the

7.0 END ITEM DESCRIPTION (Continued)

surfaces of the light unit and minimize radiated heat absorption. The outside surfaces are dulled by sand-blasting to help dissipate the heat, thus reducing the touch temperature.

7.1 Materials & Finishes

Choice of materials was limited to those which possessed the required physical properties and offered the maximum resistance to deterioration. In general, metal parts are 6061 aluminum alloy. Lamp end caps are brass to permit proper plating and to allow soldering. The thermal barrier is corrosion resisting steel wire with welded joints, with corrosion resisting steel mounting and joining plates. Heat shrinkable Teflon tube is used for sleeves at wire-to-component terminal connections, and for sleeving the basic lamp tubes. Wire is Teflon insulated.

Finishes were chosen for their resistance to abrasion and their lack of a tendency to flake, chip, or powder. Aluminum parts are either black anodized or treated with chemical coat per MIL-C-5541. Lamp end caps are nickel plate over copper plate on the brass parts. Finish on the polished aluminum reflector strips was chosen solely for its optical properties, and while hard, is nevertheless subject to damage through mishandling. This finish is a proprietary process, identified as Denton FSS-99, of Denton Vacuum, Inc., Cherry Hill, New Jersey. Corrosion resisting steel parts are passivated to remove free iron from their surfaces. Gold plate was chosen for the thermal barriers and switch guard plates because of its heat reflective characteristics. Bonding, coating, and potting materials were chosen from the list of acceptable materials in MSFC publication 50M02442, Revision K, "ATM Material Control for Contamination Due to Outgassing."

Generally, the electrical components chosen were those listed in MSFC publication 85M02716, Revision B, "Preferred Electrical Parts List for AAP." In the case of fabrication of special components, such as the inductors and transformers, conformance was specified with applicable sections of MSFC publication 85M02715, Revision C, "Electrical Parts Selection and Control Requirements for Apollo Applications Program (AAP)."

7.2 Operational Features

The light unit is nominally rated for 26.5 VDC input, but for operation of the fluorescent lamps the special inverters in the electrical system change this to high frequency AC.

The power connector cable terminates in a Zero-G type connector which permits the operator to hook-up to the power supply cable with the use of only one hand.

Switches are conveniently grouped on the top of the electronics housing at the rear of the light with their functions clearly marked. Guard plates are secured to each actuating toggle lever to help dissipate any heat that might otherwise concentrate there. The guard plate is gold-plated on the side next to the housing to reflect heat back into the housing on the flight and qualification units. On units X1 and X2 the plate is polished aluminum on the housing side. The switches provide for operating each lighting subsystem either separately or simultaneously in either low (dim) or high (bright) modes, or either subsystem may be operated in high mode with the other in low.

If the light overheats, a thermostat in one of the two subsystem circuits interrupts the power in one system only. Restart of de-energized unit will no occur until the temperature has dropped to an acceptable level.

The individual lamps contain an indium amalgam to assist in controlling their internal mercury vapor. Gas charge in the lamp is a mixture of neon and argon. The internal coating does not cover the entire inside surface of the lamp tube. Rather, it is controlled to leave a clear window of nominally 60° of the circumference along the entire length of the lamp; providing a greater illumination intensity from that area. A Teflon sleeve is shrunk over the full length of the lamp and a metal cap is potted on each end to prevent or minimize escape of mercury vapor and of glass particles in event of accidental lamp breakage.

The first experimental lights used bare polished aluminum as the reflector surfaces. However, the two qualification and six flight units have reflector strips bonded to the sides of the slots in the reflector frames, the rounded ends of the slots still being bare polished aluminum. The aluminum sheet reflector strips are ground and polished by optical procedures to provide maximum reflectance, and are then coated with a hard optical finish. Units X1 and X2 were subsequently changed to this configuration.

A folding handle that locks in two positions (open and closed) by a thumb pushbutton actuated detent allows the operator to hold the light in any chosen position with only one hand.

Special adapters on the four sides of the light provide for mounting a camera on the unit in the most convenient location. The light may also be tripod mounted through these adapters.

The thermal barrier which completely surrounds the light (with exception of the folding handle) assists in dissipating the heat load but does not itself reach the 105°F maximum allowable touch temperature. This barrier has a sand-blasted finish on exterior surfaces and a gold plate finish on interior surfaces. Its sole purpose is to protect the operator from the hot surfaces of the

7.2 Operational Features (Continued)

housings and reflector with minimum weight material. It is not primarily intended for protection of the light in event of mishandling, such as dropping the unit.

8.0 DOCUMENTATION

Reproducible drawings completely define the light unit assembly, all subassemblies, and all detail parts. Assembly instruction sheets, inspection instruction sheets, special process instructions, test procedures, and test instruction sheets provide information for all operations. Data from in-house testing is recorded on appropriate data sheets. Parts and materials were obtained by purchase orders which established requirements for submission of certifications and test data. Stores records provide information of receipt of parts and materials, and also requisitions of parts and materials for assembly operations. Records were kept of environmental conditions within the assembly area. Quality Control History Records for each light unit provide historical data for the individual units as well as its components, and also contain shipping records. Records also include data on receipt of Government Furnished Equipment and materials, and its use or disposition. Assembly personnel certifications were also retained.

8.1 Drawings

Complete assembly and detail design drawings are on vellum reproducibles of standard size and format, and are prepared in accordance with MIL-D-1000, Category F, Form 2. After initial release of the drawings, all changes were submitted for customer approval on MSFC Form 390-4, "Contractor Drawing Change Request," and no changes were incorporated prior to receipt of approval.

8.2 Test Procedures

Specific test procedures were prepared detailing equipment required, electrical connection information, and the specific tests to be made. The procedures covered insulation, corona, and continuity tests, and also the detailed acceptance test for the assembled light. They included data sheets for recording the information obtained.

8.3 Processes

Most of the processes applied to parts and assemblies were performed by qualified vendors or subcontractors in their own facilities, according to their own established or licensed procedures. The only processes performed at IOTA were soldering, potting, bonding, Teflon shrinking and conformal coating. Soldering was done in accordance with NASA publication NHB 5300.4(3A), and the affected IOTA personnel

8.3 Processes (Continued)

were certified at a school held in the Motorola facilities in Phoenix, Arizona. Detailed process instructions were prepared covering all phases of the potting, bonding, and conformal coating procedures, and affected personnel were certified after test by DCAS representative.

8.4 Handling and Operation Manuals

The handling manual for ground procedures details requirements related to unpacking, inspecting and ground testing the light unit so as not to compromise the cleanliness characteristics to which it was built. Pre-launch operational restrictions are also detailed. The manual also includes a reminder that all operational use should be recorded in the log book which accompanies the unit.

The operational use handbook describes the mechanical and electrical characteristics of the unit; provides set-up information; the operational sequences for starting and shutting down the light; special usage information; and also information on stowage and life characteristics. Operational constraints are listed, and a section is devoted to malfunctions and trouble-shooting.

9.0 ASSEMBLY

The light units were assembled at the IOTA facility, 1735 East Fort Lowell Road, Tucson, Arizona. All parts, components, and materials were gathered at this location and were wired and assembled to produce the finished product.

9.1 Facilities

IOTA facilities at the above address did not orginally contain sufficient space to permit proper controls for the assembly of the unit--with associated needs for storage for accumulated parts and materials, and for testing. A 12 foot by 50 foot Mobile Office Unit (trailer) was therefore leased and set up adjacent to the IOTA permanent facility. The trailer contained a partition dividing it into two rooms, the larger approximately 12 x 32 feet, the smaller approximately 12 x 16 feet. A door in the partition joined the two rooms. The small room was contiguous to the heater enclosure and lavatory. The large room was used as the clean room for assembly and test operations, and the small room as an ante-room to the clean area. In it were kept clean room clothing, test equipment, files, and office equipment and supplies. Addition of shelves in the lavatory made possible its use as a storage area as no plumbing facilities were connected. Fire extinguishers were placed in the

9.1 Facilities (Continued)

two large rooms. Originally, butane was used for heating, but with institution of the 100,000 class clean room requirements it was necessary to seal off the heating unit to permit pressurizing the assembly area. Thereafter, heating was accomplished by thermostatically controlled floor type electric heaters. An air conditioning unit provided necessary cooling during hot weather.

9.1.1 Environmental Control of Assembly Areas. The large room in the trailer was established as a Class 100,000 clean room as defined by MSFC-STD-246A (cover leaf of Fed. Std. 209a). The door from the large room to the outside was locked, to be used as an emergency exit only. Entrance to the trailer was possible through the ante-room only.

The door joining the two rooms was closed at all times except during passage of personnel between areas. Windows and cracks were sealed and a blower was mounted on the partition in the small ante-room discharging air to raise the pressure in the assembly area. Sealing the windows and cracks in the assembly area made it possible for the blower to achieve more than .05 inches of water pressure differential.

Thermostatic controls on the heating and cooling units kept the assembly area between 68° and 78 °F. No attempt was made to control humidity, but in eight months of recorded observation, the highest value of humidity reached was 55 percent and that on only two days.

Access to the assembly area was limited to those persons performing necessary assembly, test, and quality functions. All persons in the area wore clean room smocks and caps. A vacuum cleaner was located in the ante-room to remove street dust from shoes and clothing before entering the clean area.

Air samples were taken at least three times a week, and dust counts were performed to verify that the area was in compliance with Class 100,000 requirements. A glass view panel in the door to the clean area helped reduce the need of frequent passing between rooms.

9.1.2 Laminar Flow Work Station. Assembly and wiring of the lights was done on a horizontal laminar flow work station manufactured by Edcraft Industries, Inc., Linden, New Jersey. Nameplate identification is Model BHP 1045, S/N 1007. This unit has a catalog rating of 1250 cfm of air at 100 fpm velocity. High Efficiency Particulate Air (H.E.P.A.) filters listed as 99.97% efficient on 0.3 micron particles are used as final filters on this unit. The unit was in operation when Class 100,000 clean room practices were instituted, and operated continuously. Operation was discontinued when all clean room practices ended with shipment of the last light unit.

9.2 Personnel Access and Control

Although all IOTA personnel were familiarized with the clean room practices and requirements, only the minimum number of regular operators, supervisory and service personnel were allowed access to the clean room. Any special requirements for personnel were handled on a temporary basis. All others than those regularly assigned to the area were required to sign an entrance-exit log, and to be accompanied by a regularly assigned employee at all times.

Soldering and inspecting of soldering was done by qualified and certified personnel. Bonding and conformal coating and inspecting was also done by qualified and certified personnel. On rare occasions special skills were required and special tasks were performed by qualified personnel on a temporary basis. Authorized visitors were admitted when occasion required.

9.3 Assembly Operations

Bonding of reflector strips to reflector frames, of capacitors to chassis, and of potting end caps to lamps was done in the clean room, but not on the laminar flow work station. Dependent on its nature, some conformal coating was applied with the light unit on the laminar flow station, some was not. A chemical beam scale was used to weight out the proper proportions of the various compounds. De-aeration of the mixed compounds was accomplished using a bell jar and a vacuum pump. An electric oven in the clean room was used for curing as required.

Mechanical assembly of components to chassis, of the chassis to one another, and of lamps to the reflector frames was not ordinarily done on the laminar flow station. However, in all cases wire preparation, wire routing, soldering, and sleeving were done on the laminar flow station. After completion of wiring, the assembly of reflector frame and lamps, the wired chassis, and the housings were assembled on the laminar flow station.

Immediately prior to closing the units, the interior of the housing, chassis, lamps, and back of the reflector frame were cleaned using approved solvents; and the surfaces inspected using a high intensity ultra-violet spot light. Assembly of the handle and of the thermal barrier to the light was not generally done on the laminar flow station.

Quality surveillance was continuous with inspection occuring as and where the particular operation was performed. Inspection instruction sheets were available at all phases of assembly, and inspection acceptance or action was noted on them. Nonconformances were presented for Material Review Board action. Deviations were submitted for customer approval before disposition was made.

9.3.1 Product Cleanliness. Cleanliness requirements for the light are established by Paragraph 4.3 and related subparagraphs of MFSC publication 95M11360, Revision A, "Materials Processing in Space Experiment M512/M479 Environmental and Cleanliness Control Plan." Methods and materials specified therein were used for the cleaning operations, and inspection complied with Paragraph 4.3.3 and related subparagraphs.

Cleaning of the lights was accomplished in three phases, the first being the internal cleaning noted above. The second phase was cleaning the exterior of the housings and lamp reflector after they were assembled. Immediately after this cleaning the thermal barriers and the handle were installed and all tests and inspections were performed. The third cleaning phase was performed after all operations were complete and immediately before wrapping the unit in anti-static nylon film and sealing it in polyethylene bags for shipment.

10.0 TESTS

Tests were conducted at appropriate and timely points in the fabrication of the light units. These varied from receiving inspection test of electrical components to the final acceptance test of the particular light unit.

10.1 Receiving Inspection Tests

To establish confidence in electrical components prior to incorporating into circuits, appropriate confirming electrical and functional tests were performed. Switches, thermostats, transistors and other items were subjected to tests that verified their conformance with the required electrical characteristics, and the proper functioning of the component. Data obtained from these tests is part of the historical records of the contract.

10.2 Insulation, Corona, and Continuity Tests

Continuity was verified at various levels of assembly. One source of verification was visual conformance with the wire running list, IOTA Document No. 150224. A second verification was visual conformance with the "Terminal Connections Verification List" which is included in the QCHR for each particular light. Electrical tests for continuity were performed at the level of assembly where accessibility best permitted it. Further electrical continuity tests were performed in accordance with Paragraph 6.4 of IOTA Test Procedure No. 150231 and the data obtained is a part of the QCHR for each particular light.

The insulation resistance test was performed in accordance with Paragraph 6.3 of 150231 and the data obtained is also a part of the QCHR for each particular light.

The corona test was performed in accordance with Paragraph 6.5 and related subparagraphs of 150231 and the data obtained is also a part of the QCHR for each particular light.

10.3 Acceptance Tests (Including Vibration)

The acceptance tests were performed in accordance with IOTA Acceptance Test Procedure No. 150232. The test not only verified proper control and functioning of the light but also verified its ability to withstand specified vibration inputs. The electrical tests verified warm-up and stabilization characteristics, and power input requirements. Light brightness and color temperature were determined, and light distribution patterns were developed. Data obtained from these tests is a part of the QCHR for each particular light.

11.0 PACKAGING, PACKING AND SHIPPING

Prepackaging, packaging, packing, marking, handling, and shipping met the applicable requirements of MSFC publication 95M11360. The final boxed item was designed to protect the light against the environment specified in Paragraph 4.7.3 of that publication.

Immediately after the final cleaning operation, the finished light was inspected to visibly clean under both white and ultraviolet light. It was wrapped with antistatic nylon film and closed with tape. Environmental cleanliness integrity seals were applied by the DCAS representative, the unit was placed in a polyethylene bag which was then purged with dry nitrogen, evacuated and heat sealed. Required labels and markings were placed on this bag. The specified amount of desiccant and moisture content indicator were taped to this package, and the package was placed in a second polyethylene bag which was then evacuated and heat sealed.

The bagged light was fitted snugly into a corrugated board box containing rigid foamed sheet dunnage. The box was sealed with pressure sensitive filament tape, the required labels and markings applied, then placed in a second corrugated board box in which it was supported by eight corner pads of flexible polyurethane foam.

Items specified to comprise the data package for the light were placed in a polyethylene bag and taped to the top of the inner box between the corner pads. A single piece of interlocking type of flexible polyurethane foam was placed with its smooth side against the data package bag, its fingers pointing up, the box was closed and sealed with pressure sensitive filament tape. Applicable identifying labels and markings were applied to this box. Addition of shipping labels then completed the preparation for air shipment to the customer.

12.0 SPARES

Spare parts as such were not a necessary item in the concept of the light unit package. However, some purchases were made in anticipation of possible failure of some components. The wisdom of this action was demonstrated as extra part needs arose during final assembly operations.

Lamps were an exception, and a specified number of these were included in the contract. After completing assembly of the flight article, lights residual components were shipped to MSFC for possible use as spares.

13.0 TEST DATA

Test data for each particular light is contained in the applicable QCHR as noted in Paragraphs 10.2 and 10.3 of this report.

14.0 INVENTORY

An inventory will be performed and recorded covering all contract items at IOTA. This hardware and equipment will be held at IOTA pending disposition instructions from NASA.

15.0 FINANCIAL

A final statement will be submitted with the final contract invoice.

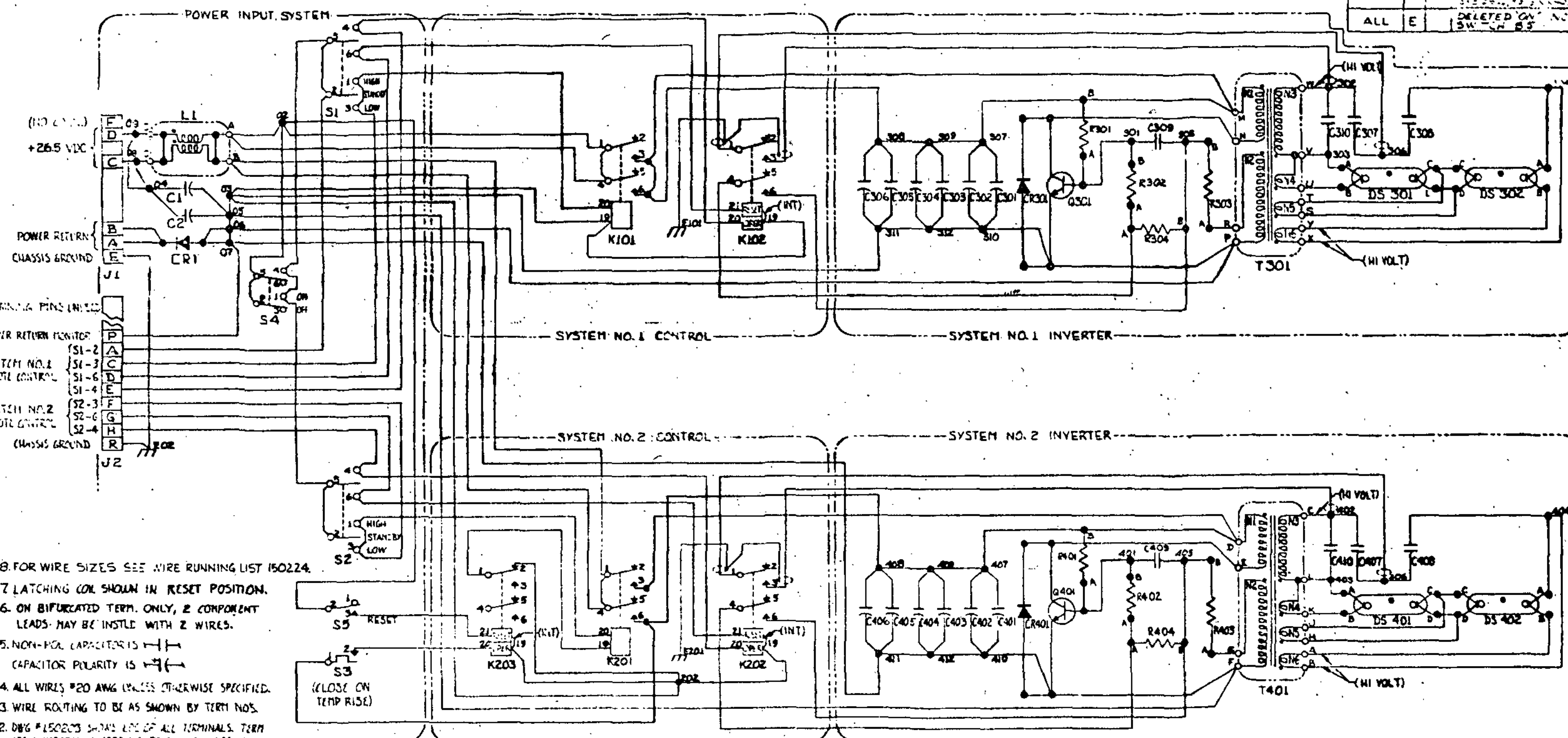
16.0 ACKNOWLEDGEMENTS

Mr. Robert W. Bushroe was the IOTA Project Engineer from the inception, in the spring of 1969, until the final few weeks of this project in early 1972. He was separated from IOTA because of unrelated circumstances. IOTA gratefully acknowledges his major contributions toward the successful achievement of the technical goals in the program.

Mr. W. A. Wall, the NASA Project Engineer throughout the program, also contributed in a major way. His experienced guidance, consultation and understanding support helped us to avoid many problems associated with space qualified hardware; and, he helped us to achieve a timely solution for those problems that could not be avoided.

EFFECTIVE	LTR	ZONE	REVISIONS DESCRIPTION	DATE	APPROVED
			INITIAL RELEASE		
ALL	A		CORRECT PIN LETTER ON J2		
ALL	B		[illegible]		
ALL	C		R304, R404 WAS [illegible]		
ALL	D		[illegible]		
ALL	E		DELETED "ON" [illegible] FROM SWITCH S5		

APPENDIX I



8. FOR WIRE SIZES SEE WIRE RUNNING LIST 150224.

7. LATCHING COIL SHOWN IN RESET POSITION.

6. ON BIFURCATED TERM. ONLY, 2 COMPONENT LEADS MAY BE INSTLD WITH 2 WIRES.

5. NON-POL CAPACITOR IS ⊢|⊢
CAPACITOR POLARITY IS ⊢+|(⊢

4. ALL WIRES #20 AWG UNLESS OTHERWISE SPECIFIED.

3. WIRE ROUTING TO BE AS SHOWN BY TERM NOS.

2. DWG #150203 SHOWS LOC OF ALL TERMINALS. TERM ARE NUMBERED ACCORDING TO PHYSICAL LOC, GENERALLY PER CONVENTION SET-FORTH IN NOTE #1:
0-99 SER TERM: INDUCTOR CHASSIS.
100 SER TERM: CONTROL CHASSIS, SYS NO. 1
200 SER TERM: CONTROL CHASSIS, SYS NO. 2
300 SER TERM: INVERTER CHASSIS, SYS NO. 1 SIDE
400 SER TERM: INVERTER CHASSIS, SYS NO. 2 SIDE

1. COMPONENTS ARE REF-NUMBERED ACCORDING TO SYSTEM/FUNCTION AS FOLLOWS:
0-99 SERIES: POWER INPUT SYS
100 SERIES: SYS NO. 1 CONTROL
200 SERIES: SYS NO. 2 CONTROL
300 SERIES: SYS NO. 1 INVERTER
400 SERIES: SYS NO. 2 INVERTER

NOTES:

COMPONENTS TABULATION (REF)

PWR IN	SYS #1	SYS #2	DESCRIPTION
C1-2	C301-6	C401-6	15UF±10%, 75VDC, TANT
	C307	C407	2200PF±5%, 1000VDC MICA
	C308	C408	33000PF±5%, 1000VDC MICA
	C309	C409	.68UF±5%, 200VDC, MYLAR
	C310	C410	6800PF±5%, 1000VDC, MICA
J1			6-PIN MALE
J2			15-PIN, MALE
	K101	K201	DPDT, 10A, 28VDC, 300Ω
	K102	K202-3	DPDT, 2A, 28VDC, 800Ω/COIL
L1			IOTA DWG #150208
	Q301	Q401	S2N5539-5, NPN

PWR IN	SYS #1	SYS #2	DESCRIPTION
	R301	R401	1000Ω, 10W, RER 65
	R302	R402	56.2Ω 10W, RER 65
	R303	R403	8.06Ω 10W, RER 65
	R304	R404	33.2Ω, 10W, RER 65
S1+2			DPDT, 3-POSIT
S3			(O) 160°F, (C) 270°F, 3A 30VDC
S4			DPDT
S5			SPDT, MAINT/MOMEN
	T301	T401	IOTA DWG #150202
CR1	CR301	CR401	S1N1204A (RECTIFIER)
	DS301+2	DS401+2	IOTA DWG #150189

APPENDIX I

CONTRACT NO. NAS 5-24527

IOTA ENGINEERING, INC. TUCSON, ARIZONA

SCHEMATIC DIAGRAM

SIZE D | CODE IDENT NO. 31046 | 150138

Appendix II

List of Major Subassemblies for High Intensity Fluorescent Light P/N 150200

150159	Barrier, Thermal - Forward
150160	Barrier, Thermal - Rear
150167	Assembly Inverter and Control Chassis
150184	Mechanical Subassembly
150185	Electrical Subassembly
150189	Lamp Assembly

MAJOR ASSY: 150200 NON-METALIC MAT'L PART LIST REVISED ______ SHT 1 OF 3

PART NO.	MANUFACTURER	TRADE NAME/ CATALOG NO.	SPECIFICATION	USAGE CAT.	WT. (ASSY (GMS.)	EXPOSED AREA(sq.in)	TEST STATUS	NEXT ASSY	QTY. USED	PROCESS
-----	Denton Optical	FSS-99 high reflectivity coating		B	Negligible	93	None	150198	32 pcs	
-----	Westinghouse Lamp Div.	Mercury	Westinghouse XF-097576-1	E	.164	None	"	150192	4 pcs	
PC-22	Hysol	Polyurethane Conformal Coating	MSFC-SPEC-393, Type I	B&F	5 to 10 (EST)	52	I, p. 62	150209, -85		MSFC-PROC-293
150221-1	IOTA	TFE Rod	MIL-P-19468	F	.33	None	I, p. 87	150167	2	
" -2	"	" "	" "	F	.12	None	"	150167	1	
" -3	"	" "	" "	F	.72	None	"	150209	2	
" -4	"	" "	" "	F	.61	None	"	150185	16	
———	Dow Corning	RTV 3116 Silicone Rubber	IOTA Process 150237	B&F	38	8	I, p. 101	150167 150204	--	150237 150238
———	"	Primer 1201	" "	B&F	.1	None	?	150167, 150204	--	"
———	"	Catalyst S	" "	B&F	--	--	I, p. 101	150167, 150204		"
———	General Electric	Silicone Grease G-683	-----	B&F	7-8 (EST.)	1.5	I. p. 111	150167, 184,-150,-194, -185		--
# 24 AWG # 18 AWG # 20 AWG	-----	Telfon Sleeve	MIL-I-22129	F	5 (EST.)	4	?	150167, -189, -189		
150202	EMP Electronics	Transformer	150206	E	209(EST.)	None	None	150167	2	Potting
B-60W-PP	Electrical Industries	Glass Terminal	1250V, 10amp.	F	6	.18	None	150202	6	
80GS/63W-NP-8B	"	" Header	1600V, 10 amp	F	3	.94	None	150202	2	
3019P-L00-3B7	Ferroxcube	Ferrite Core 3B7		E	65.6	None	None	150202	4	
572-4859-01-05-16	Cambion	Bifurcated Terminal	Dial. Phth., Brass Cad. Plate, Solder Plate	F	21	Conformal Coated over Cad plate	None	150167	12	

MAJOR ASSY: 150200 | NON-METALIC MAT'L PART LIST | REVISED ________ | SHT 2 OF 3

PART NO.	MANUFACTURER	TRADE NAME/ CATALOG NO.	SPECIFICATION	USAGE CAT.	WT. (ASSY (GMS.)	EXPOSED AREA(sq.in)	TEST STATUS	NEXT ASSY	QTY. USED	PROCESS
572-4811-01-05-16	Cambion	Turret Terminal	Dial. Phth., Brass, Cad. Plate, Solder Plate	F	30	Over Cad. Plate see above	None	150167 150223	18	
43-02-10	Thermalloy	Kapton Washer	------	F	.5	3	I, p. 119	150167	6	
RTV 602	General Electric	Silicone Potting	MSFC-SPEC-379, Type III	F	30	0.5	I, p. 98	150189		MSFC-PROC-380
SRC 05	"	Catalyst (Silicone)	" "	F	--	--	-----	150189		"
150192	Westinghouse Lamp Div.	Fluorescent Lamp	XF-097576-1	E	252	None	None	150189	4/18"	150190
TFE-R 1 1/4"	Raychem	Teflon Shrink Sleeve (TFE)	Com'l	B	34	188	I, p. 83	150189	4	
SN60WRAP	-------------	Solder	MSFC-SPEC-457	F	--	--	I, p. 124	150189, 150185	--	NHB 5300.4(3A)
B-60T-SS, MODA	Electrical Industries	Glass Terminal	-------	F	16	0.5	None	150147	16	------
SN60WRAP	-------	Solder	QQ-S-571	F	--	---	I, p. 124	150147		IOTA STD 2020726
MS18114-12-9	ITT	Wire, TFE 1000V #12	MIL-W-22759	F	2	28	?	150185	6 ft.	---
X-81	Armstrong	Epoxy Adhesive	MSFC-SPEC-411 Type II	B	0.5	0.25	I, p. 53	150185		MSFC-PROC-293
Activator A	"			B	--	--	--			
Flexible Resin #1	"			B	--	--	?			
CCT-16-0-0H	Icore	Convoluted TFE tubing with internal fiber-glass braid		B	20 (EST.)	30 (EST.)	?	150185	1 ft.	---
Zg-GSP-12	Bendix	Nylon Sealing Plug	40M39580-APPB	F	0.1	0.005	?	150185	1	---
W6W2ON	Haveg	Wire, #20, 600V, 260°C	40M39513A/7	F	127	120	?	150185	50 ft.	---
W6N20NINB	"	Shielded Cable #20	40M39526A/7	F	28	10	?	150185	4 ft.	---
50M02239-9	Raychem	Heat shrink Solder Sleeve	DWG. 50M02239	F	0.8	1.2	II, p. 180	150185	4	---
Size 2 (.125)	Western Filament	125LOF17, TFE coated fiberglass lacing core	MIL-T-43435 Type IV, Finish D	F	6 (EST.)	45 (EST.)	?	150185	20 ft.	---
3622P-LOO-3B7	Ferroxcube	Ferrite Core 3B7	-------	E	56	None	None	150208	2	---

MAJOR ASSY: 150200 NON-METALIC MAT'L PART LIST REVISED ______ SHT 3 OF 3

PART NO.	MANUFACTURER	TRADE NAME/ CATALOG NO.	SPECIFICATION	USAGE CAT.	WT. (ASSY (GMS.)	EXPOSED AREA(sq.in)	TEST STATUS	NEXT ASSY	QTY. USED	PROCES
90GS/63W-HP-4B	Electrical Industries	Glass Header 1750V, 10 AMP	--------	F	3	0.5	None	150208	1	----
150208	EMP Electronics	Inductor	150207	E	286 (EST.)	None	None	150223	1	Potting
276-21ATD144DIA	Raychem	TFE Shrink Sleeve	MSFC-SPEC-276	F	5.5	10	I, p. 83	150185		
276-21ATD096DIA	"	" "	" "	F	5.0	10	"	150185		
1/2 - 6T	Weckesser	TFE Cable Clamp	------	F	2.8	4	I, p. 87	150185	1	
5/16 - 6T	"	" " "	-------	F	2.2	4	"	150185	1	
3/16 - 6T	"	" " "	-------	F	8.5	12	"	150185	6	
1/8 - 6T	"	" " "	-------	F	2.5	4	"	150185	2	
G1109E14C3-2	Glenair Inc.	Dust cover seal for bayonet connector neoprene	------	F	1.5	0.1	?	150184	1	

REVISED ______ METALIC MAT'L PART LIST FOR MAJOR ASSY. 150200

COM DESIG.	ELECT. REF. DESIG.	PART NO.	SPEC. NO.	NAME	FAIL. RATE	NEXT ASSY	QTY. USED	MAT'L	PROCESS
Nut	-	MS35649-224	-	Nut, plain, hex, machine screw, UNC-2B	-	150167 150184	272	Cres 300 series	Passivate
"	-	" -264	-	" "	-	150202, -208 -167, 223	336	"	"
"	-	" -284	-	" "	-	150185	136	"	"
Screw	-	MS16995-2	-	Screw cap, socket HD-HEX Cres, UNC-3A	-	150184 150167	272	"	"
"	-	" -9	-	" "	-	150185	32	"	"
"	-	" -16	-	" "	-	150167	32	"	"
"	-	" -17	-	" "	-	150209	48	"	"
"	-	" -25	-	" "	-	150200, - -185, 184	536	"	"
"	-	" -26	-	" "	-	150184 150185	248	"	"
Screw	-	MS24693-C47	-	Screw, mach., flat, CSK, HD, 100° Cross-recessed, UNC-2A	-	150160	72	"	"
"	-	MS35233-15	-	Screw, mach, pan HD, slot. Cres., Pass., NC-2A	-	150194	32	"	"
"	-	44D31	-	Screw, SOC, HD, Shld, Precision	-	150209	16	Cres 300 series	"
Washer	-	MS35333-72	-	Washer, lock, flat-int tooth	-	150200 150185	208	Cres 300 series	Passivate
Washer	-	MS15795-802	-	Washer, flat-met., RD, General Purpose	-	150184	192	Cres 300 series	"
"	-	" -803	-	" "	-	150185	32	"	"
"	-	" -807	-	" "	-	150200, -185 -184		"	"
"	-	" -808	-	" "	-	150167	48	"	"
"	-	31D54	-	Washer, Mach., Precision	-	150209	32	"	"
Rivet	-	MS16535-77	-	Rivet tubular, oval HD	-	150167 150223	160	Al alloy	Anodize
"	-	" -154	-	" "	-	150167	32	" "	"

REVISED ______________ METALIC MAT'L PART LIST FOR MAJOR ASSY. 150200 Sheet 2 of 7

COM DESIG.	ELECT. REF. DESIG.	PART NO.	SPEC. NO.	NAME	FAIL. RATE	NEXT ASSY	QTY. USED	MAT'L	PROCESS
Terminal Lug	-	MS35431-5	-	Term., lug, solder type Cop. Stamping, one hole, flat	-	150185	32	Copper Annealed	Electro-Deposited Tin
" "	-	" -7	-	" "	-	150167	32	"	"
Insert	-	MS21208-C4-10	-	Insert, SCR, THD, coarse & fine free running, helical coil Cres	-	150217, -158 -157	64	Cres	
"	-	MS21209-CO-615	-	Insert, SCR, THD, coarse & fine, SCR, locking, helical coil, Cres	-	150212 150210	48	Cres	
"	-	" " -815	-	" "	-	150139 150215	208	"	
"	-	" " -820	-	" "	-	150139	128	"	
Spring	-	MS24585-C294	-	Spring, helical, compression for loads below 20 lbs.	-	150209	8	Cres	Passivate
Relay, Gen. Pump	K101 K201	S2GH-3-58B	MSFC-SPEC-339/58B, X-ray Req'd.	28VDC, 2PDT, 10A, solder hook, Two 1-hole reverse ear mtg. 300	-	150167	16	-	-
Relay, Mag, Latch	K102, K202 K203	S2BLH-8-91B	MSFC-SPEC-339/91B X-ray Req'd.	28VDC, 2PDT, 10A, solder hook Reverse flange, 800 /coil	-	150167	24	-	-
Capacitor, Fixed	C310 C410	HRDM30D682-J1000WV5CR	MSFC-SPEC 400/4	1000VDC MICA, 6800PF, 5% Tol	-	150167	16	-	-
" "	C307 C407	HRDM20D202 J1000WV5CR	" " "	1000VDC MICA, 2000PF, 5% Tol	-	150167	16	-	-
" "	C308 C408	HRDM43D333J 1000WV5CR	" " "	1000VDC MICA33000PF, 5% Tol	-	150167	16	-	-
" "	C309 C409	SCTM684VB-J	MSFC-SPEC-50M60148	Mylar tubular, 2000VDC @ 80°C 1000VDC @ 125°C; 68ufd, 5% Tol	P	150167	16	-	-
" "	C301, C306 C401, C406	CSR13H156K-2	MIL-C-39003/01A 661	Tantalum, pol. solid, elect. 75.0VDC 15ufd, style CSR13 case D, Tol. 10%	P	150167 150223	112	-	-
Transistor	Q301 Q401	S2N5539-5	85M03886	NPN high power MTO-63 selected for the following: VCBO=160VMIN, VCEO=115VMIN	-	150167	16	-	-
				hFE=60 to 85 @ I_C=10A, VCE=5V					
Resistor fixed	R304 R404	RER65F33R2P	MIL-R-39009/1	Power, wire wound, chassis MTD, RER65, 10W, 33.2ohm	P	150167	16	-	-
" "	R301 R401	RER65F1001P	" "	Power, wire wound, chassis MTD, RER65, 10W, 1.0K ohm	P	150167	16	-	-
" "	R302 R402	RER65F56R2P	" "	Power, wire wound, chassis MTD, RER65, 10W, 56.2ohm±1%	P	150167	16	-	-
" "	R303 R403	RER65F8R06P	" "	Power, wire wound, chassis MTD, RER65, 10W, 8.06 ohm	P	150167	16	-	-

REVISED ____________ METALIC MAT'L PART LIST FOR MAJOR ASSY. 150200

COM DESIG.	ELECT. REF. DESIG.	PART NO.	SPEC. NO.	NAME	FAIL. RATE	NEXT ASSY	QTY. USED	MAT'L	PROCESS
Diode Rect.	CR301 CR401	S1N1204A	85M01673	I_o=12A @ T_c= 150°C, VR=400 VDC D0-4	-	150167	24	-	-
Thermostat	S3	95M10142-7	95M10143	Hermetically sealed, 3A 30VDC, open 160°F, close 270°F	-	150167	8	-	-
Switch, Toggle	S4	95M10102-3	95M10103	2PDT on maint. -none-on maint. Extra screen:500 cycles x-ray	-	150185	8	-	-
" "	S5	95M10102-9	"	Single pole maint. -none- Momentary, extra screen; x-ray 500cycles	-	"	8	-	-
" "	S1, S2	40M37764-9 95M10102-55	"	2 PDT, 3-position, non-locking, Hermatic sealed, on maintained-off-on maintained, extra	-	"	16	-	-
				Screen: 500 cycles, x-ray					
Connector Elect. (Test)	J2	NB7H-14-15PN	40M39569/6		-	150185	8	-	-
Connector Elect. (power)	J1	ZG6E1717-6-PA	40M39580/4	Conn. Plug Environ., 6-pin male #12 contacts	-	"	8	-	-
Dummy Receptacle	-	ZG-DR-17	40M39580/6		-	"	8	-	-
Can	-	HU-4410-2375	MIL-T-27AJ	Can, plain, steel	-	150208	8	Steel	Nickel plated
Cover	-	HU-4525-CB	MIL-T-27AJ	Cover, SK#1500-54, steel	-	150208	8	"	"
Can	-	HU-4410-1.688	MIL-T-27AH	Can, plain, steel	-	150202	16	"	"
Cover	-	HU-4410-CB	MIL-T-27AH	Cover, SK#1500-53, steel	-	150202	16	"	"
Component Holder	-	104-300-5A-2	-		-	150167 150223	112	Beryllium Copper	"
" "	-	140-300-10-3	-		-	150167	16	"	"
Round Case	-	HU-2440BRX .984	-	Standard Round Brass Case	-	150147	64	Brass	-
Adapter	-	CRN113-17-16	Comm'l	Conflex Adapter Assy NASA Zero-G connector	-	150185	8	Alum. 6061-T6	Chrome Plated
Fitting	-	0082-16-092-15	"	Conflex Series 008	-	150185	8	Alum. 2011-T3	Anodize Sulphuric Black
Clinch Nut	-	LHCFM2-2860-82	-	Nut-clinch, flush mtg. miniature 450° & non-magnetic, 900°F	-	160160	72	Stainless Steel	Silver Place
Shims	-	869, 870, 871, 872, 877, 878, 879, 880, 881, 882	-	Precision Shim Spacers	-	150209	A/R	Stainless Steel, 303	-

REVISED ______________ METALIC MAT'L PART LIST FOR MAJOR ASSY. 150200 Sheet 4 of 7

COM DESIG.	ELECT. REF. DESIG.	PART NO.	SPEC. NO.	NAME	FAIL. RATE	NEXT ASSY	QTY. USED	MAT'L	PROCESS
Eyelet	-	8954856-106	-	Eyelet-Metallic, Rolled Flange	-	150140	16	Brass Nickel Plate	White Nickel
"	-	8954853-115	-	" "	-	150194	32	"	"
"	-	8954853-113	-	" "	-	150194	32	"	"
Wire	-	Types soft or #20 AWG annealed	QQ-W-343	Wire Elect. Buss, Tinned	-	150185	A/R	Copper	Tinned
-	-	150138	-	Schematic Diagram	-	150185	-	-	-
-	-	150139	-	Reflector Frame	-	150204	8	Alum Plate 6061-T6 QQ-A-250/11	MIL-A-8625 Type III MIL-C-5541 Type I GR. C, CL. 3
-	-	150140	-	Lamp House	-	150184	8	AL ALY .032 SHT 6061-T4 per QQ-A-250/11	MIL-A-8625 MIL-A-8604 MIL-C-5541
-	-	150141	-	Electronics Cover	-	"	"	"	Type I, GR. C, CL3 "
-	-	150144	-	Spacer	-	"	40	303 STN HEX per QQ-S-764	MIL-F-14072 E300
-	-	150145	-	Lamp Cap	-	150147	64	HU-2440 BR. X .984 long	--
-	-	150147	-	Cap Assy	-	150189	8	.040 BR. QQ-B-6136	MIL-B-7883 QQ-S-561 QQ-N-290
								COMP. 4-ITEM 1	CL1 Type IV IOTA STD 2020726
-	-	150150	-	Chassis Inverter	-	150194	8	.090 THK AL. 6061-T4 QQ-A-250/11	MIL-A-8625 TYPE III MIL-C-5541
									Type I GR. C, CL. 3
-	-	150157	-	Mount, Camera - LH	-	150184	8	AL ALY 2024 per QQ-A-225/6 TEMP T3	MIL-A-8625 TYPE III
-	-	150158	-	Mount, Camera - Side	-	"	8	AL ALY 2024 T351 per QQ-A-225/6 TEMP T3	MIL-A-8625 TYPE III

REVISED ______ METALIC MAT'L PART LIST FOR MAJOR ASSY. 150200 Sheet 5 of 7

COM DESIG.	ELECT. REF. DESIG.	PART NO.	SPEC. NO.	NAME	FAIL. RATE	NEXT ASSY	QTY. USED	MAT'L	PROCESS
-	-	150159	QQ-S-766 QQ-S-763	Barrier, Thermal-FWD	-	150200	8	Cres	MIL-W-8611, MSFC-SPEC 85M01106 Type I or Type II CL2 MIL-F-14072, E300
-	-	150160	QQ-S-766 QQ-S-763	Barrier, Thermal - Rear	-	150200	8	Cres	"
-	-	150161	-	Standoff, Barrier	-	150184	32	303 STN HEX QQ-S-764	MIL-F-14072, E300
-	-	150162-1	-	" "	-	"	8	"	"
-	-	150162-2	-	" "	-	"	32	"	"
-	-	150167	-	Assy - Inverter & Control Chassis	-	150185	8	-	-
-	-	150177	-	Nameplate, Functions	-	150184	8	.03 THK AL. ALY. 6061-T6 QQ-A-250/11	MIL-A-8625 Type III
-	-	150178	-	" , Warning	-	"	8	.03 THK AL SHT 6061-T6 per QQ-A-250/11	"
-	-	150179	-	" , Identification	-	"	8	"	"
-	-	150184	-	Mechanical Sub-Assy	-	150200	8	-	-
-	-	150185	-	Electrical " "	-	150200	8	-	-
-	-	150186	-	Nameplate, Power	-	150184	8	.03 THK. AL. SHT. 6061-T6 per QQ-A-250/11	MIL-A-8625 Type III
-	-	150187	-	" Remote Control	-	"	8	"	"
-	-	150189	-	Lamp Assy	-	150185	32	-	PROC. SPEC MSFC PROC-380 NHB 5300.4 (3A)
-	-	150194	-	Chassis - Sub Assy.	-	150167	8	-	-
-	-	150198-1	-	Strip, Reflector	-	150204	128	.032 SHT AL 6061-T6 per QQ-A-250/11	FSS-99
-	-	" -2	-	" "	-	"	128	"	FSS-99
-	-	150199	-	Holder, Component	-	150194	16	.030 THK. AL. ALY. 6061-T4 per QQ-A-250/11	MIL-A-8625 Type III

COM DESIG.	ELECT. REF. DESIG.	PART NO.	SPEC. NO.	NAME	FAIL. RATE	NEXT ASSY	QTY. USED	MAT'L	PROCESS
-	-	150200	-	Top Assy.	-	-	8	-----	-----
-	T301	150202-1	-	Transformer, #T301	-	150167	8	-----	Nickel Plate Per QQ-N-290 CL. 1 Type II
									NHB 5300.4 (3A)
-	T401	150202-2	-	" #T401	-	"	8	----	"
-	-	150203	-	Terminal Location	-	REF	-	-----	---
-	-	150204	-	Reflector Assy.	-	150184	8	-----	--
-	-	150205	-	Chassis, Inductor	-	150219	8	.062 THK AL 6061-T4 per QQ-A-250/11	MIL-C-5541 Type I GR. C CL. 3
-	L1	150208	-	Inductor, Filter, L1	-	150223	8	----	Nickel Plate per QQ-N-290 CL. 1 Type II NHB 5300.4 (3A)
-	-	150209	-	Handle Assy.	-	150184	8	----	----
-	-	150210	-	Grip	-	150209	8	Al ALY6061-T4, T4 per QQ-A-225/8	MIL-A-8625 Type III
-	-	150211-1	-	Support, Grip	-	150209	8	AL ALY 2024-T4 per QQ-A-225/6	"
-	-	150211-2	-	" "	-	"	8	"	"
-	-	150212	-	Guide Rod	-	"	8	303 STN STL per QQ-S-764	MIL-F-14072 E300
-	-	150213	-	Button Latch	-	"	8	"	"
-	-	150214	-	Rod Latch	-	"	8	Cres 17-4 PH per AMS-5643E Cond A	MIL-F-14072 E300 MIL-H-6875
-	-	150215	-	Base Handle	-	"	8	303 STN STL Per QQ-S-764	MIL-F-14072 E300
-	-	150216	-	Plate, Switch	-	150185	32	.090 THK AL ALY 6061-T6 per QQ-A-250/11	MIL-A-8625 type III MSFC-SPEC-95M01106 Type I or Type II CL. 2
-	-	150217	-	Mount, Camera - RH	-	150184	8	AL ALY 2024 per QQ-A-225/6 TEMP T3	MIL-A-8625 Type III

REVISED ________ METALIC MAT'L PART LIST FOR MAJOR ASSY. 150200

COM DESIG.	ELECT. REF. DESIG.	PART NO.	SPEC. NO.	NAME	FAIL. RATE	NEXT ASSY	QTY. USED	MAT'L	PROCESS
-	-	150218-1	-	Chassis Control	-	150194	8	.060 THK AL 6061-T4 PER QQ-A-250/11	MIL-C-5541, Type I GR. C, CL. 3
-	-	150218-2	-	" "	-	"	8	"	"
-	-	150219	-	Chassis Sub Assy - Inductor	-	150223	8	----	----
-	-	150223	-	Chassis Assy - Inductor	-	150185	8	---	----
-	-	150225	-	Bracket, Harness Support	-	"	80	.090 THK AL 6061-T4 PER QQ-A-250/11	MIL-A-8625 Type III
-	-	150234-1	-	Pemnut	-	150194 150219	64	AISI 303 STN STL	Tin Plate per MIL-T-10727 Type I
-	-	150234-3	-	"	-	150140	112	"	"
-	-	150234-4	-	"	-	150194	88	"	"
-	-	150240-1	-	Washer	-	150185	8	.080 SHT. ALALY 6061-T6 PER QQ-A-250/11	MIL-C-5541 TYPE I GR. C, CL. 3
-	-	150240-2	-	"	-	"	8	"	"
-	-	150241	-	"C" Washer	-	150185	80	22 Gauge Steel	Nickel Plate PER QQ-N-290 CL1, TYPE II

Appendix III

Electrical Component Usage List

150185	Electrical Subassembly
40M37764-9	Switch, Toggle, on-off-on
95M10102-3	Switch, Toggle, (Power) on-on
95M10102-9	Switch, Toggle, (Reset) MOM
NB7H-14-15PN	Connector, 15-Pin Male (Deutsch)
ZG6E1717-6PA	Connector, 6-Pin Male (Bendix)
150167	Assembly Inverter & Control Chassis
150202-3	Transformer (IOTA)
150202-4	Transformer (IOTA)
95M10142-7	Thermostat (Open 160°F, Close 270°)
M39003/01-2661	Capacitor 15 mfd, 75VDC (Kemet)
RER65F8R06P	Resistor, 8.06 ohm, 10 watt (Dale)
RER65F33R2P	Resistor, 33.2 ohm, 10 watt (Dale)
RER65F56R2P	Resistor, 56.2 ohm, 10 watt (Dale)
RER65F1001P	Resistor 1 k ohm, 10 watt (Dale)
S1N1204A	Diode, Rectifier (G.E.)
S2BLH-8-91B	Relay, 2A, DPDT (Potter & Brumfield)
S2GH-3-58B	Relay, 10A, DPDT, (Babock)
52N5539-5	Transistor (Solitron)
SCTM684VBJ	Capacitor, .68 mfd, 200 VDC (Dearborn)
WM2DM20D202JP1000WV5CR	Capacitor, 2000 pf, 100 VDC (Elmenco)
WM2DM30D682JP1000WV5CR	Capacitor, 6800 pf, 1000 VDC (Elmenco)
WM2DM43D333JP1000WV5CR	Capacitor, 33000 pf, 1000 VDC (Elmenco)
150189	Lamp Assembly (IOTA)
150223	Chassis Assembly, Inductor
150208	Filter, Inductor (IOTA)
M39003/01-2661	Capacitor, 15 mfd, 75 VDC (Kemet)

MAJOR ASSY: 150200 NON-METALIC MAT'L PART LIST REVISED________ SHT 1 OF 3

PART NO.	MANUFACTURER	TRADE NAME/ CATALOG NO.	SPECIFICATION	USAGE CAT.	WT. (ASSY (GMS.)	EXPOSED AREA (sq.in)	TEST STATUS	NEXT ASSY	QTY. USED	PROCESS
-----	Denton Optical	FSS-99 high reflectivity coating		B	Negligible	93	None	150198	32 pcs	
-----	Westinghouse Lamp Div.	Mercury *in lamp*	Westinghouse XF-097576-1	E	.041 per lamp .164 Total	None	"	150192	4 pcs	
PC-22	Hysol	Polyurethane Conformal Coating	MSFC-SPEC-393, Type I	B&F	5 to 10 (EST)	52	I, p. 62	150209, -85		MSFC-PROC-293
150221-1	IOTA	TFE Rod	MIL-P-19468	F	.33	None	I, p. 87	150167	2	
" -2	"	" "	" "	F	.12	None	"	150167	1	
" -3	"	" "	" "	F	.72	None	"	150209	2	
" -4	"	" "	" "	F	.61	None	"	150185	16	
——	Dow Corning	RTV 3116 Silicone Rubber	IOTA Process 150237	B&F	38	8	I, p. 101	150167 150204	--	150237 150238
——	"	Primer 1201	" "	B&F	.1	None	?	150167, 150204	--	"
——	"	Catalyst S	" "	B&F	--	--	I, p. 101	150167, 150204		"
--	General Electric	Silicone Grease G-681	-----	B&F	7-8 (EST.)	1.5	I, p. 111	150167, 184,-150, 194, -185		--
# 24 AWG # 18 AWG # 20 AWG	-----	Telfon Sleeve	MIL-I-22129	F	5 (EST.)	4	?	150167, -189, -189		
150202	EMP Electronics	Transformer	150206	E	209(EST.)	None	None	150167	2	Potting
B-60W-PP	Electrical Industries	Glass Terminal	1250V, 10amp	F	6	.18	None	150202	6	
80GS/63W-NP-8B	"	" Header	1600V, 10 amp	F	3	.94	None	150202	2	
3019P-L00-3B7	Ferroxcube	Ferrite Core 3B7		E	65.6	None	None	150202	4	
572-4859-01-05-16	Cambion	Bifurcated Terminal	Dial. Phth., Brass Cad. Plate, Solder Plate	F	21	Conformal Coated over Cad plate	None	150167	12	

MAJOR ASSY: 150200 NON-METALIC MAT'L PART LIST REVISED ______ SHT 2 OF 3

PART NO.	MANUFACTURER	TRADE NAME/ CATALOG NO.	SPECIFICATION	USAGE CAT.	WT. (ASSY (GMS.)	EXPOSED AREA(sq.in)	TEST STATUS	NEXT ASSY	QTY. USED	PROCESS
572-4811-01-05-16	Cambion	Turret Terminal	Dial. Phth., Brass, Cad. Plate, Solder Plate	F	30	Over Cad. Plate see above	None	150167 150223	18	
43-02-10	Thermalloy	Kapton Washer	------	F	.5	3	I, p. 119	150167	6	
RTV 602	General Electric	Silicone Potting	MSFC-SPEC-379, Type III	F	30	0.5	I, p. 98	150189		MSFC-PROC-380
SRC 05	"	Catalyst (Silicone)	" "	F	--	--	-----	150189		"
150192	Westinghouse Lamp Div.	Fluorescent Lamp	XF-097576-1	E	252	None	None	150189	4/18"	150190
TFE-R 1 1/4"	Raychem	Teflon Shrink Sleeve (TFE)	Com'l	B	34	188	I, p. 83	150189	4	
SN60WRAP	-------------	Solder	MSFC-SPEC-457	F	--	--	I, p. 124	150189, 150185	--	NHB 5300.4(3A)
B-60T-SS, MODA	Electrical Industries	Glass Terminal	------	F	16	0.5	None	150147	16	------
SN60WRAP	-------	Solder	QQ-S-571	F	--	---	I, p. 124	150147		IOTA STD 2020726
MS18114-12-9	ITT	Wire, TFE 1000V #12	MIL-W-22759	F	2	28	?	150185	6 ft.	---
X-81	Armstrong	Epoxy Adhesive	MSFC-SPEC-411 Type II	B	0.5	0.25	I, p. 53	150185		MSFC-PROC-[illegible]
Activator A	"			B	--	--	--			
Flexible Resin #1	"			B	--	--	?			
CCT-16-0-0H	Icore	Convoluted TFE tubing with internal fiber-glass braid		B	20 (EST.)	30 (EST.)	?	150185	1 ft.	---
Zg-GSP-12	Bendix	Nylon Sealing Plug	40M39580-APPB	F	0.1	0.005	?	150185	1	---
W6W2ON	Haveg	Wire, #20, 600V, 260°C	40M39513A/7	F	127	120	?	150185	50 ft.	---
W6N20NINB	"	Shielded Cable #20	40M39526A/7	F	28	10	?	150185	4 ft.	---
50M02239-9	Raychem	Heat shrink Solder Sleeve	DWG. 50M02239	F	0.8	1.2	II, p. 180	150185	4	---
Size 2 (.125)	Western Filament	125LOF17, TFE coated fiberglass lacing core	MIL-T-43435 Type IV, Finish D	F	6 (EST.)	45 (EST.)	?	150185	20 ft.	---
3622P-LOO-3B7	Ferroxcube	Ferrite Core 3B7	-------	E	56	None	None	150208	2	---

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PART NO.	MANUFACTURER	TRADE NAME/ CATALOG NO.	SPECIFICATION	USAGE CAT.	WT. (ASSY (GMS.)	EXPOSED AREA(sq.in)	TEST STATUS	NEXT ASSY	QTY. USED	PROCES
90GS/63W-HP-4B	Electrical Industries	Glass Header 1750V, 10 AMP	---------	F	3	0.5	None	150208	1	----
150208	EMP Electronics	Inductor	150207	E	286 (EST.)	None	None	150223	1	Potting
276-21ATD144DIA	Raychem	TFE Shrink Sleeve	MSFC-SPEC-276	F	5.5	10	I, p. 83	150185		
276-21ATD096DIA	"	" "	" "	F	5.0	10	"	150185		
1/2 - 6T	Weckesser	TFE Cable Clamp	------	F	2.8	4	I, p. 87	150185	1	
5/16 - 6T	"	" " "	-------	F	2.2	4	"	150185	1	
3/16 - 6T	"	" " "	-------	F	8.5	12	"	150185	6	
1/8 - 6T	"	" " "	-------	F	2.5	4	"	150185	2	
G1109E14C3-2	Glenair Inc.	Dust cover seal for bayonet connector neoprene	------	F	1.5	0.1	?	150184	1	

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METALIC MAT'L PART LIST

FOR MAJOR ASSY. 150200

COM DESIG.	ELECT. REF. DESIG.	PART NO.	SPEC. NO.	NAME	FAIL. RATE	NEXT ASSY	QTY. USED	MAT'L	PROCESS
Nut	-	MS35649-224	-	Nut, plain, hex, machine screw, UNC-2B	-	150167 150184	272	Cres 300 series	Passivate
"	-	" -264	-	" "	-	150202, -208 -167, 223	336	"	"
"	-	" -284	-	" "	-	150185	136	"	"
Screw	-	MS16995-2	-	Screw cap, socket HD-HEX Cres, UNC-3A	-	150184 150167	272	"	"
"	-	" -9	-	" "	-	150185	32	"	"
"	-	" -16	-	" "	-	150167	32	"	"
"	-	" -17	-	" "	-	150209	48	"	"
"	-	" -25	-	" "	-	150200, - -185, 184	536	"	"
"	-	" -26	-	" "	-	150184 150185	248	"	"
Screw	-	MS24693-C47	-	Screw, mach., flat, CSK, HD, 100° Cross-recessed, UNC-2A	-	150160	72	"	"
"	-	MS35233-15	-	Screw, mach, pan HD, slot. Cres., Pass., NC-2A	-	150194	32	"	"
"	-	44D31	-	Screw, SOC, HD, Shld, Precision	-	150209	16	Cres 300 series	"
Washer	-	MS35333-72	-	Washer, lock, flat-int tooth	-	150200 150185	208	Cres 300 series	Passivate
Washer	-	MS15795-802	-	Washer, flat-met., RD, General Purpose	-	150184	192	Cres 300 series	"
"	-	" -803	-	" "	-	150185	32	"	"
"	-	" -807	-	" "	-	150200, -185 -184		"	"
"	-	" -808	-	" "	-	150167	48	"	"
"	-	31D54	-	Washer, Mach., Precision	-	150209	32	"	"
Rivet	-	MS16535-77	-	Rivet tubular, oval HD	-	150167 150223	160	Al alloy	Anodize
"	-	" -154	-	" "	-	150167	32	" "	"

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METALIC MAT'L PART LIST

FOR MAJOR ASSY. 150200

COM DESIG.	ELECT. REF. DESIG.	PART NO.	SPEC. NO.	NAME	FAIL. RATE	NEXT ASSY	QTY. USED	MAT'L	PROCESS
Terminal Lug	-	MS35431-5	-	Term., lug, solder type Cop. Stamping, one hole, flat	-	150185	32	Copper Annealed	Electro-Deposited Tin
" "	-	" -7	-	" "	-	150167	32	"	"
Insert	-	MS21208-C4-10	-	Insert, SCR, THD, coarse & fine free running, helical coil Cres	-	150217, -158 -157	64	Cres	
"	-	MS21209-CO-615	-	Insert, SCR, THD, coarse & fine, SCR, locking, helical coil, Cres	-	150212 150210	48	Cres	
"	-	" " -815	-	" "	-	150139 150215	208	"	
"	-	" " -820	-	" "	-	150139	128	"	
Spring	-	MS24585-C29	-	Spring, helical, compression for loads below 20 lbs.	-	150209	8	Cres	Passivate
Relay, Gen. Purp	K101 K201	S2GH-3-58B	MSFC-SPEC-339/58B, X-ray Req'd.	28VDC, 2PDT, 10A, solder hook, Two 1-hole reverse ear mtg. 300	-	150167	16	-	-
Relay, Mag. Latch	K102, K202 K203	S2BLH-8-91B	MSFC-SPEC-339/91B X-ray Req'd.	28VDC, 2PDT, 10A, solder hook Reverse flange, 800 /coil	-	150167	24	-	-
Capacitor, Fixed	C310 C410	HRDM30D682-J1000WV5CR	MSFC-SPEC 400/4	1000VDC MICA, 6800PF, 5% Tol	-	150167	16	-	-
" "	C307 C407	HRDM20D202 J1000WV5CR	" " "	1000VDC MICA, 2000PF, 5% Tol	-	150167	16	-	-
" "	C308 C408	HRDM43D333J 1000WV5CR	" " "	1000VDC MICA 33000PF, 5% Tol	-	150167	16	-	-
" "	C309 C409	SCTM684VB-J	MSFC-SPEC-50M60148	Mylar tubular, 2000VDC @ 80°C 1000VDC @ 125°C; 68ufd, 5% Tol	P	150167	16	-	-
" "	C301, C306 C401, C406	CSR13H156K-2661	MIL-C-39003/01A	Tantalum, pol. solid, elect. 75.0VDC 5ufd, style CSR13 case D, Tol. 10%	P	150167 150223	112	-	-
Transistor	Q301 Q401	S2N5539-5	85M03886	NPN high power MTO-63 selected for the following: VCBO=160VMIN, VCEO=115VMIN	-	150167	16	-	-
				hFE=60 to 85 @ I_C=10A, VCE=5V					
Resistor fixed	R304 R404	RER65F33R2P	MIL-R-39009/1	Power, wire wound, chassis MTD, RER65, 10W, 33.2ohm	P	150167	16	-	-
" "	R301 R401	RER65F1001P	" "	Power, wire wound, chassis MTD, RER65, 10W, 1.0K ohm	P	150167	16	-	-
" "	R302 R402	RER65F56R2P	" "	Power, wire wound, chassis MTD, RER65, 10W, 56.2ohm±1%	P	150167	16	-	-
" "	R303 R403	RER65F8R06P	" "	Power, wire wound, chassis MTD, RER65, 10W, 8.06 ohm	P	150167	16	-	-

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FOR MAJOR ASSY. 150200 Sheet 3 of 7

COM DESIG.	ELECT. REF. DESIG.	PART NO.	SPEC. NO.	NAME	FAIL. RATE	NEXT ASSY	QTY. USED	MAT'L	PROCESS
Diode Rect.	CR301 CR401	S1N1204A	85M01673	I_o=12A @ T_c = 150°C, VR=400 VDC D0-4	-	150167	24	-	-
Thermostat	S3	95M10142-7	95M10143	Hermetically sealed, 3A 30VDC open 160°F, close 270°F	-	150167	8	-	-
Switch, Toggle	S4	95M10102-3	95M10103	2PDT on maint. -none-on maint. Extra screen:500 cycles x-ray	-	150185	8	-	-
" "	S5	95M10102-9	"	Single pole maint. -none- 500cycles Momentary, extra screen; x-ray	-	"	8	-	-
" "	S1, S2	40M37764-9 95M10102-55	"	2 PDT, 3-position, non-locking, Hermatic sealed, on maintained-off-on maintained, extra Screen: 500 cycles, x-ray	-	"	16	-	-
Connector Elect. (Test)	J2	NB7H-14-151N	40M39569/6		-	150185	8	-	-
Connector Elect. (power)	J1	ZG6E1717-6-PA	40M39580/4	Conn. Plug Environ., 6-pin male #12 contacts	-	"	8	-	-
Dummy Receptacle	-	ZG-DR-17	40M39580/6		-	"	8	-	-
Can	-	HU-4410-237	MIL-T-27A	Can, plain, steel	-	150208	8	Steel	Nickel plated
Cover	-	HU-4525-CB	MIL-T-27AJ	Cover, SK#1500-54, steel	-	150208	8	"	"
Can	-	HU-4410-1,688	MIL-T-27AH	Can, plain, steel	-	150202	16	"	"
Cover	-	HU-4410-CB	MIL-T-27AH	Cover, SK#1500-53, steel	-	150202	16	"	"
Component Holder	-	104-300-5A-2	-		-	150167 150223	112	Beryllium Copper	"
" "	-	140-300-10-3	-		-	150167	16	"	"
Round Case	-	HU-2440BRX .984	-	Standard Round Brass Case	-	150147	64	Brass	-
Adapter	-	CRN113-17-16	Comm'l	Conflex Adapter Assy NASA Zero-G connector	-	150185	8	Alum. 6061-T6	Chrome Plated
Fitting	-	0082-16-092-5	"	Conflex Series 008	-	150185	8	Alum. 2011-T3	Anodize Sulphuric Black
Clinch Nut	-	LHCFM2-2860-82	-	Nut-clinch, flush mtg. miniature 450° & non-magnetic, 900°F	-	160160	72	Stainless Steel	Silver Place
Shims	-	869, 870, 871, 872, 877, 878, 879, 880, 881, 882	-	Precision Shim Spacers	-	150209	A/R	Stainless Steel, 303	-

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COM DESIG.	ELECT. REF. DESIG.	PART NO.	SPEC. NO.	NAME	FAIL. RATE	NEXT ASSY	QTY. USED	MAT'L	PROCESS
Eyelet	-	8954856-106	-	Eyelet-Metallic, Rolled Flange	-	150140	16	Brass Nickel Plate	White Nickel
"	-	8954853-115	-	" "	-	150194	32	"	"
"	-	8954853-113	-	" "	-	150194	32	"	"
Wire	-	Types soft or #20 AWG annealed	QQ-W-343	Wire Elect. Buss, Tinned	-	150185	A/R	Copper	Tinned
-	-	150138	-	Schematic Diagram	-	150185	-	-	-
-	-	150139	-	Reflector Frame	-	150204	8	Alum Plate 6061-T6 QQ-A-250/11	MIL-A-8625 Type III MIL-C-5541 Type I GR. C, CL. 3
-	-	150140	-	Lamp House	-	150184	8	AL ALY .032 SHT 6061-T4 per QQ-A-250/11	MIL-A-8625 MIL-A-8604 MIL-C-5541 Type I, GR. C, CL3
-	-	150141	-	Electronics Cover	-	"	"	"	"
-	-	150144	-	Spacer	-	"	40	303 STN HEX per QQ-S-764	MIL-F-14072 E300
-	-	150145	-	Lamp Cap	-	150147	64	HU-2440 BR. X .984 long	--
-	-	150147	-	Cap Assy	-	150189	8	.040 BR. QQ-B-6136 [illegible]	MIL-B-7883 QQ-S-561 QQ-N-290
								COMP. 4- ITEM 1	CLI Type IV IOTA STD 2020726
-	-	150150	-	Chassis Inverter	-	150194	8	.090 THK AL. 6061-T4 QQ-A-250/11	MIL-A-8625 TYPE III MIL-C-5541 Type I GR. C, CL. 3
-	-	150157	-	Mount, Camera - LH	-	150184	8	AL ALY 2024 per QQ-A-225/6 TEMP T3	MIL-A-8625 TYPE III
-	-	150158	-	Mount, Camera - Side	-	"	8	AL ALY 2024 T351 per QQ-A-225/6 TEMP T3	MIL-A-8625 TYPE III

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METALIC MAT'L PART LIST

FOR MAJOR ASSY. 150200 Sheet 5 of 7

COM DESIG.	ELECT. REF. DESIG.	PART NO.	SPEC. NO.	NAME	FAIL. RATE	NEXT ASSY	QTY. USED	MAT'L	PROCESS
-	-	150159	QQ-S-766 QQ-S-763	Barrier, Thermal-FWD	-	150200	8	Cres	MIL-W-8611, MSFC-SPEC 55201106 Type I or Type II CL2 MIL-F-14072, E300
-	-	150160	QQ-S-766 QQ-S-763	Barrier, Thermal - Rear	-	150200	8	Cres	"
-	-	150161	-	Standoff, Barrier	-	150184	32	303 STN HEX QQ-S-764	MIL-F-14072, E300
-	-	150162-1	-	" "	-	"	8	"	"
-	-	150162-2	-	" "	-	"	32	"	"
-	-	150167	-	Assy - Inverter & Control Chassis	-	150185	8	-	-
-	-	150177	-	Nameplate, Functions	-	150184	8	.03 THK AL. ALY. 6061-T6 QQ-A-250/11	MIL-A-8625 Type III
-	-	150178	-	" , Warning	-	"	8	.03 THK AL SHT 6061-T6 per QQ-A-250/11	"
-	-	150179	-	" , Identification	-	"	8	"	"
-	-	150184	-	Mechanical Sub-Assy	-	150200	8	-	-
-	-	150185	-	Electrical " "	-	150200	8	-	-
-	-	150186	-	Nameplate, Power	-	150184	8	.03 THK. AL. SHT. 6061-T6 per QQ-A-250/11	MIL-A-8625 Type III
-	-	150187	-	" Remote Control	-	"	8	"	"
-	-	150189	-	Lamp Assy	-	150185	32	-	PROC. SPEC MSFC PROC-380 NHB 5300.4 (3A)
-	-	150194	-	Chassis - Sub Assy.	-	150167	8	-	-
-	-	150198-1	-	Strip, Reflector	-	150204	128	.032 SHT AL 6061-T6 per QQ-A-250/11	FSS-99
-	-	" -2	-	" "	-	"	128	"	FSS-99
-	-	150199	-	Holder, Component	-	150194	16	.030 THK. AL. ALY. 6061-T4 per QQ-A-250/11	MIL-A-8625 Type III

REVISED __________

METALIC MAT'L PART LIST

FOR MAJOR ASSY. 150200

COM DESIG.	ELECT. REF. DESIG.	PART NO.	SPEC. NO.	NAME	FAIL. RATE	NEXT ASSY	QTY. USED	MAT'L	PROCESS
-	-	150200	-	Top Assy.	-	-	8	-----	-----
-	T301	150202-1	-	Transformer, #T301	-	150167	8	-----	Nickel Plate Per QQ-N-290 CL. 1 Type II NHB 5300.4 (3A)
-	T401	150202-2	-	" #T401	-	"	8	----	"
-	-	150203	-	Terminal Location	-	REF	-	-----	---
-	-	150204	-	Reflector Assy.	-	150184	8	-----	--
-	-	150205	-	Chassis, Inductor	-	150219	8	.062 THK AL 6061-T4 per QQ-A-250/11	MIL-C-5541 Type I GR. C CL. 3
-	L1	150208	-	Inductor, Filter, L1	-	150223	8	----	Nickel Plate per QQ-N-290 CL. 1 Type II NHB 5300.4 (3A)
-	-	150209	-	Handle Assy.	-	150184	8	----	----
-	-	150210	-	Grip	-	150209	8	Al ALY6061-T4, T4 per QQ-A-225/8	MIL-A-8625 Type III
-	-	150211-1	-	Support, Grip	-	150209	8	AL ALY 2024-T4 per QQ-A-225/6	"
-	-	150211-2	-	" "	-	"	8	"	"
-	-	150212	-	Guide Rod	-	"	8	303 STN STL per QQ-S-764	MIL-F-14072 E300
-	-	150213	-	Button Latch	-	"	8	"	"
-	-	150214	-	Rod Latch	-	"	8	Cres 17-4 PH per AMS-5643E Cond A	MIL-F-14072 E300 MIL-H-6875
-	-	150215	-	Base Handle	-	"	8	303 STN STL Per QQ-S-764	MIL-F-14072 E300
-	-	150216	-	Plate, Switch	-	150185	32	.090 THK AL ALY 6061-T6 per QQ-A-250/11	MIL-A-8625 type III MSFC-SPEC-25X10110 Type I or Type II CL. 2
-	-	150217	-	Mount, Camera - RH	-	150184	8	AL ALY 2024 per QQ-A-225/6 TEMP T3	MIL-A-8625 Type III

REVISED ____________ METALIC MAT'L PART LIST FOR MAJOR ASSY. 150200

COM DESIG.	ELECT. REF. DESIG.	PART NO.	SPEC. NO.	NAME	FAIL. RATE	NEXT ASSY	QTY. USED	MAT'L	PROCESS
-	-	150218-1	-	Chassis Control	-	150194	8	.060 THK AL 6061-T4 PER QQ-A-250/11	MIL-C-5541, Type I GR. C, CL. 3
-	-	150218-2	-	" "	-	"	8	"	"
-	-	150219	-	Chassis Sub Assy -- Inductor	-	150223	8	----	----
-	-	150223	-	Chassis Assy - Inductor	-	150185	8	---	----
-	-	150225	-	Bracket, Harness Support	-	"	80	.090 THK AL 6061-T4 PER QQ-A-250/11	MIL-A-8625 Type III
-	-	150234-1	-	Pemnut	-	150194 150219	64	AISI 303 STN STL	Tin Plate per MIL-T-10727 Type I
-	-	150234-3	-	"	-	150140	112	"	"
-	-	150234-4	-	"	-	150194	88	"	"
-	-	150240-1	-	Washer	-	150185	8	.080 SHT. ALALY 6061-T6 PER QQ-A-250/11	MIL-C-5541 TYPE I GR. C, CL. 3
-	-	150240-2	-	"	-	"	8	"	"
-	-	150241	-	"C" Washer	-	150185	80	22 Gauge Steel	Nickel Plate PER QQ-N-290 CL1, TYPE II

APPENDIX IV

OPERATIONAL USE HANDBOOK, 150302, FOR HIGH INTENSITY PORTABLE FLUORESCENT LIGHT

CONTRACTOR'S PART NO. 150200

CONTRACTING AGENCY: George C. Marshall
Space Flight Center
Huntsville, Alabama

CONTRACT: NAS8-24527

CONTRACTOR: IOTA ENGINEERING, INC.
1735 E. Fort Lowell Rd.
Tucson, Arizona 85719

PREPARED BY: Robert W. Bushroe

APPROVED BY: W. A. Wall

Date: 20 July 1971

R E V I S I O N S

REV. DATE	PAGE NO.	REVISION	APPROVAL
30 Aug 71		INITIAL RELEASE	RWB

TABLE OF CONTENTS

III. FUNCTIONAL DESCRIPTION

A. General Description

The light consists of two separately controlled systems, No. 1 and No. 2. Each system operates two fluorescent lamps in a series configuration. A transistor inverter in each system changes the DC input power to 20kHz AC for the lamps. Control switches and relays provide local control for each system. A test receptacle (J2) provides access to the control circuits for remote operation during bench testing. (This function will not be used in flight.)

The lamps and inverters are housed in an aluminum structure which serves as the radiating cooling surface. A wire thermal barrier provides a cool surface for the astronaut for handling. A folding handle is available to assist in handling or aiming the light.

Brackets on the side of the structure accept adapters for the MSC universal support bracket, and a 1-foot-long pigtail cable mates with a separate power cable for input power. The connector is a Bendix Zero-G type, with an operating toggle lever.

The light beam is optically controlled to provide a beam pattern suitable for the anticipated photographic tasks. Each lamp is individually jacketed with a Teflon sleeve and end-capped to retain mercury vapor and glass splinters in case of glass breakage. The lamps are recessed in slots within the reflector structure to provide mechanical protection.

B. Functional Circuit Description - Power Input and Logic Control Sections

The power input section of the light serves to distribute power to the logic and inverter sections, provide RFI attenuation and reverse polarity protection. Main power enters through connector J1. Positive power connects with capacitors C1/C2 and inductor L1 which, in conjunction with the inverter input capacitors C301 - 306 and C401 - 406, comprise a pi network filter for RFI suppression. The negative power line connects through diode CR1 which provides a reverse polarity protection for the unit. Spacecraft ground enters and connects to the chassis and body of the light through J1. At the inductor L1 output, positive power is distributed to three points: the main control switch, S4, System 1 main power relay K101 and System 2 main power relay K201. When S4 is placed in the "ON" position, it allows power to pass to the system control switch wipers of S1 and S2. Control switches S1 and S2 are three-position switches which control power to the energizing coils of the respective System 1 and System 2 relays. In the "STANDBY" condition of S1 and S2, no relays are energized. When S1 (S2) is moved to the "HIGH" position, K101 (K201) is energized through one set of contacts allowing main power to pass to the inverter. The operated coil of relay K102 (K202) is also energized through the other set of contacts, providing bypass of the inverter base circuit resistor R304 (R404) and bypass of the inverter secondary ballast capacitor C307 (C407) through two separate relay contact sets, effecting "HIGH MODE" operation of the lamps. With S1 (S2) in the "LOW" position, K101 (K201) and the reset coil of K102 (K202) are energized. K101 (K201) again supplies main power to the inverter while the components R304 (R404) and C307 (C407) are now allowed to operate functionally in the inverter circuit, effecting "LOW MODE" operation of the lamps. Note that in moving between any two operational modes the main inverter power is interrupted, avoiding any high voltage switching problems associated with bypassing the ballast capacitor C307 (C407).

In System 2 only, a thermal cutout system is incorporated. Upon overheating of the unit*, thermal switch S2 closes, energizing the operate coil of K203. This can occur only when K201 is energized; i.e., System 2 is on. The contacts of K203 open, removing the negative side power of relay K201 and in turn removes power from S3 and K203, shutting off System 2. This comprises a so-called thermal protection circuit. The circuit is reset by operation of thermal protection switch, S5, to the "RESET" position. This energizes the reset coil of K203, restoring the negative power return path for K201. S5 is a momentary operation switch so that a permanent disabling of the thermal cutout is not possible.

The switching logic is designed to operate the lamps in the rapid-start mode. Arc power is applied simultaneously with filament heat, and filament heat is on whenever the inverter is operating. The arc voltage is not high enough to strike the arc until one or both filaments heat up (each lamp).

C. Functional Description of Inverter Sections

With a nominal 26.5 VDC applied through operation of the logic unit, R301 biases the base of Q301 through R302, R303, and N2

---

* Thermostat closing temperature is nominally 270°F (130°C). Thermostat reopens at 160°F (70°C).

winding (feedback) of T301. Q301 turns on, letting current flow through the primary of the transformer (N1 of T301). Once oscillation has started, the filament windings N4, N5, and N6 provide current to keep the filaments heated independent of arc current. The two filaments which are at the common arc point between the two lamps are driven in parallel by one winding. Filament heat and arc power are applied simultaneously to the lamps. As current is established in the lamps, the oscillator shifts downward in frequency and the voltage across the secondary, N3, drops to the operating level. At the same time the filament voltages drop a corresponding amount.

The high voltage required for starting the lamps is provided by the flyback action of the transformer. After the lamps are lit, the operating voltage is only about 20 percent of the open circuit voltage. The action of the base drive components R302, R303 and C309 are as follows. R303 serves the purpose of base current limitation under driven half cycle. C309 is a speed-up capacitor which initiates faster transistor switching. R302 serves the multiple purpose of providing d.c. coupled transistor drive, capacitor discharge path and a d.c. starting bias. In the dim mode, R304 is placed in series with R302 to compensate for the lower required drive conditions.

Lamp current is limited by the "ballast" capacitor, C312, for "HIGH" operation, and C311 in series with C312 for the "LOW" mode. The open circuit voltage is limited by the action of C310 across the secondary.

The lamp filaments are continuously heated to reduce the current density of the arc spot at the filaments. If a lamp filament were to lose heat, it would raise the starting voltage required to strike the arc. Once lit, however, the lamp would continue to operate without external filament heat. The circuit has been designed to provide starting capability under the following worst conditions when switched to "HIGH" mode:

1. Temperature of -18°C (0°F), low input voltage of 24 VDC (all filaments good).

2. Normal ambient, one filament open.

CR301 provides a parallel path for reverse current which is caused by high reverse bias during open circuit and dim operations.

IV. NORMAL USAGE (ORBITAL)

A. Removal From Stowage

The following minimum precautions should be taken when removing the High Intensity Portable Light from its stowage case: (1) Visually inspect for loose, broken, and damaged parts. (2) Visually inspect the electrical connection for bent or damaged pins. (3) Verify that the input POWER switch is "OFF".

B. Setup

A crew safety tether can be attached to the wires of the thermal barrier or to the handle if required. It is not necessary to unfold the handle for normal operation of the light.

Secure the light with a camera mount aimed at the desired location. The wires of the thermal barrier may be used as a sighting aid in aiming the light at the target.

The handle can be locked opened as an aid in positioning and moving the light (See Figure B). To release the handle from either locked position, press the button at one end of the handle until the handle is free to move. Push the handle in the desired direction, with the button released, until the lock engages. Some free play in the locked position is normal.

Place the switches in the following positions before mating the input power connector:

FUNCTION	POSITION
Power	"OFF"

Thermal Protection	Opposite "RESET" (UP or Forward)
System 1	"Standby"
System 2	"Standby"

Mate the input power connector (at end of pigtail) with the OWS 15 foot power cable (Stowage #0610.17.00). If the control switches are inadvertently left in an "ON" state, operation would be initiated immediately upon application of power; this operation is not detrimental to the light, but can cause undesirable damage (arcing, pitting, etc.) to the power connector.

C. <u>Operation</u>

1. Place the "POWER" (left-hand) switch in the "ON" position.

2. Place the "SYSTEM 1" switch in the "HIGH" position. The outer pair of lamps will show glowing filaments, followed by a dim glow of light over the length of the lamps. A bright "neon red" region around the filaments is normal. As the lamp warms up, the full length of the aperture becomes brighter, and the "neon red" glow around the filaments gradually fades. The lamps at normal room temperature will reach 3/4 brightness within two minutes from a cold start. Normal time to peak brightness is four to five minutes. If they were still warm from previous operation, they will reach peak brightness in less than four minutes. The light output will decrease slightly after both systems have been on "HIGH" for twenty minutes. This decrease is due to the lamps exceeding their optimum operating temperature, but does not constitute an abnormal or unsafe operating condition.

3. For minimum power consumption and lowest light output, place the "SYSTEM 1" switch in the "LOW" position after the lamps have warmed up in the "HIGH" position. The lamps can be started in the "LOW" position, but warm-up would be very slow.

   It is recommended that operation of both systems simultaneously in "LOW" mode be avoided. The electrical efficiency is much lower in the "LOW" mode, and electrical energy is wasted.

4. Follow the same procedure for operation of System 2, using the "SYSTEM 2" switch. The light is designed to operate continuously with both systems on "HIGH".

D. Shutdown

The light can be turned off by use of the "POWER" switch, which shuts off both systems simultaneously; or by placing the "SYSTEM 1" and "SYSTEM 2" switches in the "Standby" position. Deliberate or inadvertent disconnection of the input connector will also shut off both systems; this is not harmful to the unit, but could damage the connector.

NOTE: If the light has been on for a long time, (i.e., 30 minutes or longer), the control switches may be hot to the touch, but not hot enough to injure (approximately 125 °F). Within a minute after shutdown, the lamps become cool enough to again appear dim when restarted.

E. Stowage

Place the "POWER" switch in the "OFF" position. Disconnect the power cable. To stow the light in the original compartment, remove the mount adapters. The light may be stowed while warm; cool-down is not required.

F. Life Characteristics

The only components which show an aging characteristic are the lamps. Two types of degradation take place: (1) a gradual fading of light output along with clouding of the lamp ends, and (2) eventual failure to start.

The gradual fading is caused by the operation of the lamps at full power. Clouding of the lamps is caused by emission of the filaments, especially during lamp start. From initial conditions, the output may be decreased by one-third in 1,000 hours of "HIGH" operation. Since the two systems operate independently, the operation of System 1 does not affect the aging of System 2. NOTE: System operating hours should be logged separately.

The failure to start is primarily related to the number of starts applied to a lamp during its life. Eventually, the electrodes degrade to such an extent that no start is possible. The lamps are designed to start more than 1,000 times.

V. SPECIAL USAGE (PLANNED ONLY FOR QUALIFICATION, ACCEPTANCE, OR BENCH TESTS)

The light can be operated remotely through use of the test receptacle, J2. See Figure C for wiring information.

A. To mate the test connector, remove the flat-head screw from the sheet metal portion of the wire door covering the receptacle. Slide the door end-wise to release the hooked portion of wire from the thermal barrier; then rotate the door open. Using fingers, remove the dust cover from the test receptacle and move it aside. (Do not attempt to disengage the retaining chain.) Insert the test connector through the opening, mate the connector, and rotate the lock ring until the lock pins show.

B. The control switches must be in the following positions for successful remote control:

FUNCTION	SWITCH POSITION
Power	"ON"
Thermal Protection	Opposite "RESET"
System 1	"STANDBY"
System 2	"STANDBY"

System power is applied (as normal) through J1. Note that internal inverter voltages are available for monitoring at certain pins of the test receptacle. See Figure C for pin assignments. Monitor voltage from J2-A (+) to J2-P.

C. To remove the test connector, reverse the steps of paragraph V-A.

VI. MALFUNCTIONS AND TROUBLESHOOTING (NORMAL SPACECRAFT USE)

This section is written to help the user to detect faults, to clear them, to bypass them, and to take the appropriate long-term action. The format for this section is as follows:

1. Description of symptom (or non-typical operation)
2. Description of probable cause.
3. Immediate actions to be attempted.
4. Final disposition of article.

The assumption has been made that satisfactory performance can be achieved by providing a certain level of illuminance on a specific target of relatively small area.

A. Overheat

1. Symptom: Center pair of lamps goes out by itself (System 2).

2. Probable Cause: Light has reached upper limit of operating temperature, causing thermostat, S3, to shut off System 2.

3. Immediate Action: Push "Thermal Reset" switch to momentary "Reset" position, then release. If thermostat has cooled sufficiently, System 2 will restart. If thermostat is still above upper temperature limit, then System 2 will not restart.

4. Final Disposition: Allow light to cool down before further use. If light has been operating close to a warm object, relocate the light closer to a cooler surrounding surface. (The light is cooled primarily by radiation to cool surfaces.)

B. Failure to Light - Both Systems

1. Symptom: Lamps will not light when activated (both systems).

2. Probable Cause:

(1) Low Temperature - [below -18°C (0°F)]

(2) Insufficient or no input voltage

(3) Internal component failure

3. Immediate Action:

(1) (Low Temp) Allow light to warm up to -18°C, or higher, if possible. If it is necessary to force the light into immediate operation after a cold soak, turn on System 2, the central pair of lamps, to the "HIGH" mode. The filament heat should eventually warm the lamps sufficiently to create the arc (one to two minutes). Allow the light to operate several minutes so that the outer lamps will be warmed from the heat of operation. Then turn System 1 on "HIGH". If the lamps are still cold, the arc may be delayed until the filament heat warms them sufficiently to create the arc.

(2) (Low or No Voltage) Wait until power drain on spacecraft power has been reduced, or plug into a different receptacle for test purposes. Then start one system on "HIGH." After that system has reached peak brightness, turn the system off. Quickly start the other system on "HIGH". Promptly follow by restarting the first system.

(Lamps will start at a lower input voltage after they have been warmed up.)

(3) No repair possible.

4. Final Disposition: Continue normal use (1 and 2) or discontinue use (3).

C. Failure to Light - One System Only

1. Symptom: Lamps won't light when turned on (one system OK)
2. Probable Cause: Broken filament, one or more places.
3. Immediate Action: Turn functioning system on "HIGH." Cover light with a cloth so that the light will heat up as much as possible for 10 to 15 minutes. Then try the failed lamps again, starting them in "HIGH" mode. If only one filament is damaged, the lamps should light.
4. Final Disposition: Continue operation with one system, or with both systems if the start is successful.

D. Blackened Ends on Lamps

1. Symptom: Ends of lamp develop dark deposits inside the glass cylinder in vicinity of electrodes. This may be located at one or both ends of a lamp.

2. Probable Cause: This deposition normally occurs with age. The number of starts is usually the related factor.

3. Immediate Action: None

4. Final Disposition: Continue normal use.

E. Low Light Output

1. Symptom: Brightness of lamps is visibly low after five minutes of warm-up, with both systems on "HIGH."

2. Probable Causes:

   (1) Lamps approaching end of life

   (2) Lamps cold

   (3) Input voltage low

3. Immediate Action: Move light closer to the target. Moving light from six feet away to four feet away doubles the illuminance on the target centerline.

4. Final Disposition: Same as immediate action.

F. Cracked Lamps

1. Symptom: Cracks visible in glass cylinder of one or more lamps (Teflon sleeve still intact).

2. Probable Cause: Thermal/mechanical shock has fractured the thin glass cylinder.

3. Immediate Action: Discontinue use of system containing the cracked lamp. If lamp is still operating, turn the system off and allow the lamp to cool.

WARNING: The lamp contains mercury. If the outer Teflon sleeve is also damaged, immediate disposal of the light is required.

4. Final Disposition: Dispose of the light. The lamps are not replaceable.

G. Short Circuit

1. Symptom: Light does not operate; circuit breaker trips (in spacecraft).

2. Probable Cause: Internal component failure.

3. Immediate Action: Turn both systems to "STANDBY" and turn power "OFF." Reset circuit breaker. If circuit breaker still trips, the light is unusable. If reset is successful, turn power to "ON". If circuit breaker trips, the light is unusable. If circuit breaker stays reset, turn System 1 on "HIGH." If circuit breaker trips, then System 1 is defective and should not be used. Return control switch to "STANDBY." Reset circuit breaker. If System 1 operates normally, without tripping the circuit breaker, then that system is still usable. Verify System 2 in the same way.

(NOTE: The light does not contain any internal short circuit protection. It is designed to use the spacecraft circuit breaker only.)

4. Final Disposition: Continue to use the operational system if desired.

VII. MAINTENANCE AND DISASSEMBLY

No provisions have been included for repair of the light. No maintenance is anticipated. If the mirrors should become contaminated, they should be cleaned by the same procedures used for coated optical lenses. However, the reduction in light output is small with amounts of contamination which are easily visible to the naked eye. Do not attempt to clean the mirrors if contamination is equal to a layer of dust, and if the observer can view his own image in the mirror surfaces.

If any of the wires of the thermal barrier become bent, grasp them firmly by hand and straighten them. The wires are not considered structural.

VIII. OPERATIONAL CONSTRAINTS

A. Do not connect or disconnect the input power connector with the "POWER" switch in the "ON" position.

B. Do not operate more than one system in "LOW" mode.

C. Do not turn lamps on and off at a rapid cyclic rate.

D. Do not use cable for a handle in translation or stabilization of the light.

E. The lamps are shock sensitive. Do not allow the light to impact rigid objects.

F. The lamp contains mercury. If the outer Teflon sleeve and lamp glass are both damaged, immediate disposal of the light is required.

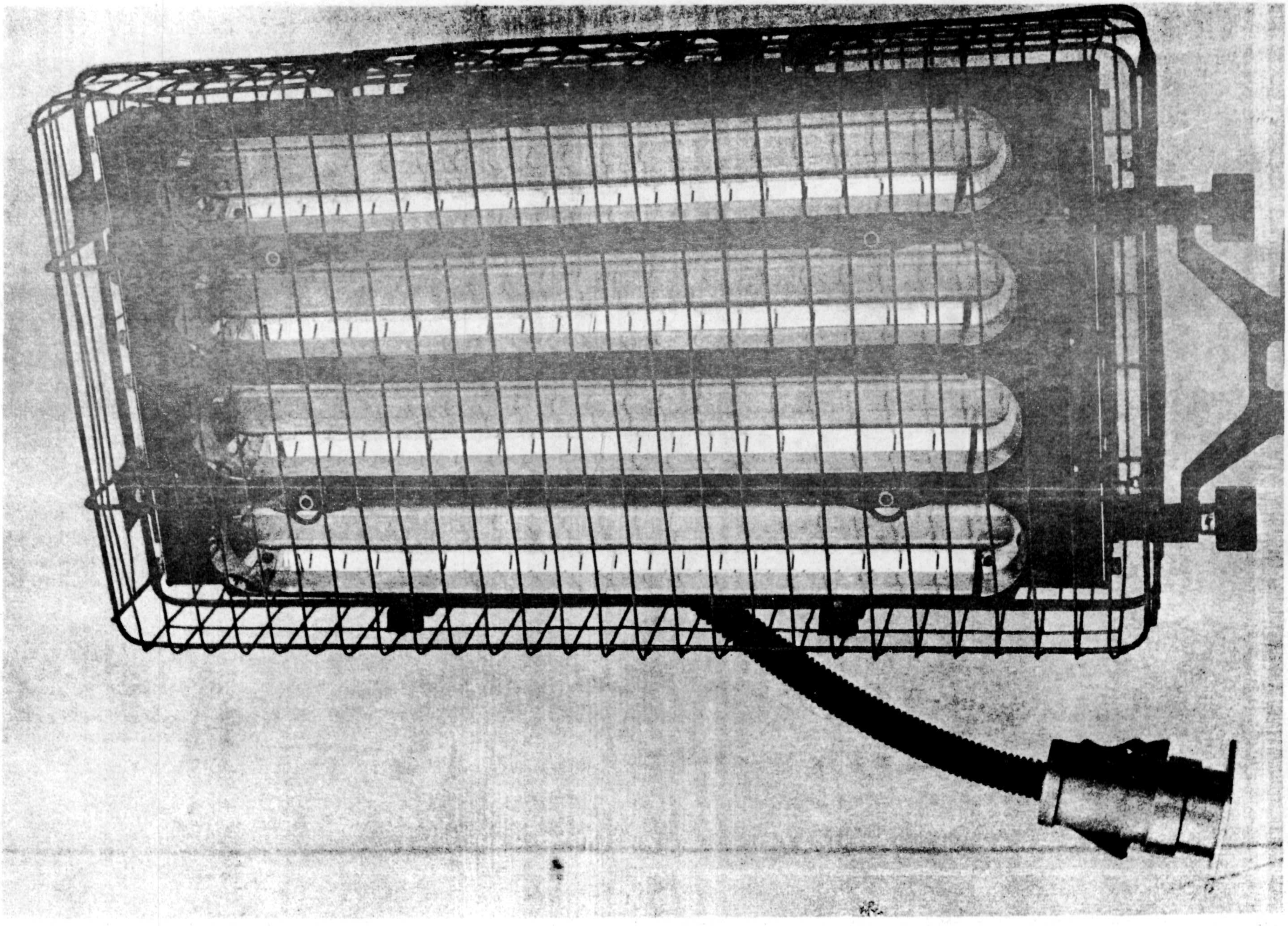
G. Do not attempt repairs of the light.

H. Do not attempt to clean the mirrors of moderate contamination.

I. The light does not contain any internal short circuit protection. It is designed to use the spacecraft circuit breaker only.

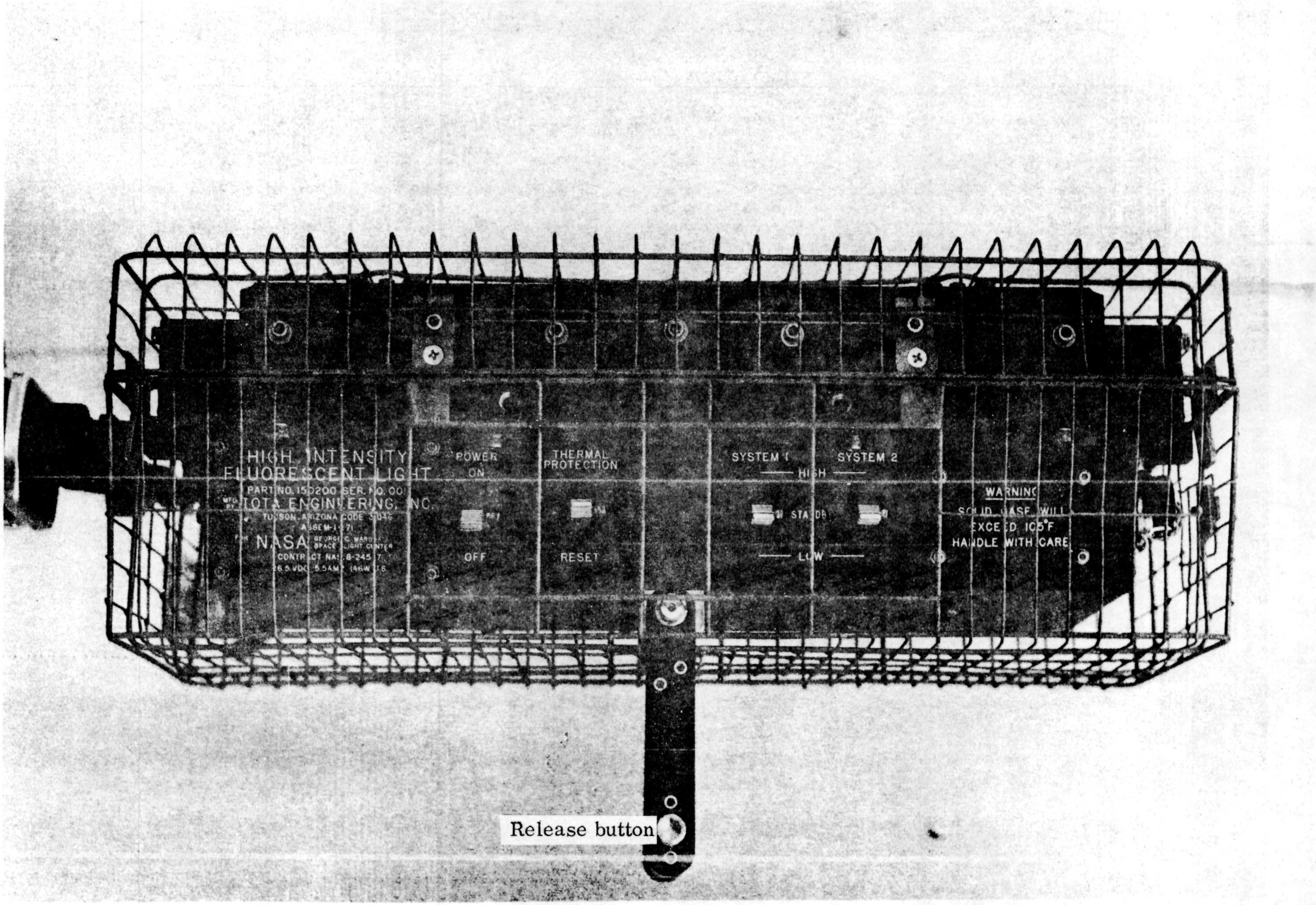
J. Do not attempt to remove the chain on the J2 dust cover.

K. Do not start the light more than 200 times, and do not operate more than 100 hours, prior to launch.



FRONT VIEW — HIGH INTENSITY FLUORESCENT PORTABLE LIGHT

FIGURE A



TOP VIEW — HIGH INTENSITY FLUORESCENT PORTABLE LIGHT

FIGURE B

APPENDIX V

HANDLING PROCEDURE, 150303

(GROUND OPERATIONS)

FOR

HIGH INTENSITY PORTABLE FLUORESCENT LIGHT

CONTRACTOR'S PART NO. 150200

CONTRACTING AGENCY: George C. Marshall
Space Flight Center
Huntsville, Alabama

CONTRACT: NAS8-24527

CONTRACTOR: IOTA ENGINEERING, INC.
1735 E. Fort Lowell Rd.
Tucson, Arizona 85719

PREPARED BY: Robert W. Bushroe

APPROVED BY: W. G. Wall
Contract COR

Date: 9 August 1971

REVISIONS

REV. DATE	PAGE NO.	REVISION	APPROVAL

I. PACKAGING FOR SHIPMENT

This unit is packaged in accordance with IOTA Procedure 150233 "A." The data package is fastened at the top of the carton for rapid access.

II. UNPACKING

Review this entire "Handling Procedure" prior to removing the unit from its carton. Determine whether the anticipated usage requires functional testing of this unit. If functional tests are required, they must be performed in such a way as to maintain the cleanliness of the unit. The outer wrap has provisions for operation of the unit without penetrating the cleanliness barrier.

A. Visual Inspection

Remove the unit from the carton and perform a visual inspection. Look for the following: loose pieces; parts deformed; torn bags; humidity indicator turned color; cracked lamp envelopes; contamination on mirror surfaces.

B. Rattle Test

Shake the unit by hand as an assist in determining whether any internal damage exists. No rattles should be present, with two possible exceptions: the handle and the J2 dust cover chain.

III. ENVIRONMENTAL CONDITIONS

This unit was cleaned and packaged to the 100,000 level in accordance with NASA MSFC-STD-246 and MSFC SPEC 95M11360. All operations shall be controlled to maintain this level of cleanliness. For storage, temperatures shall lie between -40°F and +160°F. During operation, the ambient temperature shall be between 0°F and 90°F. The unit shall not be operated for more than 30 minutes continuously with the bag in place. A cooling period of one hour shall follow each 30 minutes of operation (intermittent or continuous).

IV. FUNCTIONAL TEST WITH BAG ON

Switches are accessible through the bags. Apply 28 $^{+2}_{-4}$ DC power through an appropriate connector, ZGOE-1717-6SA, or equivalent, to the pigtail connector (plus on Pins C and D, return on pins A and B, ground on pin E, no connection on pin F). Turn "POWER" switch to "ON." Move "SYSTEM 1" and "SYSTEM 2" switches to "HIGH." Unit will draw about 6 amps of input power. Operation of the lights can be observed through the bags.

V. PRE-LAUNCH OPERATIONAL RESTRICTIONS

1. All operations shall be logged in the MSFC Log Book which accompanies each piece of hardware.

2. Ambient temperature should not exceed 90°F for operator touch temperature reasons.

3. The light shall not be acceptable for SKYLAB launch if it has accumulated more than 100 hours of ground operation and/or 200 starts per system prior to launch.

4. The light 150200 shall not be acceptable for SKYLAB launch if the lumen output at 6 feet ± 1 inch, as measured under the conditions

and restrictions of IOTA Acceptance Test Procedure 150232, paragraph 6.5.2, is less than 28 footcandles.

VI. DATA PACKAGE

All test operations shall be recorded in the log book assigned to each unit and verified by the cognizant quality control organization.

APPENDIX VI

END ITEM SPECIFICATION
PERFORMANCE/DESIGN (PART I)
REQUIREMENTS
(END-ITEM NO. 95M10750)
HIGH INTENSITY PORTABLE LIGHT
FOR
SKYLAB A AND B

APPROVAL:

W. A. Wall
Hardware Developer
S&E-PT-MEI

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GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

LIST OF EFFECTIVE PAGES

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1.0 SCOPE

Part I of this End-Item Specification (EIS) establishes the requirements for performance, design, test and qualification of equipment identified as the Space Oriented High Intensity Portable Work-Photographic Light as required by End-Item No. 95M10750 for the proposed Skylab Program Projects.

"Light and "Lamp" Identification

For purposes of this EIS only:

a. Light, as shown, refers to the total assembly or total item of hardware.

b. Lamp, as shown, refers to the individual lighting element and is that component which actually converts electrical energy into light.

This specification complies with and is prepared in detail on a paragraph-by-paragraph basis as outlined in Section 3 of the Office of Manned Space Flight (OMSF) Experiment General Specification (EGS) for Hardware Development, dated March 27, 1969. If a paragraph in the EGS can be used verbatim, it is so indicated by the word "applicable". If it is not applicable, it is so stated.

The Light and Task Hardware which consist of flight hardware, backup hardware, qualification test hardware, and flight type training hardware shall be developed in accordance with the requirements of this EIS.

The End-Item Criticality Category to which requirements must be specified for the design, development, manufacturing, and testing of the hardware shall be based on the results of the Failure Mode, Effects, and Criticality Analyses as specified in Para. 8.5.1 of the EGS.

When completed and accepted, this document will become the official control specification for the basic design configuration of the Flight and Qualification Hardware and as such, will be subject to subsequent change only by configuration control methods.

Light - This end item is used to provide auxiliary illumination for visual and photographic tasks on Skylab Program Projects during orbit only.

1.1 CHANGES

All approved changes to Part I of the EIS shall be as specified in Para. 8.3.4, 8.3.5, and 8.3.6 of the EGS.

2.0 APPLICABLE DOCUMENTS

Existing MSFC and Military Specifications shall be utilized in the performance and administration of this task wherever practical. When such documents exist, wherein the subject matter is applicable but specific requirements are not appropriate and/or are inadequate because of advanced design conditions and/or are inadequate because of advanced design conditions and/or requirements, the specifications referenced herein shall be followed only to the extent that the intent of such requirements shall be met. It is not the intent to inhibit or restrict the equipment manufacturer with respect to utilizing the latest proven state-of-the-art. Primary consideration shall be given to suitability in and for the application consistent with the latest state-of-the-art. By the same token, complete compliance with the pertinent military and other specifications by the equipment manufacturer shall not constitute a waiver in whole or in part of any of the requirements of this specification.

a. "The following documents, of exact issue shown, form a part of this specification to the extent specified herein. In the event of conflict between this specification and other documents herein, the requirements of this specification shall prevail".

b. When documents are mentioned elsewhere in this document, revision letters and/or amendment numbers are omitted and only the basic numbers are used.

SPECIFICATIONS

Military

MIL-I-6181D	Interference Control Requirements, Aeronautical Equipment
MIL-I-8500	Interchangeability and Replaceability of Component Parts for Aircraft and Missiles
MIL-W-8604	Welding of Aluminum Alloy, Process for
MIL-B-5087B	Bonding, Electrical, and Lightning Protection, for Aerospace Systems

National Aeronautics and Space Administration (NASA)

No Number	OMSF Experiment General Specification for Hardware Development

George C. Marshall Space Flight Center (MSFC)

MSFC-SPEC-101B	Flammability Requirements and Test Procedures for Materials in Gaseous Oxygen Environment
MSFC-SPEC-164	Cleanliness of Components for use in Oxygen, Fuel, and Pneumatic Systems

SPECIFICATIONS

George C. Marshall Space Flight Center (MSFC) (Con.)

MSFC-SPEC-278B (AMDT-1)	Specification for Electrical Terminals	
MSFC-SPEC-393B (AMDT-1)	Compound, Printed Circuit Board Conformal Coating, Elastomeric	
MSFC-SPEC-40M39513A	Wire, Electrical, Hookup	
MSFC-SPEC-40M39526	Cable, Electrical, Shielded, Jacketed, Specification for	
MSFC-SPEC-85M02716	Preferred Electrical Parts List for Apollo Applications Program (AAP)	
MSFC 10M32447	Human Engineering Design Constraints for AAP Experiments	
MSFC 40M39580	Connectors, Electrical, Zero-G, Specification for	
RS003M00003	Performance and Design Integration Requirements for the Cluster System/Apollo Applications Program, General Specification for	Aug. 8, 1969 and supplements
10M32157	Flights AAP 1 and 2 Manned Systems Test Analysis, Part III	

STANDARDS

Military

MIL-STD-130	Identification Marking of United States Military Property	
MIL-STD-143A	Specification and Standard Order of Precedence for the Selection of	
MIL-STD-163	Electrical Engineering Design Practice, Standard for	
MIL-STD-810B (USAF)	Military Standard Environmental Test Methods for Aerospace and Ground Equipment	June 15, 1967
MS 24123	Plate Identification	
MS 33586A	Metals, Definition of Dissimilar	

George C. Marshall Space Flight Center (MSFC)

MSFC-STD-105A (AMDT-3)	Synthetic Rubber, Age Control of
MSFC-STD-156	Riveting, Fabrication and Inspection, Standard for
MSFC-STD-246A	Design and Operational Criteria Controlled Environment Areas

STANDARDS

George C. Marshall Space Flight Center (MSFC) (Con.)

MSFC-STD-267A	Standard, Human Engineering Design Criteria

PUBLICATIONS

Military

AFSC DH 1-4	Electromagnetic Compatibility
MIL-HDBK-217A	Reliability Stress and Failure
MIL-HDBK-5	Metallic Materials and Elements for Aerospace Vehicle Structures
USN-FARDA	Failure Rate Data Handbook

National Aeronautics and Space Administration (NASA)

NHB 5300.4 (3A)	Requirements for Soldering Electrical Connections
NPC 200-2	Quality Program Provisions for Space Systems Contractors
NPC 200-3	Inspection System Provisions for Suppliers of Space Materials, Parts, Components, and Services
NPC 250-1	Reliability Program Provisions for Space System Contractors

George C. Marshall Space Flight Center (MSFC)

MSFC-PPD-600	MSFC Preferred Parts Document
MSFC-PROC-274A	Terminals, Installation of, Procedure for
MSFC-PROC-293A (AMDT-4)	Polyurethane Conformal Coating, Procedure for Printed Circuit Assemblies
MSFC-85TP1-MR&T-SK-1044	Test Procedure - Qualification Tests for 150 Watt High Intensity Portable Light - Skylab
40M35690	Auxiliary Support Equipment/Cluster Electrical Interface Control Document

Manned Space Center (MSC)

MSC-D-NA-002	Procedures and Requirements for the Flammability and Off-Gassing Evaluation of Manned Spacecraft	July 1968

DRAWINGS

George C. Marshall Space Flight Center (MSFC)

95M10750-1	High Intensity Portable Light
95M10751-1	Bracket Mount

Manned Space Center (MSC)

SEC 39104366	Camera Mount Assembly

(Copies of specifications, standards, drawings, and publications may be obtained from NASA Documentation Repository.)

2.1 SUPERSEDENCE

If any of the specifications, standards, drawings, and publications which form a part of this document are superseded, the later issue may be used provided that the later requirements are equal to or exceed the requirements of this document or of any of the publications forming a part thereof and providing that the terms of the contract are not changed.

2.2 PRECEDENCE

When the requirements of this specification and subsidiary specifications are in conflict, the following precedence shall apply:

a. This specification

b. Specifications referenced herein

c. Specifications subsidiary to those referenced herein

3.0 PERFORMANCE AND DESIGN REQUIREMENTS

3.1 PERFORMANCE

3.1.1 Functional

The functional characteristics of the Light shall be as specified herein.

3.1.1.1 Overall System Requirements

The Light shall be used to illuminate the area at which a particular experiment is to be performed. The primary purpose is twofold, namely, to provide a lighting level sufficient for the astronaut to complete his task, and to provide a lighting level sufficient for obtaining a color or black and white cinematographic record of the astronaut performing his task in a nominal 5.5 Psia environment. Means of holding, mounting, carrying, and operating the Light shall require little or no additional effort on the part of the astronaut. It shall be designed to be hand-held, mountable on a tripod or mountable to portions of the spacecraft structural members. A connecting power cable shall be provided by others with zero-G connectors at each end. There are provisions for a remote control station, but no remote control station shall be provided. Input voltage to the Light shall be 28 +2 or -4 volts DC and per Para. 3.3.2.13. The input power shall be 160 watts maximum at 26.5 VDC.

The Light shall maintain at least 90% of it's peak light output for 30 minutes when operating continuously in air or in a mixture of 70% oxygen and 30% nitrogen at a nominal ambient pressure of 230 mm Hg (about 4.8 Psia) and at rated Light input power of 160 watts. Ambient temperature shall be 25 + 5°C. Peak light is defined as the lumen output of the Lamp at it's optimum operating temperature. Lamps shall reach 75% of peak light within two minutes of operation after a 25°C maximum start.

a. Color Temperature and Chromaticity - Color temperature of the Light at rated full power shall be 5150 ±250°K. C.I.E. chromaticity coordinates shall be $x = 0.337 \pm 0.006$ and $y = 0.324 \pm 0.009$ for essentially equal energy distribution at rated wattage. Spectral energy distribution shall approximate figure 1 within a conformity of ±5% at rated voltage and power after three minutes of operation at 25 ±5°C and normal atmospheric pressure (15 ±1 Psia).

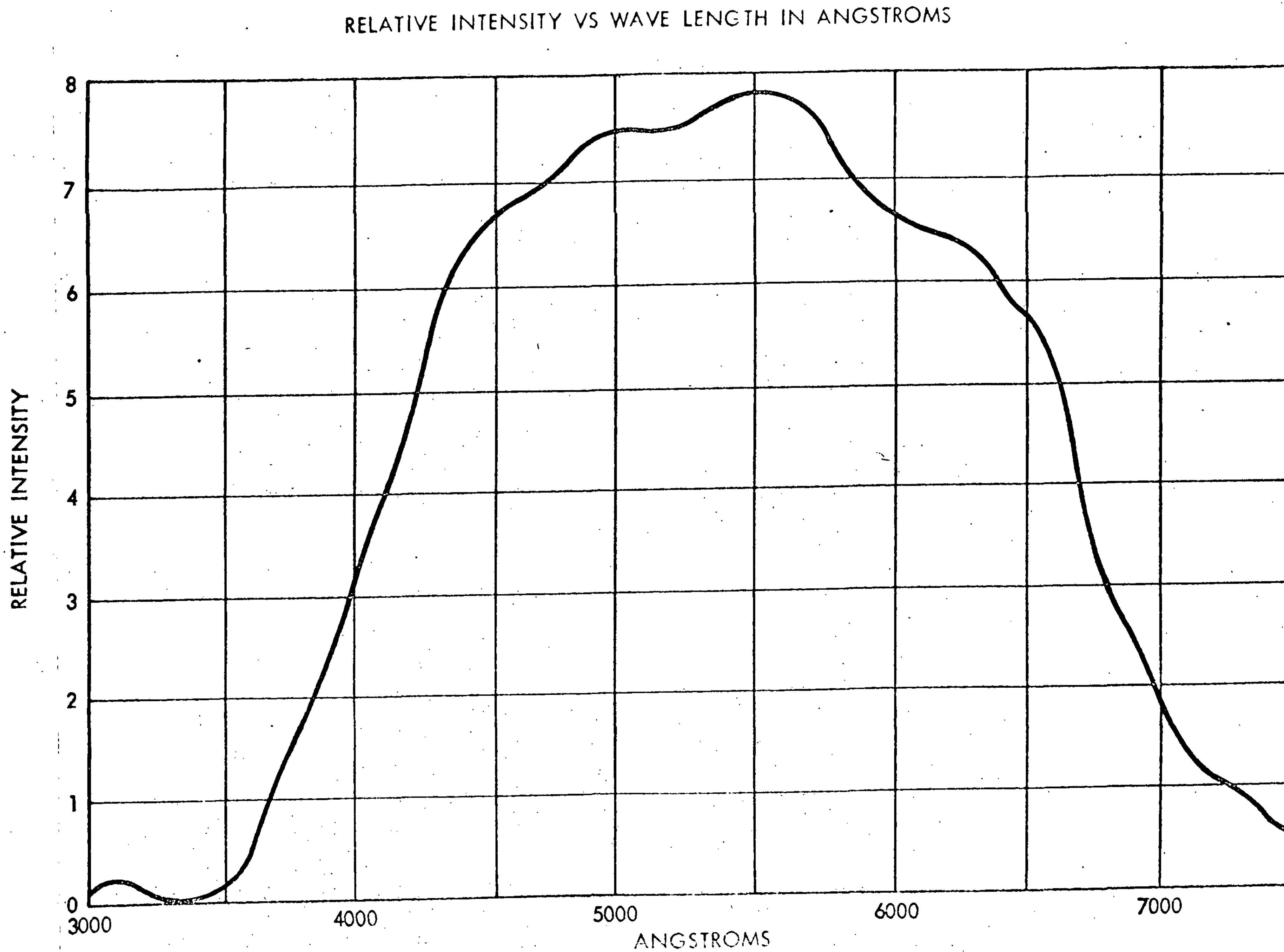

Figure 1. Spectral Energy Distribution

b. Target Illuminance - When operated at rated voltage and power for 30 minutes in an ambient of 25 ± 5°C and 15 $\pm$ 1 Psia, center beam light illuminance, ± 10 degrees, shall not be less than 28-foot candles when measured on a flat plane magnesium oxide target 6 feet $\pm$1 inch (1.83 meters $\pm$2.5 cm) from the face of the Light with a 1/2 degree Photo Research Company spot meter or a calibrated light meter. The rate of illuminance fall-off from center beam out either way 42 inches (106.5 cm) along the axis of the Lamps and 30 inches (76 cm) either way vertical to the axis of the Lamps shall not exceed by 10% the typical distribution of figure 2. For temperature and voltage derating, see figures 3 and 4.

3.1.1.2 Subsystem Requirements

The lighting system shall consist of two independent lighting subsystems in one package. A single power switch shall be provided to isolate both systems from the input power source. One system shall be called System #1 and the other System #2. Each system shall have a high and low mode capability with the following approximate power delivered to the Lamp drivers at rated input voltage.

	LOW MODE	HIGH MODE
System #1	50 Watts	80 Watts
System #2	50 Watts	80 Watts

Control shall be by maintained toggle switches. Each system shall be controlled by an independent 3-position switch. Switch shall be center "STANDBY", down "LOW", and up "HIGH". Operation of the Lamp shall be as follows with the Light connected to a rated power source:

SYSTEM	MODE	APPROXIMATE INPUT POWER TO LIGHT
#1 only	Standby	0 Watts
#1 only	Low	50 Watts
#1 only	High	80 Watts
#2 only	Standby	0 Watts
#2 only	Low	50 Watts
#2 only	High	80 Watts
#1 & #2	Low-Low	100 Watts
#1 & #2	Low-High	130 Watts
#1 & #2	High-High	160 Watts

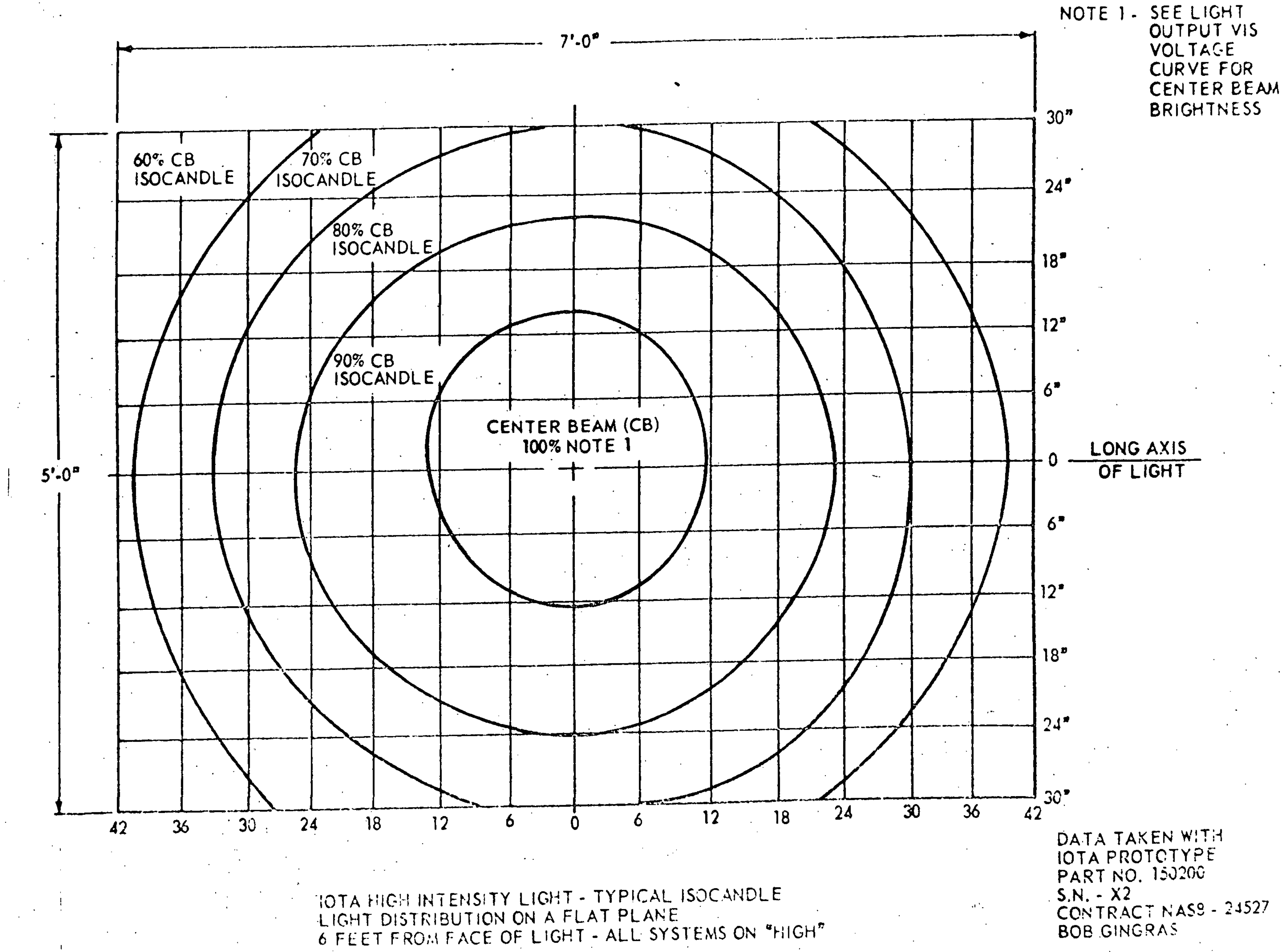

Figure 2. Typical Light Distribution

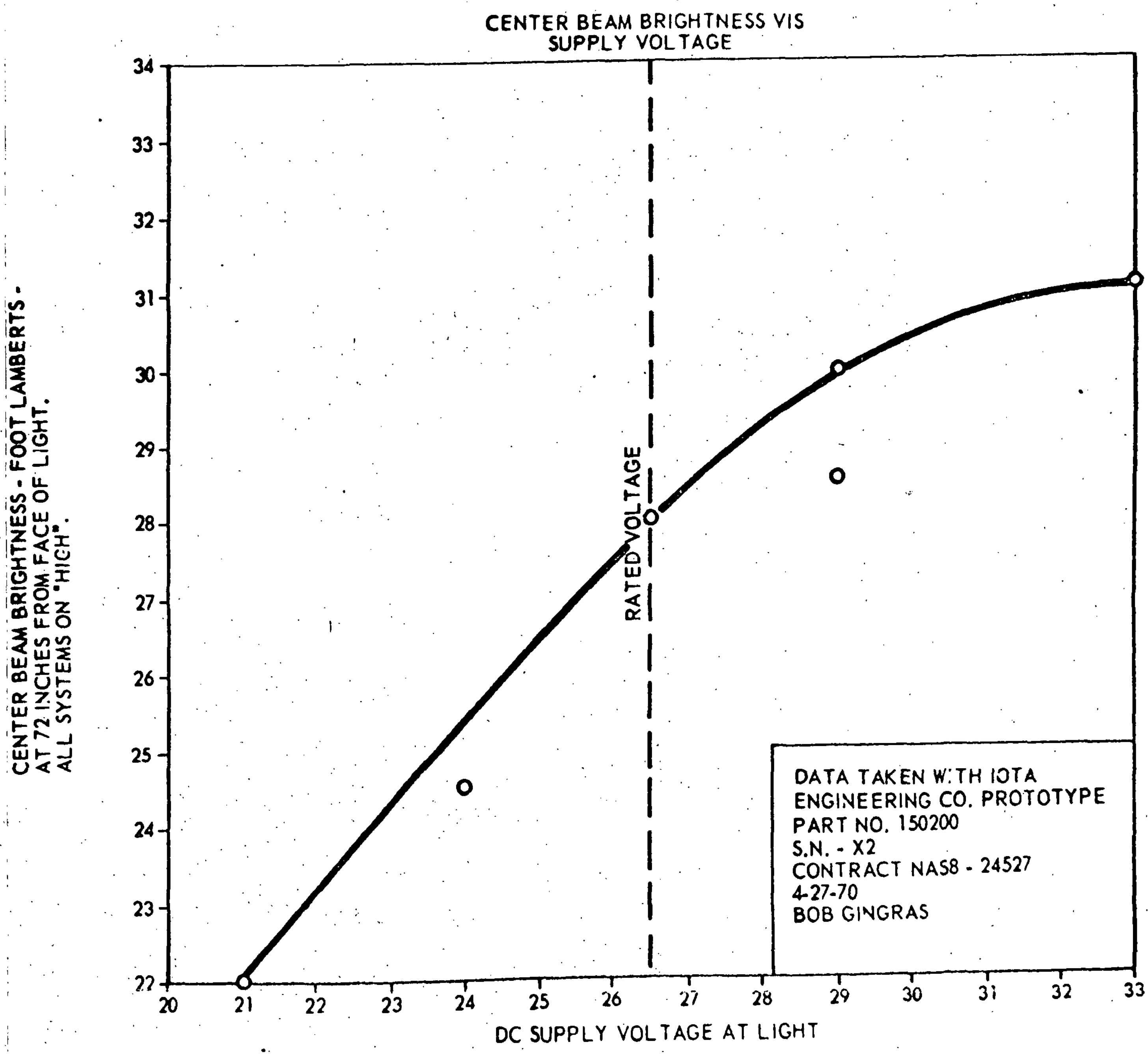

Figure 3. Typical Voltage Derating Curve

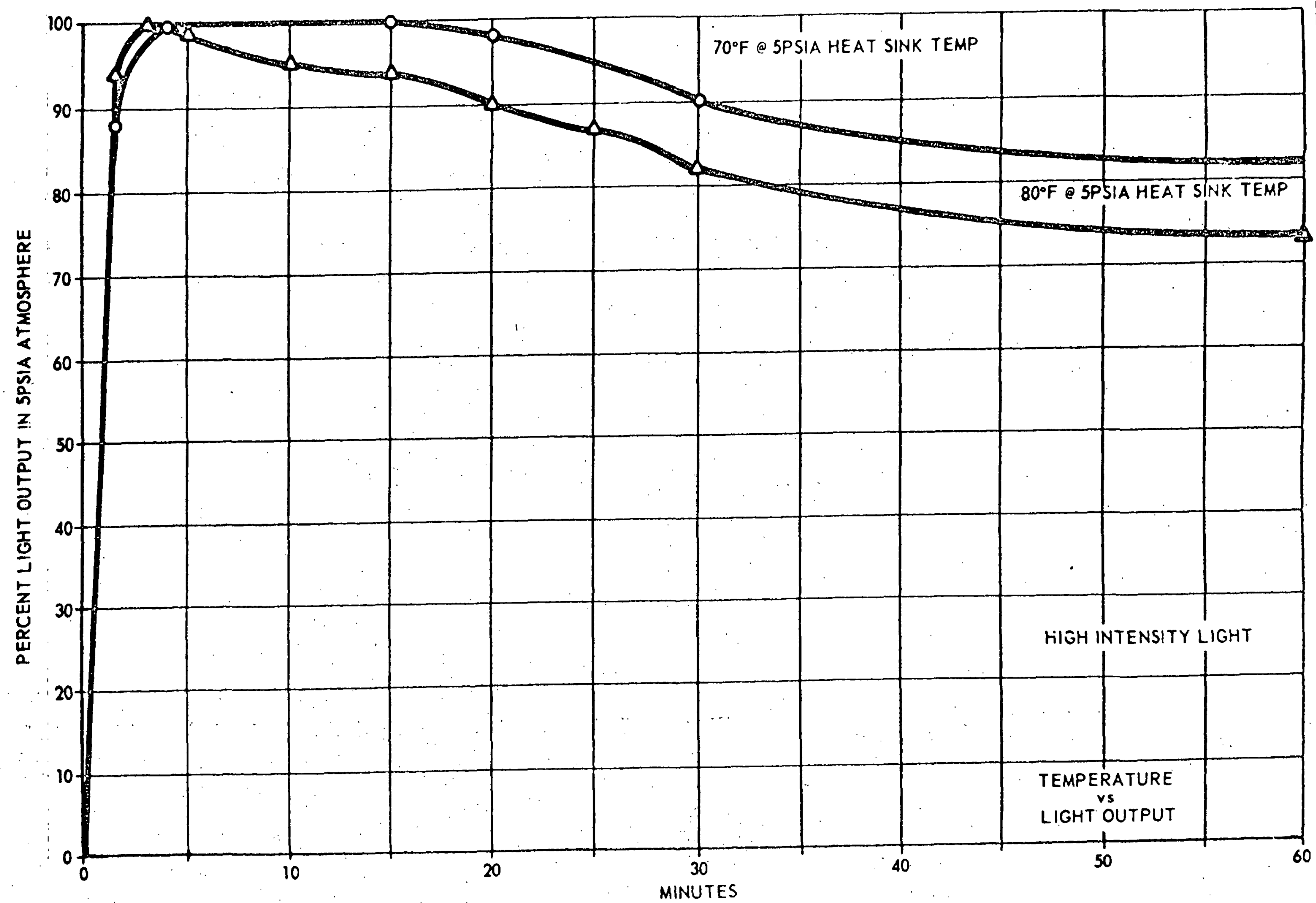

Figure 4. Typical Temperature Derating Curve

3.1.1.2 (Con.)

Switches and controls shall be grouped according to function.

In the event of a power outage, Lamps shall restart automatically upon resumption of power.

Criticality Category - Each subsystem and each component of each subsystem is in criticality category 4.

3.1.1.2.1 Mechanical

All moving parts shall operate satisfactorily in the natural and induced environmental conditions of orbital space flight. All mechanical latches shall be one-hand operation and be positive action. Handles shall be attached as near the center of gravity as possible.

3.1.1.2.2 Electrical/Electronic

The Light shall be designed to perform satisfactorily with a nominal 28 VDC source and power consumption of 160 watts. The unit shall generate no audible signals and be in compliance with MIL-I-6181D.

3.1.1.2.3 Other

Not applicable.

3.1.2 Operability

3.1.2.1 Reliability

The Light shall have a 95 per cent probability of successful operation for 500 hours under the natural and induced environmental conditions specified herein and shall not affect the safety of the crew or delay the launch of the vehicle.

3.1.2.2 Maintainability

3.1.2.2.1 General Requirements

The equipment defined herein shall be designed to:

3.1.2.2.1 (Con.)

a. Minimize the number and complexity of maintenance tasks (i.e., pre/post installation, calibration, adjustment, inspection, etc.)

b. Minimize the number and types of tools and test equipment (standard and special required for maintenance).

c. Optimize the accessibility to all units, assemblies, and sub-assemblies requiring maintenance, inspection, removal, and replacement.

d. Maximize the safety of personnel and equipment involved in the performance of maintenance.

3.1.2.2.2 Additional Requirements for In-Flight Maintainability

Not applicable.

3.1.2.3 Useful Life

Service life requirements will be satisfied provided the Light is designed to meet the requirements of Para. 3.1.2.1 and 3.3.18 of this EIS.

3.1.2.4 Natural Environment

Environmental requirements to which the Light shall be designed shall be in accordance with figure 5, Design Environments, and the Acceptance and Environmental Tests Requirements.

3.1.2.5 Induced Environment

The experiment hardware shall be capable of successfully performing the required function after being subjected to the induced environmental conditions specified below and those of figure 5, Design Environments.

3.1.2.5.1 Vibration

The sinusoidal and random vibration levels to which the Light shall be designed are as follows:

a. Sinusoidal - A logarithmic sweep from 5 to 2000 to 5 Hz

3.1.2.5.1

a. (Con.)

at a rate of one octave per minute in each of three mutually perpendicular axes.

Frequency	Test Level
5 to 48 Hz	0.100 inch D.A. Displacement
48 to 2000 Hz	10g Peak

b. Random - A shaped broad-band random vibration for five minutes in each of three mutually perpendicular axes. The acceleration density input profile is as follows:

Frequency	Test Level
20 to 50 Hz	+6 db/octave
50 to 100 Hz	0.9 g^2/Hz
100 to 270 Hz	-12 db/octave
270 to 500 Hz	0.0172 g^2/Hz
500 to 2000 Hz	-3 db/octave
2000 Hz	0.0043 g^2/Hz

Overall = 12g rms

3.1.2.5.2 Acceleration

The Light shall withstand a centrifugal acceleration of 70 meters per second^2 (7g) in both directions of each of three mutually perpendicular axes.

3.1.2.6 Transportability

Applicable.

EQUIPMENT LIFE PHASE	PRELAUNCH OPERATION & STORAGE	LAUNCH	ORBIT (OPERATIONAL)	ORBIT (STORAGE)
Length of Time	Up to 5 Years	30 Minutes	1st 28 days 2nd 56 days 3rd 30 days	6 Months between
Ambient Temperature	-40^{o} to $160^{o}F$	-40^{o} to $160^{o}F$	0^{o} to $90^{o}F$	-35^{o} to $160^{o}F$
Ambient Pressure (mm Hg)	700 to 1320	1320 to 66 in 10 minutes	315 to 66	315 to 25
Relative Humidity	0 to 100%	0 - 95%	16 - 95%	0 - 100%
Salt Sea Atmosphere	N/A	N/A	N/A	N/A
Sand and Dust	N/A	N/A	N/A	N/A
Fungus	N/A - if non-nutrient to fungi.			
Atmospheric Composition	20% 0_2 & 80% N_2 to 100% 0_2	N/A	70% 0_2 & 30% N_2 to 100% 0_2	100% to 0% 0_2
Shock	20g Design, 4" Corner Drop, Floor Drop	N/A	30g For 11 Milli-seconds any Combination of Axes	N/A
Vibration	See Para. 3.1.2.5	See Para. 3.1.2.5	N/A	N/A
Acceleration	4g All Axes	See Para. 3.1.2.5	N/A	N/A
Acoustic Noise	N/A	SPL of 133 db	74db	N/A
Radio Interference	The equipment will be subjected to radio interference type environment in all areas. The equipment must not be susceptible to, nor be a source of radio interference.			
Electromagnetic Interference	Spec. MIL-I-6181D Interference Control Requirements, Aeronautical Equipment			
Radiation (Rad/day)	N/A	N/A	0.5014	0.5014
Air Movement (ft/min)	N/A	N/A	15 to 100	N/A
Contaninants	MSFC-SPEC-164	N/A	N/A	N/A
Meteoroid	N/A	N/A	N/A	N/A

Figure 5. Design Environments

3.1.2.7 Human Engineering

All knobs, grips, toggles, switch buttons, and handles shall be designed for ease of manipulation by a pressure-suited astronaut. The design shall consider the anthropometric constraints imposed by the astronaut's pressure suit per MSFC Human Factors Specification 10M32447 and MSFC-STD-267A.

Movable handles and knobs must be capable of being manipulated with one hand.

3.1.2.8 Safety

In the event of breakage of a Lamp, reasonable precaution shall be taken to prevent particles of glass, mercury, etc. from escaping the Lamp. No glass particles larger than 50 microns shall escape the Light. Mercury vapor escapement shall not exceed 0.004 milligrams total per Lamp in the event of Lamp breakage while it is installed in its approved mounting. Refer to Para. 3.3.1.2 and 3.3.2.14.

3.2 INTERFACE REQUIREMENTS

The interface requirements shall be as specified herein. Refer to Para. 3.2.5.

3.2.1 Flight Hardware

The Flight Hardware shall be designed to be physically and functionally compatible with the Skylab. This aspect of the hardware design shall be controlled through the applicable coordinated and approved interface specifications and drawings.

3.2.1.1 Flight Vehicle Interfaces

Applicable.

3.2.1.1.1 Location, Envelope, Weight, and Center of Gravity

The location, envelope, weight, and center of gravity for each of the following conditions shall be specified on referenced Dwg. Nos. 95M10750, 105200.

a. Stowed for launch - Refer to ICD 13M13410 and 1-SL-002 Skylab Stowage List.

b. Mounted for flight experiments - Not Critical.

3.2.1.1.1 (Con.)

c. Stowed/mounted while not in use - Not Critical.

d. Stowed and/or mounted for return and recovery - Not applicable.

3.2.1.1.2 Structural

The requirements for stowing, mounting, attaching, and/or re-stowing shall be in accordance with referenced drawings indicated in Para. 3.2.1.1.1.

The Light shall be equipped with a removable bracket for attachment to top, sides, or bottom of Light. The bracket shall have provisions for attachment to camera mount assembly, MSC Dwg. SEC 39104366. Refer to Para. 3.2.5.

3.2.1.1.3 Fluid (Gas and Liquid)

Not applicable.

3.2.1.1.4 Electrical

a. Stowed for launch - Not applicable.

b. Mounted for flight experiments - Light requires a 7.5 ampere circuit at 28 +2 or -4 VDC. Vehicle electrical receptacle shall mate with MSFC-40M39580, type ZG6E-1717-6PA, power cable connector.

Connection shall be wired as follows:

PIN	FUNCTION
A	28 VDC Return
B	28 VDC Return
C	+28 VDC Power
D	+28 VDC Power
E	Ground
F	Spare

3.2.1.1.4 (Con.)

c. Stowed/mounted while not in use - Not applicable.

d. Stowed and/or mounted for return and recovery - Not applicable.

3.2.1.1.5 Communications and Instrumentation

Not applicable.

3.2.1.1.6 Environmental Control

a. Stowed for launch - Not applicable.

b. Mounted for experiments - Maximum touch temperature of 105°F cannot necessarily be maintained continuously if the ambient air and vehicle wall temperature exceeds 80°F in a 5.5 Psia atmosphere. See Para. 3.3.2.14.

c. Stowed/mounted while not in use in the Skylab - Not applicable.

d. Stowed and/or mounted for return and recovery - Not applicable.

3.2.1.1.7 Controls and Displays

Not applicable.

3.2.1.1.8 Lighting

Not applicable

3.2.1.1.9 Other

Not applicable.

3.2.1.2 Interfaces with Other Experiments

Specified in Task Analysis Report for AAP-1 and -2, 10M32157.

3.2.1.3 Ground Communications Interfaces

Not applicable.

3.2.1.4 Flight Crew Interfaces

Flight crew interface requirements are as specified in Para. 3.1.2.7 and all uses and manipulations required of the Light will be specified in Task Analysis Report for AAP 1 and 2, 10M32157.

3.2.1.5 Mission Interfaces

Thermal - Refer to Para. 3.2.1.1.6.b.

3.2.1.6 Ground Support Equipment (GSE) Interfaces

The Light shall be designed so that standard tools and test equipment may be used to the greatest possible extent to accomplish all necessary adjustments and maintenance. For performance verification the following test equipment will be required: One-half degree brightness spot meter, 5% accuracy, Standard brightness source, 2% accuracy, Spectroradiometer, 400 to 700 nanometers, 99% reflectance target, Color temperature attachment for spot meter, and Closeup lens for brightness spot meter.

3.2.1.7 Facility Interfaces

Not applicable.

3.2.2 Zero Gravity Type Training Hardware

Flight equivalent or prototype units shall serve as zero gravity training hardware.

3.2.3 Neutral Buoyancy Type Training Hardware

Not applicable

3.2.4 Simulator Type Training Hardware

Shall be as indicated herein.

3.2.4.1 Simulation Devices

Flight equivalent type hardware shall be utilized.

3.2.4.2 Simulators

Not applicable.

3.2.5 Interface Control Document List

MSFC Publication 40M35690 - Auxiliary Support Equipment/ Cluster Electrical Interface Control Document.

13M13410 - Portable High Intensity Photo Lamp to OWS Mechanical Requirements, Stowage.

3.3 DESIGN AND CONSTRUCTION

Light shall be designed for ease of assembly and disassembly. Lamps shall be replaceable as a unit, i.e., all Lamps, their housing, and protective lens shall be replaceable as a unit. Modular units shall in turn be repairable by skilled electrical technician using standard tools.

a. The light covered by this EIS shall be designed in accordance with the requirements of this specification and shall be capable of operating as specified by the performance requirements herein.

b. The Light assembly, less removable handles, shall be compactly designed with a maximum volume of 19,000 cm^3 (1150 $in.^3$).

c. A power cable shall be provided by others for connection of the Light to the 160 watt power source. The cable shall be equipped with zero-G connectors on both ends.

d. For electrical schematics and complete details, refer to:

(1)	High Intensity Portable Light	95M10750
(2)	Bracket Mount	95M10751-1
(3)	Electrical Schematic Iota Engineering, Inc. Tucson, Arizona (See EIS Part II, Para. 3.2.)	150138

3.3.1 Mechanical

3.3.1.1 Rigging Devices

Not applicable.

3.3.1.2 Shatterable Material

Shatterable material shall not be used unless positive protection is provided to assure essentially zero percent dispersion under the normal or induced conditions specified herein. Refer to Para. 3.1.2.8 for better definition.

3.3.1.3 Restriction on Coatings

Surfaces of hardware shall not be painted, coated, or finished with materials which are subject to flaking under the normal and induced conditions stated herein.

3.3.1.4 Decompression

Hardware shall be designed to withstand rapid decompression without damage. Rapid decompression is defined as a pressure drop from 5.5 Psia to 1×10^{-3} Psia in 5 seconds.

3.3.1.5 Mechanical Locks

All handling and mounting devices shall have positive mechanical locking provisions to prevent accidental release. Release of handles and mounting provisions shall be by one hand operation.

3.3.1.6 Weight and Size

Maximum mass (weight) of the Light assembly, less removable handles, shall be 6.3 Kg (14 pounds) maximum. For weight and size of complete unit, refer to MSFC Dwg. 95M10750.

3.3.1.7 Factors of Safety

3.3.1.7.1 Structural

Applicable.

3.3.1.7.2 Fluid Systems (Gas and Liquid)

Not applicable.

3.3.1.8 Lubrication

Hardware shall be designed so that no lubrication is required.

3.3.2 Electrical and Electronic

All electrical connectors for interfacing with an astronaut shall be zero-G type per MSFC-SPEC 40M39580. Contractor shall furnish dummy plugs and receptacles as required to protect the wired receptacles and store the dummy plugs. Dummy plugs shall be captive by use of flexible wire covered with an approved non-metallic sheath or a MSFC approved substitute method.

a. Lamp Power Converter Efficiency - Efficiency of each Lamp power converter and Lamp combination, actual power transferred, shall not be less than 70%.

$$\frac{\text{Power into Lamp}}{\text{Power into converter}} \times 100 = 70\%$$

b. Fail Safe Power Converter Circuitry - It is mandatory that the power converter circuitry shall be designed to limit current to safe limits in the event of a Lamp failure. Circuit breakers shall not be acceptable as a current limiting device for failure-to-light overloads.

3.3.2.1 Flammability of Wiring Insulation, Materials, and Accessories

Insulation used in wiring shall not be capable of sustaining combustion after removal of the source of ignition or following melting of the electrical conductor by high currents such as those resulting from short circuits or circuit breaker failures. Insulation on conductors subjected to these high currents shall not be capable of igniting the insulation on other conductors which may be in contact with it. This requirement does not apply to wiring which is completely isolated from the compartment atmosphere by potting or hermetic sealing. Materials and accessories associated with wiring, such as potting, bundle ties, bundle chafe guards, heat shrinkable tubing, protective covering, solder sleeves, cable clamps and bundle identification tags that are in contact with electrical wire bundles, shall meet these flammability requirements.

3.3.2.2 Toxicity of Wiring Insulation, Materials and Accessories

Applicable, except change word nominal to normal in first sentence, change last part of second sentence to read "meet the requirements of MSC-D-NA-0002 test Nos. 6 and 7", and delete third sentence.

3.3.2.3 Electrical Connectors - Keying

All electrical plugs and receptacles shall be positively keyed to prevent interconnection with other accessible plugs or receptacles. Connectors shall be per MSFC Spec 40M39580.

3.3.2.4 Electrical Connectors - Pin Assignment and Pin or Socket Selection

a. Electrical circuits shall not be routed through adjacent pins of an electrical connector if a short circuit between them would constitute a single point failure as defined in Section 3.3.7.

b. Cable connections shall be designed so that pin and socket connectors are properly used to prevent power from shorting to ground. They also shall be designed to protect personnel when connected or disconnected and during the operations of connection and disconnection.

3.3.2.5 Electrical Connectors - Protective Covers or Caps

Protective caps shall be provided for electrical plugs and receptacles.

The protective caps shall:

a. Applicable.

b. Applicable.

c. Applicable.

d. Not applicable.

e. Applicable.

f. Be made of material which is compatible with the connector materials.

3.3.2.6 Materials Detrimental to Electrical Connectors

Materials containing or coated with substances which are detrimental to metals used in electrical connectors shall not be used adjacent to exposed electrical contact surfaces. Specifically included in this category are materials containing or coated with sulfides or free sulfur.

3.3.2.7 Electrical and Electronic Piece Parts - Closure

Applicable.

3.3.2.8 Protection of Exposed Electrical Circuits

All exposed connection points shall be capped by a captive cover when not in use and provided with a dummy receptacle to store cap when circuit is in use.

3.3.2.9 Protection of Electrical and Electronic Devices

The Light shall incorporate protection against reverse polarity or other improper electrical inputs during qualification, acceptance, and other tests.

3.3.2.10 Corona Suppression

Electrical and electronic systems and components shall be designed so that proper functioning will not be impaired by corona discharge under any of the required operating conditions and shall not be a source of corona which will adversely affect other equipment.

a. Not applicable.

b. Not applicable.

3.3.2.11 Moisture Protection of Electrical and Electronic Devices

Applicable.

3.3.2.12 Redundant Electrical Circuit

Not applicable.

3.3.2.13 Electrical Operating Requirements

a. Hardware shall operate on direct current ranging from 24 to 30 volts. It shall withstand continuous operation on under voltage ranging from 21 to 24 volts or an over voltage ranging from 30 to 33 volts without damage, and shall give specified performance upon return to the rated operating voltage after temperature stabilization. The hardware shall withstand voltage transients not to exceed $\pm$50V about 28 VDC with a pulse width not to exceed 10 microseconds.

b. The Hardware shall be capable of recovery to specified performance after momentary interruptions of all power.

c. The Hardware shall not be damaged by a 1 volt peak-to-peak ripple voltage on the input power at a frequency ranging from 20 to 20K Hz.

d. Power Requirements - Rated power and voltage

Rated Voltage:	26.5 VDC
Rated Wattage:	160 Watts maximum

e. Electrical resistance from Light housing to ground pin in electrical power connector shall not exceed two (2) milliohms (.002 ohms) per MIL-B-5087-B, Class R.

3.3.2.14 Temperature Control

The maximum astronaut Touch Temperature shall not exceed 105°F after 45 minutes operation into a 80°F (27.7°C) maximum heat sink at 4.8 +1-0 psia. Touch Temperature shall be defined as the temperature of Light surfaces which would be touched by operator during normal operational handling. System #2 HIGH & LOW modes shall be automatically switched off if the temperature of the most critical electrical component approaches its rated temperature upper limit. Restart, after cooling, shall be initiated by manually switching "ON" the System #2 reset switch.

3.3.2.15 Wiring Splicing

Splicing of wires shall be forbidden.

3.3.2.16 Wire Bundle and Harness Protection

All wire bundles and harnesses shall be designed to withstand anticipated handling, including disconnection and reconnection, and operating deformations without damage to the wires, insulation, or electrical connections. Wire smaller than 22 gauge shall not be used in wire bundles. Routing and installation of all wire bundles and harnesses shall be specified on the drawings. Special precautions shall be taken to prevent damage as a result of extreme temperature conditions, chafing or any other conditions that may result in damage.

3.3.3 Fluid (Gas and Liquid)

Not applicable.

3.3.4 Debris Protection

Applicable.

3.3.5 Cleanliness

Flight hardware shall be fabricated under conditions of 100,000 level, or better clean room per MSFC-STD-246A. Qualification hardware shall be fabricated under conditions of NHB 5300.4 (3.A).

3.3.6 Test Provisions

3.3.6.1 Test Points

Test points, where necessary, shall permit planned tests to be made without disconnecting electrical connectors which are normally connected in flight.

3.3.6.2 Test Equipment

Applicable.

3.3.7 Single Point Failures

Hardware shall be designed so that a single point failure will not affect astronaut or ground personnel safety, cause loss of a flight vehicle/module, prevent or compromise accomplishment of a primary mission objective or cause a launch to be rescheduled.

3.3.8 Redundancy

3.3.8.1 Separation of Redundant Paths

Not applicable.

3.3.8.2 Redundant Paths - Verification of Operation

Not applicable.

3.3.9 Selection of Specifications and Standards

a. Specifications and Standards for all materials, parts, and government certification and approval of processes and equipment, which are not specifically designated herein and which are necessary for the execution of this specification, shall be selected in accordance with MIL-STD-143.

b. Wire, Cable, Soldering, Insulation, Components, and Assemblies - These materials shall be capable of meeting the environmental, reliability, and load requirements specified herein. Applicable Military, MSFC, and MSC documents are:

MSFC-STD-163	Electrical Engineering Design Standard for
MSFC-SPEC-40M39513A	Wire, Electrical, Hookup
MSFC-SPEC-40M39526	Cable, Electrical, Shielded, Jacketed, Specification for
MSFC-SPEC-85M02716	Preferred Electrical Parts List for AAP
NHB 5300.4(3A)	Requirements for Soldering Electrical Connections
MSFC-SPEC-101B	Flammability Requirements and Test Procedures for Materials in Gaseous Oxygen Environments
MSFC-PROC-274A	Terminals, Installations of, Procedure for
MSFC-SPEC-278B (AMDT-1)	Specification for Electrical Terminals
MSFC-PROC-293A (AMDT-4)	Polyurethane Conformal Coating, Procedure for Printed Circuit Assemblies

3.3.9

b. (Con.)

MSC-D-NA-0002	Procedures and Requirements for the Flammability and Off-Gassing Evaluation of Manned Spacecraft, July 1968
MSFC-SPEC-393	Compound, Printed Circuit Board, Conformal Coating, Elastomeric
MSFC-STD-154A	Supplement 1 - Standard, Printed Circuit Design and Construction

3.3.10 <u>Materials, Parts and Processes</u>

a. Materials used in the fabrication of all components shall be of the highest quality and lightest weight compatible with the design requirements of this specification and shall conform to applicable government specifications and as specified herein; contractor's use of materials for which no government specification exists and which are not covered herein shall require prior written approval by MSFC. Contractor's requests for approval to use non-standard materials shall include sufficient supporting data to permit MSFC's analysis and evaluation of the intended usage. The use of magnesium and titanium is prohibited.

b. Dissimilar Metals - Unless suitably protected against electrolytic corrosion, dissimilar metals as defined in MS 33586A, such as brass, copper, or steel shall not be used in intimate contact with aluminum or it's alloys. Any protection used shall offer a low impedance path to radio frequency currents.

c. All screws and fasteners having cross recess type heads shall be of the (Frearson/Phillips) recessed type. This shall apply to mounting screws, cover plate screws, and other fasteners normally removed by service personnel while servicing, repairing, or replacing equipment in the field. However, hi-torque recess flush bolts are preferred over Frearson/Phillips recessed type bolts in all structural applications. Frearson/Phillips recessed type bolts shall in no case be specified in any

3.3.10

c. (Con.)

application where the ultimate tension load exceeds 25% of the nominal bolt tension strength. Any screws holding modular sub-assemblies which could be changed out in flight shall be hex socket 5/32 inch hex socket wrench.

3.3.10.1 Toxicity of Materials

Whenever the use of inflammable or non-heat resistant material cannot be avoided, the material shall be of such composition that it will not liberate toxic fumes or noxious odors when the material is burned or exposed to the temperatures specified herein or the maximum inherent temperature of the equipment when operating as specified herein. Material used in equipment under the service condition specified herein shall not liberate gases which will combine with the atmosphere (air at one atmosphere and 100% oxygen at five psia) to form acid or corrosive alkali or an explosive or combustible mixture. Equipment utilizing any material which temporarily liberates fumes or any volatile matter shall be preconditioned by some suitable process, such as baking, to expel all such matter prior to shipment. Such expulsion shall be permanent under the service conditions specified herein. The use of non-metallic materials shall be subject to MSFC written approval and shall be tested, as required, per MSFC-SPEC-101 "Flammability Requirements and Test Procedures for Materials in Gaseous Oxygen Experiments".

3.3.10.2 Restriction on Use of Transistors and Capacitors.

Point contact, grown junction, or alloy junction transistors shall not be used unless approved by MSFC.

3.3.10.3 Soldering

Applicable.

3.3.10.4 Welding

3.3.10.4.1 Resistance Welding

Applicable.

3.3.10.4.2 Fusion Welding

All fusion welding shall conform to requirements of MIL-W-8604.

3.3.10.5 Ultrasonic Processes

3.3.10.5.1 Cleaning

Ultrasonic vibration shall not be used as a method for cleaning electronic assemblies of this Light.

3.3.10.6 Etching of Wire Insulation for Potting

Applicable, except delete word "experiment" in first sentence and add word "lighting" instead.

3.3.10.7 Adhesive Bonding

All adhesive bonding shall be per MSFC specifications and procedures.

3.3.10.7.1 Adhesives, Encapsulation, and Coating

Where adhesives, potting foam encapsulation or conformal coating is applied to lighting equipment, the materials, application process and process controls shall be per referenced documents of Para. 3.3.9 or per approved contractor procedures.

3.3.10.8 Restriction on Use of Mercury

Refer to Para. 3.1.2.8.

3.3.10.9 Brazing

Applicable.

3.3.10.10 Engraving

Applicable.

3.3.10.11 Riveting

Not Applicable.

3.3.11 Standard Parts

AN or MS parts shall be used whenever they are suitable for the purpose and shall be identified by their part numbers. Commercial utility parts, such as screws, bolts, nuts, cotter pins, etc., may be used provided they have suitable properties and are replaceable by the AN or MS parts without alteration and provided the corresponding AN or MS part numbers are referenced on the drawings and in the parts list. In applications for which no suitable corresponding AN or MS parts are in effect on date of invitation for bids, commercial parts may be used provided they conform to the requirements of this specification.

3.3.12 Fungus Resistance

Applicable, except delete words "experiment hardware" from first sentence and words "when tested in accordance with paragraph 6.2.3.7 of the EGS" from last sentence.

3.3.13 Corrosion Prevention

Materials shall be of a corrosion resistant type or suitably processed to resist corrosion. Alternate materials and processes shall be subject to MSFC approval.

3.3.14 Interchangeability and Replaceability

All parts having the same manufacturer's part number shall be directly and completely interchangeable with each other with respect to installation and performance. Detail components, other than those utilized in test samples, shall not be considered interchangeable unless such substitutions are substantiated by the equipment manufacturer and approved by MSFC. Physical interchangeability shall be in accordance with MIL-I-8500.

3.3.15 Workmanship

All machined surfaces shall have a smooth finish and details of manufacture, including the preparation of parts, subassemblies and accessories, shall be in accordance with the best practice for high quality electrical equipment and specific references in this specification.

3.3.16 Electromagnetic Interference

a. Electrical and Electronic Interference - The Light shall be designed such that the generation of radio interference by the overall system and the susceptibility of the system to radio interference, shall be controlled to the maximum practical extent using MIL-I-6181D as a guide toward this end. Mutual interference between units of the system shall not prevent satisfactory operation of the system as defined herein.

b. Applicable.

c. Applicable.

d. Applicable.

e. Applicable.

f. Reflected Ripple - Reflected ripple shall not exceed ±1 millivolt peak for each watt of steady state power required by the Light.

3.3.17 Identification and Marking

a. A nameplate conforming to the requirements of MS 24123 and permanently marked in accordance with the requirement of MIL-STD-130, shall be permanently attached to each part requiring separate installation by MSFC. Sheet metal nameplates and structure to support nameplates, only, shall not be used. Metal engraving, if used, shall not compromise the structural and installation integrity of the equipment. Metal stamped and engraved nameplates may be used. The nameplate shall contain the following information:

(1) Nomenclature
(2) Serial Number
(3) Manufactured by
(4) For (Government Agency)
(5) Per (Applicable NASA Contract Number)
(6) Seller's Part Number
(7) Seller's Model Number (if applicable)
(8) "US"

Information such as voltage, power, and current will be included.

3.3.17

a. (Con.)

(9) Assembly Date - Each part requiring serialization under this paragraph shall be marked with the assembly date. The assembly date shall consist of the abbreviation "ASSEM" followed by the numerical designation for the quarter and year separated by "Q" (Example: "ASSEM 2Q69" indicates that the assembly date is in the second quarter of 1969). The assembly date may be included on the nameplate.

b. Applicable.

c. Applicable.

d. Wires and cables shall not be identified by hot stamping directly onto primary or secondary (shield) insulation.

3.3.18 Storage

The equipment defined herein shall have storage life of no less than 60 months as a design goal without parts replacement or maintenance. After 60 months, it shall have the capability of meeting the specified performance and reliability requirements for no less than the total specified service life. The contractor shall notify MSFC, in writing, of any post storage special conditioning, reforming, etc. which may be necessary to effect specified operation following storage. Such procedures shall be subject to MSFC Technical Supervisor approval.

3.3.19 Pyrotechnic Devices

Not applicable.

4.0 TEST/PRODUCT ASSURANCE REQUIREMENTS

An effective reliability engineering program shall be maintained to satisfy the following paragraphs of NASA Reliability Publication NPC 250-1, "Reliability Program for Space System Contractors":

a. 3.2 Design Specifications

b. 3.3 Reliability Prediction and Estimation

c. 3.4 Failure Mode, Effect, and Criticality Analyses

d. 3.5 Maintainability and Elimination of Human-Induced Failures

e. 3.6 Design Review Program

f. 3.8 Standardization of Design Practices

An Inspection System shall be maintained that will satisfy the requirements of NASA Quality Publication NPC 200-3, "Inspection System Provisions for Suppliers of Space Materials, Parts, Components, and Services". Paragraph 3.2 of NPC 200-3 shall be changed to read as follows:

> When Government Source Inspection is required, purchase orders shall include the following statement: "All work on this order is subject to inspection and test by the Government at all times and places. The Government representative who has been delegated NASA quality assurance functions on this procurement shall be notified immediately upon receipt of this order." All other orders shall include the following statement: "The Government reserves the right to inspect any or all of the work included in this order at the supplier's plant." The inspection plan shall be expanded to include provisions for compliance with sub sections 4.1 and 4.2.1 of NPC 200-2 "Quality Program Provisions for Space Systems Contractors."

4.1 VERIFICATION MATRIX

The verification matrix is shown in Figure 4.1.

4.2 TEST TYPES

4.2.1 Development

4.2.1.1 Assessment

4.2.1.1.1 Analysis

3.1.2.1, 3.3.1.7.1, 3.2.2.6, 3.3.2.15, 3.3.10, 3.3.10.1, 3.3.13, 3.3.14, 3.3.18

4.2.1.1.2 Demonstration

3.3.2.1, 3.3.2.2, 3.3.2.4, 3.3.2.8, 3.3.2.16, 3.3.4, 3.3.5, 3.3.10.2, 3.3.10.3, 3.3.10.4.1, 3.3.10.4.2, 3.3.10.6, 3.3.10.7, 3.3.10.7.1, 3.3.10.9, 3.3.10.10, 3.3.11, 3.3.15

4.2.1.2 Test

4.2.1.2.1 Functional

4.2.1.2.2 Mechanical

4.2.1.2.3 Electrical/Magnetic

3.3.2

4.2.1.2.4 Environmental

4.2.1.2.5 Life

4.2.1.2.6 Off-Limits

3.1.2.8, 3.3.1.2

4.2.2 Qualification

The qualification tests for the qualification test hardware shall be performed as specified in MSFC test procedure 85TP1-MR&T-SK-1044, Revision A dated January 25, 1972.

4.2.2.1 Assessment

4.2.2.1.1 Similarity

4.2.2.1.2 Analysis

3.3.2.2, 3.3.6.2, 3.3.12

4.2.4.1.3 Inspection

3.3, 3.3.1.3, 3.3.2.3, 3.3.17

4.2.2.1.4 Demonstration

3.1.1.1, 3.1.1.2, 3.3.1.6

4.2.2.2 Test

4.2.2.2.1 Functional

3.1.1.1, 3.1.1.2

4.2.2.2.2 Mechanical

3.1.1.2.1

4.2.2.2.3 Electrical/Magnetic

3.1.1.1, 3.1.1.2, 3.1.1.2.2, 3.3.2.9, 3.3.2.10, 3.3.2.13, 3.3.6.1, 3.3.16

4.2.2.2.4 Environmental

3.1.1.2.1, 3.2.1.1.6, 3.3.1.4, 3.3.2.11, 3.3.2.14, 3.3.10.7.1, 3.3.12

4.2.2.2.5 Life

3.1.2.1, 3.1.2.3

4.2.2.2.6 Off-Limits

4.2.3 Reliability

4.2.3.1 Assessment

4.2.3.1.1 Analysis

3.3.7

4.2.3.2 Test

4.2.4 Other Tests

4.2.4.1 Integrated Systems

4.2.4.1.1 Assessment

4.2.4.1.1.1 Analysis

3.1.1.1, 3.2.1.1.6

4.2.4.1.1.2 Inspection

3.3.2.3, 3.3.2.5

4.2.4.1.1.3 Demonstration

3.1.1.1, 3.1.1.2.1, 3.1.2.7, 3.2.1.1.1, 3.2.1.1.2, 3.2.1.1.4, 3.2.1.1.6, 3.2.1.2, 3.2.1.4, 3.3.1.5, 3.3.2.3

4.2.4.1.1.4 Validation of Records

4.2.4.1.2 Test

4.2.4.1.2.1 Functional

4.2.4.1.2.2 Mechanical

4.2.4.1.2.3 Electrical/Magnetic

3.1.1.2.2, 3.2.1.1.4, 3.3.16

4.2.4.2 Flight Verification

Not applicable.

4.2.4.3 Post Flight

Not applicable.

4.3 REJECTION

Rejection for failure is required when a test article is unable to perform its required functions as defined in MSFC 85TP1-MR&T-SK-1044, Test Procedure.

4.3.1 Qualification Failure

Applicable.

4.3.2 Reliability Test Failure

Applicable.

5.0 DATA LIST

Applicable.

6.0 PREPARATION FOR DELIVERY

Applicable.

7.0 NOTES

Not applicable.

Nomenclature	Criticality Category	End item No.
High Intensity Portable Light	4	95M10750-1

Requirements for Verification

TEST TYPES

- A - Development
- B - Qualification
- C - Reliability
- D - Integrated Systems
- N/A - Not Applicable

VERIFICATION METHODS

1. Test
   - a. Functional
   - b. Mechanical
   - c. Electrical/Magnetic
   - d. Environmental
   - e. Materials Compatibility
   - f. Life
   - g. Off Limits
   - h. Combined Tests
2. Assessment
   - a. Similiarity
   - b. Analysis
   - c. Inspection
   - d. Demonstration
   - e. Validation of Records

Section 3.0 Performance/Design Requirement Reference	Test Types/Verification Methods A	B	C	D	N/A	Section 4.0 Test Assessment Requirement
3.0 Performance & Design Requirements					X	
3.1 Performance					X	
3.1.1 Functional					X	
3.1.1.1 Overall System Requirements		1a 1c 2d		2b 2d		
3.1.1.2 Subsystem Requirements		1a 1c 2d				
3.1.1.2.1 Mechanical		1b 1d		2d		
3.1.1.2.2 Electrical/Electronic		1c		1c		
3.1.1.2.3 Other					X	

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Figure 4-1

	A	B	C	D	N/A	
3.1.2 Operability					X	
3.1.2.1 Reliability	2b	1f				
3.1.2.2 Maintainability					X	
3.1.2.2.1 General Requirements					X	
3.1.2.2.2 Additional Requirements for In-Flight Maintainability					X	
3.1.2.3 Useful Life		1f				
3.1.2.4 Natural Environment					X	
3.1.2.5 Induced Environment					X	
3.1.2.6 Transportability					X	
3.1.2.7 Human Engineering				2d		
3.1.2.8 Safety	1g					
3.2 Interface Requirements					X	
3.2.1 Flight Hardware					X	
3.2.1.1 Flight Vehicle Interface					X	
3.2.1.1.1 Location, Envelope, Weight, and Center of Gravity				2d		
3.2.1.1.2 Structural				2d		
3.2.1.1.3 Fluid (Gas & Liquid)					X	
3.2.1.1.4 Electrical				1c 2d		
3.2.1.1.5 Communications and Instrumentation					X	
3.2.1.1.6 Environmental Control		1d		2b 2d		

	A	B	C	D	N/A	
3.2.1.1.7 Controls & Displays					X	
3.2.1.1.8 Lighting					X	
3.2.1.1.9 Other					X	
3.2.1.2 Interface with Other Experiments				2d		
3.2.1.3 Ground Communications Interfaces					X	
3.2.1.4 Flight Crew Interfaces				2d		
3.2.1.5 Mission Interfaces					X	
3.2.1.6 Ground Support Equipment (GSE) Interfaces					X	
3.2.1.7 Facilities Interfaces					X	
3.2.2 Zero Gravity Type Training Hardware					X	
3.2.3 Neutral Buoyancy Type Training Hardware					X	
3.2.4 Simulator Type Training Hardware					X	
3.2.4.1 Simulation Devices					X	
3.2.4.2 Simulators					X	
3.2.5 Interface Control Document List					X	
3.3 Design & Construction		2c				
3.3.1 Mechanical					X	
3.3.1.1 Rigging Devices					X	
3.3.1.2 Shatterable Material	1g					
3.3.1.3 Restrictions on Coatings		2c				
3.3.1.4 Decompression		1d				

	A	B	C	D	N/A	
3.3.1.5 Mechanical Locks				2d		
3.3.1.6 Weight and Size		2d				
3.3.1.7 Factors of Safety					X	
3.3.1.7.1 Structural	2b					
3.3.1.7.2 Fluid Systems (Gas & Liquid					X	
3.3.1.8 Lubrication					X	
3.3.2 Electrical and Electronic	1c					
3.3.2.1 Flammability of Wiring Insulation, Materials, and Accessories	2d					
3.3.2.2 Toxicity of Wiring Insulation, Materials, and Accessories	2d	2b				
3.3.2.3 Electrical Connectors - Keying		2c		2c 2d		
3.3.2.4 Electrical Connectors - Pin Assignment and Pin or Socket Selection	2d					
3.3.2.5 Electrical Connectors - Protective Covers or Caps				2c		
3.3.2.6 Materials Detrimental to Electrical Connectors	2b					
3.3.2.7 Electrical & Electronic Piece Parts - Closure					X	
3.3.2.8 Protection of Exposed Electrical Circuits	2d					
3.3.2.9 Protection of Electrical and Electronic Devices		1c				
3.3.2.10 Corona Suppression		1c				

	A	B	C	D	N/A	
3.3.2.11 Moisture Protection of Electrical and Electronic Devices		1d				
3.3.2.12 Redundant Electrical Circuits					X	
3.3.2.13 Electrical Operating Requirements		1c				
3.3.2.14 Temperature Control		1d				
3.3.2.15 Wire Splicing	2b					
3.3.2.16 Wire Bundle and Harness Protection	2d					
3.3.3 Fluid (Gas & Liquid)					X	
3.3.4 Debris Protection	2d					
3.3.5 Cleanliness	2d					
3.3.6 Test Provisions					X	
3.3.6.1 Test Points		1c				
3.3.6.2 Test Equipment		2b				
3.3.7 Single Failure Points			2b			
3.3.8 Redundancy					X	
3.3.8.1 Separation of Redundant Paths					X	
3.3.8.2 Redundant Paths - Verification of Operation					X	
3.3.9 Selection of Specifications and Standards					X	
3.3.10 Materials, Parts, and Processes	2b					
3.3.10.1 Toxicity of Materials	2b					

	A	B	C	D	N/A	
3.3.10.2 Restriction on Use of Transistors and Capacitors	2d					
3.3.10.3 Soldering	2d					
3.3.10.4 Welding					X	
3.3.10.4.1 Resistance Welding	2d					
3.3.10.4.2 Fusion Welding	2d					
3.3.10.5 Ultrasonic Processes					X	
3.3.10.5.1 Cleaning					X	
3.3.10.6 Etching of Wire Insulation for Potting	2d					
3.3.10.7 Adhesive Bonding	2d					
3.3.10.7.1 Adhesives, Encapsulation, and Coating	2d	1d				
3.3.10.8 Restriction on Use of Mercury					X	
3.3.10.9 Brazing	2d					
3.3.10.10 Engraving	2d					
3.3.10.11 Riveting					X	
3.3.11 Standard Parts	2d					
3.3.12 Fungus Resistance		1d				
3.3.13 Corrosion Prevention	2b					
3.3.14 Interchangeability and Replaceability	2b					
3.3.15 Workmanship	2d					
3.3.16 Electromagnetic Interference		1c		1c		

	A	B	C	D	N/A	
3.3.17 Identification and Marking		2c				
3.3.18 Storage	2b					
3.3.19 Pyrotechnic Devices					X	

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Revision A

APPENDIX VII

END ITEM SPECIFICATION

PRODUCT CONFIGURATION (PART II)

REQUIREMENTS

(END-ITEM NO. 95M10750)

HIGH INTENSITY PORTABLE LIGHT

FOR

SKYLAB A AND B

APPROVAL:

W. A. Wall
Hardware Developer
S&E-PT-MEI

January 25, 1972

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

LIST OF EFFECTIVE PAGES

Insert latest changed pages; destroy superseded pages.

SECTION	REV. DATE	PAGE NO.	REVISION	APP.

TABLE OF CONTENTS

1.0 SCOPE

This Specification establishes the requirements for complete identification and acceptance of all units of 95M10750, High Intensity Portable Light, to be formally accepted by the National Aeronautics and Space Administration. It specifies the performance, configuration, and manufacturing techniques that are necessary to reproduce the end-item and becomes the controlling document for acceptance of the end-item.

1.1 PRODUCT CONFIGURATION BASELINE ACCEPTANCE

The Product Configuration Baseline shall be established by Configuration Inspection of serial number 3. This unit and all subsequent units, regardless of intended use, shall be accepted to the configuration defined by serial number 3, unless formally approved otherwise as required by Section 7 of the EGS.

1.2 CHANGES

Applicable.

2.0 APPLICABLE DOCUMENTS

The following documents, of exact issue shown, form a part of this Specification to the extent specified herein. In the event of conflict between the Specification and other documents herein, the requirements of this Specification shall prevail.

SPECIFICATIONS

National Aeronautics and Space Administration (NASA)

No Number	OMSF Experiment General Specification for Hardware Development

George C. Marshall Space Flight Center (MSFC)

RS003M00003	Performance and Design Integration Requirements for the Cluster System/Apollo Applications Program, General Specification for
10M32157	Flights AAP 1 and 2 Manned Systems Test Analysis, Part III

STANDARDS

Military

MIL-STD-202D	Test Methods for Electrical and Electronic Component Parts

PUBLICATIONS

Iota Engineering Inc., Tucson, Arizona

150232	Acceptance Test Procedures for High Intensity Portable Light

DRAWINGS

George C. Marshall Space Flight Center (MSFC)

95M10750-1	High Intensity Portable Light

3.0 PRODUCT REQUIREMENTS

3.1 PERFORMANCE

3.1.1 Functional Characteristics

3.1.1.1 Seasoning

The Lamps shall be seasoned at rated Lamp voltage and current for 100 hours or 1% of rated life, whichever is shorter. The value for rated life shall be obtained from tests and the Lamp manufacturer's data.

3.1.1.2 Functional Systems Test

The Light shall be operated at rated voltage in each mode, i.e., System #1 high, low; System #2 high, low; in both local and remote control operations.

3.1.1.3 Low Level Vibration

The light shall be subjected to a sinusiodal vibration in the Z direction, front to rear, at 1 octave per minute at the following levels to verify mechanical integrity.

Levels

20 - 100 Hz @ 0.002 inches DAD

100 - 2000 Hz @ 1.0g Peak Above Ambient

3.1.1.4 Light Output

With the Light operated at rated voltage and current for five minutes in an ambient of 25 $\pm 5^{o}$C and 15 ± 1 psia, center beam Light illuminance, ± 10 degrees, shall not be less than 28 foot candles when measured on a flat plane magnesium oxide (or equivalent) target 6 feet ± 1 inch (1.83 meters ± 2.5 cm) from the face of the Light with a 1/2 degree Photo Research Company Spotmeter or a Calibrated Light Meter.

3.1.1.5 Light Distribution

The rate of illuminance fall-off from the center beam out either way 42 inches (108.5 cm) along the axis of the Lamps and 30 inches (76 cm) either way vertical to the axis of the Lamps shall not exceed by 10% the typical distribution of figure 1.

3.1.1.6 Color Coordinates

The C.I.E. chromaticity coordinates shall be x = 0.337 ± 0.006 and y = 0.324 ±0.009 for essentially equal energy distribution at rated wattage. The spectral energy distribution shall approximate figure 2 within a conformity of ±10% at rated voltage and current after three minutes operation at 25 ±5°C and normal atmospheric pressure (15 ±1 psia).

3.1.1.7 Color Temperature

The color temperature of the Light shall be 5150 ± 250°K.

3.1.1.8 Efficiency

The efficiency of each Lamp power converter and Lamp combination, actual power transferred, shall not be less than 70%.

3.1.1.9 Dielectric Withstanding Voltage

The Dielectric Test shall be conducted per MIL-STD-202D, Method 302, Test Condition A to verify insulation resistance for all circuits carrying 100V peak to peak or less and Test Condition C for all circuits carrying more than 100V peak to peak.

3.2 CONFIGURATION

Top assembly drawing 95M10750 is shown in figure 3. Drawing No. 150200 is shown in figure 4. Electrical Schematic No. 150138 is shown in figure 5.

3.2.1 Manufacturing Drawings

95M10750-1	High Intensity Portable Light
95M10751-1	Mounting Bracket Assembly
95M10754-1	Bracket
95M10755-1	Stem
95M10756-1	Shoe
95M10757-1	Knob
SEC 39104366	Camera Mount Assembly
SDC 39104367	End Piece Assembly
SDC 39104369	Grip Assembly
SDC 39104370	Pad
SDC 39104371	Side Plate
SDC 39104372	Trigger
SDC 39104373	Spring Mount

3.2.1 (Con.)

SDC 39104374	Swivel Mount
SDC 39104375	Washer
SDC 39104376	Cover
SDC 39103521	Bottom Plate
SDC 39103525	Spring Stop
SDC 39103528	Swivel
SDC 39103536	Washer
SDC 39104605	Extender
SEC 39104377	Slide Assembly
SDC 39104378	Slide
SDC 39104379	Rail
SDC 39104380	Lock Pin
SDC 39104381	Button
150200	High Intensity Fluorescent Light Assembly
150184	Mechanical High Intensity Fluorescent Light Subassembly
150139	Reflector
150140	Lamphouse
150141	Electronics Cover
150147	Lamp Cap Assembly
150145	Lamp Cap
150146	Lamp Cap Bracket
150157-1	End Camera Attachment Mount
150157-2	End Camera Attachment Mount
150158-1	Slide Camera Attachment Mount
150177	Functions Nameplate
150178	Warning Nameplate
150179	Identification Nameplate
150182	Power Nameplate
150186	Power Connector Nameplate
150187	Remote Control Connector Nameplate
150144	Spacer
150161	Stud Spacer
150162-1	Stud Spacer
150162-2	Stud Spacer
150159	FWD Thermal Barrier
150160	Rear Thermal Barrier
150185	Electrical NASA Light Subassembly
150167	Assy Control Logic and Inverter
150150	Inverter Chassis
150194	Orientation Subassembly
150189	Lamp Assembly
150190	Lamp Process Spec
150192	Lamp

3.2.1 (Con.)

150138	Schematic
150156	Outline & Mounting
150216	Switch Plate
150224	Wire Running List
150203	Terminal Locations
150202	Transformer Inverter Subassembly
150208	Filter Inductor Subassembly
150219	Chassis Inductor Subassembly
150206	Inverter Transformer Spec
150199	Component Holder
150218	Chassis Control
150207	Filter Inductor Spec
150205	Chassis Inductor
150204	Reflector Assembly
150217	Right Hand Camera Mount
150209	Handle Assembly
150198	Reflector Strip
150225	Harness Support Bracket
150210	Grip
150211	Grip Support
150212	Handle Guide
150213	Latch Button
150214	Latch Rod
150215	Handle Base
150221	Spacer

4.0 TEST/PRODUCT ACCEPTANCE REQUIREMENTS

4.1 ACCEPTANCE MATRIX

The acceptance verification matrix is contained in figure 4-1.

4.2 TEST TYPES

4.2.1 Acceptance

The acceptance tests shall be performed in accordance with the instructions in Acceptance Test Procedures for High Intensity Portable Light 150232.

4.2.1.1 Assessment

4.2.1.1.1 Analysis

3.1.1.6, 3.1.1.7

4.2.1.1.2 Inspection

4.2.1.1.3 Demonstration

3.1.1.4, 3.1.1.5, 3.1.1.6, 3.1.1.7

4.2.1.1.4 Validation of Records

3.1.1.1, 3.1.1.8, 3.1.1.9

4.2.1.2 Test

4.2.1.2.1 Functional

3.1.1.2

4.2.1.2.2 Mechanical

3.1.1.3

4.2.1.2.3 Electrical/Magnetic

3.1.1.8, 3.1.1.9

4.2.1.2.4 Environmental

4.2.1.2.5 Other

4.2.2 Other Tests

4.2.2.1 Integrated Systems

4.2.2.1.1 Assessment

4.2.2.1.1.1 Analysis

4.2.2.1.1.2 Inspection

4.2.2.1.1.3 Demonstration

3.1.1.2, 3.1.1.4

4.2.2.1.1.4 Validation of Records

4.2.2.1.2 Test

4.2.2.2 Prelaunch

4.2.2.2.1 Assessment

4.2.2.2.1.1 Demonstration

3.1.1.2, 3.1.1.4

4.2.2.2.2 Test

4.3 REJECTION

Experiment hardware that does not meet the performance requirements of Section 3.0, Part I and II of this document shall be considered failures and subsequent hardware shall not be considered acceptable until all hardware failures that have occurred have been satisfactorily reported, analyzed, and corrected.

5.0 DATA LIST

Applicable.

6.0 PREPARATION FOR DELIVERY

6.1 PRESERVATION AND PACKAGING

Packing and packaging of end items shall conform to the most economical method acceptable to the common carrier, which will assure safe and proper delivery to destination.

6.2 PACKING

Refer to Para. 6.1.

6.3 SHIPMENT

Shipment shall be by common carrier. All shipments shall be clearly marked to indicate contents, contract number, and DCN number.

7.0 NOTES

Not applicable.

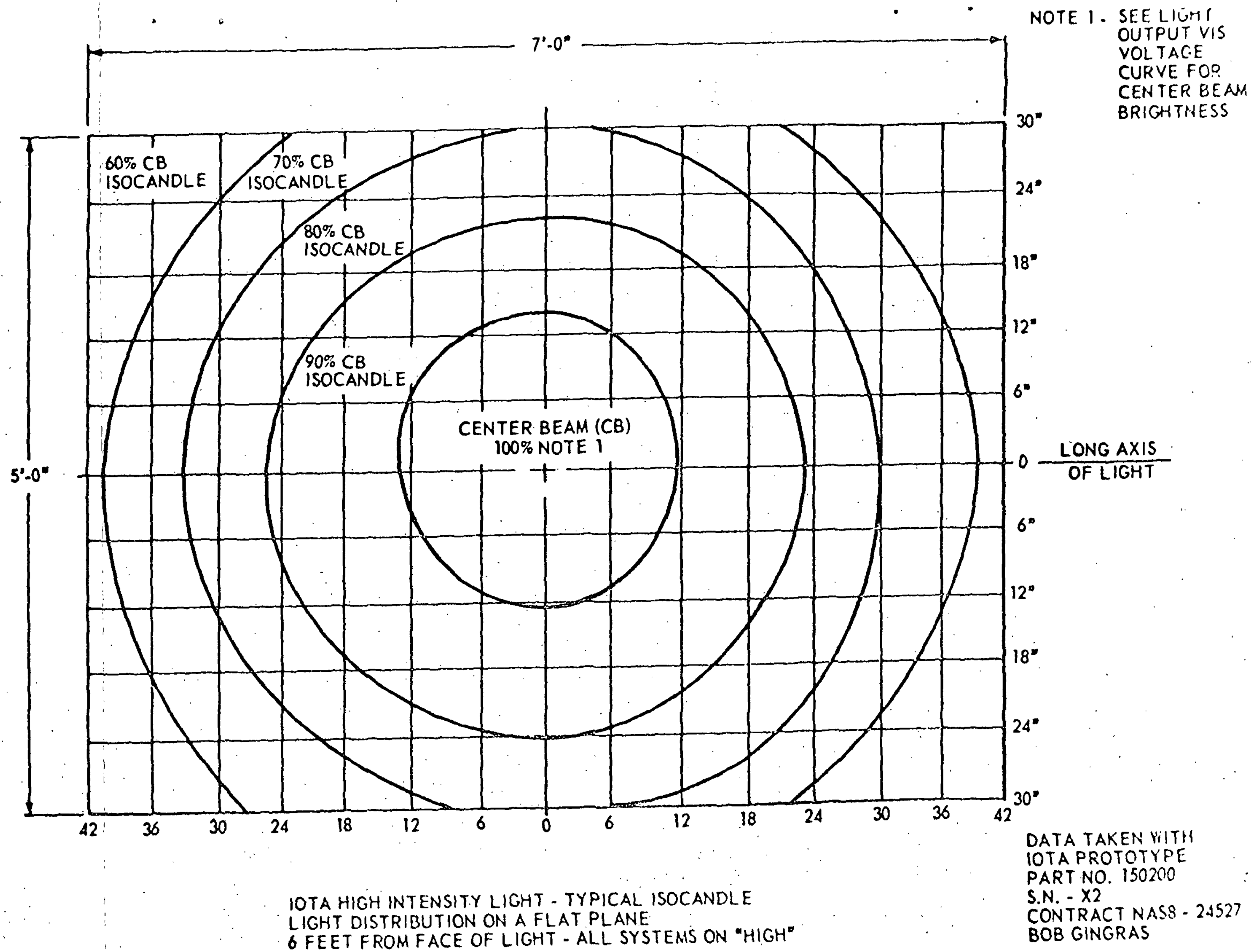


Figure 1. Typical Light Distribution

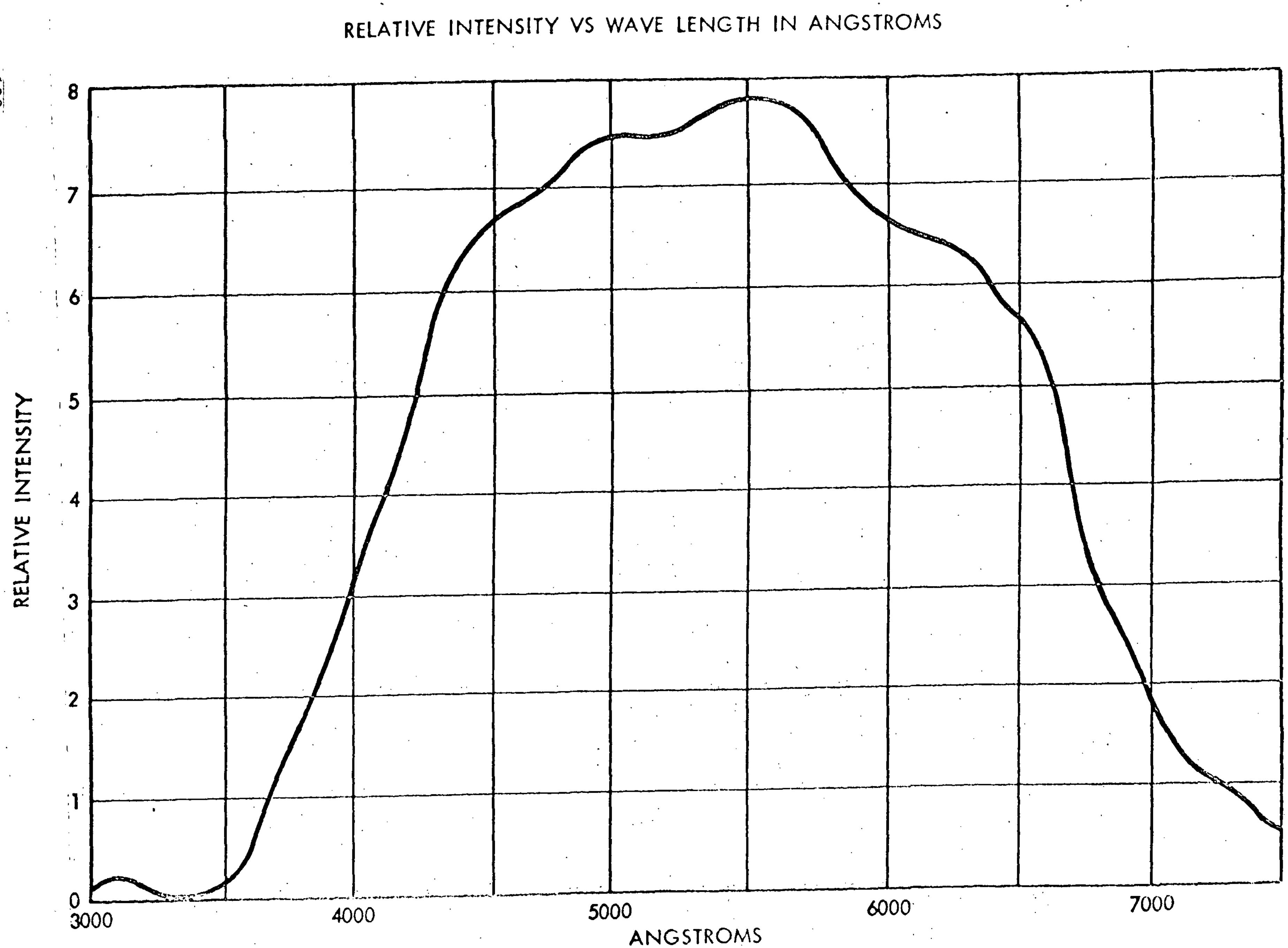


Figure 2. Spectral Energy Distribution

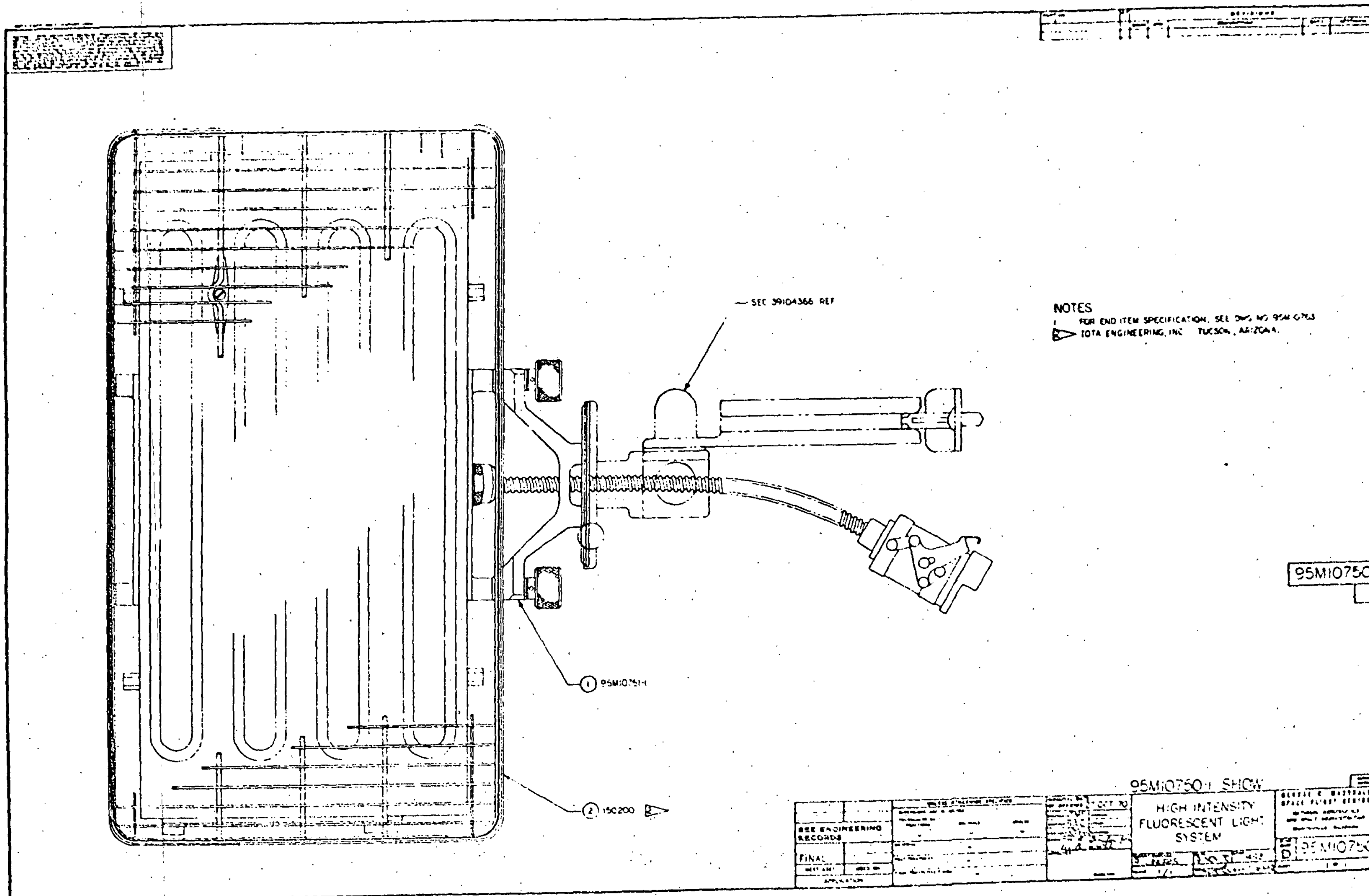


Figure 3. Top Assembly Drawing

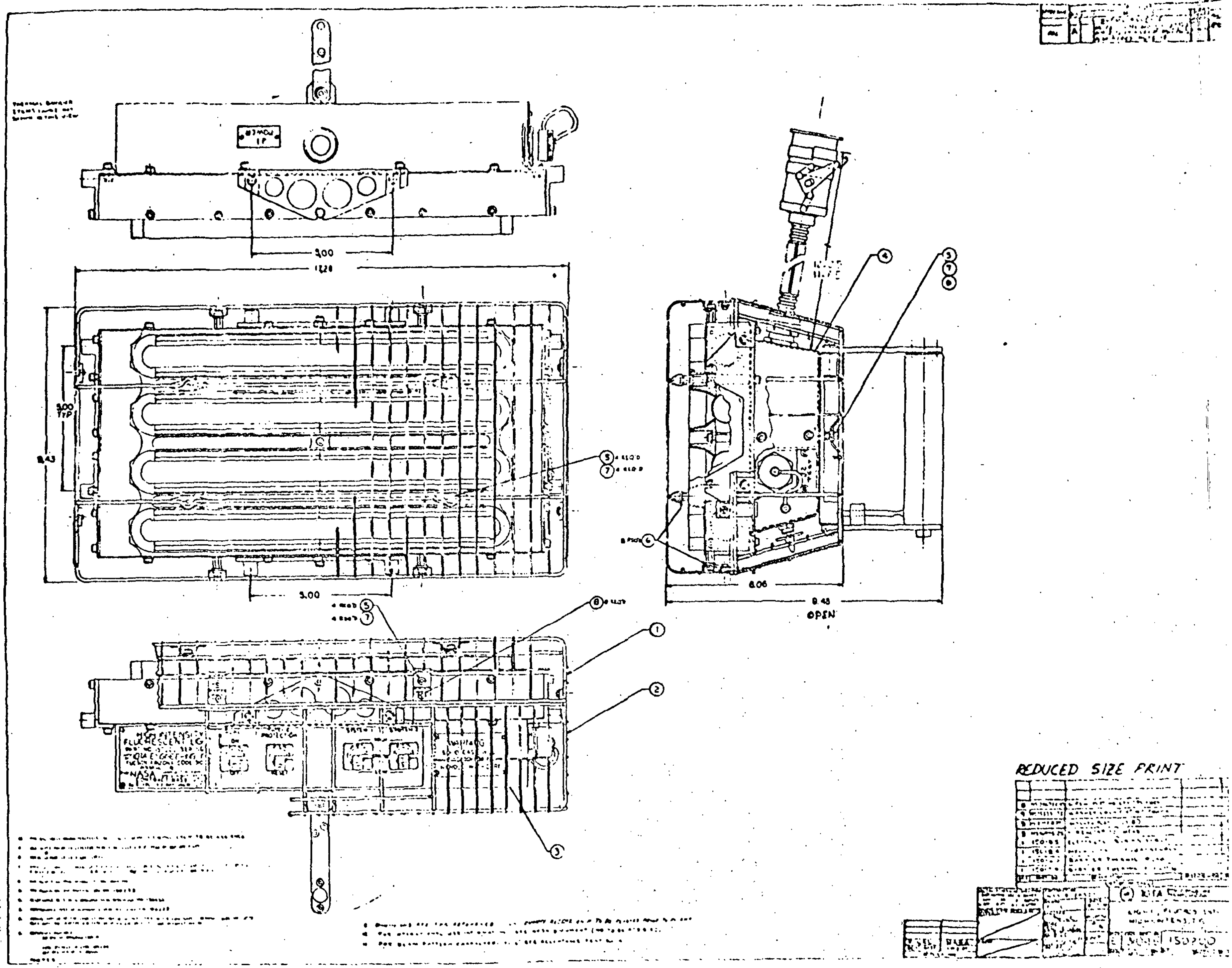


Figure 4. High Intensity Fluorescent Light (150200)

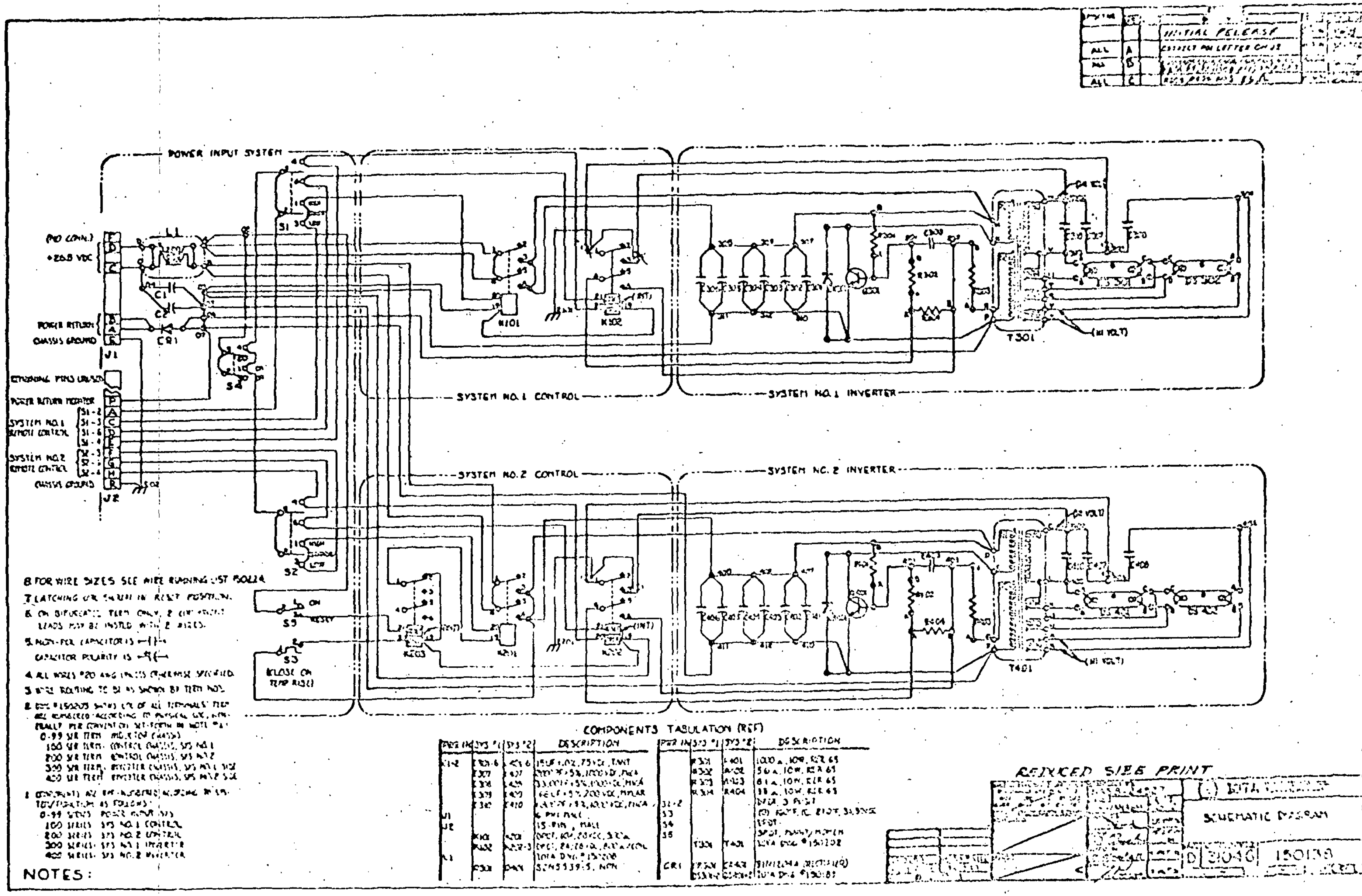


Figure 5. Electrical Schematic Diagram (150138)

Nomenclature	Criticality Category	End Item No.
High Intensity Portable Light	4	95M10750-1

Requirements for Acceptance

TEST TYPES:

- A - Acceptance
- B - Integrated Systems
- C - Prelaunch Checkout
- N/A - Not Applicable

VERIFICATION METHODS

1. Test
   a. Functional
   b. Mechanical
   c. Electrical/Magnetic
   d. Environmental
   e. Combined Tests
   f. Other Tests (Specify)

2. Assessment
   a. Analysis
   b. Inspection
   c. Demonstration
   d. Validation of records

Section 3.0 Performance/Configuration Requirement Reference	Test Types/ Verification Methods				Section 4.0 Test/Assessment Requirement
	A	B	C	N/A	
3.0				X	
3.1				X	
3.1.1				X	
3.1.1.1	2d				
3.1.1.2	1a	2c	2c		
3.1.1.3	1b				
3.1.1.4	2c	2c	2c		
3.1.1.5	2c				
3.1.1.6	2a 2c				
3.1.1.7	2a 2c				
3.1.1.8	1c 2d				
3.1.1.9	1c 2d				

Prepared by:	Org.	Date	Rev. Date	Rev. No.
Approved by:	Org.	Date	Page	

Figure 4-1

APPENDIX VIII

DESIGN PHILOSOPHY

The design philosophy of the high intensity light was determined by the design requirements and goals summarized in the body of the final report. The design can be subdivided into the areas of

1. Light Source
2. Electrical Circuitry
3. Thermal Parameters
4. Size and Weight Requirements

Light Source

It was decided for reasons of life and efficiency, that fluorescent lamps should be used in the high intensity light. The usage of fluorescent lamps raises several problems. These are mercury containments, temperature stability, optical and electrical requirements.

It was necessary to enclose the lamp to prevent mercury escape under breakage conditions. This was accomplished by sleeving the lamp in thin wall, transparent teflon and potting the end caps in silicone rubber. The technique maintains flammability requirements and prevents high rate venting of the lamp.

The operational temperature of the lamps was determined to be approximately 200°F due to the size limitations of the system. It was found that in a 1/3 atm. environment the conductive and convective losses were small compared to the radiative losses hence a direct relation to the package area exists. The Westinghouse Electric Co. has developed a lamp utilizing a mercury amalgam within the lamp for temperature stabilization. This lamp exhibits a high peak light output temperature (nom. 208°F in the lamps used in the high intensity light), and a relatively flat light output with respect to temperature about the peak point. These characteristics are a function of the eutectic operation of the amalgam in controling the mercury vapor pressure within the lamp. It has been found that amalgam control provides a further benefit in that the vapor pressure above a cold amalgam is more than two orders of magnitude less than that of elemental mercury under similar conditions. This effect eliminates the chance of toxic mercury escape in the event of lamp breakage.

The lamps utilized in the High Intensity Light have a color corrected phosphor with CIE coordinates or $X = 0.337 \pm 0.006$, $Y = 0.324 \pm 0.009$ and a relatively flat SED in the visible range. This corresponds to a black body color temperature of nominally 5250°K which is an excellent match to normal daylight photographic films.

The electrical characteristics of the lamp are generally the same as a normal discharge phenomenon lamp of this size; however, the very low mercury vapor pressure (cold) and the high percentage neon fill gas content used to increase the lamp energy density require higher starting voltages than normally encountered.

Electrical Circuitry

The electrical requirements for operation of fluorescent lamps are twofold. First, sufficient voltage must be provided to initiate avalanche or arc conditions within the lamp. Second, sufficient power must be provided in a current limited mode to operate the lamp.

Fluorescent lamps may be operated in either a DC or an

AC mode; however, DC operation is inefficient and considerably shortens normal lamp life. It was decided AC operation at a nominal 20 KHz frequency offered the most appropriate compromise of the influencing factors of inverter size, RFI/EMI minimization and lamp output.

The general category of devices for DC-AC conversion are called inverters, of which there are several varieties. There are two varieties of inverters appropriate for driving fluorescent lamps in the manner desired. These are the "one transistor-one transformer inverter" and the "two transistor-one transformer inverter." The former type was decided upon for the following reasons:

1. Circuit Simplicity
2. Dynamic output characteristic
3. Efficiency

Thermal Parameters

The thermal parameters of the system stem basically from size and power considerations. At the full design power, of 150 watts, it was found that cooling in the radiative mode was dominant. All components within the system were designed for 125°C or greater operation. The thermal parameters of the system were verified theoretically and experimentally.

Size and Weight

The size and weight of the High Intensity Light were minimized as much as possible while maintaining other system parameters. This was accomplished by use of unique optical control techniques and good packing density of the electrical circuitry.

APPENDIX IX

CIRCUIT OPERATION

There are two basic trade-offs involved in the design of a lamp driver circuit. These are:

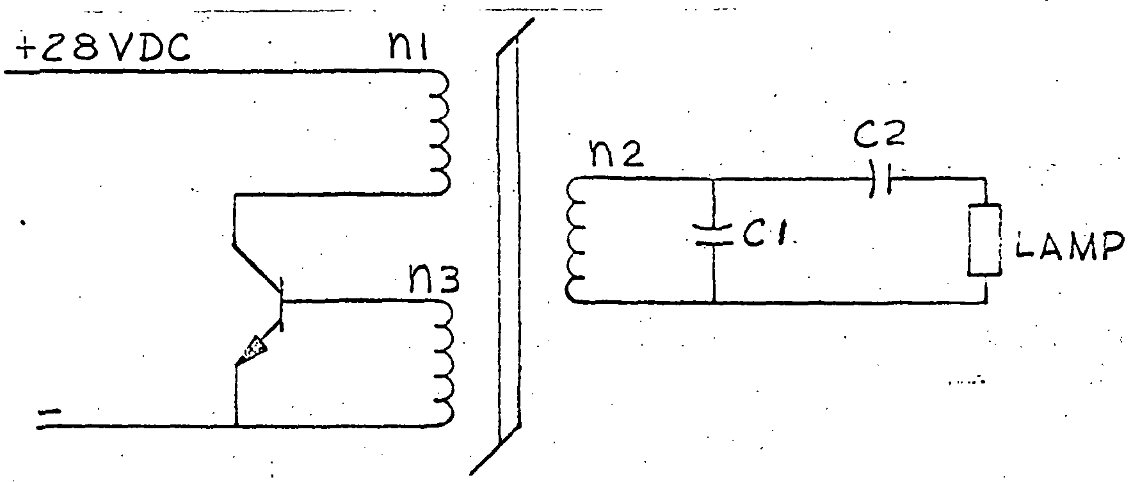
1. Reliability, and
2. Efficiency

which are in themselves interrelated. The problem in optimization of these parameters is not only a function of the driver circuitry but of the load and source characteristics. Thus, for example, a higher inverter efficiency does not imply a higher overall efficiency. When examining circuit design, the additional restraints of human factors and RFI must be keptin mind. The following constraints are necessary in the High Intensity Light:

1. Minimum weight
2. Minimum package size
3. 150 watts total input
    a. 75 watts each driver, high mode
    b. 37.5 watts, low mode
4. Maximum light output - efficiency
5. Minimum RFI
6. Maximum case temperature - 120°F
7. Maximum ease of operation
8. 20 KHz or greater inverter operationg (for minimizing component sizes and increasing lamp efficiency)

The constraints that are omitted above are not pertinent to this examination.

For purposes of this discussion a simplified model without feedback and starting additions will be used.



At an operating frequency of 20 KHz or greater, the lamp may be modeled as a resistive load which value depends on the operating point of the lamp's volt-amp characteristic curve. The operating characteristics of the circuit are dependent upon (1) the transformer, (2) the secondary loading, and (3) the transistor.

The circuit operates in the following manner. When voltage is applied to the circuit, the transistor is turned on regeneratively through transformer operation. The equations governing this action are:

$$Hl_e = Ni_m \quad \text{(Eq. 1)}$$

$$E = N\, d\phi/dt \times 10^{-8} \quad \text{(Eq. 2)}$$

or in this case,

$$E\tau = N \Delta B A \times 10^{-8} \quad \text{(a)}$$

$$\Delta B = B_r + B_s \quad \text{(b)}$$

These equations can be solved for τ and i_m for a given core type and size. This action continues until time τ when the core saturates and voltage cannot be sustained on the feedback and secondary windings. With the loss of drive, the transistor begins to turn off and the flux in the core collapes to B_r, regeneratively turning the transistor off. Note that the energy store in the core must be dissipated during turn-off of the transistor. This energy is (1) fed into the secondary capacitive load and (2) exhibited in the primary as a large voltage spike. Capacitors C_1 and C_2 then begin to discharge through the transformer secondary with time constants characterized by the effective LRC_2 circuit and the LC_1 circuit (the feedback and primary are effectively infinite impedances). During discharge of C1 and C2 the transistor is biased off. When the discharge is complete, the cycle is complete. Capacitive loading of the secondary is necessary to reset the transformer core from B_r to $-B_s$ (or as near as this method of reset will allow).

Two requirements must be met for lamp operation (1) starting conditions, and (2) operational conditions. Obviously, both requirements cannot be optimized simultaneously. Common procedure is to attempt optimization of the operational mode while maintaining acceptable starting requirements.

In the high Intensity light, the operating requirements show that tube current must be approximately 0.8 amps rms which corresponds to a steady state operating point equivalent to approximately 55 watts (55.2 watts are required for 70% electrical efficiency at rated input.) Assuming that the lamp is comparatively sluggish in its steady state response at the specified operating frequency (20 KHz), the tube can be modeled (as stated previously) by a pure resistance.

Capacitor C_1 serves the function of "resetting" the transformer core. Capacitor C_1 further serves to limit the "flyback" voltage appearing across the windings of the transformer to a safe level when the lamp is not in arc operation.

Other components in the feedback circuit of an operational inverter are utilized for current limiting and wave shaping. Capacitor C_2 serves to limit current flowing through the lamp and reset the core.

For rapid start operation, which was chosen for this system for optimum lamp life and minimized RFI, filament windings are added to the inverter transformer.

System dimming is accomplished by actuation of a relay which decreases capacitance C_1 and reduces the base drive to the transistor by increasing resistance in the feedback leg. Decreasing C_1, increases the complex impedence of the secondary circuit and reduces lamp current. Increasing the feedback circuit resistance serves to compensate for this reduced loading.

At the end of life of the lamp i.e.: the lamp fails to light, the inverter operates in what is designated as an "open circuit mode". Open circuit operation is highly dissipative since little or no power is transferred to the lamps. All components within the system have the capability to withstand open circuit operation both thermally and electrically at any input level.

Typical values of input and output at a nominal 26.5 VDC input for one system were obtained during breadboard testing. These results are as follows:

Hi mode:

Input Voltage 26.5 VDC	Input power 67.6 w.
Input Current 2.55 amp	
Output Voltage, 60.3 VRMS	Output power 49.4 w.
Output Current 820 ma.	

Dim mode:

Input Voltage 26.5 VDC	Input power 47.2 w.
Input Current 1.78 amp.	
Output Voltage 85.9 VRMS	Output power 13.2 w.
Output Current 154 ma.	

Open Circuit mode:

Input Voltage 26.5 VDC	Input power 39.7 w.
Input Current 1.5 amp.	

Note that filiment power has been neglected in the output power figures.

APPENDIX X

THERMAL ANALYSIS AND TEST RESULTS

THERMAL ANALYSIS OF THE HIGH INTENSITY LIGHT

1. Total Dissipation:

   Based upon test results of preproduction hardware the Input power at 26.5 VDC is 142 watts, with switch in "Bright" position. In dim position, input power is 100 watts or 50 watts (both on, one on).

   It is beyond the scope of the present contract to measure exactly the amount of power radiated within the visible spectrum. However, a reasonable approximation can be made. Although the lamp is running hot and at high current, there is a compensating improvement in efficacy due to the high frequency operation. Hence, it is assumed that luminous output is about 20 percent (1)

   Losses are distributed approximately as follows:

Inverter	21.6 watts
Control Circuits	2.5 watts
Lamp Filaments	18.9 watts
Lamp Arcs	99.0 watts
	142.0 watts

   Subtracting the visiable radiation leaves a net heat flux $Q = 142 -(.20)(99) = 122.2$ watts. Converting to BTU's per hour:

$$Q = 122.2 \times 3.413$$

$$= 416 \text{ BTU's/Hour} \qquad (2)$$

2. Cooling Method:

   With the very low velocity of cooling atmosphere in the spacecraft and at the reduced gas pressure, the amount of heat carried away by convection is very small (in the range of 2 to 5 percent). Consequently, it is assumed that only radiation is effective in cooling the light.

   No transient analysis will be made, since it is assumed that the light may be operated long enough to reach thermal equilibrium. This is conservative since the approach to equilibrium is asymptotic as ΔT^4.

(1) IES Lighting Hankbook, Fourth Edition, p. 8-18

(2) Internal Combustion Engines, E. F. Obert, Second Edition, 1950. Table I, appendix.

At thermal equilibrium, absorptivity and emissivity are equal. The value of emissivity is assumed as the value of a gray body radiating diffusely into a hemisphere, using total emissivity, ε.

For the case of infinite parallel planes, a reasonable statement of this case, the net interchange of energy per unit time is

$$q = A\sigma(T_1^4 - T_2^4) \frac{1}{1/\varepsilon_1 + 1/\varepsilon_2 - 1.} \quad (3)$$

A_1 is the area of gray plane 1; σ is the Stefan-Boltzmann constant [0.1713 x 10^{-8} BTU/(sq. ft.)(hr.)(deg R)^4]. T is temperature in degrees Rankine.

For anodized aluminum (black), $\varepsilon_1 = 0.8$ (4)
For cloths and painted surfaces, $\varepsilon_2 = 0.9$

The spacecraft walls are at 70°F, 530°R.

A_1, the unobstructed view of the surface of the light, is approximately 1.9 square feet. Flux q = 416 BTU's/Hour.

Substituting,

$$416 = 1.9 \times .1713 \left[\left(\frac{T_1}{100}\right)^4 - 5.3^4\right] \times \frac{1}{\frac{1}{.8} + \frac{1}{.9} - 1}$$

$$416 = .239\left(\frac{T_1}{100}\right)^4 - .239 \times 789$$

$$\left(\frac{T_1}{100}\right)^4 = 1740 + 789 = 2529$$

$$\left(\frac{T_1}{100}\right) = 7.1$$

$$T_1 = 710°R = 250°F \quad (121°C)$$

This assumes that the source temperature is uniform over the entire area, which is not true. The largest amounts of power are dissipated in the lamps, which have a clear aperture over about 20 percent of their circumference. The lamps exceed the average temperature, reducing the heat flux to be dissipated by the structure. Tests were conducted to determine the temperatures at various points to verify adequacy of cooling distribution.

(3) Heat Transmission, W. H. McAdams, Third Edition, 1954, p. 63.

(4) MIL-HDK-217A, 1965, p. 6-7, Table VI-I.

3. Temperature of Wire Cage:

A wire cage has been incorporated around the light to prevent contact of hot surfaces by using personnel. It is essential that this wire barrier be held to an outside (exposed) surface temperature of 105°F. Again, it is assumed that convection cooling will be negligible.

The general equation for direct interchange is of the form $A_1F_{12}\varepsilon_1\varepsilon_2\sigma(T_1^4 - T_2^4)$. (5)

The flux into the wire cage must equal the flux out. Since all temperatures are nearly the same, and since the source and spacecraft walls are both nearly black, the case can be stated as follows:

$$\frac{A_1F_{12}\varepsilon_1\varepsilon_{2A}\sigma(T_1^4 - T_2^4)}{A_1F_{12}\varepsilon_1\varepsilon_{2B}\sigma(T_2^4 - T_3^4)} = 1$$

Viewing areas and factors are equal, and ε_2 can be controlled. T_1 is the source, T_2 is the wire, and T_3 is the spacecraft wall. The wire can be plated to have a low emissivity facing the source (ε_{2A}) and a high emissivity (ε_{2B}) facing the wall.

By selectively polishing, plating and roughing, it is anticipated that a ratio of outside to inside surface emissivities of 7:1 can be achieved. Emissivities for gold and stainless steel, for instance, are .03 and .35 respectively. Using $\varepsilon_{2B}/\varepsilon_{2A} = 7$, (6)

$$\frac{\varepsilon_{2A}\ (T_1^4 - T_2^4)}{\varepsilon_{2B}\ (T_2^4 - T_3^4)} = 1$$

With $T_1^4 = 1740 \times 10^8$

$T_3^4 = 789 \times 10^8$

$$1740 \times 10^8 - T_2^4 = 7T_2^4 - 7 \times 789 \times 10^8$$

$$8T_2^4 = 1740 \times 10^8\ 5520 \times 10^8 = 7260 \times 10^8$$

$$T_2^4 = 980 \times 10^8$$

$$T_2 = 549°R$$

$$= 89°F$$

(5) Heat Transmission, McAdams, p. 72.

(6) Ibid. Table A-23, p. 472.

If the emissivity ratio drops to an effective 5:1,

$$1740 \times 10^8 - T_2^4 = 5T_2^4 - 5 \times 789 \times 10^8$$

$$6T_2^4 = 5685 \times 10^8$$

$$T_2^4 = 948 \times 10^8$$

$$T_2 = 555°R$$

$$= 95°F$$

At 3:1,

$$1740 \times 10^8 - T_2^4 = 3T_2^4 - 3 \times 789 \times 10^8$$

$$4T_2^4 = 4107 \times 10^8$$

$$T_2^4 = 1027 \times 10^8$$

$$T_2 = 566°R$$

$$= 106°F$$

At 1:1,

$$1740 \times 10^8 - T_2^4 = T_2^4 - 789 \times 10^8$$

$$2T_2^4 = 2529 \times 10^8$$

$$T_2^4 = 1264 \times 10^8$$

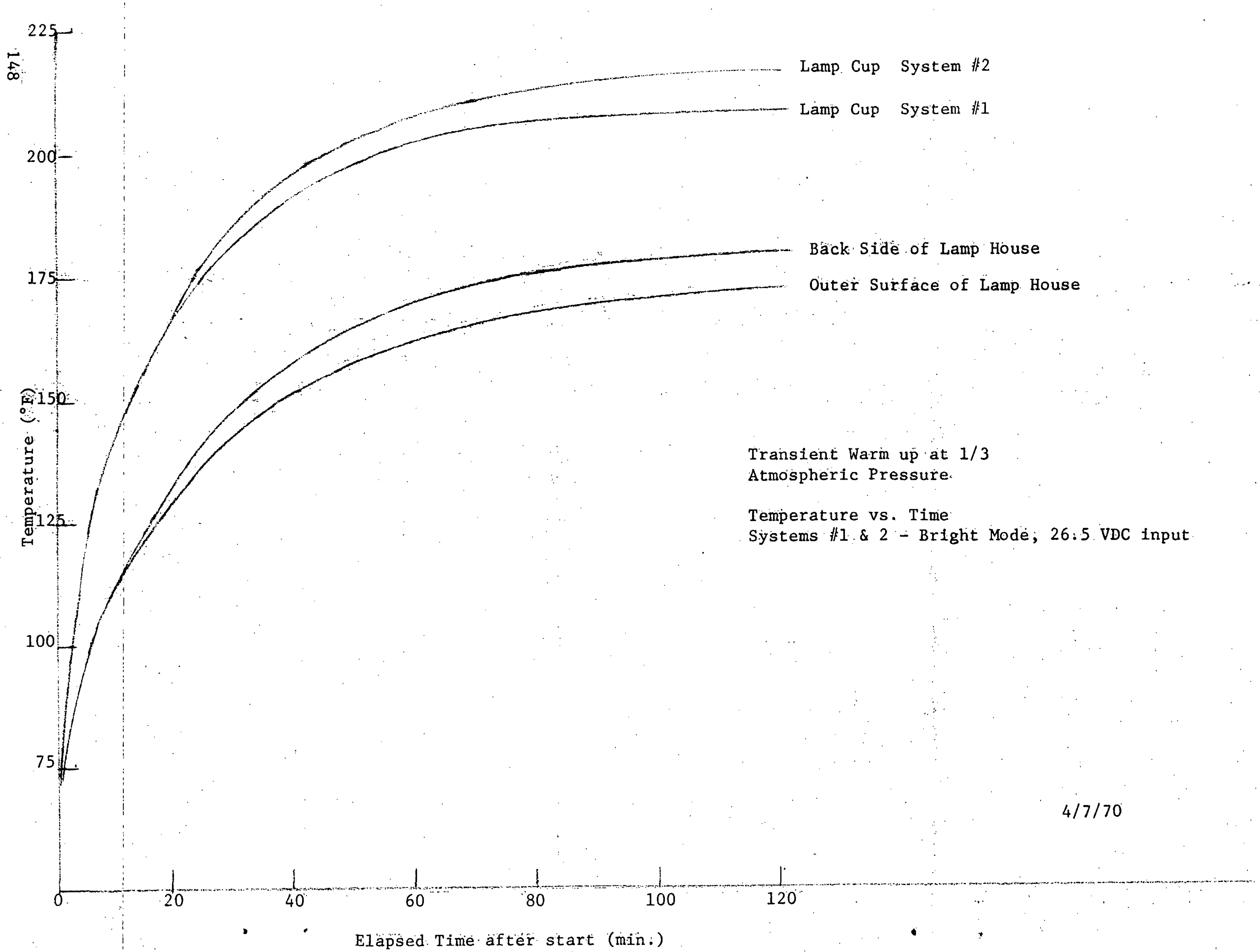
$$T_2 = 595°R$$

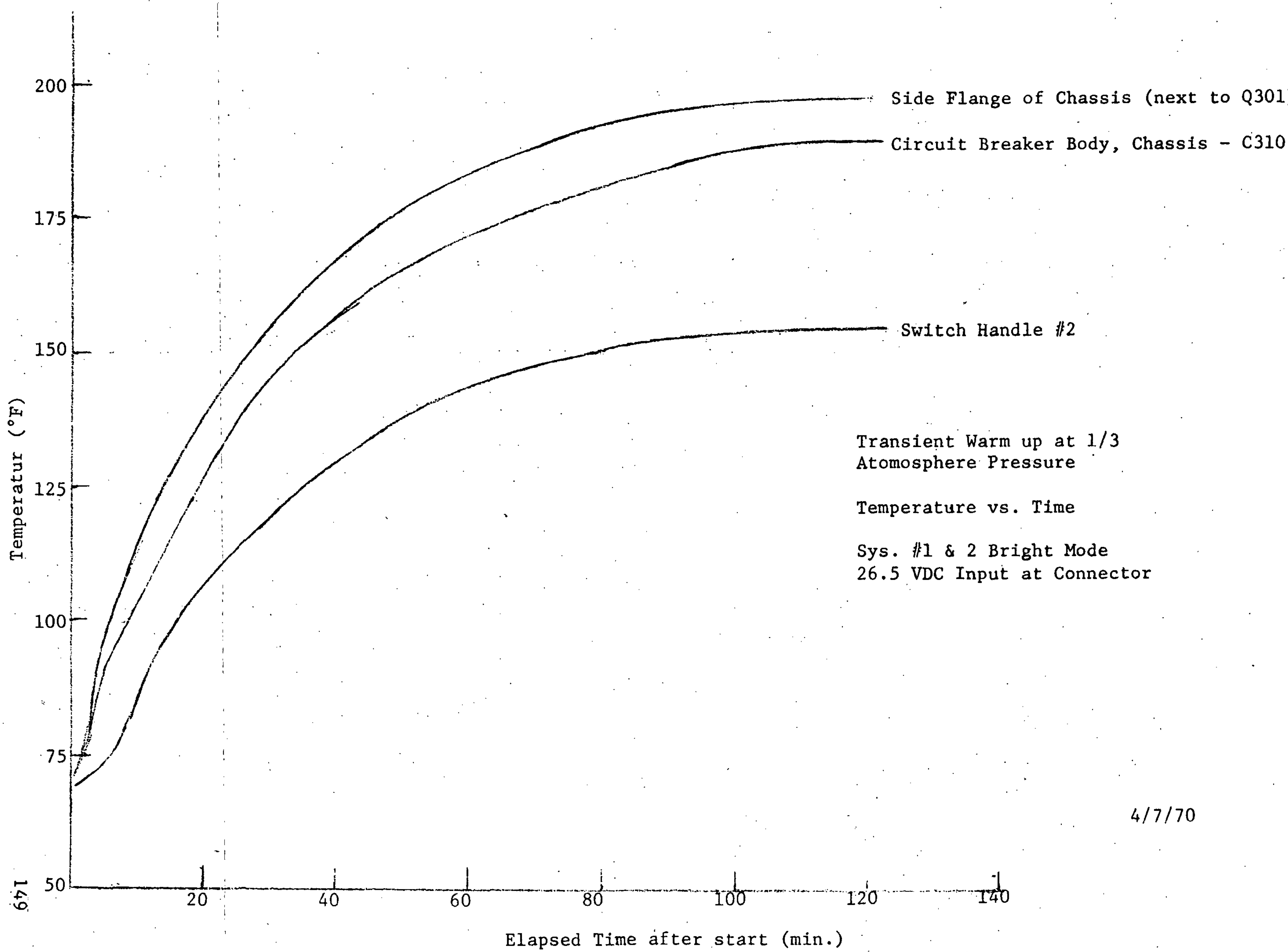
$$= 135°F$$

This indicates that there should be a sufficient degree of margin in meeting the requirement of 105°F touch temperature. Switches and connectors may require isolation from conduction paths and some reflective shielding to minimize direct radiation. Convection cooling will help to a small extent.

Thermal Test Results

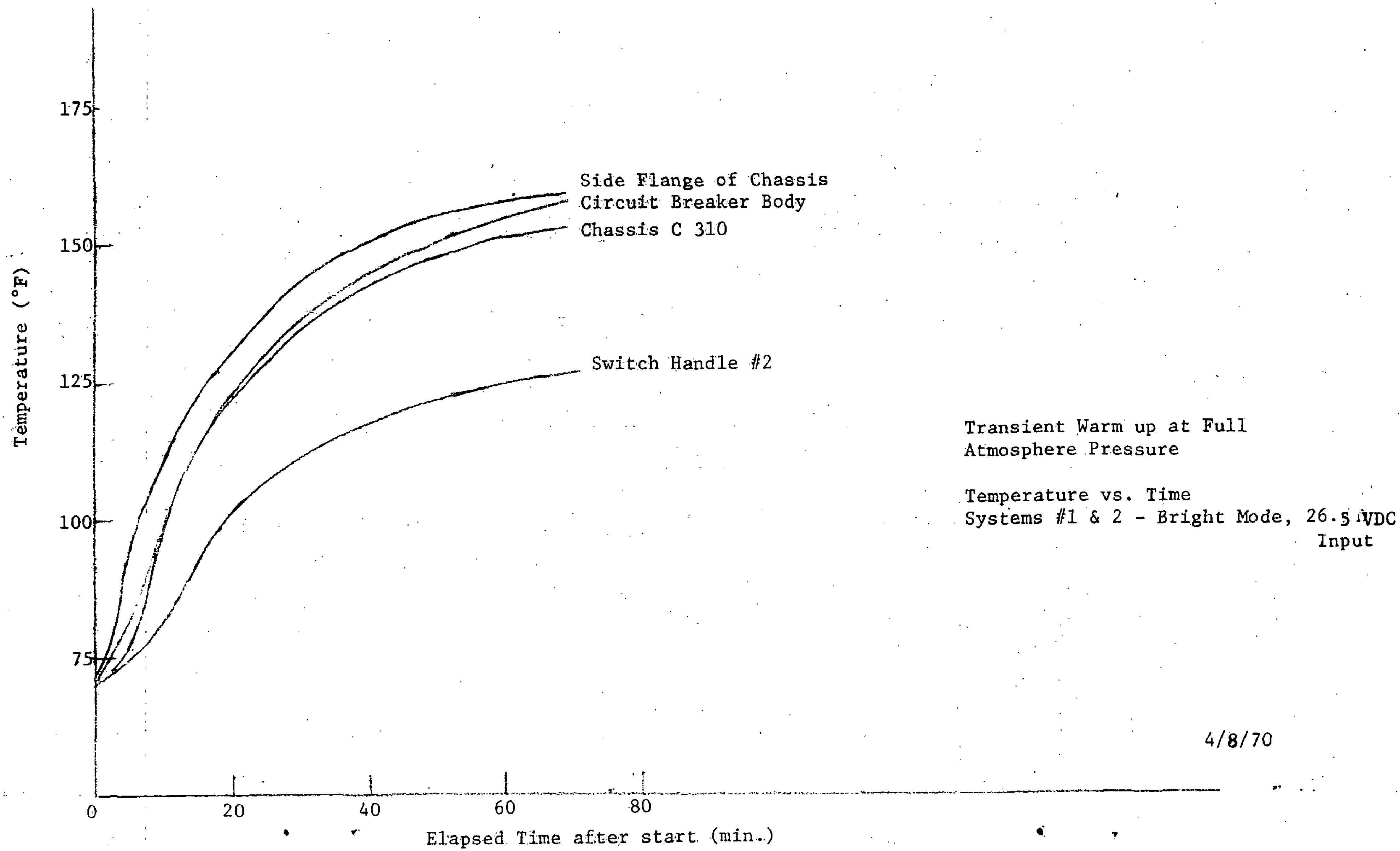
Thermal verification of the theoretical analysis was run on engineering model X-2 of the High Intensity Light. The results of these tests are presented in the following graphs. The experimental results were found to be quite close to the predicted results. It was indicated that further sheilding of the switch handles was necessary to stay within touch temperature requirements. These results were further verified during qualification tests.

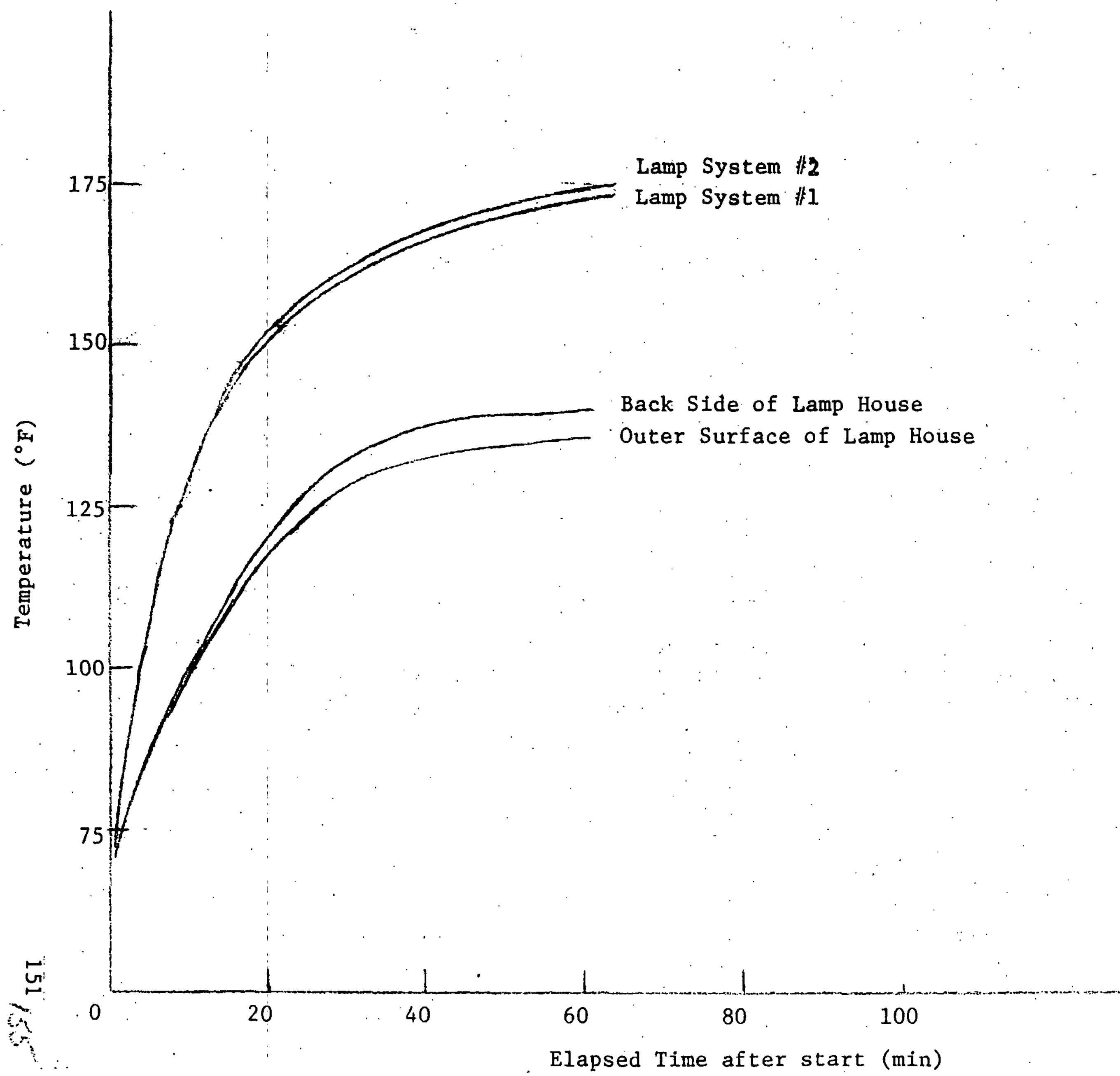

Lamp Cup System #2
Lamp Cup System #1
Back Side of Lamp House
Outer Surface of Lamp House
Transient Warm up at 1/3
Atmospheric Pressure
Temperature vs. Time
Systems #1 & 2 - Bright Mode, 26.5 VDC input
4/7/70
Temperature (°F)
225
200
175
150
125
100
75
0
20
40
60
80
100
120
Elapsed Time after start (min.)



Side Flange of Chassis (next to Q301)
Circuit Breaker Body, Chassis - C310
Switch Handle #2
Transient Warm up at 1/3
Atomosphere Pressure
Temperature vs. Time
Sys. #1 & 2 Bright Mode
26.5 VDC Input at Connector
Temperatur (°F)
200
175
150
125
100
75
50
20
40
60
80
100
120
140
Elapsed Time after start (min.)

4/7/70

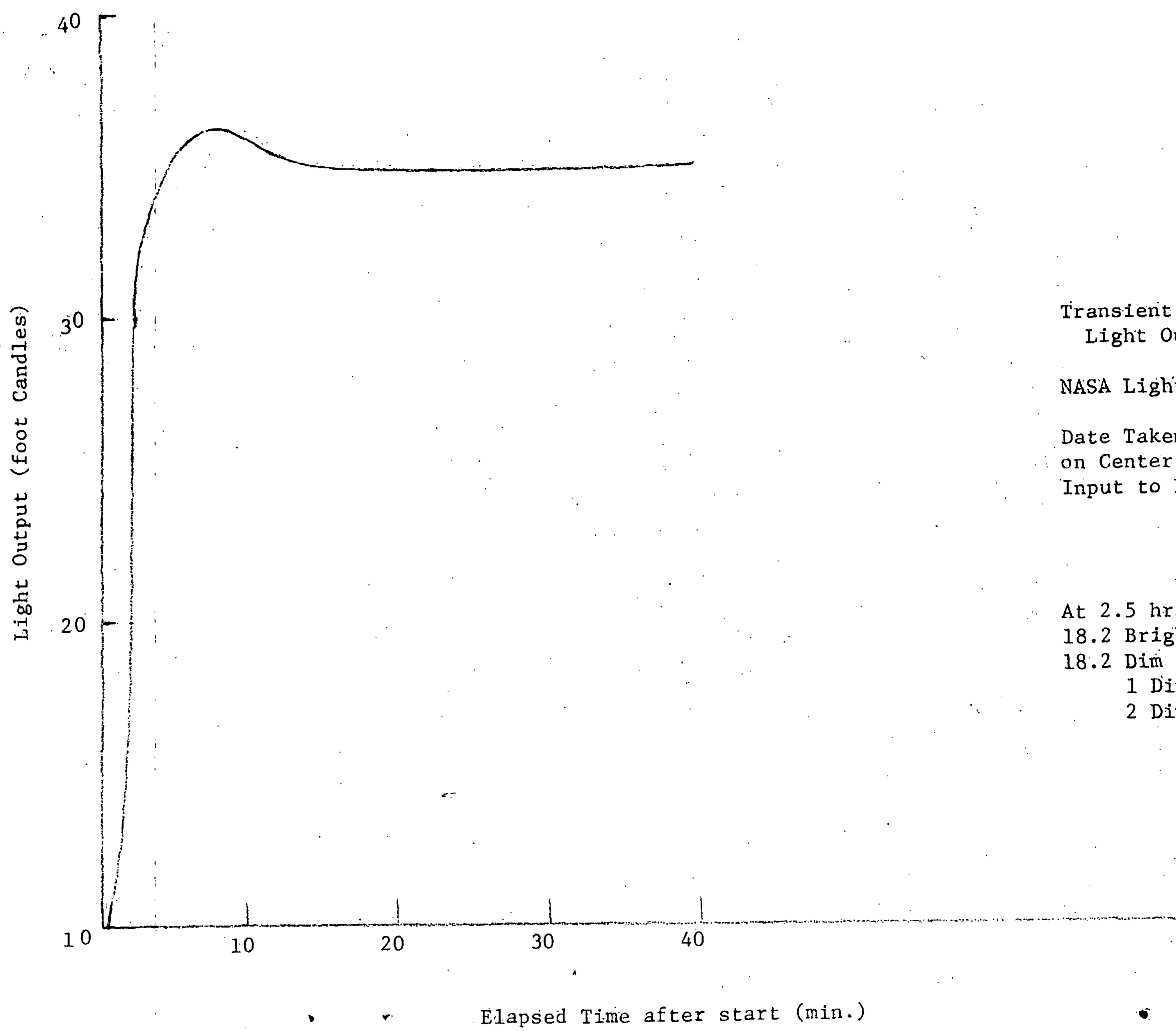

Side Flange of Chassis
Circuit Breaker Body
Chassis C 310
Switch Handle #2
Transient Warm up at Full
Atmosphere Pressure
Temperature vs. Time
Systems #1 & 2 - Bright Mode, 26.5 VDC
Input
4/8/70
Temperature (°F)
175
150
125
100
75
0
20
40
60
80
Elapsed Time after start (min.)



Transient Warm up at Full Atmosphere Pressure

Temperature vs. Time
Systems # 1 & 2 - Bright Mode 26.5 VDC Input

4/8/70



Transient Light Output
Light Output vs. Time

NASA Light Model Y2

Date Taken at a Distance of 6 ft.
on Center Line Axis - 27.785 VDC
Input to Lamp Cable - without Wire Cage

At 2.5 hrs:
18.2 Bright = 34.4 fc
18.2 Dim = 9.2
1 Dim = 4.6
2 Dim = 4.6

4/9/70

APPENDIX XI

Qualification Tests

Qualification tests will be conducted at the Marshall Space Flight Center. The results of these tests will be supplied by the Quality Assurance Laboratory, environmental test division.