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SOLAR SIMULATOR MIRROR REFURBISHMENT

Contract No. NAS 9-12960

MOD 1 Thru MOD 11

XEOS Report 2304 - Final

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Prepared For

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INTRODUCTION

This report summarizes the work done under Contract NAS9-12960, Xerox EOS Sales Order 2304, for the period from June 27, 1972 to September 30, 1974.

The original contract called for a completion of all deliverable items on or before June 15, 1973. As a result of changes in the scope of work that are detailed in Modifications Numbers 1 through 11, the schedule was extended to September 30, 1974.

The work done under this contract is the refurbishment of Solar Simulator Mirrors. Two different refurbishment methods were employed. In the first, the electroformed mirror replica was removed from the casting and replaced with a new mirror replica. In the second, only the aluminized surface, with its protective overcoat, was removed from the mirror and replaced after cleaning of the nickel surface. Details of these two methods are included.

SOLAR SIMULATOR MIRROR REFURBISHMENT

1.0 REFERENCE DOCUMENTATION

Reference documents for performance of refurbishment and Strip/Recoating of NASA Solar Simulator Mirror assemblies are listed in this section.

1.1 Basic NASA/JSC Contract NAS 9-12960 and modifications (1) through (11).

1.2 Exhibit "A" Statement of Work for Refurbishing Solar Simulator Mirrors, dated April 10, 1972.

1.3 Exhibit "B" Statement of Work for Recoating Solar Simulator Mirrors - modification of Exhibit "A", dated February 1, 1974.

1.4 Appendix "A" List of Government Furnished Property - Mirror Assemblies to be reworked.

1.5 Appendix "B" List of Government Furnished Tooling.

1.6 Specifications & Procedures - Appendices "C" through "N".

1.6.1 Appendix C -- Specifications for Solar Simulator Mirrors, dated 9/2/71.

1.6.2 Appendix D -- Detail Optical Test Procedures including Section B-1 for Mirror No. 1, Section B-2 for Mirror No. 2, Section B-3 for Mirror No. 3, and Section B-4 for Mirror No. 4.

1.6.3 Appendix E -- Rework Procedure for Water Ports

1.6.4 Appendix F -- Inspection, Marking/Packaging

1.6.5 Appendix G -- Reflectors, Front Surface Coatings

1.6.6 Appendix H -- Test-Reflectance of Solar Simulator Reflector Coatings (Reference EOS Process Spec. No. 158, Revision (A), dated December 30, 1968).

1.6.7 Appendix I -- Repairing Voids in Exposed Bond Lines (Reference EOS Directive 15-3, dated December 30, 1966).

1.6.8 Appendix J -- Bonding Nickel Replicas to Aluminum Castings (Reference EOS Directive 15-2, Revision E, dated February 5, 1971).

1.6.9 Appendix K -- Bonding of Spinning to Casting on No. 1 Aluminum Subassembly (Reference EOS Directive 12-1, dated June 4, 1968).

1.6.10 Appendix L -- Bonding of Spinning to Casting on No. 4 Mirrors (Reference EOS Process Spec. 201 dated December 15, 1965).

1.6.11 Appendix M -- Spinning Delamination Repairs Procedure for No. 4 Aluminum Subassemblies (Reference EOS Directive 15-4, dated September 10, 1969).

1.6.12 Appendix N -- Pretreatment of 356 Alloy Aluminum Prior to Adhesive Bond (Reference EOS Directive 12-2, dated October 1967).

1.6.13 Procedure No. 15-5 "Procedure for Replacement of Damaged or Loose Threaded Hole Inserts", dated May 24, 1974.

1.6.14 Procedure No. 15-6 "Weld Repairs for NASA/MSC Castings."

1.7 Appendix "0" Government Furnished Property - Mirrors to be Recoated.

1.8 The initial contract Scope of Work (see 1.2) called out complete refurbishment of the following mirrors:

Item No.	Description	Quantity
1	Primary Collector Mirror	73 ea.
2	Secondary Collector Mirror	87 ea.
3	Secondary Collimator Mirror	43 ea.
4	Primary Collimator Mirror	65 ea.

This was changed by several modifications, as explained below.

1.8.1 Modification 2C was released and reduced quantities of mirrors to be refurbished as follows:

Item No.	Description	Quantity
1	Primary Collector Mirror	from 73 ea down to 37 ea
2	Secondary Collector "	from 87 ea down to 38 ea
3	Secondary Collimator "	from 43 ea down to 7 ea
4	Primary Collimator "	from 65 ea down to 14 ea

Also, the master plating tool status was changed to one (1) each No. 1, two (2) each No. 2 & No. 3, and one (1) each No. 4 master and one (1) each No. 4 sub-master to be available at all times.

1.8.2 Modification 2S was released and was in reference to Government Furnished Property. Also, MOD 2S references no cost change as a result of MOD 1C.

1.8.3 Modification 3C was released to redefine the statement of work and define the quantities and mirror types to be reworked. This modification defined two types of rework. The first group were to be refurbished - the electroformed nickel mirror replica would be replaced. The second group of mirrors were to have only the protective thin film on the electroformed mirror replica removed, the surface cleaned and prepared and a new vacuum coating applied. The following quantities applied:

Item No.	Description	Quantities
1	No. 1 Primary Collector Mirror, Complete Refurbishment	53 ea
2	No. 2 Secondary Collector Mirror, Complete Refurbishment	62 ea
3	No. 3 Secondary Collimator Mirror, Complete Refurbishment	43 ea
4	No. 4 Primary Collimator Mirror, Complete Refurbishment	35 ea
	Total quantity of mirrors to be refurbished	193
5	No. 1 Primary Collector Mirror, Strip and Recoat	20 ea
6	No. 2 Secondary Collector Mirror, Strip and Recoat	25 ea
7	No. 4 Primary Collimator Mirror, Strip and Recoat	30 ea
	Total quantity of mirrors to be recoated	75
	Total quantity of mirrors to be reworked	268

1.8.4 Modification 4C was released to change the refurbishment quantities of No. 2 and No. 3 mirror assemblies. Contract total reduction of fifty-one (51) mirrors was made by this change as follows:

Item No.	Description	Quantities
1	No. 1 Primary Collector Mirror	53 ea
2	No. 2 Secondary Collector Mirror	45 ea
3	No. 3 Secondary Collimator	9 ea
4	No. 4 Primary Collimator	35 ea

1.8.5 Modification 5S was released to extend contract date from June 15, 1973 to January 15, 1974.

1.8.6 Modification 6C was released to add ten (10) additional No. 4 mirrors to the contract for refurbishment. The quantity was increased from 35 units to 45 units.

1.8.7 Modification 7C was released to cancel modification 6C in its entirety.

1.8.8 Modification 8S was released to include two previously water-damaged mirrors to be recoated with the other 30 units being recoated. This modification also extended the completion date from January 15, 1974 to March 15, 1974.

1.8.9 Modification 9S was released to add six (6) additional No. 4 mirrors to the refurbishment portion of the contract, changing the quantity from 35 each to 41 each for refurbishment. The contract completion date was changed from March 15, 1974 to July 31, 1974.

1.8.10 Modification 10S was released for accountability of government equipment.

1.8.11 Modification 11S was released for contract completion date, extended from July 31, 1974 to September 30, 1974. It also reduced quantity of No. 4 mirror assemblies from 41 to 39 pieces.

1.9 Applicable Drawings:

Mirror No.	Description	Dwg. No.	Date
No. 1	Primary Collector Solar Simulator Mirror Assembly	614805-C	2/15/69
No. 1	Primary Collector Solar Simulator Mirror Assembly	614331-A	3/22/66

Mirror No.	Description	Dwg. No.	Date
No. 2	Secondary Collector Solar Simulator Mirror Assembly	614806-C	2/15/69
No. 2	Secondary Collector Solar Simulator Mirror Assembly	614577-A	10/13/66
No. 3	Secondary Collimator Solar Simulator Mirror Assembly	614807-C	2/15/69
No. 3	Secondary Collimator Solar Simulator Mirror Assembly	614576-C	9/28/66
No. 4	Primary Collimator Solar Simulator Mirror Assembly	614808-C	2/15/69
No. 4	Primary Collimator Solar Simulator Mirror Assembly	614320-D	7/18/68

2.0 SUMMARY

A total of one-hundred-forty-two (142) mirror assemblies were completely processed through the Mirror Refurbishment Program. All reflectors were removed from the mirror castings, replaced and processed through the various stages of processing and testing.

The processing of the mirror assemblies was completed on eleven different contract MOD requirements. The initial contract called for two-hundred-sixty-eight (268) mirror assemblies to be completely refurbished. With the series of contract modifications, the total refurbishment quantity was reduced to one-hundred-forty-two (142) mirror assemblies to be refurbished completely, seventy-five (75) assemblies to be recoated, and five (5) additional No. 4 mirrors to be proof plated from new submaster plating tools. In all, fifty-three (53) No. 1 mirror assemblies, forty-five (45) No. 2 mirror assemblies, nine (9) No. 3 mirror assemblies, and thirty-nine (39) No. 4 mirror assemblies were completely refurbished. Also, twenty (20) No. 1 mirror assemblies, twenty-five (25) No. 2 mirror assemblies, and thirty (30) No. 4 mirror assemblies were recoated after the optical test deviations were evaluated and dispositioned. Five (5) additional No. 4 mirror assemblies were used as proof plating units for two newly fabricated sub-masters.

Three other mirrors, one each No. 1, No. 2, and No. 3 were added to the contract and returned for problems with figure and coating. These mirrors were reworked and returned to JSC as proof platings from plating tools which had been reworked. The No. 1 casting showed porosity on the contour surface, and this casting was replaced by another unit. The No. 2 unit was refurbished due to delamination of the replica, and the No. 3 replica was replaced due to coating delamination (which caused optical deviation over 16.7 fringes per inch in this area).

Five No. 4 mirrors were added to the contract and returned. One unit was recoated, the other four mirrors were completely refurbished. This was due to epoxy voids between the casting contour surface and the nickel electroformed replica. There was also delamination of the replica from the casting, which in turn caused optical deviation in excess of specified tolerances.

3.0 MIRROR REFURBISHMENT PROCESSING

There are four types of mirror assemblies requiring refurbishment, all of which consist of a water-cooled aluminum casting and an electroformed nickel replica mirror. Electroforming is the process of building a structural part by electro -deposition on a master plating tool, and in this case the tool is re-usable. XEOS used two types of tools to produce these mirrors, one of which is a reverse form of the electroformed mirror and is made from 17-4-PH stainless steel. The other unit is an electroformed nickel tool, made from a stainless plating master, with a curvature identical tc the electroformed mirror.

There are several basic steps in the sequence of production, with the first step being fabrication of the replica tooling. Stainless steel has proven to be superior to any other metal and has produced large numbers of replications for these mirror configurations.

NOTE: The above-mentioned tooling was manufactured on previous contracts, and maintained in usable condition on subsequent contracts as well as this contract.

Once a master is available, the replica is electroformed directly on the master. After the proper thickness is achieved, the replica is parted from the master, and is epoxy bonded to an aluminum casting which has a contour machined to match the electroformed replica contour. After bonding and cure, the assembly is given a preliminary optical test; if it is within specified tolerance requirements, it is sent to electric discharge machining (EDM or ELOX). The EDM is used to cut the electroformed mirror to the proper inner and outer shapes and dimensions.

After washing, deburring, and mechanical inspection, the mirror assembly is ready for final optical tests. The minor optics, surface quality and cosmetics are rechecked to verify the preliminary optical test date. If the mirror is acceptable, final inspection data and photograph buy off are completed for the data pack.

From optical testing, the mirror assembly is forwarded to the vacuum coating area. The vacuum coating which is applied protects the surface of the electroformed replica and improves the reflectivity of the mirror assembly. After final inspection, the mirror with its paper work (data pack) is boxed and shipped to NASA/JSC, Houston, Texas.

3.1 Examination of Returned Mirror Assembly

Each mirror assembly in turn was unpackaged and examined for shipping damage. Also, at this time, the mirror serial number and replica degradation was verified with the NASA/JSC discrepancy list. After all paper work was properly filled in, the mirror assembly was prepared for rework.

3.2 Electroformed Mirror Replica and Epoxy Removal

After initial examination was completed, the mirror replica was heated with a large plumed torch and removed from the casting assembly. Immediately after the replica was removed, Pittsburg Paint & Varnish remover was applied to the epoxy which retains the replica. After many applications of this remover, the epoxy softened up and was scraped from the contour surface. Care was exercised so as not to damage the casting contour while removing all epoxy. Also, it was noted, if the cured epoxy layer was heated (as it is heated during replica removal) the epoxy can be removed by hand without the use of paint and varnish remover. This technique was used whenever possible during this program.

3.3 Electroforming of Mirror Replicas and Master Plating Tool Status

The No. 1, No. 2, and No. 3 mirror replicas were electroformed directly on stainless steel master plating tools. These tools were maintained to produce the best optical quality and cosmetic finish. One complete set of master plating tools was continually in service, and a second set was being optically polished or in complete rework. All six (6) plating masters, two (2) each for the No. 1, No. 2, and No. 3 mirror assemblies, are presently in usable condition and will produce acceptable mirrors when required.

Platings for the No. 4 mirror assemblies was done on submaster assemblies. These submasters are plating tools which are made directly from the master plating tool, and are also used as a bonding centering tool until the casting bonding operation is complete.

There were no significant problems in electroforming the No. 1, No. 2, No. 3 and No. 4 replica assemblies; however, there were many problems with No. 4 submaster tools. Chrome and nickel surface degradation was the biggest problem in that the surface oxidized and became etched after prolonged storage. Four different submasters, MM-4, MM-5, MM-14 and MM-17 had to be removed from service due to surface decay. Two other submasters also had to be removed from service because of optical tolerance decay - MM-16 and MM-21. Complete status of each master is included in this report.

3.3.1 Master Plating Tooling Rework and General Status

Maintenance of the master plating tooling during this program consisted of the following:

No. 1 Master Plating Tools

Unit S/N 27-X-AOM-N1. This master plating tool was optically ground and polished twice during this program, to clean up scratches and sleeks on the optical contour surface. No other rework was required and the master tool is ready for any other electroforming if required.

Unit S/N 27-X-AOM-N2. This master plating tool was completely reworked during this contract. The master contour was remachined and then the surface was optically ground and polished. Upon completion of this rework, the master plating tool was proof plated twice to check the optical qualities. Copies of the optical test data are included in this report.

No. 2 Master Plating Tools

Unit S/N 20-X-AOM-N1. During the course of this program, this plating master was optically polished twice. Sleeks and scratches caused from operational modes and cleaning caused this rework. The surface of the master is still acceptable for electroforming No. 2 mirror replicas.

Unit S/N 20-X-AOM-N2. The contour surface of this master was remachined, optically ground and polished, and is acceptable for electroforming requirements. Rework of this master was required due to contour surface degradation.

Both No. 2 minor masters are in usable condition.

No. 3 Master Plating Tools

Unit S/N 17-12-SOM-N1. Due to sleeks and stains on the optical contour surface of this master, a cleanup polish was required. Rework was completed and the unit placed into service. This master is in usable condition for electroforming requirements.

Unit S/N 17-12-SOM-N2. This master was remachined completely, then optically ground and polished. Platings were electroformed and proof plated to check optics. This unit is acceptable for service when required.

No. 4 Submaster Plating Tools

Use of the original submasters MM-4 and MM-5 was short lived on this contract. After removal from storage and preparation for electroforming, it was found that the

chrome surfaces had decayed during storage. After electroforming of replicas and proof plating evaluation, the units were determined scrap and removed from service.

During the usage of submaster MM-14, platings exhibited questionable cosmetics. The chrome layer was removed from the nickel substrate and the surface optically polished. After polishing, there was no significant surface cosmetic improvement and the submaster was considered scrap.

Submaster MM-16 was also considered scrap due to a bright line image display and irregular optics readings. Two submasters MM-17 and MM-19 were also reworked, in that the chrome layer was removed and the nickel surface rechromed. However, during electroforming operations, the surface condition of MM-19 decayed beyond acceptable usage. Due to the depletion of the submaster inventory, two more units were fabricated. After a short period of usage, these submasters showed signs of decay. Unit MM-21 was removed from service and unit MM-20 was used for refurbishment and proof plating mirror assemblies.

The No. 4 Master Plating Tool S/N 50 x AOM-N1SX was repolished prior to fabricating any new submasters. Due to orange peal on the optical contour surface, it was necessary to optically grind and polish the surface prior to use. The optical surface was ground and polished - then the master was optically tested. During optical testing, the master exhibited a shaded image display. After examination of surface of the optical contour with a microscope, it was verified that the surface was not quite polished. Evidence of gray areas on the surface corresponded with the image display. The master was returned to the vendor and the surface polished for another thirty-five hours before all the gray areas were polished out. Upon completion of this rework, the unit was returned and tested optically, per Appendix "D", Section B-4 .

3.4 Mirror Replica Bonding

Upon completion of the replica and epoxy removal, each casting was inspected by Quality Control. Hydrostatic leak testing at 150 P.S.I. and water flow tests were conducted on each casting per the applicable drawing and reference specifications. No hydrostatic leakage was permitted and water flow requirements were checked per applicable drawing. If, however, water flow or leakage problems were encountered, repairs were made in accordance to the referenced drawings and specifications.

After each casting was tested and accepted, it was processed through cleaning per Appendix "N" (EOS Directive 12-2). Upon completion of the cleaning process, the unit was inspected and approval was given for mirror replica bonding.

Each replica was set up on a locating and holding fixture and the casting was carefully located on the back side of the replica. After all centering fixtures were in place, the outline of the casting was marked on the replica. The centering fixture and casting were removed from the replica and plastic platers tape applied outside the area to be bonded.

After all masking was completed, the surfaces to be bonded on the casting and replica were cleaned with 200° alcohol. After the areas had dried, the back side of the nickel replica was coated with Primer K-1, then allowed to dry for 45 minutes.

Bonding epoxy was weighed and mixed per Appendix "J" (EOS Directive 15-2) and applied to both the casting and replica surfaces; then, the two surfaces were indexed jointly for bond. After centering and indexing, epoxy was applied to the prepared areas on the casting and torque test buttons were positioned onto the casting and shielded with mechanical guards.

The bonded assembly was then allowed to cure a minimum of four hours, then all excess epoxy and masking was trimmed from around the casting and torque buttons. The entire assembly was then allowed to cure for 24 hours, then the breakaway torque of the test buttons were checked by Quality Control and DCAS personnel. If successful torque readings were achieved (10 foot-lbs or greater) the unit was accepted and released for preliminary optical testing.

Any unit with torque results of less than 10 foot-lbs was rejected and reprocessed. In order to check the torque test more accurately each casting (except No. 3) had three (3) torque buttons positioned and checked. This procedure is approved for the No. 4 mirror assembly and also used on the No. 1 and No. 2 mirror bonding. Reference Appendix (J).

The No. 1 mirror assemblies are bonded in place using a contoured fixture; the No. 2 mirror is bonded using a contoured vacuum fixture; the No. 3 mirror is centered on the optical axis and bonded to the casting; and the No. 4 mirror is bonded to the electroformed replica with the replica still attached to the submaster plating tool.

There were no significant problems encountered during the bonding processing on this contract. The replica usage and average torque per mirror was as follows:

	No. 1	No. 2	No. 3	No. 4
Mirrors Processed	55 each	45 each	9 each	33 each
Replicas Used	61 each	54 each	15 each	48 each
Average Torque Foot-Lbs	22.82	24.5	25.3	22.7

3.5 Preliminary Optical Test

After completion of the bonding operation, the mirror assembly was tested to see if the optical figure was correct. The test served two purposes: first, it verified that the unit was acceptable for EDM cutting; second, if it was out of optical tolerance, a plating stress correction was made. This test was the "vernier adjustment" of stress control since very small stress changes cause significant optical geometry changes. Any large deviations were investigated, and this information was then transmitted back to the cognizant processing stations for corrective action.

Each unit was set up on an optical test bench and adjustments were made with the mechanical portions of the test equipment as referenced in Appendix "D" of Contract NAS-9-12960. The Nos. 1, 2 and 4 mirrors were tested according to the test procedure in a test tower at points on the vertical (X axis) and horizontal (Y axis) of the mirror. Typical setups are shown in Figs. 1 through 3. Any areas which exhibited dark or light spots or deviations in image display patterns were also checked. The surface area was closely examined for digs, scratches, dimples, and general appearance. Any noted deformities were checked optically; and, if the required criteria were met, the unit was accepted for further processing. If the unit was not acceptable optically, it was rejected and reprocessed.

The optical testing on the No. 3 mirror was performed using a 2.0 inch diameter glass checkplate on the mirror surface, and a fringe count was made. Many optical deviations can be noted by the experienced and trained eye and were closely checked with the glass checkplate. Fringe counts in excess of 16.7 fringes/inch, using the 2.0 inch diameter checkplate were cause for rejection. If the unit was optically out of tolerance, inspections and examinations were made and all information was forwarded to the various process stations as noted above.

All acceptable units were released to production for further processing.

All units were checked optically after the mirror replica bond was completed. These tests served to check the electroforming, mirror bonding, and the replica optics in general. If the preliminary

optical test was within tolerance, then the oversized mirror could be cut to dimensional blueprint requirements. If the mirror optics was not acceptable, then the mirror was rejected and cycled through the system.

Due to the size and flatness of the required curve for the No. 4 mirror, preliminary optical tests gave much data for platings in process, and adjustments could be made with each particular submaster when required.

3.6 Electrical Discharge Machining (EDM or ELOX)

EDM - Mirror Replica cut to Blueprint Dimension and Mechanical Inspection:

After preliminary optical testing, all acceptable mirror assemblies were processed through the EDM area. Using NASA tooling/ fixtures, each mirror assembly was cut to blueprint dimensions. After cutting the electroformed nickel, the inner and outer edges of the cut nickel were deburred and the mirror assembly washed. After air drying the assembly, the optical surface was inspected for sleeks and scratches. All of this data was recorded on a mirror surface examination sheet. After the mirror was cleaned and deburred, it was mechanically inspected. If the resulting EDM cuts were undersize, or the cosmetics of the mirror bad due to slecks and scratches (which could not be buffed out), the mirror assembly was rejected and reprocessed. Some scratches and sleeks can be buffed out of the nickel; however, if they were too severe, the mirror was rejected.

The tooling used for the EDM cutting was maintained as required. Average life for each tool cutting blade is approximately thirty mirror cuts, with a resharpening occurring about every 10 to 12 cuts. This tooling is in usable condition and ready to use for additional mirror processing.

3.7 Final Optical Test

The final optical test was basically the same test as the preliminary optical test as referenced in Appendix "B", but was witnessed by both DCAS and EOS inspectors. The No. 3 mirror was tested using a 2.0 inch diameter glass checkplate which has the correct radius of curvature. A monochromatic light was used for a conventional fringe count and the entire surface of the 12.0 inch diameter convex mirror was checked. Acceptance criteria are in the specification in Appendix "D".

The Nos. 1, 2 and 4 mirrors were optically tested using a ray trace method for these specific mirrors. Typical setups are shown in Figs. 1 through 3. A point light source was placed at or near the focal point of the mirror to produce a return beam which did not diverge or converge to an extreme. A slotted mask was placed across the surface of the mirror which then projected on a target bar which showed the theoretical position of the image and the optical tolerance. This test only tests the finite area exposed, and a judgment factor was used to determine how many test points were made. Initially, tests were made across the mirror horizontal and vertical axes to align the unit in the X-Y plane and locate the central axis. Once this was done, the relationship between the mirror and light source was not changed, only the slot mask is moved for additional test points. All test data taken were recorded and included in the Manufacturing Order mirror data package.

After early problems on No. 4 mirrors on previous contracts, EOS changed the test procedure to include looking at the projected image at 360 in. for zonal check locations, and checking with the 2-inch square grid. The actual measurements of angular error were still made using the 150-inch range; but, in addition, the 2-inch square grid was projected on the target screen. The grid is made from 1/4-inch strips of steel spaced on 2-inch centers and mounted in a frame. Photos were made of the pattern produced by this grid at 150 and 360 in. using the stainless steel master. The photo was used to compare the projection of the mirror under test and the grid produced by the master at both ranges (Fig. 4). Although it was not required by the test procedure, all No. 4 mirrors were checked with the test mask projection every 2 inches around the diameter, as shown in Fig. 5.

Changes can occur to the mirror figure after (EDM) cutting, since this tends to relieve any stresses of the outside edge and center section. If significant changes were observed, the data was relayed to process control for electroform stress control changes. Usually, the situation had been corrected prior to this operation, but in some cases it did require additional correction.

Any mirror assembly out of specification requirements was rejected and was returned to production for rework.

All rejected replicas were removed from the castings, and the castings were cleaned and reprocessed.

During this program, the original optical test plate used to test the No. 3 Secondary Collimator Mirrors was scratched and replaced by a new test plate. This original test plate, though scratched, was returned at the request of NASA for use at JSC.

Production testing of the No. 3 mirror required a test plate to be free of all surface blemishes in order to test mirror replicas properly.

During final inspection of No. 3 replicas, the second test plate was scratched by a burr on the center hole of a No. 3 Mirror Assembly. This, in turn, scratched other areas of the replica, and it was decided not to use the plate on any other mirrors. Due to the size of the test plate (2.0 inch diameter), it cannot be reworked once it is scratched. Further grinding and polishing would roll the edge, and also reduce the diameter after the rolled edge area was cut away. Another test plate was fabricated and is in usable condition for any additional requirements.

3.8 Vacuum Coating

Each mirror assembly, after being inspected and tested, was cleaned thoroughly. After being installed in the vacuum chamber (along with 2-inch square glass slides) and pumped down to the required pressure, the mirror was vacuum coated to improve the spectral reflectance of the nickel as follows: The coating consisted of an aluminum reflective layer, overcoated with silicon dioxide applied slowly so as to form a highly oxidized deposit. Prior to the aluminum deposit, it was necessary to apply a thin layer of chromium for enhanced adhesion, followed by a layer of silicon dioxide to provide a diffusion barrier between the aluminum film and substrate.

The overcoat of silicon dioxide was controlled to an effective optical thickness of one-half wave length of visible light. This thickness was established as the minimum for acceptable mechanical protection of the aluminum layer but the thickest practical from an optical standpoint, i.e., solar reflectance and thermal emittances.

Upon completion of the vacuum coating, the mirror assembly and sample slides were removed from the vacuum coating chamber. The mirror assembly was tape tested, and reflectivity curves run on the sample slides. These curves were evaluated and later became part of the data package.

After five (5) days, the mirror reflective surface was tape tested and water tested. If there was no degradation or coating failure, the mirror was cleaned, inspected, and packaged for shipment.

All of the Mirror assemblies on this contract were successfully coated and returned to NASA/JSC. There were periodic coating failures witnessed in the past. In most cases, these past failures

were traced to cleanliness of the nickel substrate. Overall, the coating adhesion was very good and with proper cleaning and available chemicals coating problems were minimal.

3.9 Final Inspection

Upon completion of the mirror assembly processing, the Manufacturing Order was reviewed by the Project Engineer, Quality Control Inspector, and the DCAS representative. All paper work was reviewed and each operation verified for conformance and completion. When all paper work was in order, final inspection was completed and stamped off. All paper work was then duplicated and prepared for packaging with the shipment data package.

Cap plugs were installed in the water cooling ports. Each mirror was then bolted into a wooden shipping container, and in the case of a No. 1 or No. 4 mirror, polyethylene sheeting was placed over the boxed mirror assembly, and a green acceptance tag attached to the inner portion of the container. After all inspection, the container was sealed and palleted for shipment.

4.0 MIRROR PROCESSING STRIP AND RECOAT

4.1 Examination of Returned Mirrors for Recoating

Twenty (20) No. 1, twenty-five (25) No. 2, and thirty (30) No. 4 mirror assemblies were received from NASA/JSC for vacuum coat strip and recoat operations. During the initial unpackaging and examination of these mirrors, it was noted that many of the mirror assemblies had more severe damage than the NASA discrepancy list noted. At the request of the NASA Technical Monitor, three (3) No. 2 mirrors, six (6) No. 1 and five (5) each No. 4 mirrors were removed from service and replaced at a later date. As a result of the shipping damage sustained on the No. 4 mirrors, special containers were fabricated by NASA in order to protect the optical surface of the mirror assembly during shipping and storage operations.

4.2 Preliminary Optical Test

Each mirror assembly was tested optically, as described in paragraph 3.5 above. This was done prior to coating removal due to the surface condition of the mirror assemblies. Also, the optical quality could be evaluated and discussed with the Technical Monitor prior to further processing.

4.3 Removal of Edge Seal and Thin Film Coating

Each of the mirror assemblies, after preliminary optical tests, was cleaned and the coating removed as thoroughly as possible using MIL standard tape. After all of the removable coating was stripped, the surface was cleaned and the edge seal removed. Chemical solutions were used to remove the remainder of the coating, then the surface was cleaned as for vacuum coating application.

4.4 Mirror Replica Cleaning & Buffing

Each mirror after being tested optically was cleaned as for vacuum coating operations and then buffed, if required. After the buffing operation, the mirror was cleaned again and inspected. After surface evaluation and inspection was completed, the unit was forwarded to the Optical Test Area.

4.5 Final Optical Test

After all processing and cleaning the mirror assembly was retested optically as described in paragraph 3.7 above. After all testing was completed and the data recorded, the Technical Monitor was advised of any optical test data deviation beyond

specified tolerances. No further processing of discrepant mirrors was started until a Material Review Board between NASA and XEOS was completed.

Acceptable optical testing or disposition of discrepant mirrors completed the test cycle and the units were forwarded to the Vacuum Coating area.

4.6 Vacuum Coating

All mirror assemblies on the strip and recoat portion of the contract were cleaned, vacuum coated, and tested, as described in paragraph 3.8 above. There were some problems encountered during the coating operations in that coating delamination occurred periodically. This was traced to contaminated substrate; in most cases, the substrate had to be cleaned, buffed, and cleaned again prior to vacuum coating.

4.7 Final Inspection and Shipping

Upon completion fo the vacuum coating operations and the five-day cure cycle, the mirror assemblies were tape tested, water tested, cleaned and inspected by Quality Control and DCAS. After acceptance of the mirror assembly and paper work for the data package, the unit was packaged and shipped to NASA/JSC.

5.0 GOVERNMENT FURNISHED TOOLING AND EQUIPMENT

All NASA tooling and equipment, at the request of NASA, was packaged and returned to JSC. Attached is a list of all tooling (by Government Tooling Number) and associated equipment which was returned on DD 1149 paper work. The master plating tools and all precision equipment was packaged in special containers, palletized and inventoried by the DCAS representative.

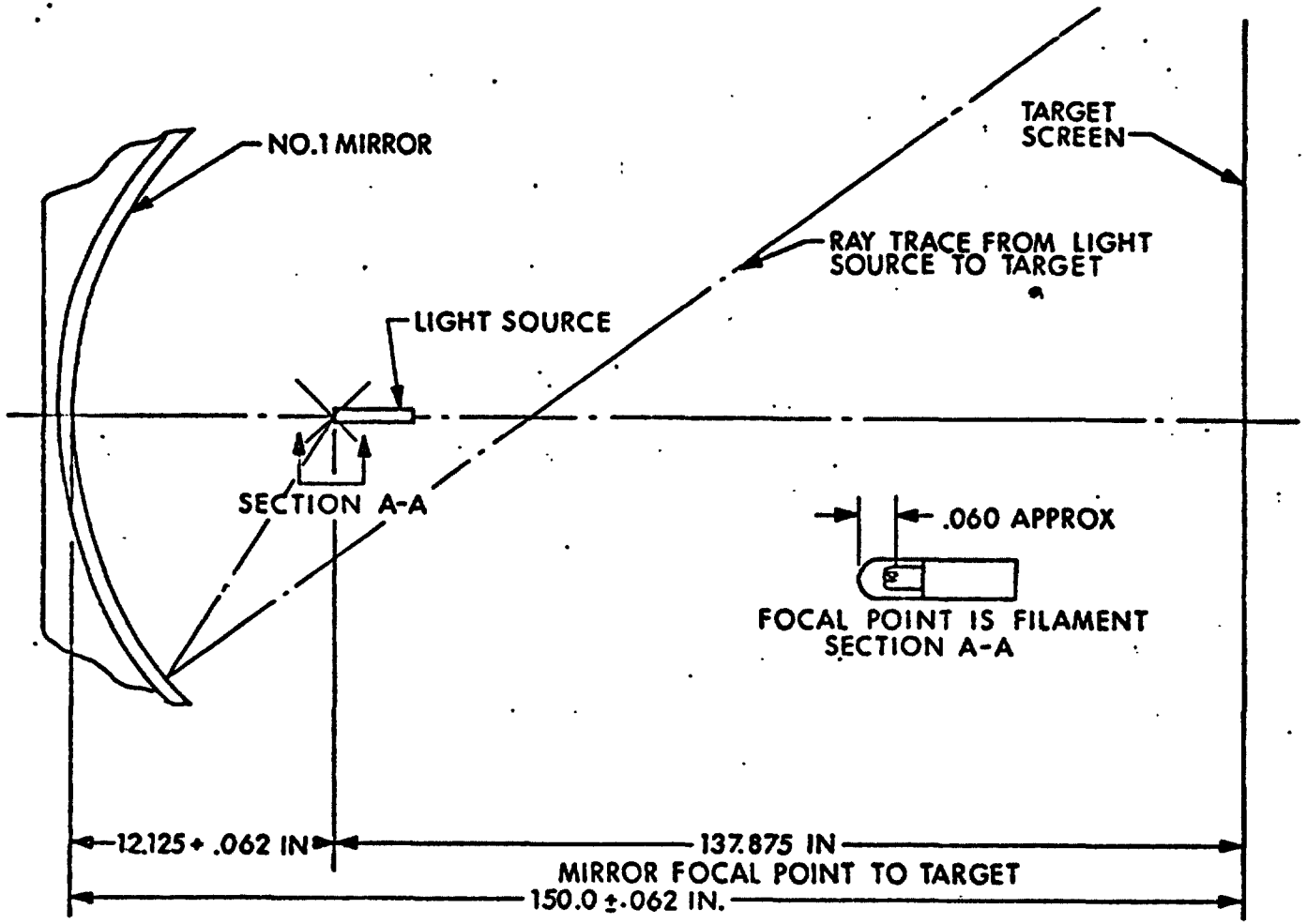


Figure 1 Schematic - No. 1 Mirror Test

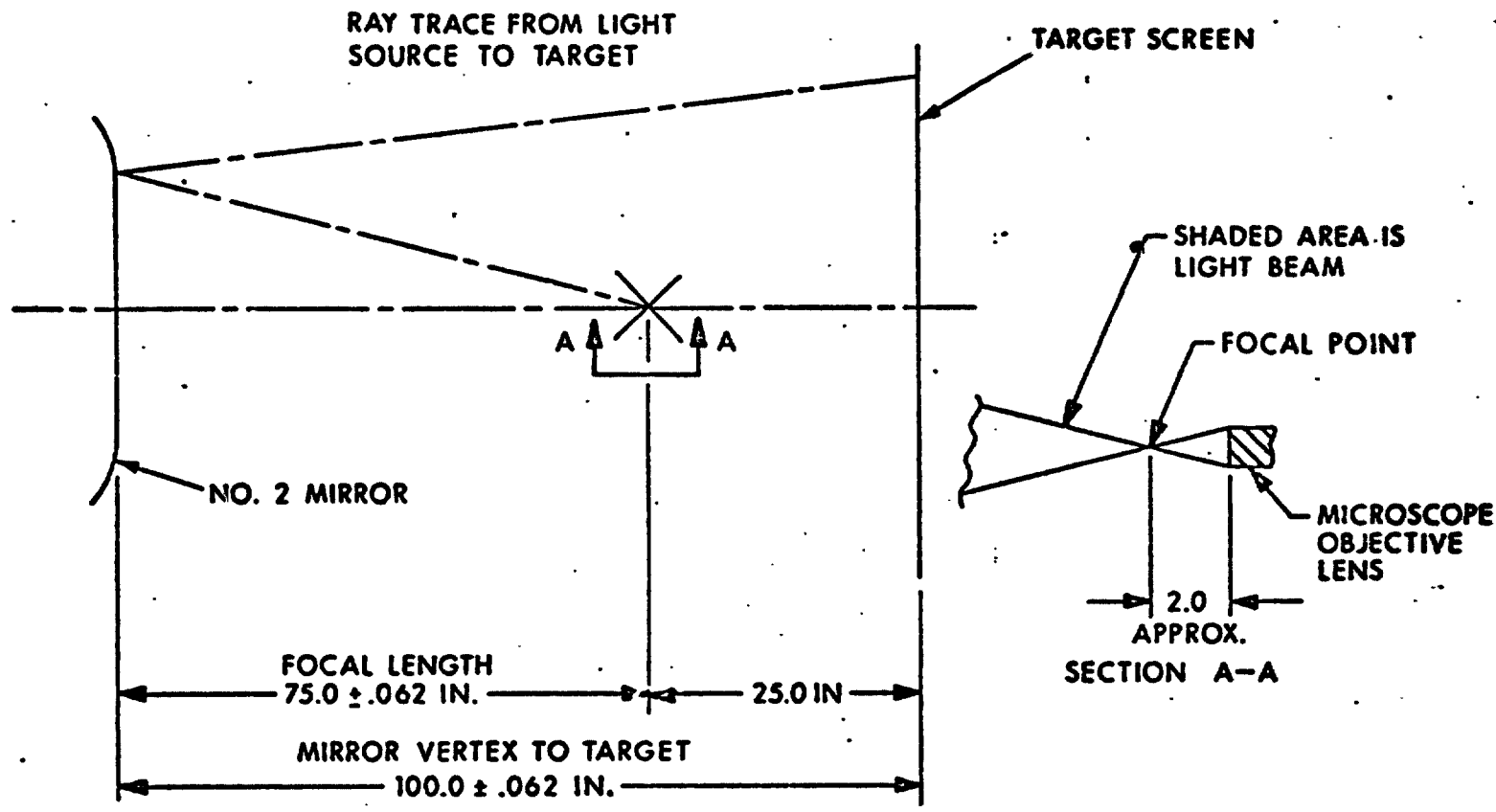


Figure 2 Schematic - No. 2 Mirror Test

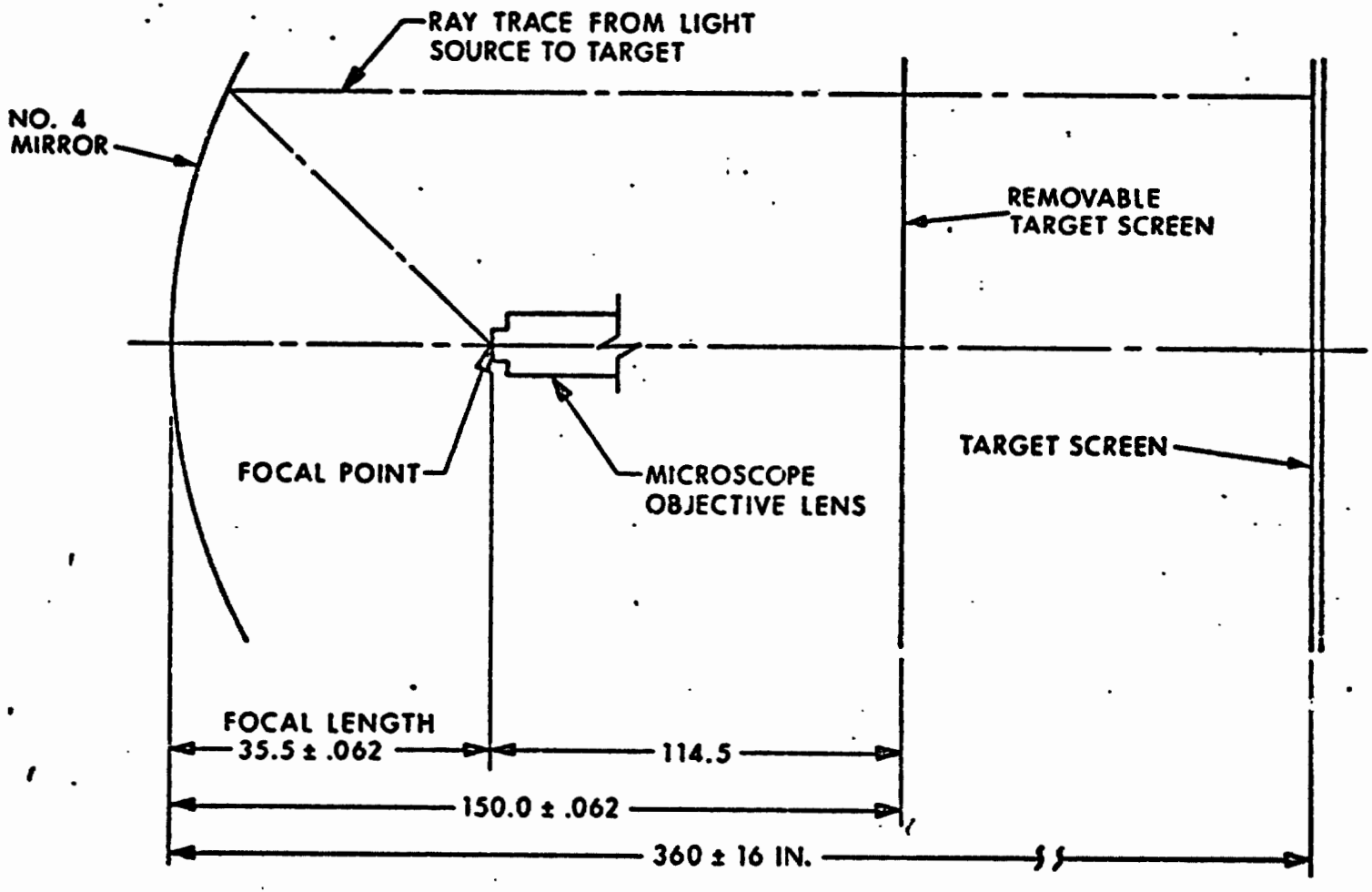


Figure 3 Schematic of No. 4 Mirror Test

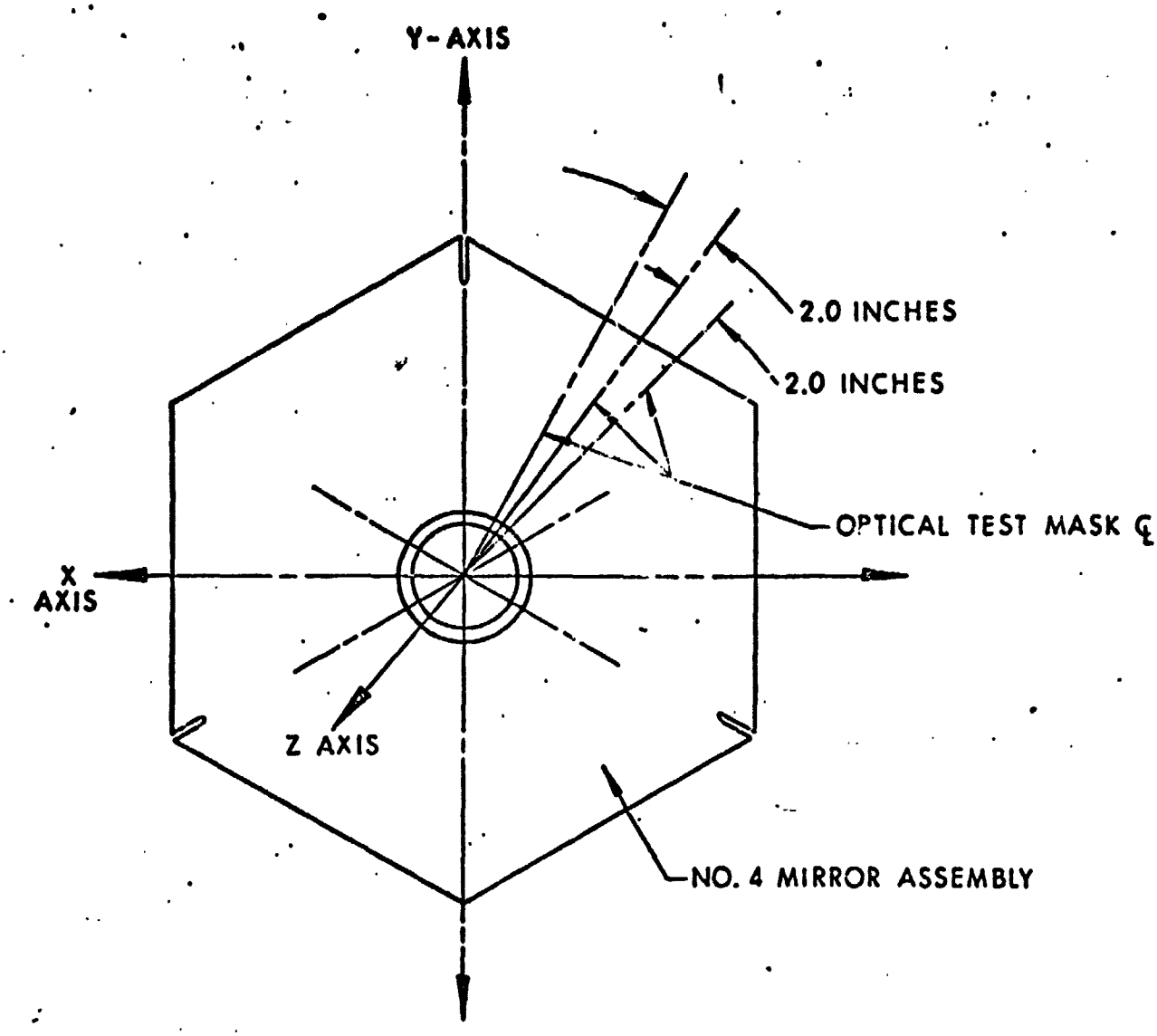
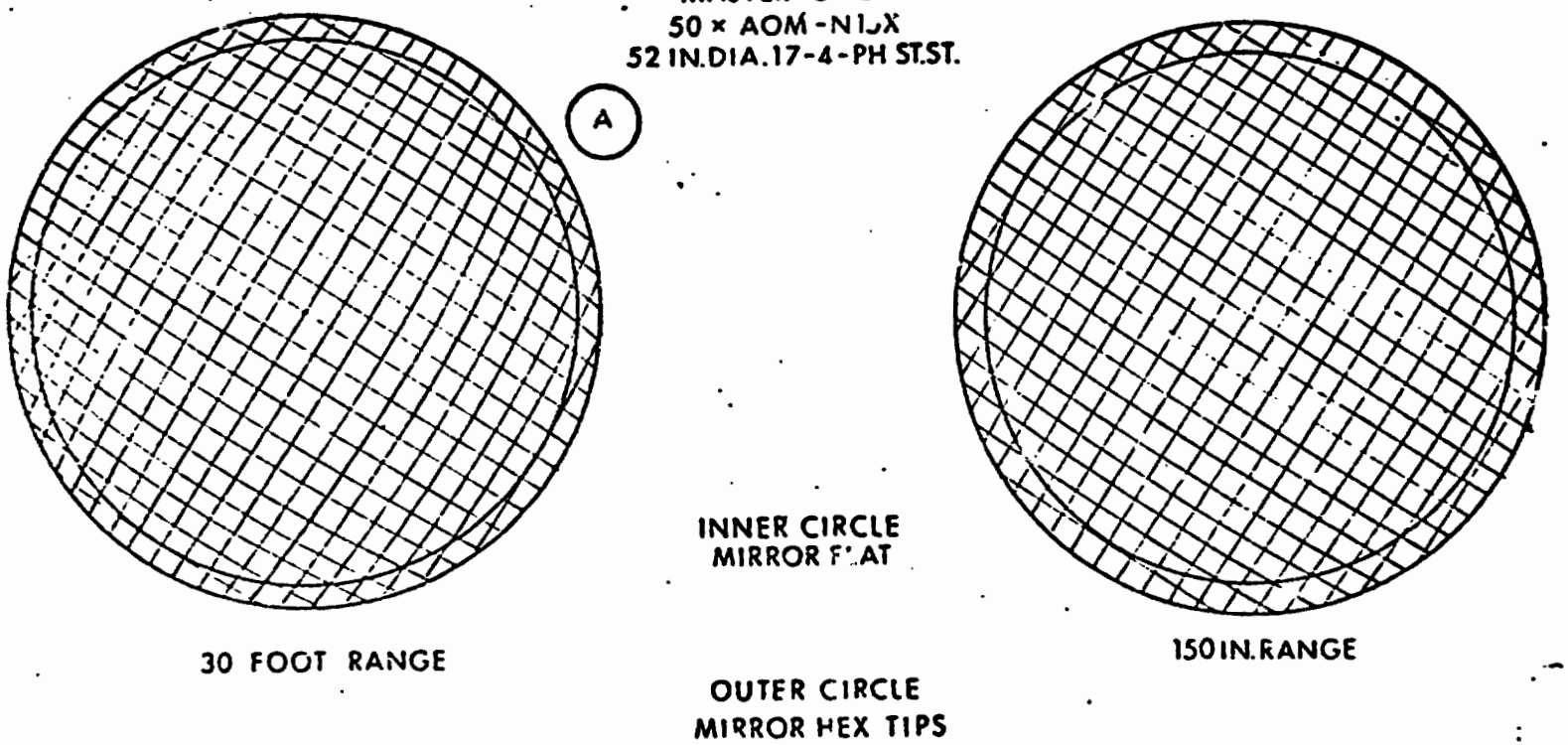


Figure 4 No. 4 Mirror Test Points



(A) { MIRROR MASTER WORKING TOOL COMPARATIVE GRIND
TO BE USED FOR OPTICAL EVALUATION OF NO.4 MIRRORS
P/N 614320 & 614808

Figure 5 No. 4 Grid Photo

PRIMARY COLLECTOR MIRROR

NASA MIRROR NO. 1 Proof Plating OPTICAL TEST

PART NO. _____ SERIAL NO. T1-17

FOCAL LENGTH 12.098

PROOF PLATING OF MIRROR MASTER 27-KAOM-MIX

Data Verification

Tested By D.F.M. Date 7-18-74 Witnessed by _____ Date 7-18-74

Diameter (Inches)	Sta. No.	Dimensional Deviation (Minutes of Arc) Theoretical					
		X Axis		Y Axis			
		Left	Right	Top	Bottom		
12.478	1	− 3 3/4	− 3 3/4	− 3 1/2	− 3 3/4	−	−
14.434	2	− 3/4	− 3/4	− 1/4	− 3/4	−	−
14.382	3	− 1 1/4	− 1 3/4	− 1	− 3/4	−	−
15.324	4	+ 1/4	− 0	− 0	+ 1 1/4	−	−
16.256	5	+ 3 1/2	+ 2 1/2	+ 3 1/4	+ 2 1/2	−	−
17.178	6	− 1 3/4	− 3	− 2 1/4	− 1 1/4	−	−
18.090	7	− 2	− 2 1/2	− 1 1/2	− 1 1/4	−	−
18.992	8	+ 1/2	+ 1/2	+ 3/4	+ 2 1/4	−	−
19.882	9	− 1 3/4	− 2	− 2	− 0	−	−
20.758	10	− 1/2	− 0	− 0	+ 2	−	−
21.622	11	− 2	− 1 1/2	− 1	+ 1/2	−	−
22.470	12	− 1 1/2	− 1 1/4	− 1 1/4	+ 1 1/4	−	−
23.302	13	− 3 1/2	− 3 1/2	− 3 1/2	− 3 1/2	−	−
24.118	14	− 3 1/2	− 3 1/4	− 2 3/4	− 1/2	−	−
24.914	15	− 2 1/4	− 2	− 1 3/4	+ 1 3/4	−	−
25.304	16	− 3/4	− 1 1/4	+ 3/4	+ 1 1/2	−	−
26.447	17	− 2	− 1 1/2	− 0	− 0	−	−

COMMENTS:

PRIMARY COLLECTOR MIRROR

NASA MIRROR NO. 1 PROOF PLATING OPTICAL TEST

PART NO. _____ SERIAL NO. 1028

FOCAL LENGTH 12.095

PROOF PLATING OF MIRROR MASTER 27 XROM-NIX-F

Data Verification

Tested By D. F. M. Date 7-15-74 Witnessed by EOS 309 Date 7-15-74

Diameter (Inches)	Sta. No.	Dimensional Deviation (Minutes of Arc) Theoretical					
		X Axis		Y Axis			
		Left	Right	Top	Bottom		
12.478	1	−2¼	−1½	−1½	−2¾	—	—
14.434	2	−0	+¾	+¾	−0	—	—
14.382	3	−¾	+¼	−¼	−¼	—	—
15.324	4	+¾	+1¼	+1¼	+1	—	—
16.256	5	+3	+3½	+4	+3¼	—	—
17.178	6	−2½	−½	−1½	−2¼	—	—
18.090	7	−1¼	+¼	−0	−1¾	—	—
18.992	8	+2¾	+2	+3	+3¼	—	—
19.882	9	+¼	−2	−½	−¾	—	—
20.758	10	+2½	−¼	+1	+2½	—	—
21.622	11	−½	+¼	−0	+¾	—	—
22.470	12	−½	+1	+½	−0	—	—
23.302	13	−1	−2¼	+¾	−1½	—	—
24.118	14	−1	−¾	+¼	−2¼	—	—
24.914	15	−0	+2¼	+1¼	−¾	—	—
25.304	16	−0	+1¼	+½	−½	—	—
26.447	17	−1	−½	−1¼	−0	—	—

COMMENTS: FOUR CIRCULAR RINGS IN MIRROR - OFF. Good

SHIPPING CONTAINER TALLY 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50

REQUISITION AND INVOICE/SHIPPING DOCUMENT

SHEET NO.	NO. OF SHEETS	5. REQUISITION DATE	6. REQUISITION NO.
1	7		

1. FROM: Xerox-Electro-Optical Systems NAS 9-12960
600 Bonita Ave., Pomona, California 91107 SO 2304

7. DATE MATERIEL REQUIRED:

8. PRIORITY:

2. TO:
Republic Van & Storage
620 East Third Street
Los Angeles, California 90013

9. AUTHORITY OR PURPOSE: J. Fuller Contracting Officer LTR# BT7-0/139-74 dated 6-25-74

10. SIGNATURE: [signature]

11a. VOUCHER NUMBER AND DATE: 74/2304/023 8-13-74

12. DATE SHIPPED: 14 Aug 1974

b. VOUCHER NUMBER AND DATE:

3. SHIP TO-MARK FOR:
Transportation Officer, Bldg. 420
NASA, Johnson Space Center, TX77058
for the property Officer 807402
for Reissue to: MR. R.J. Piotrowski, EL2, Bldg. 32

13. MODE OF SHIPMENT: Republic Van

14. BILL OF LADING NUMBER: EC 422

15. AIR MOVEMENT DESIGNATOR OR PORT REFERENCE NUMBER:

4. ACCOUNTING AND FUNDING DATA:

a ITEM NO.	b FEDERAL STOCK NUMBER, DESCRIPTION, AND CODING OF MATERIEL, AND/OR SERVICES	c UNIT OF ISSUE	d QUANTITY REQUESTED	e SUPPLY ACTION	f TYPE CONTAINER	g CONTAINER NOS.	h UNIT PRICE	i TOTAL COST
1.	III items of Tooling as listed on the attached listing pages 1 thur 6.	ea	112	111				193,479.27
2.	Proof Platings of #4 Submaster S/N's T430, T457, ER11, 4037,4056	ea	5	5			1190	5,950.00E
3.	#4 Refurbished Mirror S/N's T4-65,. T4-68	ea	2	2			1200. Est.	2.400.00E
4.	#1 Castings S/N's T-117, T-168	ea	2	2			2000.00	4,000.00E
5.	#4 Castings S/N's ER-24, T4-55, 4022	ea	3	3			5000.00	15,000.00E

[signature] 8-14-74
EOS QA DATE

[signature] 7-24
DCAS QA DATE

16. TRANSPORTATION VIA MATS OR MSTS CHARGEABLE TO

17. SPECIAL HANDLING

18a. RECAPITULATION OF SHIPMENT	ISSUED BY	TOTAL CONTAINERS	TYPE CONTAINER	DESCRIPTION	TOTAL WEIGHT	TOTAL CUBE
	CHECKED BY					
	PACKED BY					
			TOTAL			

19. RECEIPT				
CONTAINERS RECEIVED EXCEPT AS NOTED	DATE	BY	SHEET TOTAL	
QUANTITIES RECEIVED EXCEPT AS NOTED	DATE	BY	GRAND TOTAL	220,829.27
POSTED	DATE	BY	20. RECEIVER'S VOUCHER NO.	

DD FORM 1 MAR 58 1149

51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

REPLACES EDITION OF 1 MAY 58 WHICH MAY BE USED

FOLDOUT FRAME 1

MASTER LIST
OF NASA-OWNED TOOLING ACCOUNTABLE
TO
NAS9-12960 (S.O. 2304)

ITEM	TAG NO.	ACQ.YR.	DESCRIPTION	METHOD	UNIT CONTA
1.	GT 0039	67	Gage Inspection, No. 4 Mirror	III	Tag
2.	GT 0040	67	Torque Wrench	III	DC
3.	GT 13300	66	Micrometer Transport w/electronic probe	II	DC
4.	GT 13301	66	Micrometer Transport w/electronic probe	II	DC
5.	GT 13302	66	Micrometer Transport w/electronic probe	II	DC
6.	GT 13303	66	Inspection Assembly	II	WB
7.	GT 13306	66	Hold. Frame and Saddle for Overarm	I	WB
8.	GT 13307	66	Gage, Inspection, for Overarm Tooling, No. 1 Mirror Master	I	WB
9.	GT 13314	67	Fixture, Holding, No. 1 Mirror Master, Tooling Overarm	I	WB
10.	GT 13320	66	Plate, Test, 17" Dia. Glass	III	DC
11.	GT 14924	66	Template, Inspection, No. 3 Mirror, Male & Female	III	Fiber Bo
12.	GT 14925	66	Template, Inspection	III	Fiber Bo
13.	GT 14926	66	Cross Template, Inspection, No. 1 Mirror	III	Fiber Bo
14.	GT 14929	66	Template, Inspection, No. 2 Mirror, Male & Female	III	Fiber Bo
15.	GT 14930	66	Template, Inspection, No. 2 Mirror	III	Fiber Bo
16.	GT 14978	66	Centering Fixture, No. 1 Mirror	III	Fiber Bo
17.	GT 21335	71	Overarm Rotator Assembly, No. 1 Mirror Master	II	WB
18.	GT 21336	71	Anode Basket, 60", No. 4 Mirror	III	WB
19.	GT 21337	71	Anode Basket, 60", No. 4 Mirror	III	WB

M A S T E R L I S T

OF NASA-OWNED TOOLING ACCOUNTABLE

TO

NAS9-12960 (S.O. 2304)

DATE: 29 November 1973

FOLDOUT FRAME 2

-IPTION	METHOD	UNIT CONTAINERS	TOOL VALUE	
irror	III	Tag	$ 364.80	
	III	DC	39.47	
electronic probe	II	DC	800.00	
lectronic probe	II	DC	800.00	
lectronic probe	II	DC	800.00	
	II	WB	2875.00	
or Overarm	I	WB	1816.00	
erarm Tooling, No. 1 Mirror	I	WB	275.00	
Mirror Master, Tooling Overarm	I	WB	10870.00	
ass	III	DC	1400.00	
. 3 Mirror, Male & Female	III	Fiber Board	175.00	
	III	Fiber Board	325.00	
on, No. 1 Mirror	III	Fiber Board	325.00	
. 2 Mirror, Male & Female	III	Fiber Board	100.00	
. 2 Mirror	III	Fiber Board	100.00	
Mirror	III	Fiber Board	116.00	
, No. 1 Mirror Master	II	WB	1500.00	
Mirror	III	WB	1800.00	
Mirror	III	WB	1800.00	

FOLDOUT FRAME 1

MASTER LIST
OF NASA-OWNED TOOLING ACCOUNTABLE
TO
NAS9-12960 (S.O. 2304)

ITEM	TAG NO.	ACQ.YR.	DESCRIPTION	METHOD	CC
20.	GT 21338	71	Bonding Fixture, No. 1 Mirror	III	DC
21.	GT 21339	71	Bonding Fixture, No. 1 Mirror	III	DC
22.	GT 21340	71	Vacuum Bonding Fixture, No. 2 Mirror	III	DC
23.	GT 21341	71	Bonding & Centering Fixture, No. 2 Mirror	III	Fibe
24.	GT 21342	71	Bonding & Centering Fixture, No. 2 Mirror	III	Fibe
25.	GT 21343	71	Blade Holder, O.D., No. 4 Mirror	III	Wood
26.	GT 21344	71	Blade Holder, I.D., No. 4 Mirror	III	Fibe
27.	GT 21345	71	Blade Holder, O.D., No. 3 Mirror	III	Fibe
28.	GT 21346	71	Blade Holder, I.D., No. 3 Mirror	III	Fibe
29.	GT 21347	71	Blade Holder, O.D., No. 2 Mirror	III	Fibe
30.	GT 21348	71	Blade Holder, I.D., No. 2 Mirror	III	Fibe
31.	GT 21349	71	Blade Holder, O.D., No. 1 Mirror	III	Woo
32.	GT 21350	71	Blade Holder, I.D., No. 1 Mirror	III	Fibe
33.	GT 21351	71	Support Ring, No. 4 Mirror	I	Tag
34.	GT 21352	71	Support Ring, No. 4 Mirror	I	Tag
35.	GT 21353	71	Mounting Plate, No. 1, 2, & 3 Mirror	III	DC o
36.	GT 21354	71	Centering Pin, 1" Dia.	III	Tag
37.	GT 21355	71	Centering Pin, 1" Dia.	III	Tag
38.	GT 21356	71	Centering Pin, 1" Dia.	III	Tag

MASTER LIST
OF NASA-OWNED TOOLING ACCOUNTABLE
TO
NAS9-12960 (S.O. 2304)

FOLDOUT FRAME 2

DATE: 29 November 19

DESCRIPTION	METHOD	UNIT CONTAINERS	TOOL VALUE	
. 1 Mirror	III	DC	300.00	
. 1 Mirror	III	DC	300.00	
ure, No. 2 Mirror	III	DC	3500.00	
Fixture, No. 2 Mirror	III	Fiber Board	15.00	
Fixture, No. 2 Mirror	III	Fiber Board	15.00	
No. 4 Mirror	III	Wood Box	300.00	
No. 4 Mirror	III	Fiber Board	200.00	
No. 3 Mirror	III	Fiber Board	300.00	
No. 3 Mirror	III	Fiber Board	100.00	
No. 2 Mirror	III	Fiber Board	300.00	
No. 2 Mirror	III	Fiber Board	100.00	
No. 1 Mirror	III	Wood Box	300.00	
No. 1 Mirror	III	Fiber Board	100.00	
Mirror	I	Tag	200.00	
Mirror	I	Tag	200.00	
1, 2, & 3 Mirror	III	DC or WB	700.00	
ia.	III	Tag	35.00	
ia.	III	Tag	35.00	
ia.	III	Tag	35.00	

FOLDOUT FRAME 1

MASTER LIST
OF NASA-OWNED TOOLING ACCOUNTABLE
TO
NAS9-12960 (S.O. 2304)

ITEM	TAG NO.	ACQ.YR.	DESCRIPTION	METHOD	UNIT CONTAINER
49.	GT 21357	71	Centering Pin, 1" Dia.	III	Tag
50.	GT 21358	71	Centering Pin, 1" Dia.	III	Tag
51.	GT 21359	71	Blade & Centering Fixture, No. 4 Mirror	III	DC or WB
52.	GT 21360	71	Micro-Manipulator	III	DC
53.	GT 21361	71	Grid Screen, 50" Dia.	III	DC or WB
54.	GT 21362	71	Target Bar, No. 1 Mirror	III	Tag
55.	GT 21363	71	Target Bar, No. 2 Mirror	III	Tag
56.	GT 21364	71	Target Bar, No. 4 Mirror	III	Tag
57.	GT 21365	71	Test Mask, No. 1, 2, & 4 Mirrors, (set of 3)	III	DC
58.	GT 21366	71	Reticle Plate, No. 1 Mirror	III	Tag
59.	GT 21367	71	Reticle Plate, No. 2 Mirror	III	Tag
60.	GT 21368	71	Reticle Plate, No. 4 Mirror	III	Tag
61.	GT 21370	71	Light Source Projection	III	DC
62.	GT 21371	71	Light Source, B & L	III	DC
63.	GT 21372	71	Focal Length Fixture, No. 1 Mirror	III	Tag
64.	GT 21373	71	Focal Length Fixture, No. 4 Mirror	III	Tag
65.	GT 21374	71	Holding Fixture, Vacuum Coating, No. 1, 2, & 3 Mirror	III	Tag
66.	GT 21375	71	Holding Fixture, Vacuum Coating, No. 1, 2, & 3 Mirror	III	Tag
67.	GT 21376	71	Holding Fixture, Vacuum Coating, No. 1, 2, & 3 Mirror	III	DC

M A S T E R L I S T

OF NASA-OWNED TOOLING ACCOUNTABLE

TO

NAS9-12960 (S.O. 2304)

FOLDOUT FRAME 2

DATE: 29 November 1973

CRIPTION	METHOD	UNIT CONTAINERS	TOOL VALUE	
	III	Tag	35.00	
	III	Tag	35.00	
ure, No. 4 Mirror	III	DC or WB	350.00	
	III	DC	145.00	
	III	DC or WB	300.00	
or	III	Tag	200.00	
or	III	Tag	200.00	
or	III	Tag	150.00	
4 Mirrors, (set of 3)	III	DC	75.00	
irror	III	Tag	75.00	
irror	III	Tag	75.00	
irror	III	Tag	75.00	
n	III	DC	700.00	
	III	DC	150.00	
No. 1 Mirror	III	Tag	75.00	
No. 4 Mirror	III	Tag	75.00	
n Coating, No. 1. 2, & 3 Mirror	III	Tag	125.00	
m Coating, No. 1, 2, & 3 Mirror	III	Tag	125.00	
n Coating, No. 1, 2, & 3 Mirror	III	DC	125.00	

OLDOUT FRAME)

MASTER LIST
OF NASA-OWNED TOOLING ACCOUNTABLE
TO
NAS9-12960 (S.O. 2304)

ITEM	TAG NO.	ACQ.YR.	DESCRIPTION	METHOD	UNIT CONTAI
58.	GT 21377	71	Holding Fixture, Vacuum Coating, No. 1, 2, & 3 Mirror	III	DC
59.	GT 21378	71	Holding Fixture, Vacuum Coating, No. 1, 2, & 3 Mirror	III	DC
60.	GT 21379	71	Holding Fixture, Vacuum Coating, No. 4 Mirror	III	Tag
61.	GT 21380	71	Holding Fixture, Vacuum Coating, No. 4 Mirror	III	DC or WB
62.	GT 21381	71	Casting Contour Check Template, No. 1 Mirror	III	DC
63.	GT 21382	71	Casting Contour Check Template, No. 2 Mirror	III	Tag
64.	GT 21383	71	Casting Contour Check Template, No. 3 Mirror	III	Tag
65.	GT 21384	71	Casting Contour Check Template, No. 4 Mirror	III	DC
66.	GT 21385	71	Master, No. 1 Mirror	III	Anti-Tarn Paper - W
67.	GT 21386	71	Master, No. 1 Mirror	III	Anti-Tarn Paper - W
68.	GT 21387	71	Master, No. 2 Mirror	III	Anti-Tarn Paper - W
69.	GT 21388	71	Master, No. 2 Mirror	III	Anti-Tarn Paper - W
70.	GT 21389	71	Master, No. 3 Mirror	III	Anti-Tarn Paper - W
71.	GT 21390	71	Master, No. 3 Mirror	III	Anti-Tarn Paper - W
72.	GT 21391	71	Master, No. 4 Mirror	III	Anti-Tarn Paper - W
73.	GT 21479	73	Spindle Shaft, No. 4 Mirror	III	DC
74.	GT 21480	73	Spindle Shaft, No. 4 Mirror	III	DC
75.	GT 21481	73	Bonding Centering Spider, No. 2 Mirror	III	WB or DC
76.	GT 21482	73	Bonding Centering Spider, No. 2 Mirror	III	WB or DC

M A S T E R L I S T

OF NASA-OWNED TOOLING ACCOUNTABLE

TO

NAS9-12960 (S.O. 2304)

FOLDOUT FRAME 2

DATE: 29 November 1973

CRIPTION	METHOD	UNIT CONTAINERS	TOOL VALUE	
Coating, No. 1, 2, & 3 Mirror	III	DC	125.00	
Coating, No. 1, 2, & 3 Mirror	III	DC	125.00	
Coating, No. 4 Mirror	III	Tag	175.00	
Coating, No. 4 Mirror	III	DC or WB	175.00	
mplate, No. 1 Mirror	III	DC	350.00	
mplate, No. 2 Mirror	III	Tag	100.00	
emplate, No. 3 Mirror	III	Tag	120.00	
emplate, No. 4 Mirror	III	DC	750.00	
	III	Anti-Tarnish Paper - WB	15000.00	
	III	Anti-Tarnish Paper - WB	15000.00	
	III	Anti-Tarnish Paper - WB	3100.00	
	III	Anti-Tarnish Paper - WB	3100.00	
	III	Anti-Tarnish Paper - WB	1400.00	
	III	Anti-Tarnish Paper - WB	1400.00	
	III	Anti-Tarnish Paper - WB	80000.00	
ror	III	DC	80.00	
rror	III	DC	80.00	
, No. 2 Mirror	III	WB or DC	45.00	
, No. 2 Mirror	III	WB or DC	45.00	

FOLDOUT FRAME)

MASTER LIST
OF NASA-OWNED TOOLING ACCOUNTABLE
TO
NAS9-12960 (S.O. 2304)

ITEM	TAG NO.	ACQ.YR.	DESCRIPTION	METHOD	UNIT CONTA
77.	GT 21483	73	Bonding Centering Spider, No. 3 Mirror	III	WB or DC
78.	GT 21484	73	Bonding Centering Fixture, No. 3 Mirror	III	WB or DC
79.	GT 21485	73	Bonding Centering Fixture, No. 3 Mirror	III	WB or DC
80.	GT 21486	73	Bonding Centering Fixture, No. 3 Mirror	III	WB or DC
81.	GT 21487	73	Bonding Centering Fixture, No. 3 Mirror	III	WB or DC
82.	GT 21488	73	Turbo Spin Chuck Gage, Primary Collector	III	WB
83.	GT 21489	73	Template Mach. Master, No. 1 Mirror	III	DC
84.	GT 21490	73	Template, Contour Casting, (Gage)	III	WB
85.	GT 21491	73	Template, Contour, No. 4 Mirror	III	WB
86.	GT 21492	73	Check Plate, 2" Dia. Glass	III	DC
87.	GT 21493	73	Check Plate, 2" Dia. Glass	III	DC
88.	GT 21494	73	Probe Electronic, Lion PX321	1A8	DC
89.	GT 21495	73	Probe, Electronic, Lion PX321	1A8	DC
90.	GT 21496	73	Checking Fixture, No. 4 Mirror	III	WB
91.	GT 21497	73	Skin Test Support Fixture, No. 1 Mirror	III	DC
92.	GT 21498	73	Skin Test Support Fixture, No. 2 Mirror	III	DC
93.	GT 21499	72	Optical Test Mask, No. 1 Mirror (Set of 4)	III	DC
94.	GT 22200	72	Optical Test Mask, No. 2 Mirror (Set of 2)	III	DC
95.	GT 22201	72	Optical Test Mask, No. 4 Mirror (Set of 4)	III	DC

MASTER LIST

OF NASA-OWNED TOOLING ACCOUNTABLE

TO

NAS9-12960 (S.O. 2304)

FOLDOUT FRAME 2

DATE: 29 November 1973

SCRIPTION	METHOD	UNIT CONTAINERS	TOOL VALUE	
der, No. 3 Mirror	III	WB or DC	75.00	
ture, No. 3 Mirror	III	WB or DC	150.00	
ture, No. 3 Mirror	III	WB or DC	150.00	
ture, No. 3 Mirror	III	WB or DC	150.00	
ture, No. 3 Mirror	III	WB or DC	150.00	
, Primary Collector	III	WB	100.00	
, No. 1 Mirror	III	DC	60.00	
ting, (Gage)	III	WB	150.00	
. 4 Mirror	III	WB	150.00	
Glass	III	DC	50.00	
Glass	III	DC	50.00	
n PX321	1A8	DC	175.00	
ion PX321	1A8	DC	175.00	
4 Mirror	III	WB	600.00	
xture, No. 1 Mirror	III	DC	200.00	
xture, No. 2 Mirror	III	DC	75.00	
. 1 Mirror (Set of 4)	III	DC	217.00	
. 2 Mirror (Set of 2)	III	DC	217.00	
. 4 Mirror (Set of 4)	III	DC	289.00	

FOLDOUT FRAME

MASTER LIST
OF NASA-OWNED TOOLING ACCOUNTABLE
TO
NAS9-12960 (S.O. 2304)

[illegible]	TAG NO.	ACQ.YR.	DESCRIPTION	METHOD	UNIT CONTAI
	GT 22202	72	Target Bar, No. 1 Mirror	III	WB
	GT 22203	72	Target Bar, No. 2 Mirror	III	WB
	GT 22204	73	Target Bar, No. 4 Mirror	III	WB
	GT 22207	73	Submaster, No. 4 Mirror	III	WB
	GT 22208	73	Submaster, No. 4 Mirror	III	WB
	GT 22209	73	Chamber Fixture, No. 1, 2, & 3 Mirror	III	DC
	GT 22210	73	Chamber Fixture, No. 1, 2, & 3 Mirror	III	DC
	GT 22211	73	Chamber Fixture, No. 1, 2, & 3 Mirror	III	DC
	GT 22212	73	Holding Fixture No. 1, 2, & 3 Mirror	III	DC
	GT 22213	73	Ultra-Violet Bank	III	WB
	GT 22214	73	Master Test Target, No. 4 Mirror	III	DC
	GT 22215	73	Bonding Fixture Cart, No. 4 Mirror	III	Tag
	GT 22216	73	Bonding Fixture Cart, No. 4 Mirror	III	Tag
	GT 22217	73	Washdown & Ballast Cart, No. 4 Mirror	III	DC
	GT 22335	73	Submaster, No. 4 Mirror	III	WB
	GT 22336	73	Submaster, No. 4 Mirror	III	WB
	GT 22339	73	Test Plate, No. 3 Mirror	III	DC

[illegible] Packaging method to meet specification MIL-P-116. Wrapping, cushioning, bracing and blocking of each Unit containers to be fiberboard pads (DC) domestic
[illegible]vent damage during shipment and storage.
[illegible], on weight and size. Many items require special cushioning and consideration should be taken at time c
[illegible]ntainers are listed for most items. This is for information, only. Items can be consolidated as necessa
[illegible]nfiguration of items.

MASTER LIST

OF NASA-OWNED TOOLING ACCOUNTABLE

TO

NAS9-12960 (S.O. 2304)

FOLDOUT FRAME 2

DATE: 29 November 1973

IPTION	METHOD	UNIT CONTAINERS	TOOL VALUE	
	III	WB	200.00	
	III	WB	200.00	
	III	WB	225.00	
	III	WB	8000.00	
	III	WB	8000.00	
., & 3 Mirror	III	DC	100.00	
., & 3 Mirror	III	DC	100.00	
., & 3 Mirror	III	DC	100.00	
& 3 Mirror	III	DC	125.00	
	III	WB	6000.00	
Mirror	III	DC	50.00	
4 Mirror	III	Tag	300.00	
4 Mirror	III	Tag	300.00	
No. 4 Mirror	III	DC	60.00	
	III	WB	4500.00	
	III	WB	4500.00	
	III	DC	400.00	RETURNED to NASA — DD11 Vouchers FF 72/304/01

apping, cushioning, bracing and blocking of each item shall be as necessary to protect the items to it containers to be fiberboard pads (DC) domestic-fiberboard, or (WB) wood or plywood containers depen oning and consideration should be taken at time of packaging and packing to protect items as necessary nation, only. Items can be consolidated as necessary to conserve space depending on weight, size, and

SHIPPING CONTAINER TALLY 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27

REQUISITION AND INVOICE/SHIPPING DOCUMENT

SHEET NO. 1 / NO. OF SHEETS 1	5. REQUISITION DATE
6. REQUISITION NO.	
7. DATE MATERIEL REQUIRED	8. PRIORITY

1. FROM: XEROX CORPORATION, ELECTRO OPTICAL SYSTEMS, INC.
600 EAST BONITA AVENUE, POMONA, CALIFORNIA 91767

2. TO: NASA MANNED SPACECRAFT CENTER
TRANSPORTATION OFFICER
BLDG. 420
HOUSTON, TEXAS 77058

3. SHIP TO-MARK FOR:
RE-ISSUE TO JAMES P. VINCENT
EL23 BLDG. 103

9. AUTHORITY OR PURPOSE: VERBAL REQUEST FROM JAMES P. VINCENT

10. SIGNATURE: FOR: R. WHITNEY

11a. VOUCHER NUMBER AND DATE:

12. DATE SHIPPED: 10-17-72

b. VOUCHER NUMBER AND DATE: 72/2304/047 10/17-72

13. MODE OF SHIPMENT: AIR MAIL - REGISTERED

14. BILL OF LADING NUMBER:

15. AIR MOVEMENT DESIGNATOR OR PORT REFERENCE NUMBER

4. ACCOUNTING AND FUNDING DATA

ITEM NO. a	FEDERAL STOCK NUMBER, DESCRIPTION, AND CODING OF MATERIEL, AND/OR SERVICES b	UNIT OF ISSUE c	QUANTITY REQUESTED d	SUPPLY ACTION e	TYPE CONTAINER f	CONTAINER NOS. g	UNIT PRICE h	TOTAL COST i
1	2.0 INCH DIAMETER OPTICAL GLASS TEST PLATE FOR #3 SOLAR SIMULATOR MIRRORS. P/N: 614807 & 614576. (CHECK PLATE HAS 24.867 INCH RADIUS) GOVERNMENT PROPERTY NO. GT-21369	EA	1					

16. TRANSPORTATION VIA MATS OR MSTS CHARGEABLE TO

17. SPECIAL HANDLING

18a. RECAPITULATION OF SHIPMENT	ISSUED BY	TOTAL CONTAINERS	TYPE CONTAINER	DESCRIPTION	TOTAL WEIGHT	TOTAL CUBE
	CHECKED BY					
	PACKED BY					
			TOTAL			

19. RECEIPT				
CONTAINERS RECEIVED EXCEPT AS NOTED	DATE	BY	SHEET TOTAL	
QUANTITIES RECEIVED EXCEPT AS NOTED	DATE	BY	GRAND TOTAL	
POSTED	DATE	BY	20. RECEIVER'S VOUCHER NO.	

DD FORM 1 MAR 58 1149

51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

REPLACES EDITION OF 1 MAY 58 WHICH MAY BE USED