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COST ENGINEERING SUPPLEMENT

TO

FINAL REPORT

Project No. A-344

21 July 1960

Contract No. DA 36-039 SC-74870

Department of the Army Project No. 3-20-00-400

Signal Corps Technical Requirements SCL-5449

Placed By

United States Army Signal Supply Agency

Fort Monmouth Procurement Office

Fort Monmouth, New Jersey

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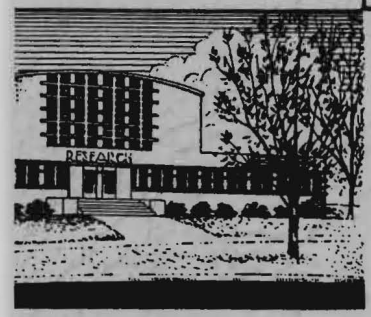

Engineering Experiment Station

Georgia Institute of Technology

Atlanta, Georgia

ENGINEERING EXPERIMENT STATION
of the Georgia Institute of Technology
Atlanta, Georgia

COST ENGINEERING SUPPLEMENT TO FINAL REPORT

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Prepared by R. M. Goodman, Jr.

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DEPARTMENT OF THE ARMY PROJECT NO.: 3-20-00-400
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I. ABSTRACT

A summary of expenditures for the research, development and construction of the 4.3 millimeter AN/MPS-29 combat surveillance radar is provided; manufacturing expenditures and estimates of production costs for major antenna components are given. The production capability of the manufacturing techniques developed for the reflector, geodesic lens, ring switch and scan-searchlight mechanism is discussed.

II. INTRODUCTION

The development of an experimental 4.3 millimeter combat surveillance radar was begun in July 1957 at Georgia Tech under the sponsorship of the Signal Corps. The fabrication of the first radar, designated the AN/MPS-29 (XE-1), was started in June 1958; delivery was made to Fort Huachuca for field observations in August 1959. A second radar, the AN/MPS-29 (XE-2), was delivered to Fort Monmouth during April 1960. The system and components were designed to meet the performance objectives set forth in Signal Corps Technical Requirements No. SCL-5449 and are described in References 1 and 2.

Total contract funding to date has been $1,261,773.88. Estimates of expenditures for equipment development are summarized in Table 1.

In this experimental equipment, packaging objectives, especially for the electronic units, stressed reliability and ease of maintenance rather than compactness and weight (Figures 1 and 2). Redesign and repackaging of these units to meet applicable military standards would be required prior to the manufacture of the system as field equipment; such redesign, in large measure, would follow standard practices and would involve conventional manufacturing procedures. The trailer and pedestal (Figure 3) used were designed for the AN/MPQ-4 radar and furnished by the Government for this contract. New designs of both the trailer and pedestal are required for an optimum antenna design (see Chapter IX, Reference 2) and therefore, cost and production reference to these units

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1. Georgia Tech Staff, Operating Instructions for AN/MPS-29 Radar, May 1960.

2. M. W. Long, G. E. Allen, Jr., and others, Combat Surveillance Radar, Final Report, Contract DA 36-039 SC-74870, June 1960.

Table I.

Equipment Development Expenditures

	Research and Preliminary Design 1 July 1957 to 1 June 1958	Final Design, Fabrication and Testing, XE-1 1 June 1958 to 1 August 1959	Fabrication and Testing, XE-2 1 August 1959 to 1 May 1960
Radar Branch Personal Services (includes overhead at 57 percent)	$259,000	$372,000	$115,000
EES Machine Shop Personal Services (includes overhead at 57 percent)	52,000	80,000	52,000
Materials and supplies, incorporated equipment and outside shop services such as spinning, machining and plating	33,000	100,000	70,000
Other expenses such as travel, freight and computer charges	10,000	8,000	3,000
Totals	$354,000	$560,000	$240,000

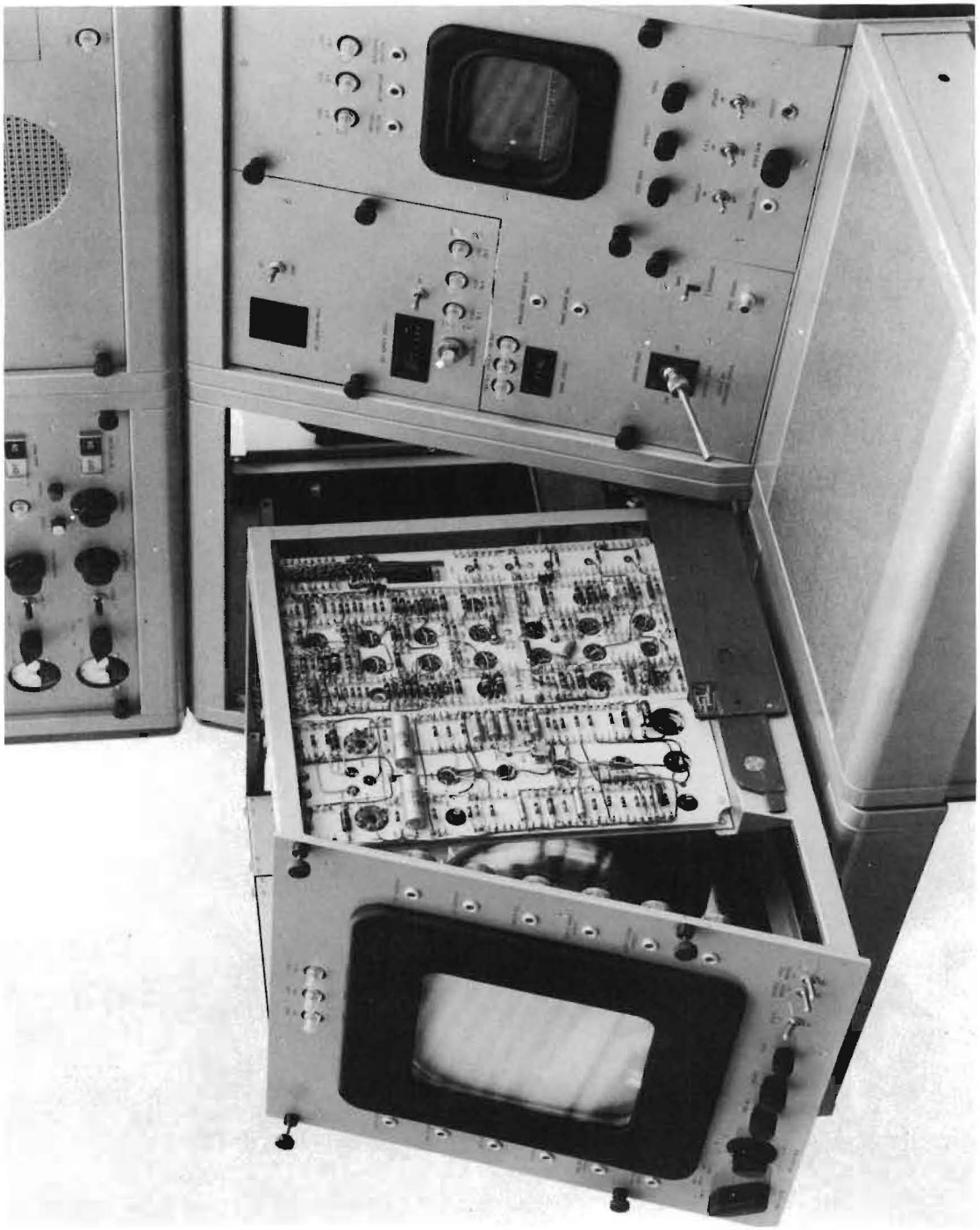

Figure 1. Front View of Console
The B-Indicator Unit is in the Maintenance Position.

Figure 2. Rear View of Console

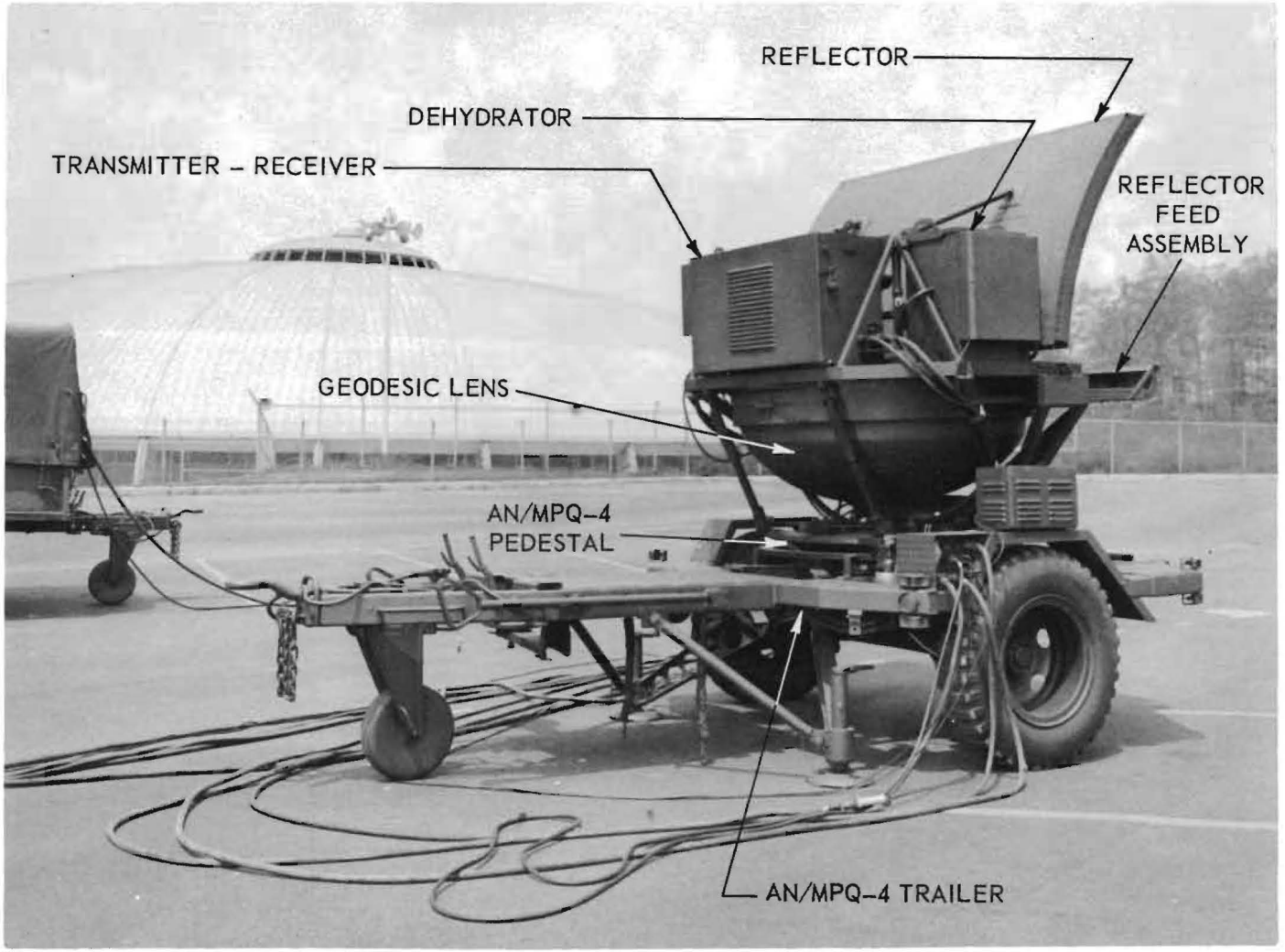

Figure 3. AN/MPS-29 (XE-2) Antenna

is not included. Similarly, no cost and production comments are made about the antenna frame, the dehydrator, and the transmitter-receiver because these components (Figure 3) would require redesign for use with production models of the pedestal and trailer. Manufacture of these, and other components not discussed herein, can be accomplished by conventional manufacturing methods. Manufacturing and checking techniques used in producing certain major components of the antenna, however, had to be developed during the course of the project and are of special significance because no other experience exists to guide either a production redesign of the antenna or the production design of similar equipment.

Consideration of specific components of the AN/MPS-29 radar will be limited to discussions concerning (1) the cost of the reflector, geodesic lens, ring switch, and scan-searchlight mechanism, (2) the production capability of the manufacturing methods used to produce these units on the contract, and (3) suggested approaches for increasing production capacity for these components.

During the preliminary antenna design phase of the contract, a major effort was devoted to the assignment of reasonable mechanical tolerances for components operating at a wavelength of 4.3 millimeters and the selection of manufacturing methods commensurate with these tolerances. Since it was apparent that the state of the art in manufacturing techniques had to be advanced in order to create many parts of the antenna, considerable difficulty was anticipated in achieving the required accuracy. The production plan adopted for each major development involved the proving of each step in the manufacturing process prior to the start of the subsequent step. The possibility of accidental damage to components at any stage of construction dictated that all tooling and fixtures be suitable for use in the manufacture of replacement parts. Thus the manufacturing plan,

the quality control procedures, and the required tooling -- while intended for use in the construction of a single unit -- were designed in such a manner as to be useful for limited production.

A contract modification authorized the construction of the AN/MPS-29(XE-2). The forged rings and spinnings produced as spares for the lens and ring switch during the manufacturing phase of the XE-1 program were utilized in the XE-2. With the few exceptions described in Reference 2, manufacturing techniques, tooling, and shop aids developed for the XE-1 were used in producing the XE-2. Table II is a list of approximate costs of manufacture for the major antenna components developed under the contract.

The components listed in Table II, being development items having stringent accuracy requirements, were produced by manufacturing techniques intended for use on this program only. All special techniques, tools, and shop aids are capable of limited production, however, and in certain instances, are considered suitable for use in quantity production.

Table II.

XE-1 and XE-2 Component Fabrication Costs

	Tooling Cost*	Incorporated Equip., Outside Machining and Plating	Ga. Tech Shop Cost (Inc. Shop Aids)	Fabrication Cost Totals*
		XE-1		
Reflector	$ 5,988	$ 2,591	$ 1,800	$ 4,391
Lens Assembly	9,888	16,589	11,600	28,189
Ring Switch	1,100	218	4,204	4,422
Scan-Searchlight Mechanism		12,160	10,800	22,960
		XE-2		
Reflector		2,657	1,400	4,057
Lens Assembly		15,501	9,200	24,701
Ring Switch		218	2,400	2,618
Scan-Searchlight Mechanism		11,880	8,792	20,672
Proposed Alternate Scan-Searchlight Mechanism**		9,500	5,600	15,100

*Design Engineering, Engineering Supervision and Testing Costs are not included.

**Estimated Cost of Experimental Model.

III. REFLECTOR

The manufacturing methods (Reference 2, Chapter V, Section C3) used to produce the XE-2 reflector (Figure 3) are adaptable to quantity production; appreciable cost savings are possible, however, over the cost incurred for the XE-2. The bonding tool is suitable for moderate production quantities, as is the template controlled method of machining the face of the reflector. Additional manufacturing methods work would be required on the procedure for facing the reflector to reduce the handwork in locating and applying the aluminum block machinable facing to the reflector sandwich structure.

IV. GEODESIC LENS

The lens tolerance requirements (generally ±0.005 inch) called for the development of manufacturing procedures having a high inherent accuracy potential; suitability of these procedures for quantity production was secondary. Only the minimum tooling, special equipment and manufacturing aids were designed and constructed. All work was done under close engineering supervision and frequent quality control checks were made during the manufacturing process. Chapter VI, Section D, of Reference 2 describes the mechanical design and fabrication of the lens. Using this procedure, a lapsed time of approximately 7 months is required to produce a lens complete with flat plate extensions and reflector feed assembly. Operations requiring the longest lead times are (1) machining the partial figures of revolution in the lens parts, (2) mating and mechanical joining of the lens parts (Figure 4), and (3) machining and assembling the reflector feed assembly. These manufacturing procedures are capable of producing parts of satisfactory accuracy but are not adapted to quantity production without a considerable modification of the processes, tooling and manufacturing equipment.

Two production approaches are possible. One involves duplication of the tooling and shop aids used during the three long lead time operations, and the other requires a complete re-examination of the manufacturing plan with the intent of developing a new approach -- one better adapted to quantity production and with proved retention of product quality. It is estimated that the present procedures, with three additional sets of tooling, could be used to produce one lens assembly per month for a unit cost of $25,000. A production

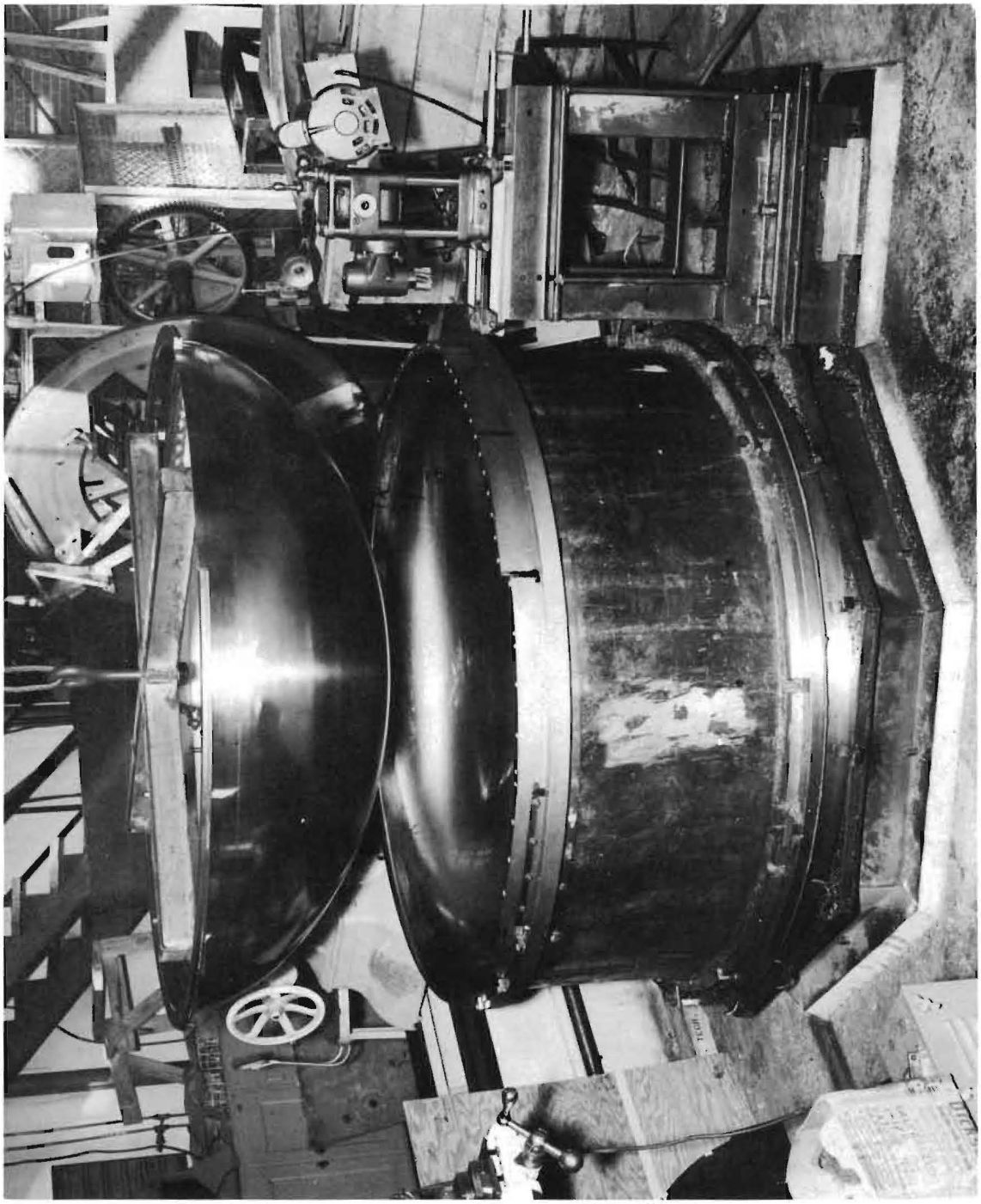

Figure 4. Inner and Outer Lens Parts
The Outer lens part is mounted in its special tooling.

development program to improve producibility without impairing lens accuracy is recommended; such a program would cost an estimated $150,000. Assuming $75,000 for production tooling costs, it is estimated that within one year lens assemblies could be produced at the rate of one per week. It is believed that such a program could reduce the lens unit cost to $15,000, with a goal of $10,000 per unit.

V. RING SWITCH

The manufacturing plan developed for the ring switch (Figure 5) is considered generally suitable for quantity production. A single cavity plastic injection mold has been made which produces electroform mandrels of satisfactory accuracy for the ring switch junctions. Electroforming, machining, and plating techniques have been developed and are adequate. Fixtures which reduce the need for highly skilled work in the machining, installation, and alignment of the electroformed ring switch junctions would be required, and would have to be developed. Cost for these fixtures is estimated at $10,000.

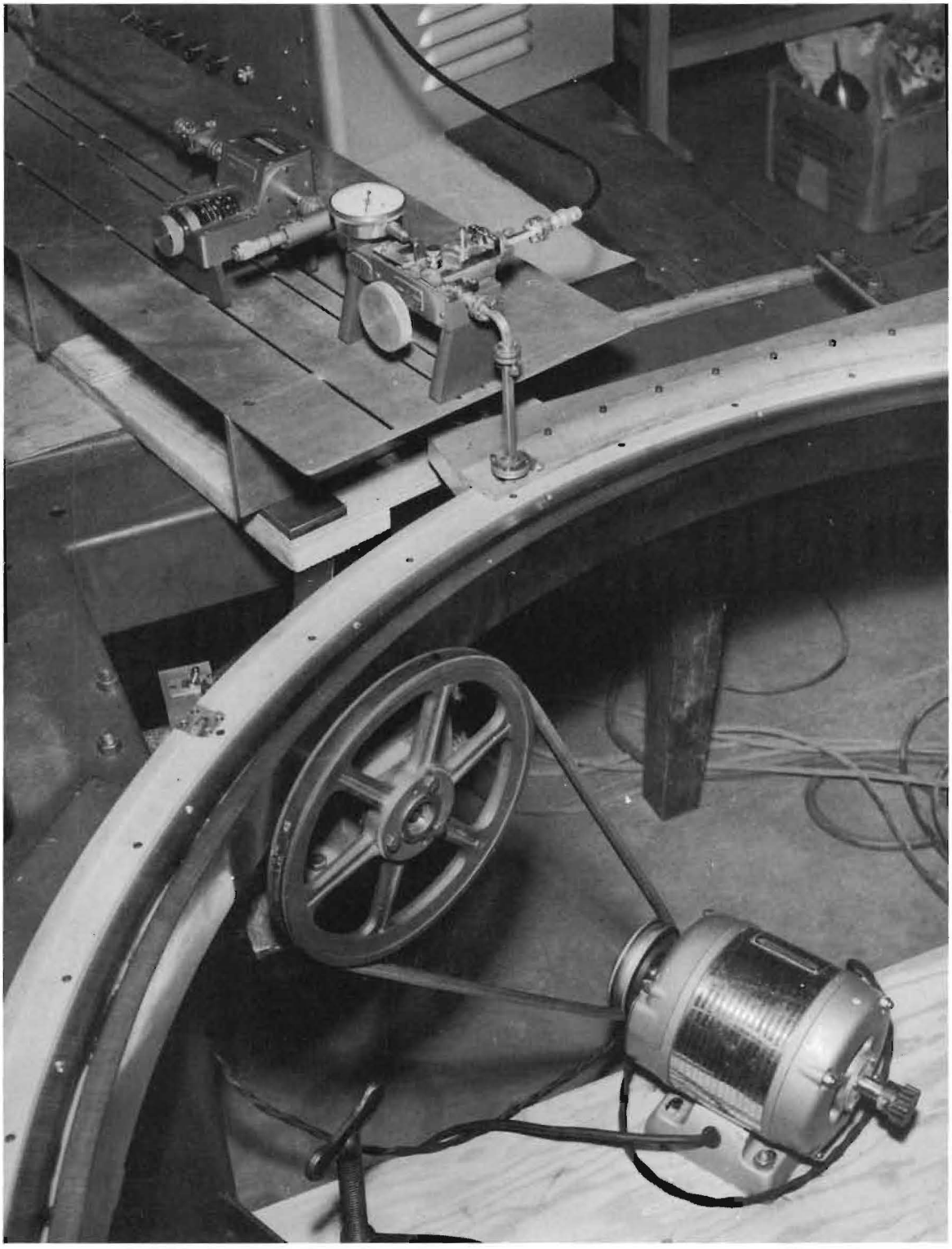

Figure 5. Ring Switch Rotor and Stator
The rotor is shown mounted on the scanner bearing during testing.

VI. SCAN-SEARCHLIGHT MECHANISM

Hydraulic components used in the scan-searchlight mechanism in both the XE-1 and XE-2 systems are either items now being regularly manufactured or similar units, designed and built on the contract, which could be produced in quantity by any competent hydraulic equipment manufacturer. The manufacturer of the bearing and gear is an excellent one; the manufacturing methods used are adequate for reasonable production quantities. Welding jigs and machining fixtures would be required for other parts of the mechanism but would represent no problem to a qualified manufacturer.

The scan-searchlight mechanism (Figure 6) incorporated in the two systems produced has proven to be satisfactory, meeting or exceeding the applicable technical requirements. During the construction of the XE-2 system, however, an alternate approach to the scan-searchlight function was conceived. This approach is described in Chapter VIII, Section B3 of Reference 2. Aside from the mechanical and electrical operating advantages associated with the less complicated mechanism required, appreciable reductions in manufacturing costs would result from its adoption.

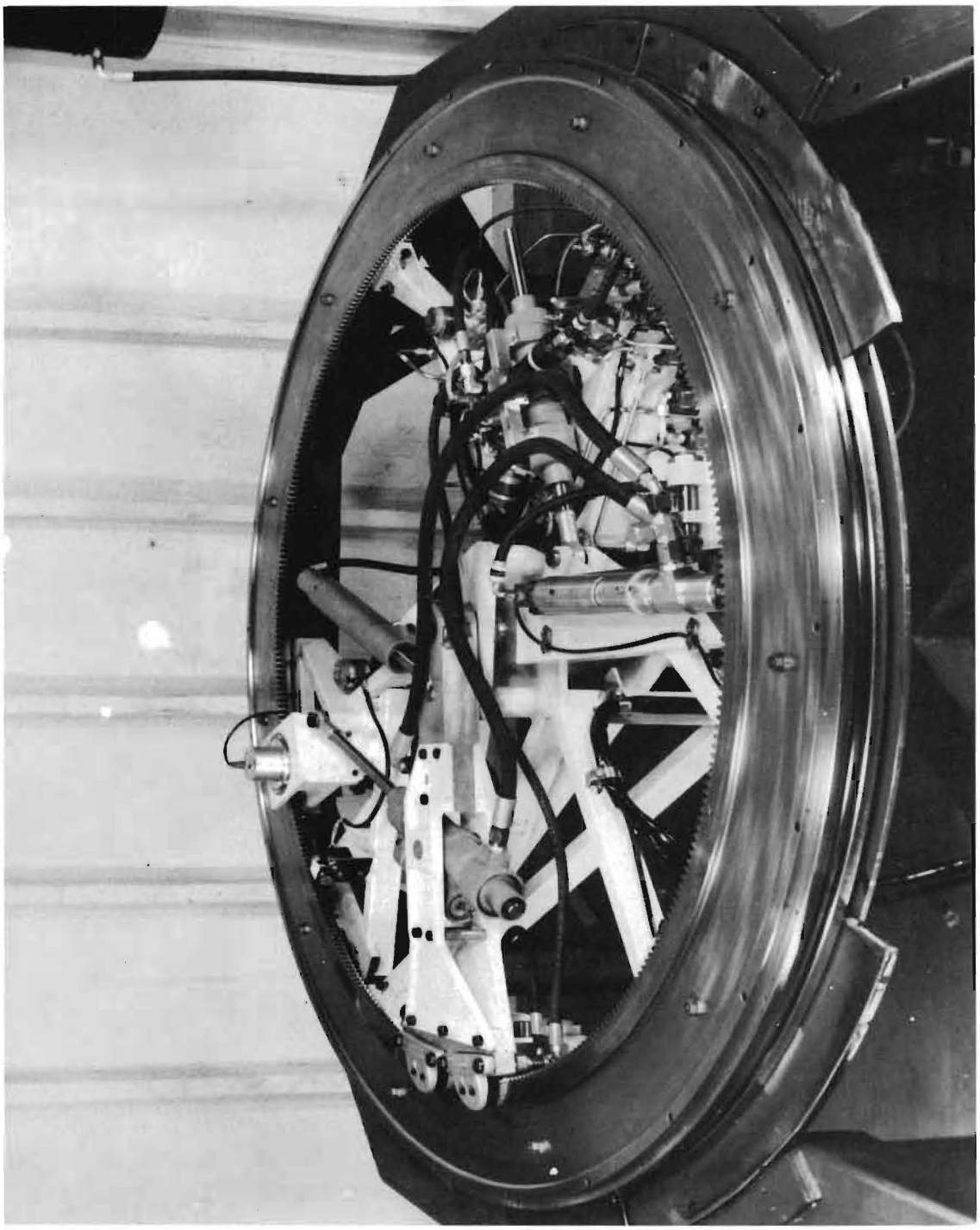

Figure 6. Scan-Searchlight Mechanism
The mechanism is shown on its mechanical test stand.

Table III.

Component Production Costs

	New Tooling Required, Estimated	Unit Cost, Estimated
Reflector	$ 5,000.00	$ 3,500.00
Geodesic Lens	75,000.00*	15,000.00*
Ring Switch	10,000 00	2,000.00
Scan-Searchlight Mechanism		
XE-1 and XE-2 Type	2,500.00	10,000.00
Proposed Alternate	1,500.00	6,500.00

*Estimate assumes a successful conclusion to the production development program recommended in text

Table III contains estimates of production unit costs of the components discussed herein; all estimates are based on a minimum production rate of one unit per week in 100 unit lots.

VII. CONCLUSIONS

It should be recognized, in reviewing the component unit price estimates in Tables II and III, that the AN/MPS-29 antenna, because of its complexity and the accuracy requirements of certain incorporated components, will be difficult to manufacture in quantity. The Engineering Experiment Station at Georgia Tech, by producing the XE-1 and XE-2 systems on Contract No. DA 36-039 SC-74870, has demonstrated, however, that such manufacture is practical. The experience gained during this contract is the basis for all estimates of cost in this supplement.

Respectfully submitted:

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Approved:

M. W. Long, Chief
Electronics Division