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AVRO AIRCRAFT LIMITED

AVROMOBILE
AVROCAR

# PROGRESS REPORT NO. 3

## AVROCAR 1

U.S. Army designation VZ-9AV

1 August 1958 - 30 September 1958

USAF Contract

AF 33(600)37496

The number of pages in this report including Security Warning, Title Page, Approvals Page, Preface, Table of Contents, List of Illustrations and Appendix is 71.

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# PREFACE

This is the third Progress Report on a program which covers the design and construction of an airborne vehicle designated by the Company as AVROCAR 1, and by the U.S. Army as VZ-9AV.

The program was called for in the Statement of Work, 58RDZ-12743, dated 1 May 1958 and the Company's interpretation of it is set forth in the Avrocar Program Planning Report, 58RDZ-11206, dated 20 May 1958.

To the extent specified in the above documents, this program covers the design, component development and construction of an experimental test vehicle of the AVROCAR type by June 1959. Later the program will be extended to cover a demonstration of the basic feasibility of this type of vehicle.

Reports on the 1/5 Scale Avrocar Model and Simulation Study programs, in this publication, are being discontinued to avoid overlapping and possible confusion in reporting. These spheres of work form part of the USAF Re-Directed System 606A program and as such are covered in the Bi-Monthly System 606A Progress Reports.

Formal progress reports supplemented by interim letter reports are published on alternate months. The formal reports cover the previous two-monthly reporting period and the interim report summarizes work for the preceding month only.

The present formal report covers the work period from 1 August 1958 to 30 September 1958 and the cost period from 1 February 1958 to 3 October 1958.

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# PART 1

# SUMMARY

Satisfactory progress is being maintained on the overall Avrocar program.

Design of the Test Vehicle is almost complete and stressing of structural components, powerplant installations, services and equipment is well advanced. Tooling and manufacture is proceeding at a satisfactory rate and is ahead of schedule.

The Mock-up structure is nearing completion and a large percentage of the equipment has been fabricated and installed.

Research on the 1/20 Scale Avrocar Model is continuing and further studies have been completed on a selection of control configurations. The model was modified for the purpose of improving the flow characteristics in the radial diffuser.

Stressing of the Full Scale Wing Tip Segment is complete and manufacture is well advanced. Installation details have been finalized with Orenda Engines and preliminary checks have been carried out at their Nobel, Ontario test facility.

Information on the Orenda Engines turborotor contract is contained in the Appendix to this report.

# PART 2

# TEST VEHICLE

## 2.1 Engineering

### 2.1.1 Design

A structure cutaway of the Avrocar test vehicle is illustrated in Fig. 1 and has been included for reference purposes.

#### 2.1.1.1 Structure

A number of major structural sub-assemblies consisting of the centre base, wing segments, wing tip, partition bulkheads, trunk compartment doors and canopy decks were detailed and released for manufacture. It has been found necessary to provide for local stiffening of some structural members. Drawing modifications to incorporate this stiffening have been finalized and issued for production. Design of the transparent canopies is now complete and manufacturing drawings have been released.

#### 2.1.1.2 Powerplant

Detail and assembly drawings for the engine air intakes, engine cowlings, exhaust bullets, turborotor casing and turbine exhaust boxes have been released for fabrication. Detail drawings only have been released on the turborotor intake. Installation details are complete for both the turborotor and engine throttle controls and the majority of drawings have been issued for production.

A meeting was held at WADC on August 26 to discuss the introduction of twenty-five minor modifications to the Continental J69-T-9 Engines. All but item 18 of the proposed modification list were approved and later confirmed by AMC, Wright-Patterson Air Force Base, Dayton, Ohio in their letter of 10 September 1958. A revised modification proposal for item 18, installation of the exhaust bullet, was requested and an alternative scheme for mounting the exhaust bullet on six guide vanes in the jet pipe assembly is being prepared.

#### 2.1.1.3 Services and Equipment

The design of the pneumatic system, flying controls, operator's instrument panels and footrests, cockpit consoles and engine controls has been completed. Design of both electrical and radio systems is well advanced. A large percentage of detail drawings for these components and assemblies have been released for manufacture. Schemes for the operator's seat, harness and armrest installations have still to be finalized.

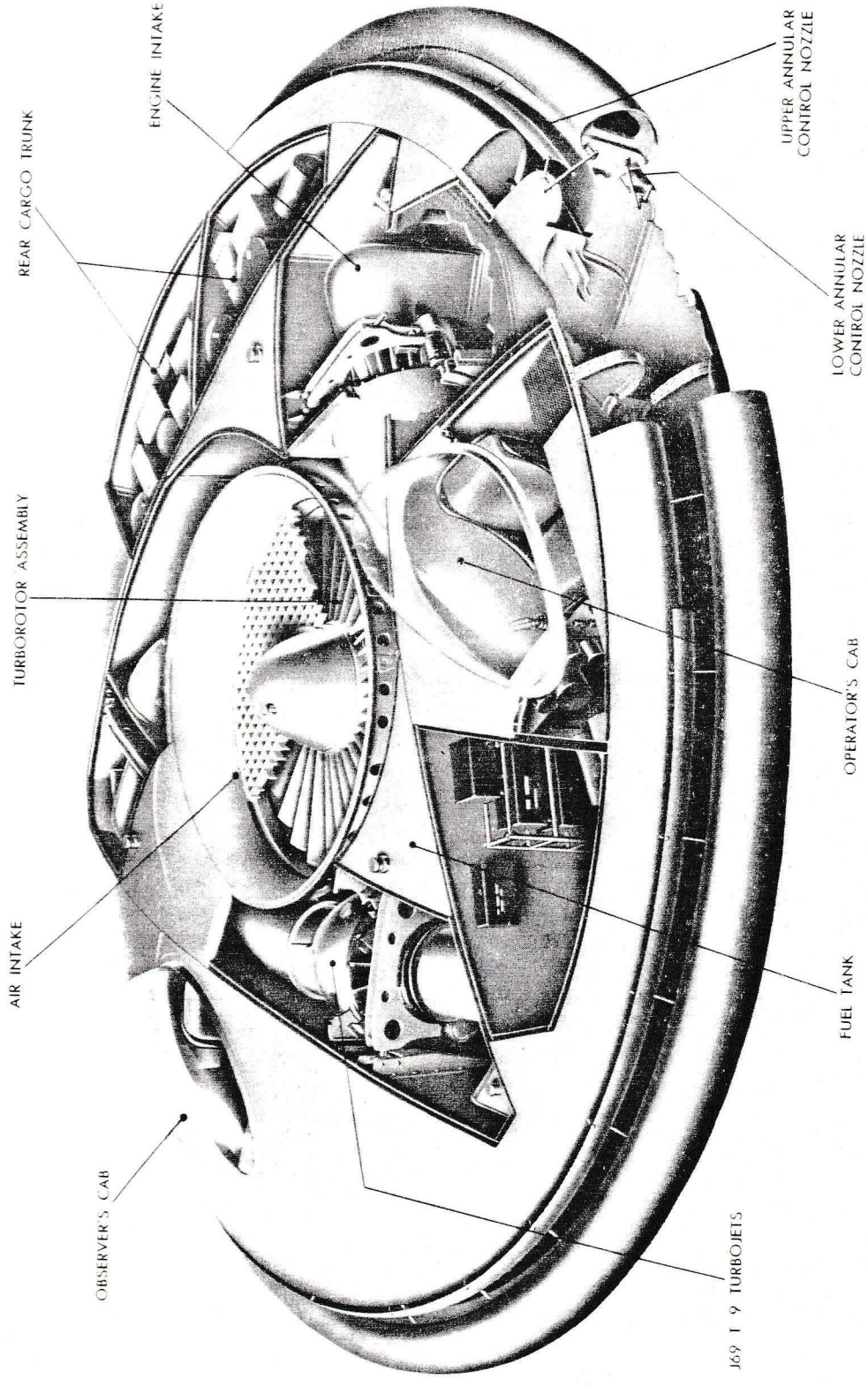


FIG. 1 TEST VEHICLE - STRUCTURE CUTAWAY

2.1.2 Stress

2.1.2.1 Structure

The preliminary stress analysis of all structural components was completed under the initial loading assumptions. Stressing of some details is continuing and a number of reports are being prepared.

2.1.2.2 Powerplant

Analysis of the powerplant, engine exhaust duct, engine cowlings and firewalls is complete and reports are being prepared. Work is continuing on the rotor casing under revised intake loading.

2.1.2.3 Services and Equipment

Analysis of the pneumatic installation and modifications to the central control mechanism have been completed, and the results incorporated in AVRO/SPG/TR 227 - 'Flight Controls Stress Analysis Report'.

Work is continuing on the pilot's consoles, instrument installations, radio and electrical system details, and crew furnishings.

2.1.3 Aerodynamics

2.1.3.1 Stability and Control

Analysis of the electronic analog and digital computing programs is continuing. For further information on this phase of the program refer to Part 4 of the System 606A Bi-Monthly Progress Report No. 9.

2.1.3.2 Propulsion

Work on engine performance estimates is continuing and a Preliminary Engine Performance Report, AVRO/SPG/TR 188, is being prepared.

Reference should be made to the Appendix for information on the progress of Orenda Engines turborotor contract.

2.1.3.3 Loads and Weights

2.1.3.3.1 Loads

Work on this phase of the program is proceeding slowly. The

lack of wind tunnel test data from the 1/5 Scale Avrocar Model has retarded progress.

Present work centres about evaluation of chordwise surface pressures and load distributions at three span stations in trimmed manoeuvre and at gusts of 120, 225 and 270 knots EAS. Four cases for symmetric flight have been completed using aerodynamic data evaluated from the 1/6 Scale Model tests conducted under USAF Project 1794.

Other load data passed to the Stress section during the period was based on rough assumptions. No formal report has yet been prepared as it was hoped to introduce aerodynamic data from the 1/5 Scale Avrocar Model which had been anticipated at an earlier date.

2.1.3.3.2 Weight, Balance and Inertia

AVRO/SPG/TR 125 - 'Weight, Balance and Inertia Report' has been completed.

2.1.3.4 Performance

Investigations on vehicle performance were confined to certain theoretical aspects of jet drag and thrust recovery and the report, AVRO/SPG/TR 185 - 'A Review of Lift and Drag Data' has been completed.

Further work on this phase of the program has been temporarily discontinued as supporting test data on the 1/5 Scale Avrocar Model is not yet available.

2.2 Production Manufacturing

Engineering drawings for approximately 95% of detail parts and assemblies have been received in Production Manufacturing. This provides for the release of 1127 details for fabrication, 823 of which have been completed and are in Stores. The total number of detail parts have been increased to 1218 because of design changes involving simplification of parts to facilitate manufacture and the introduction of additional stiffeners for a number of structural sub-assemblies.

Process planning and tool build are respectively 90% and 85% complete and it is estimated that planning, tool design and tool build will be substantially complete at the end of October.

No serious problems were encountered during the period, but fabrication of spot welded sub-assemblies was delayed as the new spot welding machine, mentioned in the previous report, required modification by the manufacturer to meet local power supply conditions.

A more suitable method for cleaning of the light gauge aluminum alloys, requiring spot welding, was investigated as present processing methods for heavier materials were found to be unsatisfactory. A successful pilot plant operation was established and production cleaning equipment was installed.

Because of the delay in placing the welding machine in operation, it was found impossible to complete its qualification tests if production schedules were to be met. Certification was, however, successfully completed on a representative selection of test pieces in our laboratories and production of spot welded sub-assemblies is proceeding on schedule. Qualification testing of the machine will be completed at the first opportunity.

Test Rig Component

Assembly of the rotor test rig, ref. Fig. 2, is almost complete. The rig has been removed from the final assembly jig, ref. Fig. 3, and placed in a floor stand for clean-up operations and installation of exhaust boxes.

Centre Structure

The second component for the test vehicle, ref. Figs. 4 and 5, has been completed and removed from the jig for clean-up operations.

Wing Segment

Detail tooling is now complete and 98% of detail parts are in Stores. Sub-assembly of ribs is well advanced and the first wing segment, ref. Fig. 6, is being assembled.

Wing Tip

Detail tooling for the wing tip structure has been completed but further work is required to improve tooling, ref. Fig. 9, for the wing tip skins. Detail tooling for both inner and outer sub-assemblies of the wing tip were completed during the period. The outer wing tip sub-assembly jig is 90% complete. The inner wing tip sub-assembly jig, ref. Fig. 10, has been completed and

three components have been fabricated and fitted to the first wing segment, ref. Fig. 6, for checking purposes.

Wing Structure

Detail tooling for the first phase of assembly which comprises the marry-up of the three wing segments to the centre support structure is 96% complete.

Planning for the second phase of assembly, which includes installation of compartment bulkheads above the floor, is well advanced but design changes to improve stiffening of the bulkheads are still to be released.

The final assembly jig, ref. Fig. 3, was completed except for installation of additional bulkhead locators which are now being fitted. Work on the latter details was delayed as the jig was required for final assembly of the rotor test rig.

Rotor

Manufacture of this component has been sub-contracted and reference should be made to the Orenda Engines Appendix for details.

Exhaust Boxes and Fuel Tanks

Detail and assembly tooling for both the exhaust boxes and fuel tanks, ref. Figs. 11 and 12, is 95% complete. Sets of detail parts have been produced for both components and sub-assemblies are being fabricated.

Jet Pipes

Sub-assemblies are being manufactured and the key tooling, comprising the final assembly weld fixture and the master model, ref. Fig. 13, are completed. The latter is being used for manufacture of tooling for the shell pressings. Recent design requirements for an internal fairing and support have not yet been released. Tooling is now 60% complete.

Engine Air Intakes

Two key tools are required for the fabrication of this component. One is an assembly fixture, ref. Fig. 14, to locate the manifolds in the fibreglass moulding, the other is a master model, ref. Fig. 15, for the laminated fibreglass duct. Both tools have

been completed, the latter being used to provide a two piece female mould for the casting of plaster male forms. The male forms are used for fabrication of the fibreglass duct and are not re-useable. A new high temperature pre-preg fibreglass material is on order for this work and delivery has been promised for the middle of October.

Rotor Intake

Planning and tool design has been completed and tooling for the rotor intake is 60% complete. Two large spinnings have been ordered and delivery is promised for the middle of October.

Trunk Doors, Cockpit Decks and Cowlings

The master model, ref. Fig. 16, which represents a portion of the upper skin surface, will be used to obtain contour and trim media for the small components forming the upper surface of the inner wing.

Engine Mounting Yoke

Three engine mounting yokes, ref. Fig. 17, have been completed during the period.

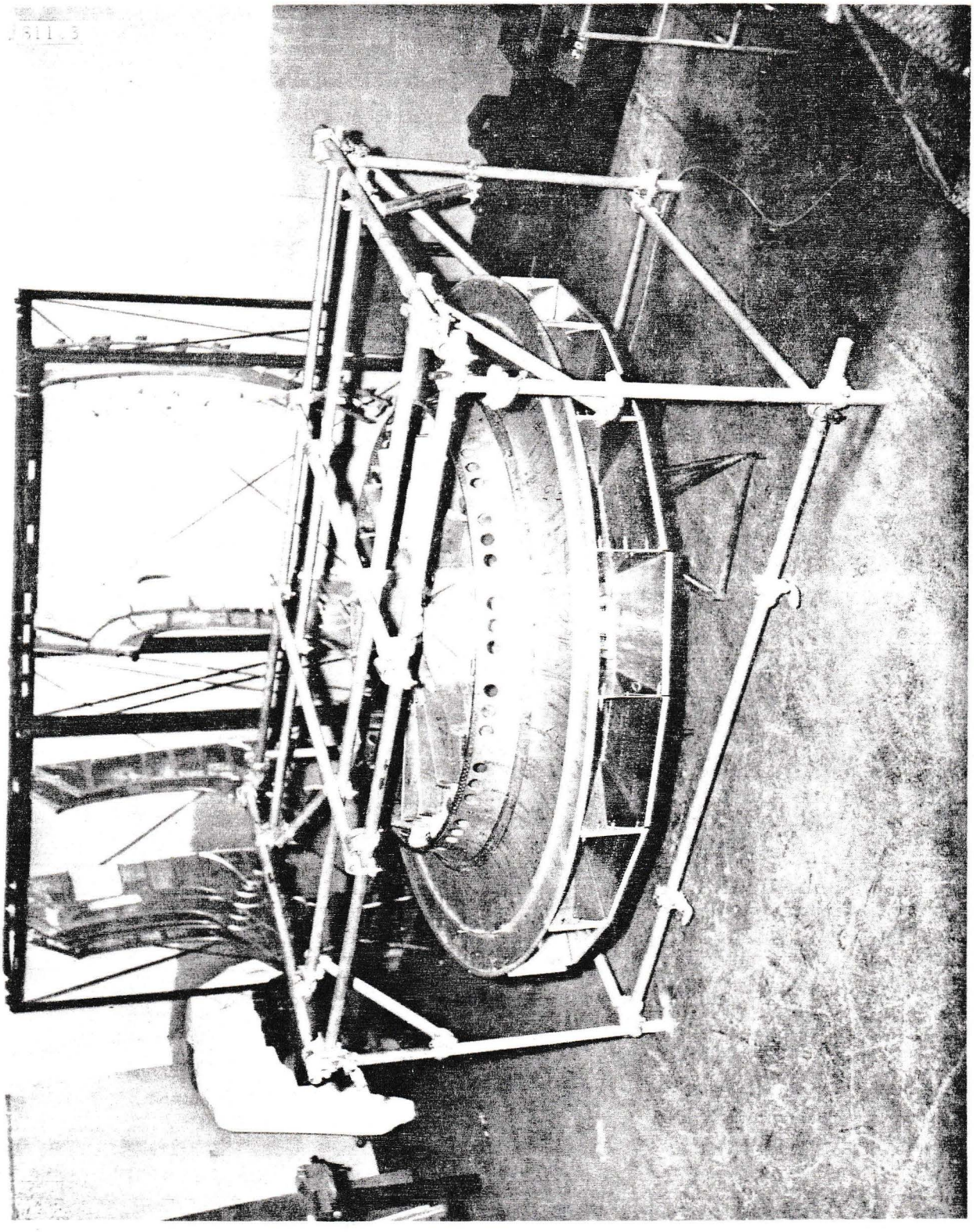

FIG. 2 CENTRE STRUCTURE ASSEMBLY FOR ROTOR TEST RIG

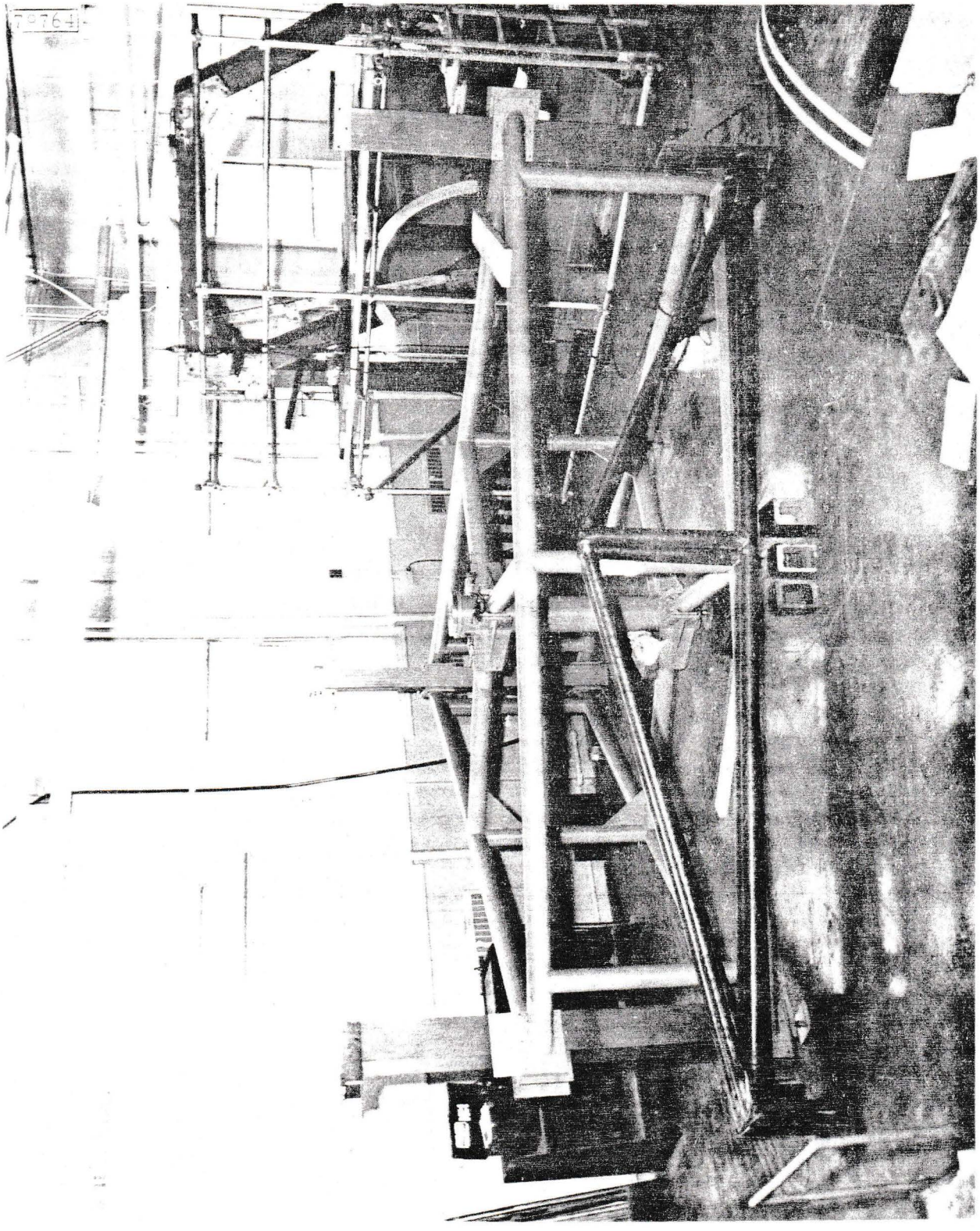

FIG. 3 FINAL ASSEMBLY JIG FOR VEHICLE STRUCTURE

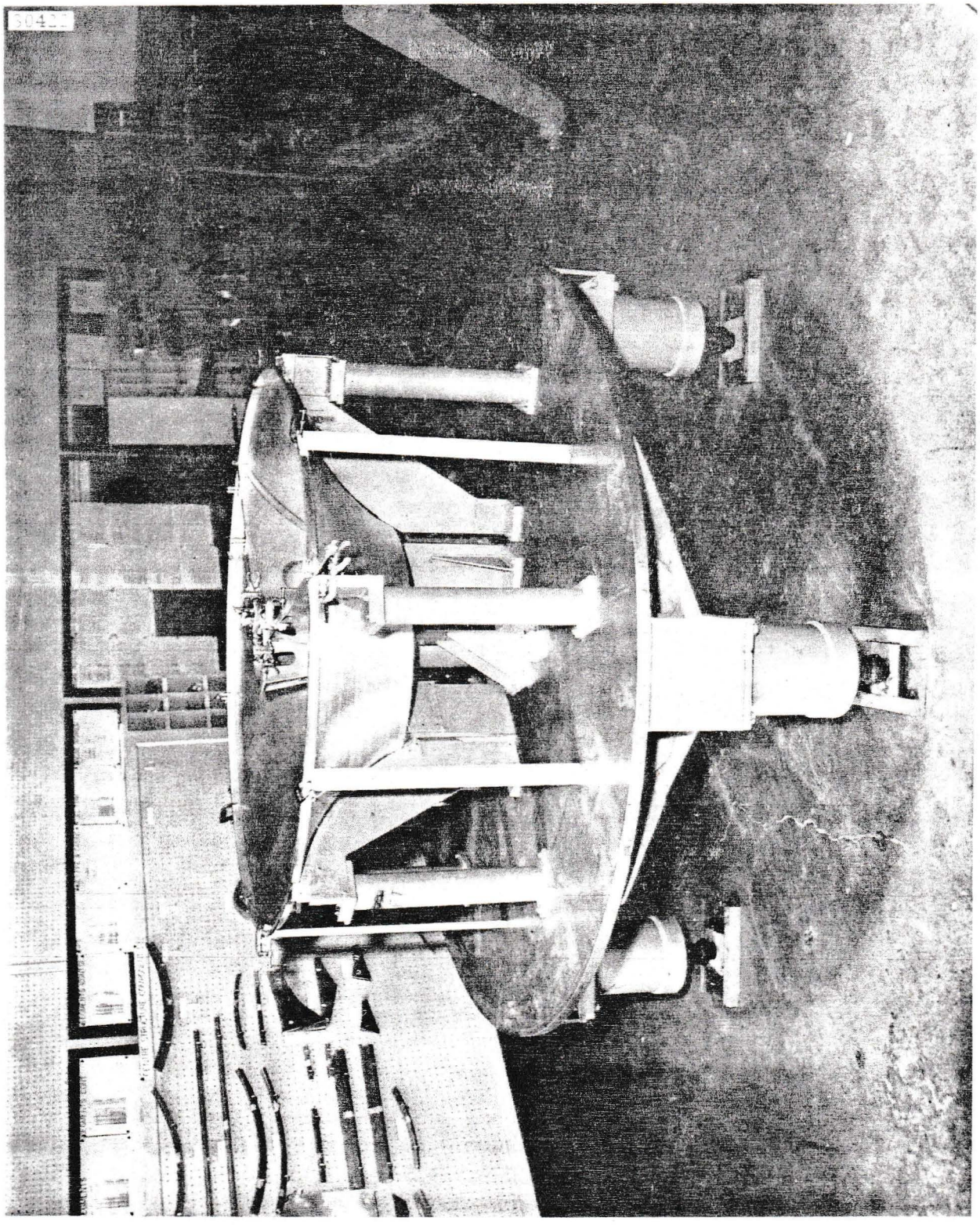

FIG. 4 CENTRE STRUCTURE SPINNING CLAMPED IN CENTRE STRUCTURE ASSEMBLY JIG

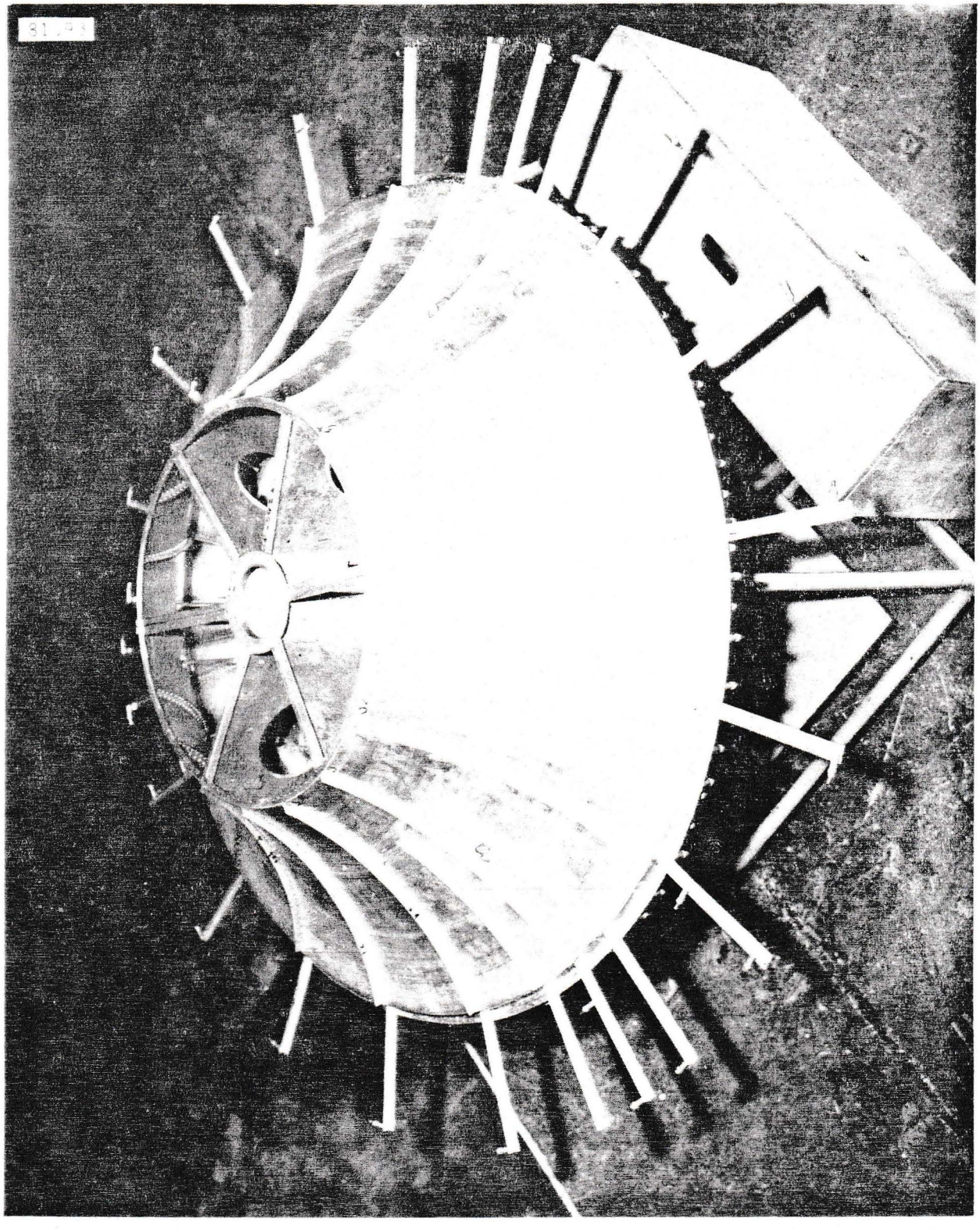

FIG. 5 CENTRE STRUCTURE ASSEMBLY FOR TEST VEHICLE

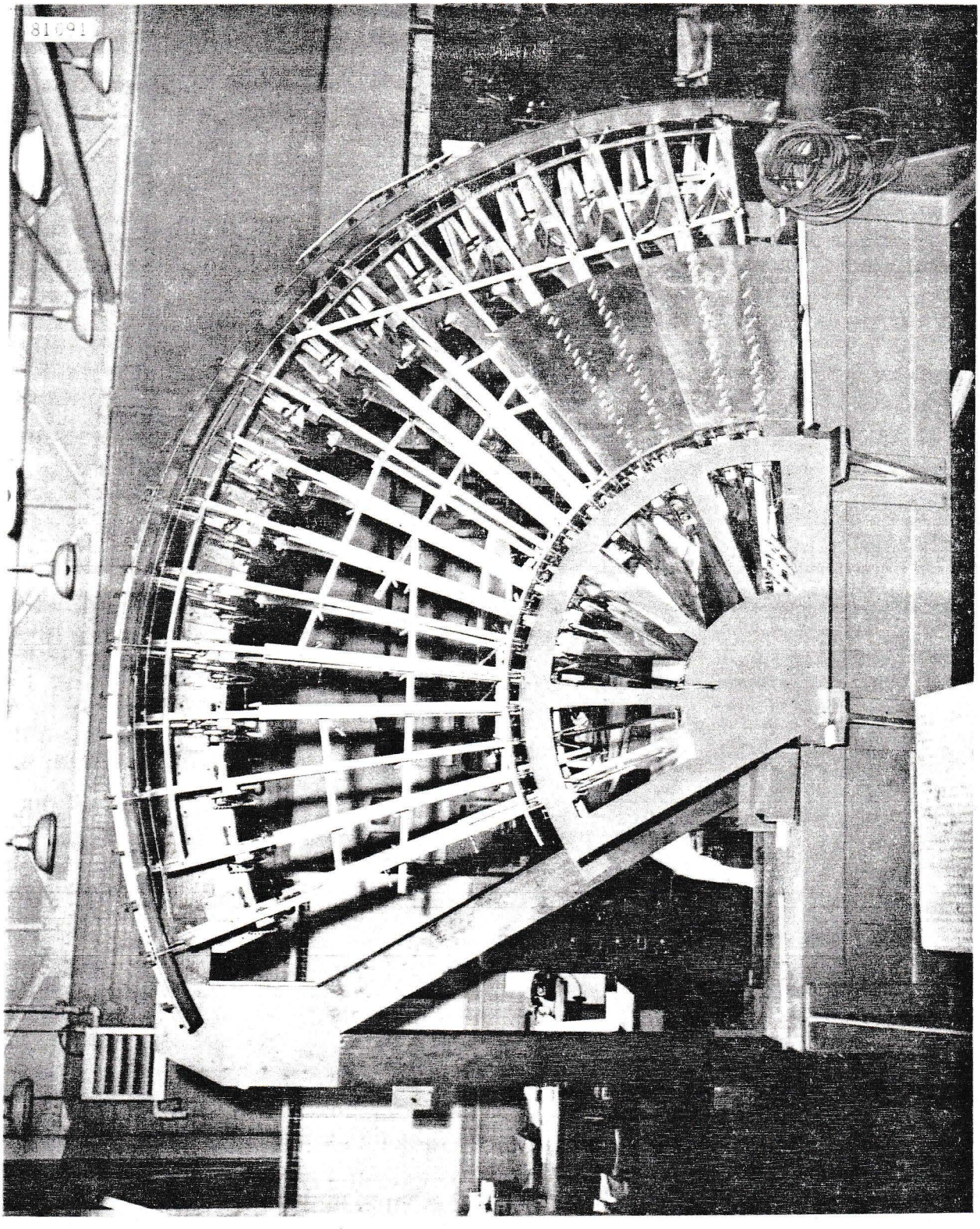


FIG. 6 WING SEGMENT IN COURSE OF ASSEMBLY IN JIG

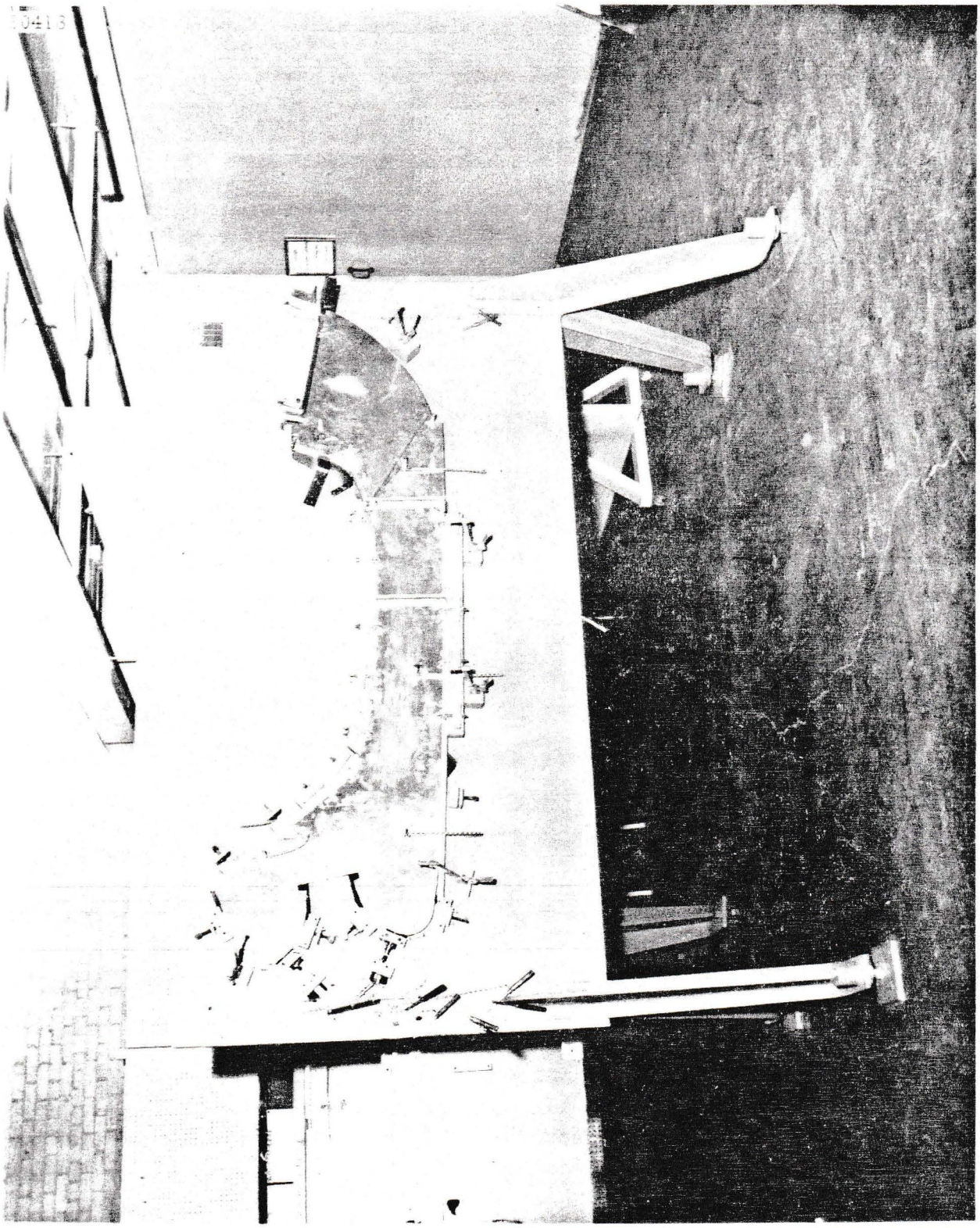

FIG. 7 MAIN RIB WEB IN JIG FOR MAIN AND INTERMEDIATE RIBS

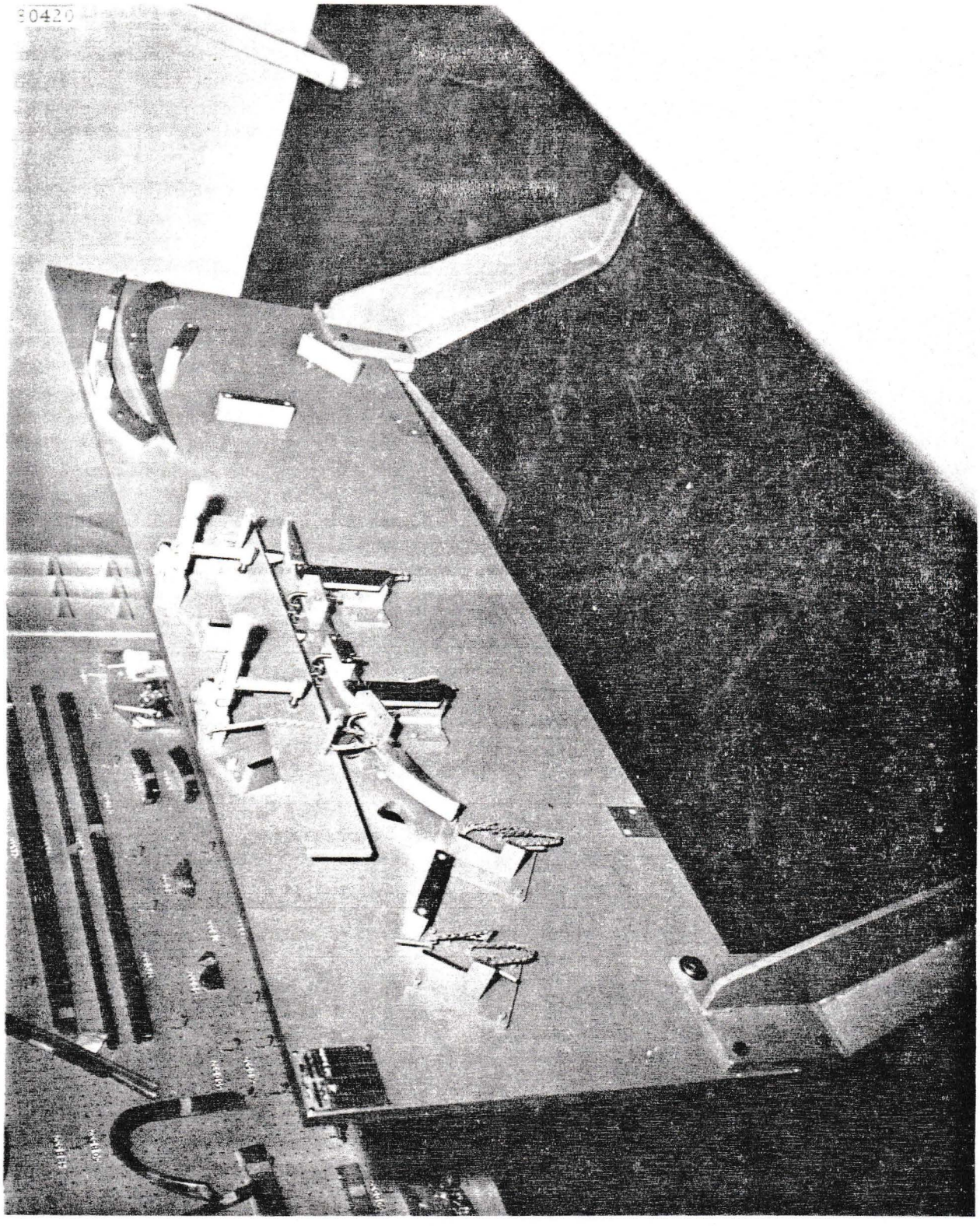

FIG. 8 SUB-ASSEMBLY JIG FOR ENGINE INTAKE DUCT RIBS

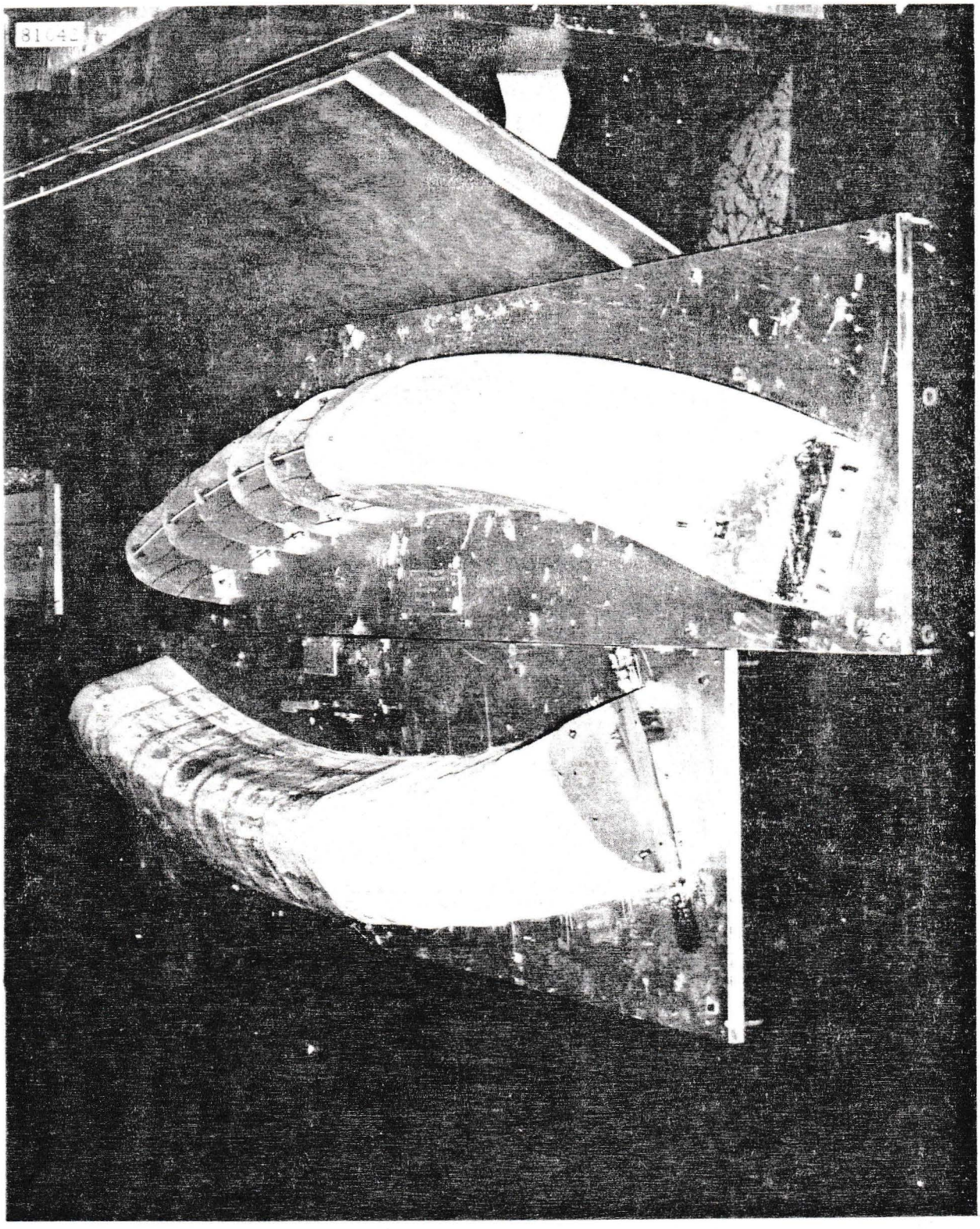

FIG. 9 FORM TOOL PATTERNS FOR OUTER WING TIP SKINS

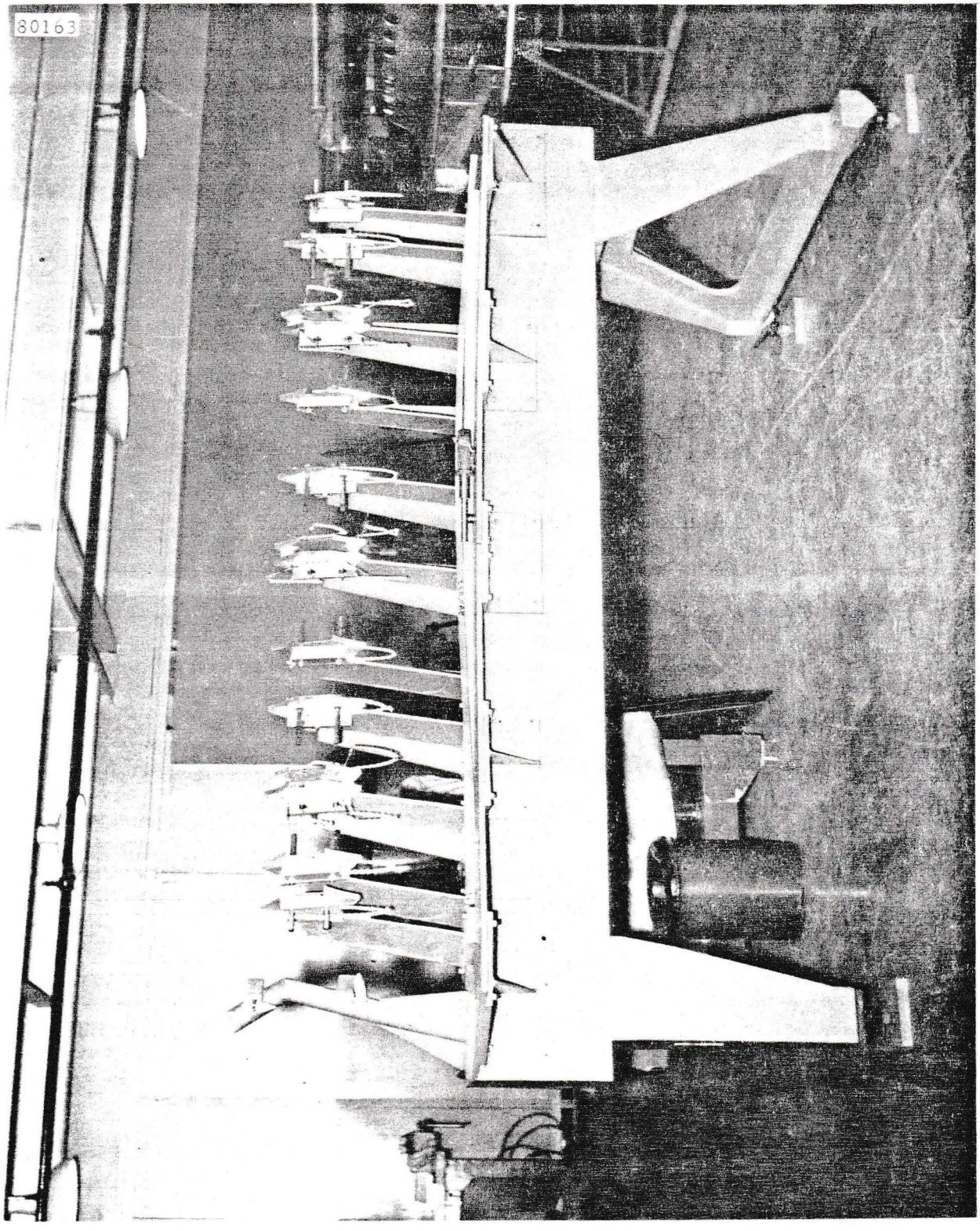


FIG. 10 SUB-ASSEMBLY JIG FOR INNER SEGMENT OF THE WING TIP

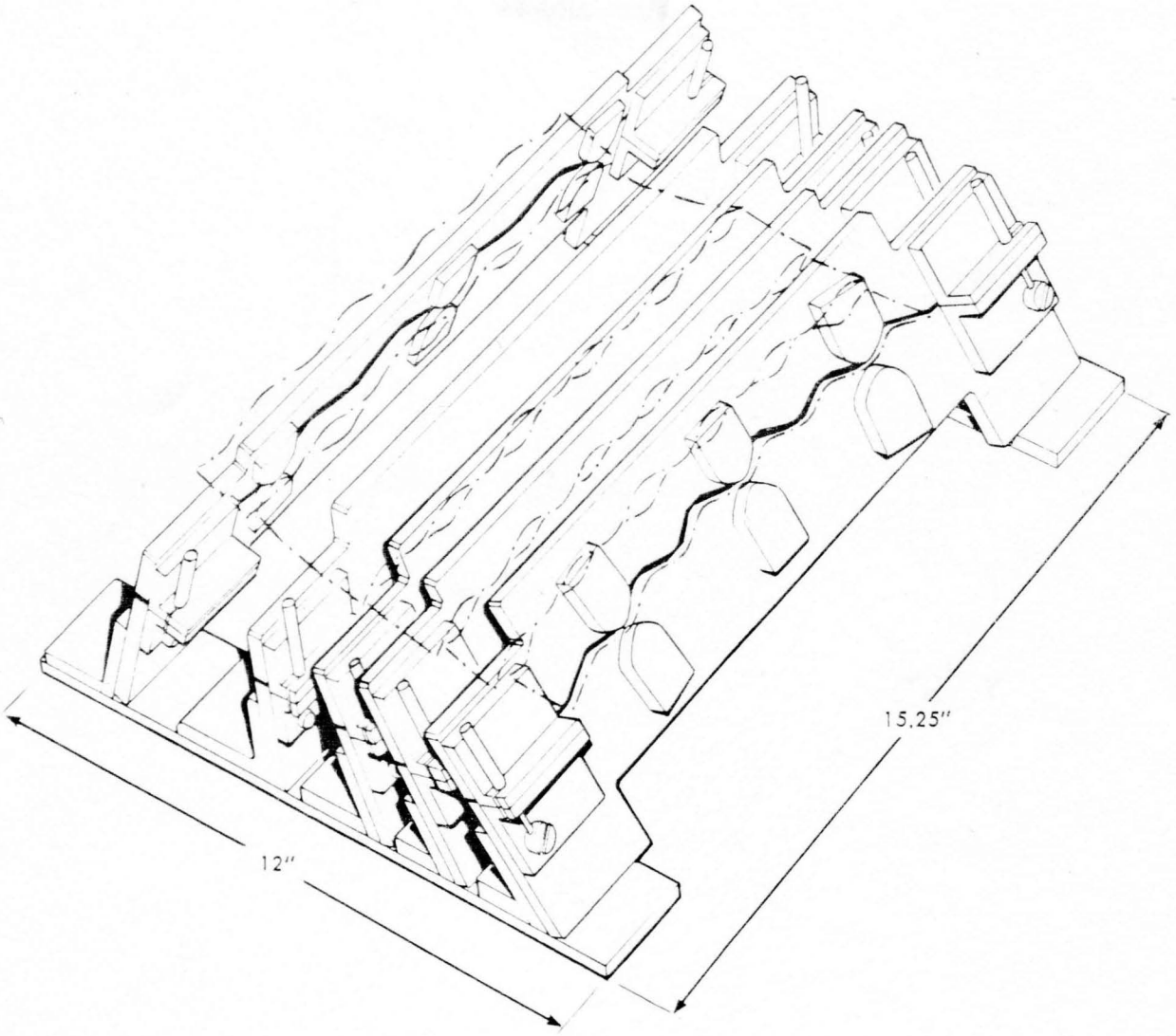


FIG. 11 ASSEMBLY JIG FOR EXHAUST BOX CORRUGATIONS

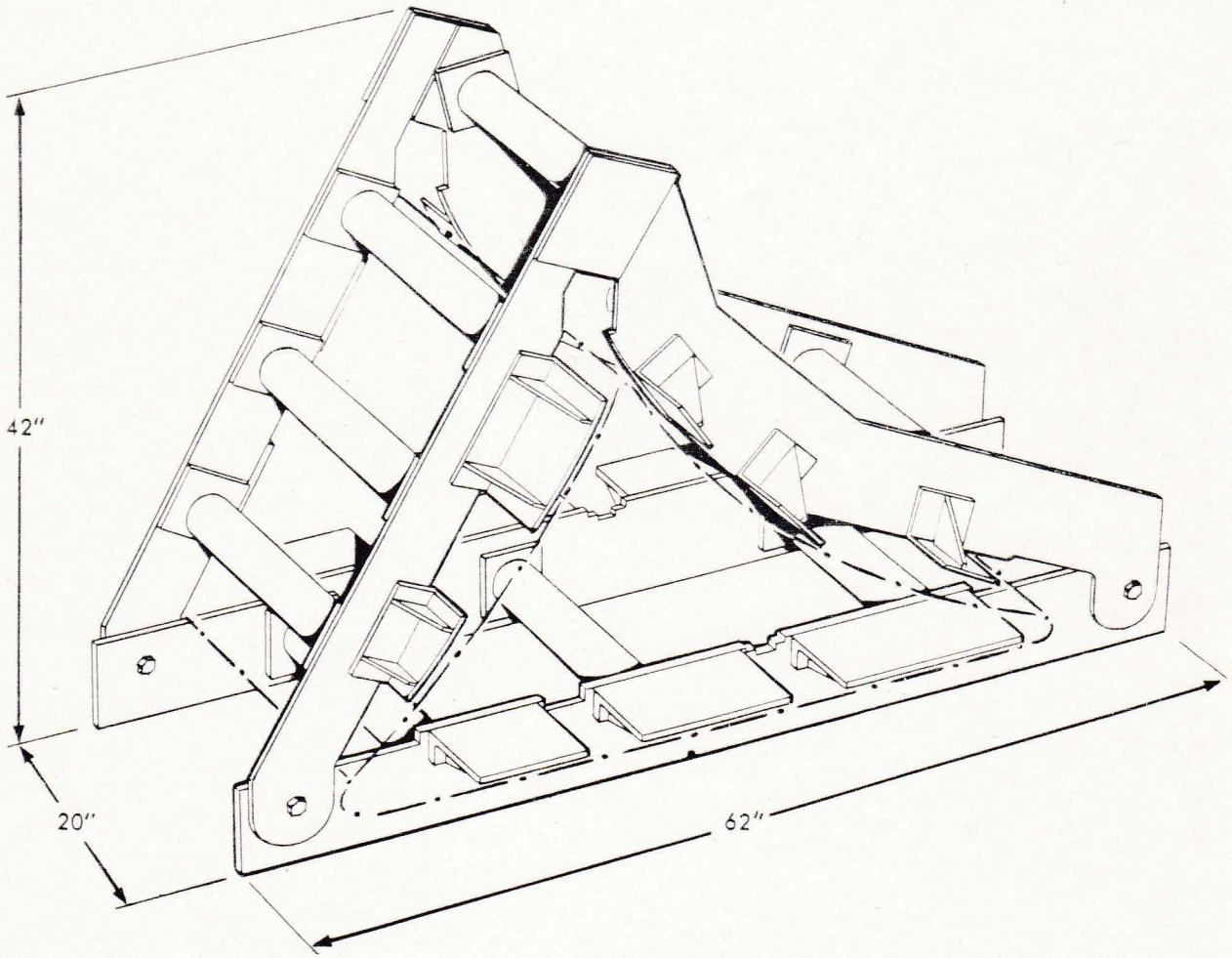


FIG. 12 ASSEMBLY JIG FOR FUEL TANK

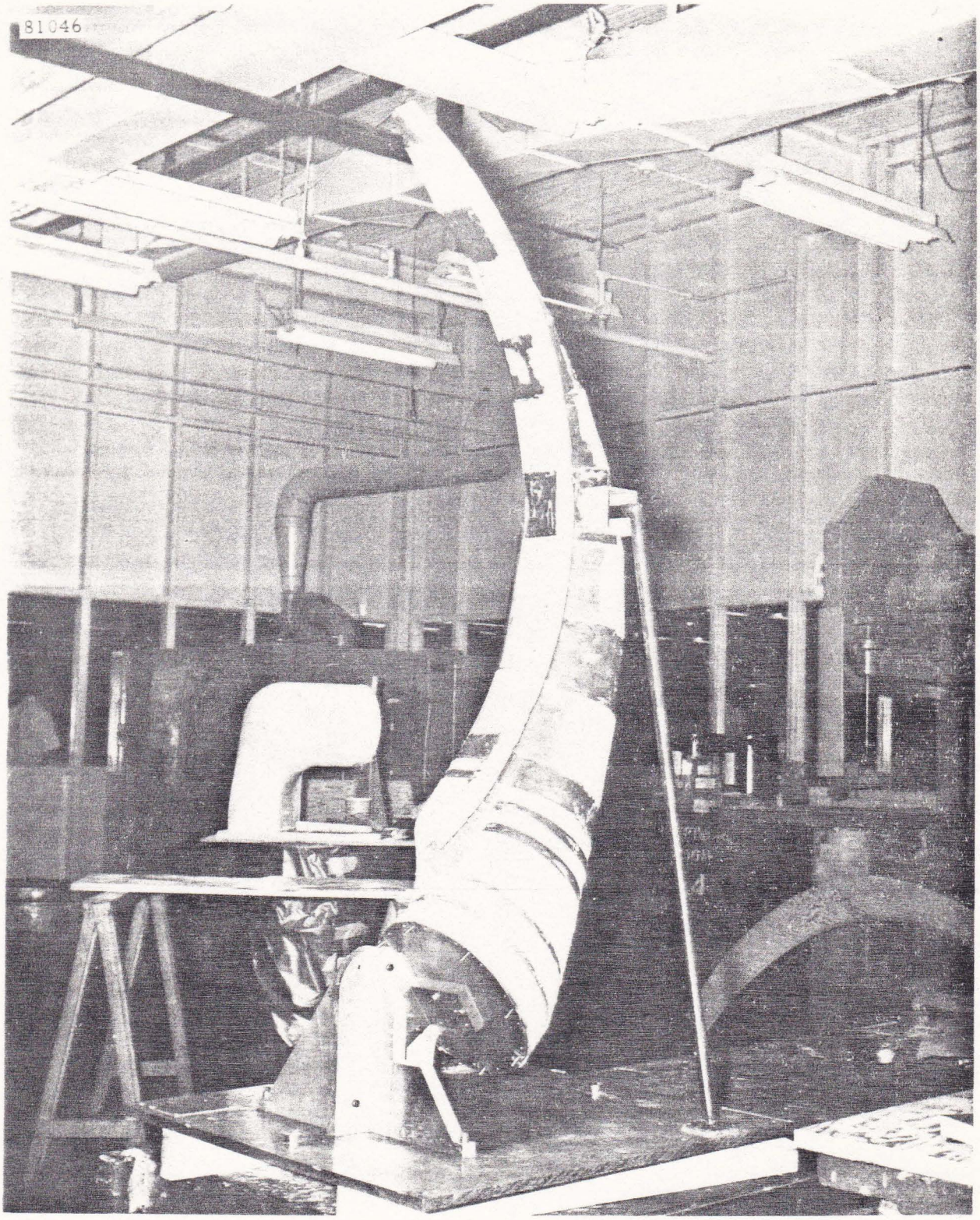


FIG. 13 MASTER MODEL FOR ENGINE JET PIPES

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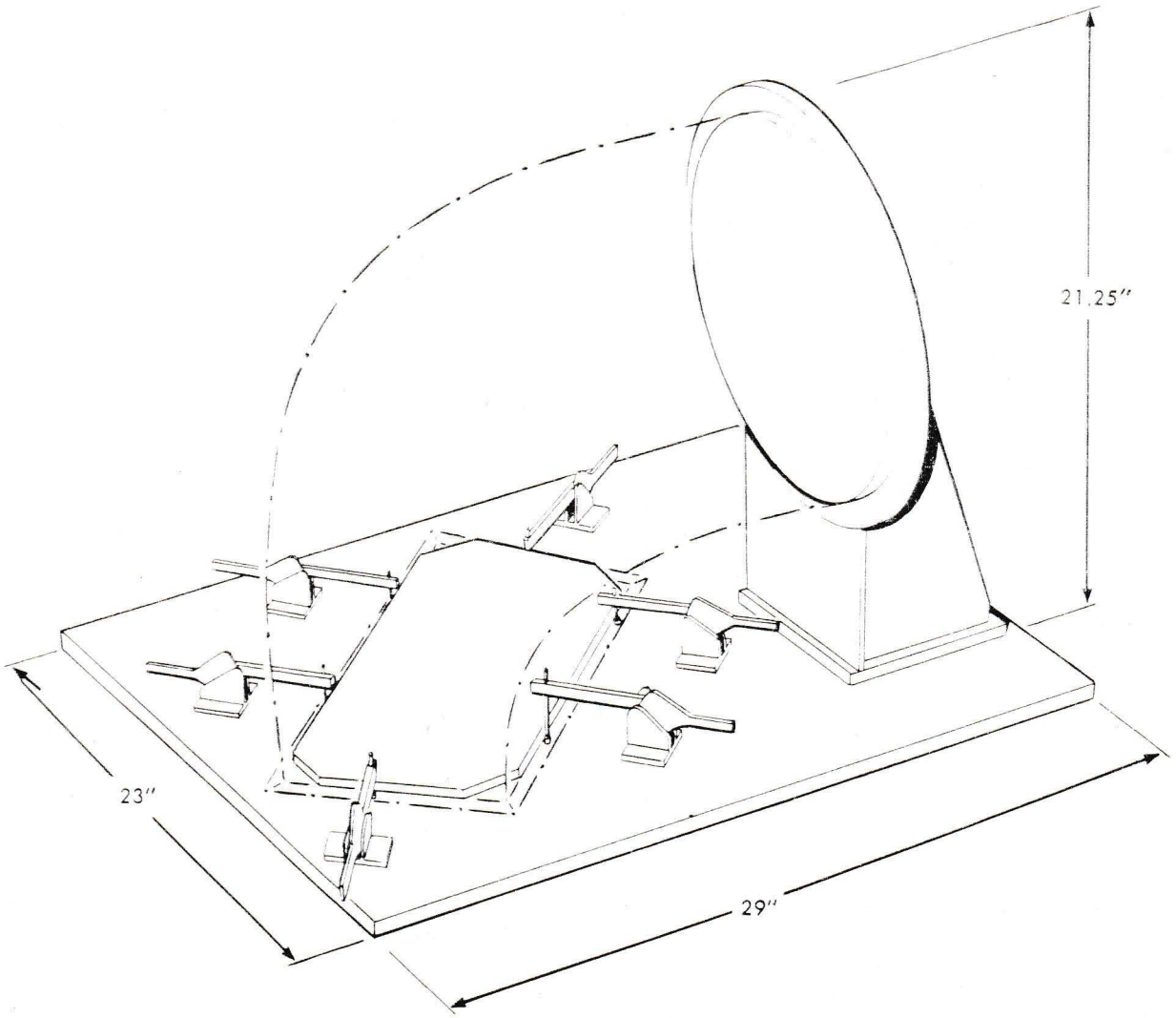


FIG. 14 ASSEMBLY JIG FOR ENGINE AIR INTAKE

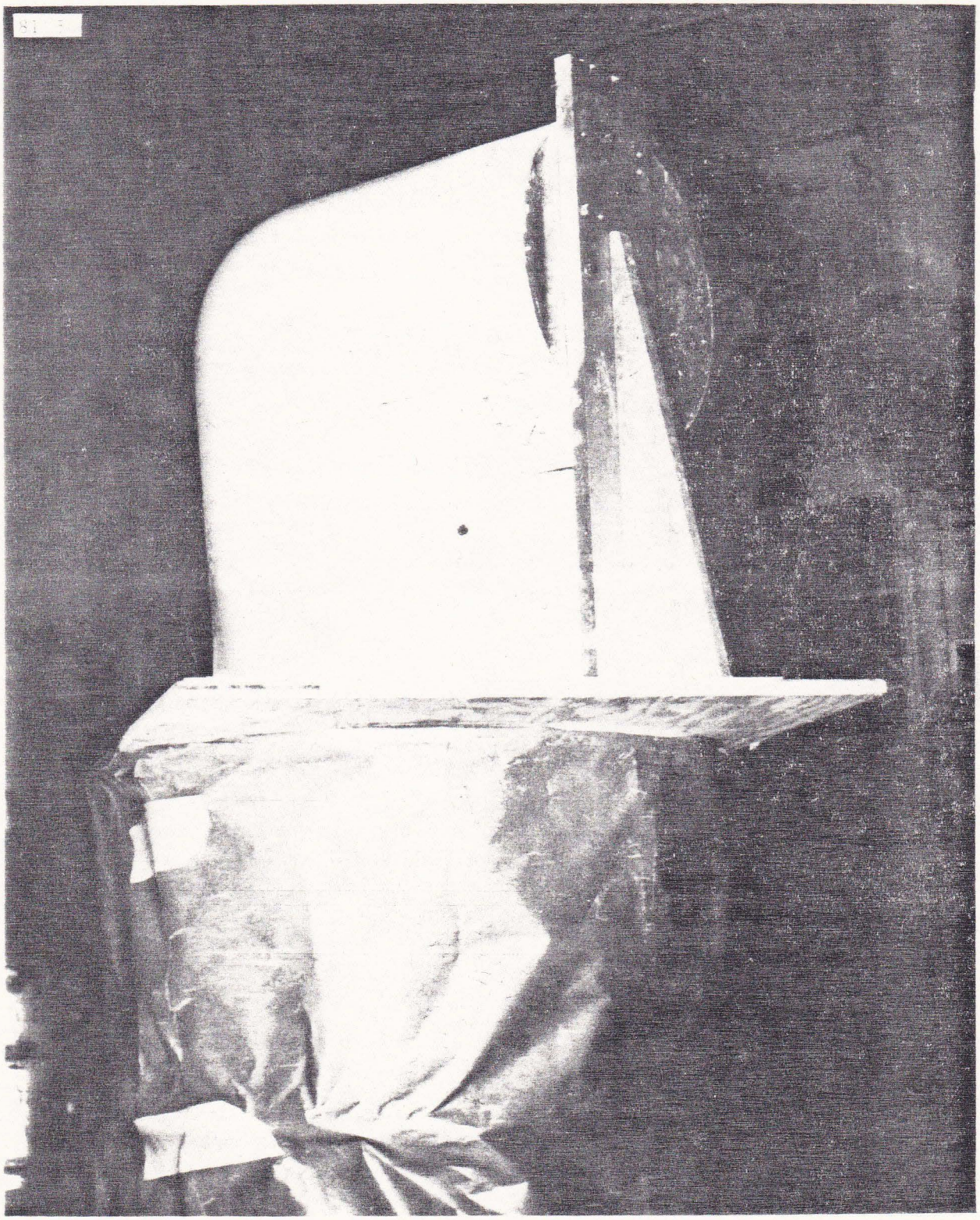

FIG. 15 MASTER MODEL FOR ENGINE AIR INTAKE DUCTS

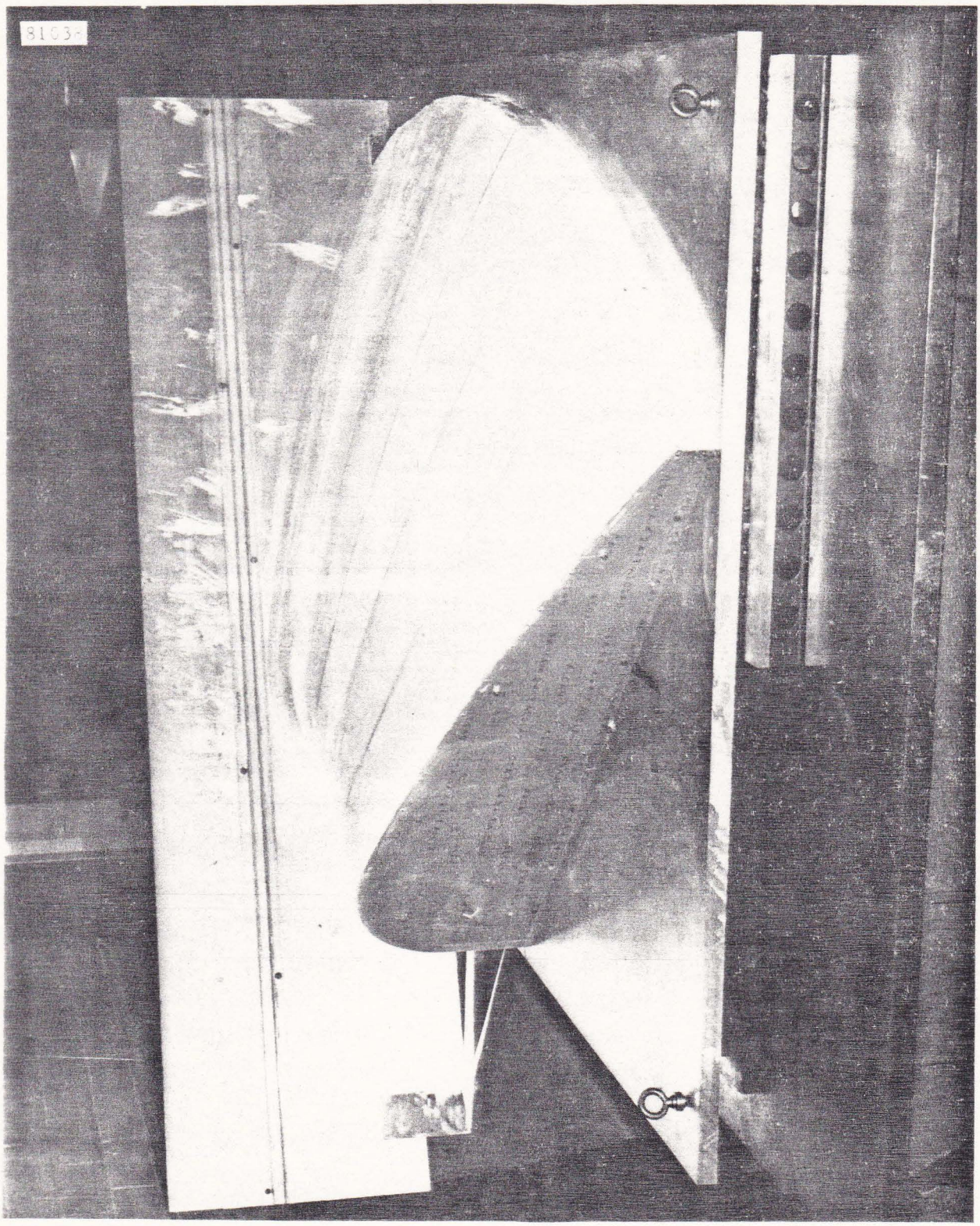


FIG. 16 MASTER MODEL FOR UPPER SKIN SURFACE OF THE INNER WING

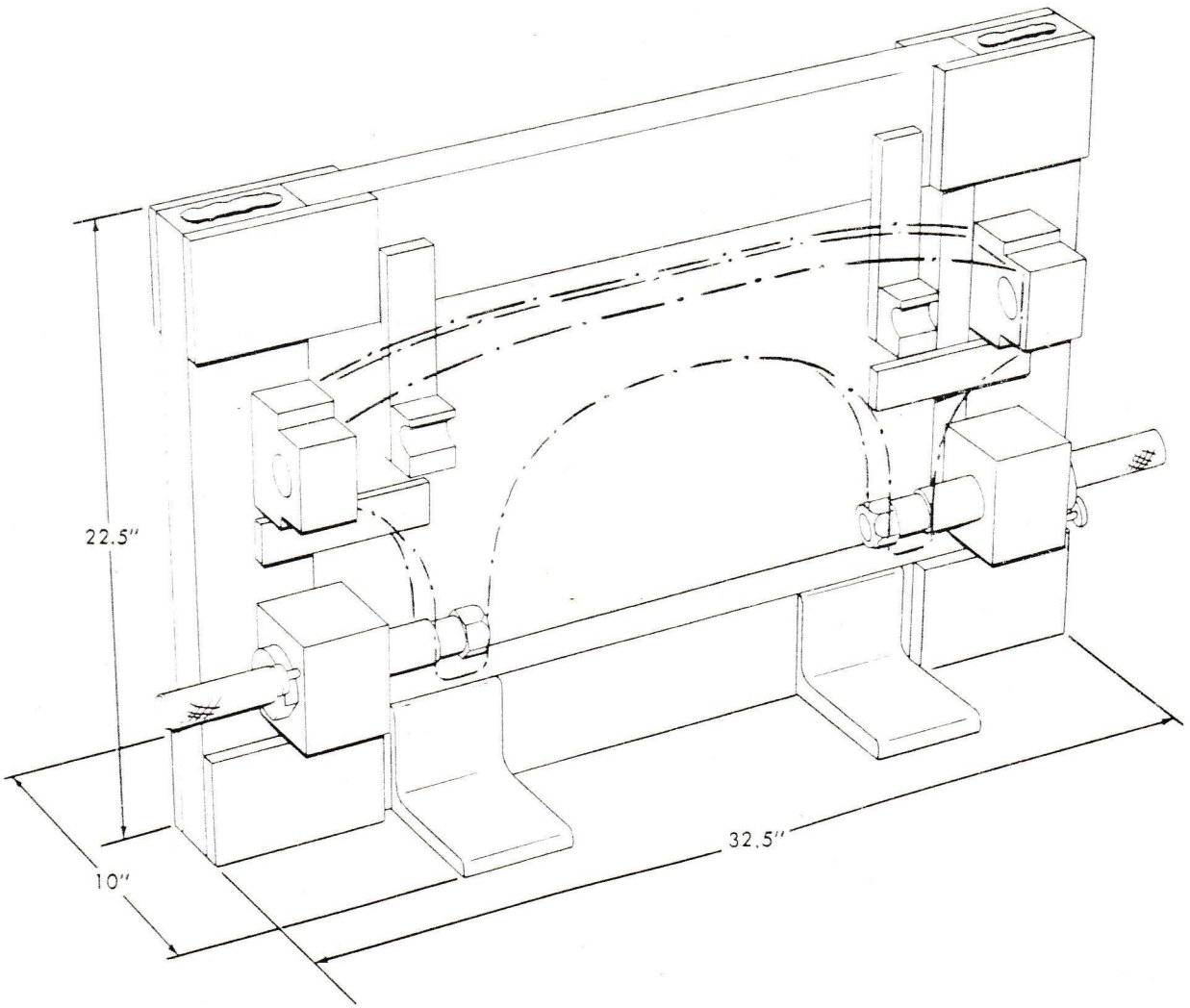


FIG. 17 FINAL ASSEMBLY JIG FOR ENGINE MOUNTING YOKE

# PART 3

# MOCK-UP

3.1 Engineering

3.1.1 Design

Design of the Mock-up has been completed except for some miscellaneous wiring and piping services.

3.2 Experimental Manufacturing

3.2.1 Planning and Fabrication

Fabrication of the Mock-up structure, ref. Figs. 18 and 19, is complete except for the canopies.

A large percentage of the equipment has been installed and work is continuing on the fabrication of jet pipes, engine installation details, footrests and pilot's compartment latching mechanism.

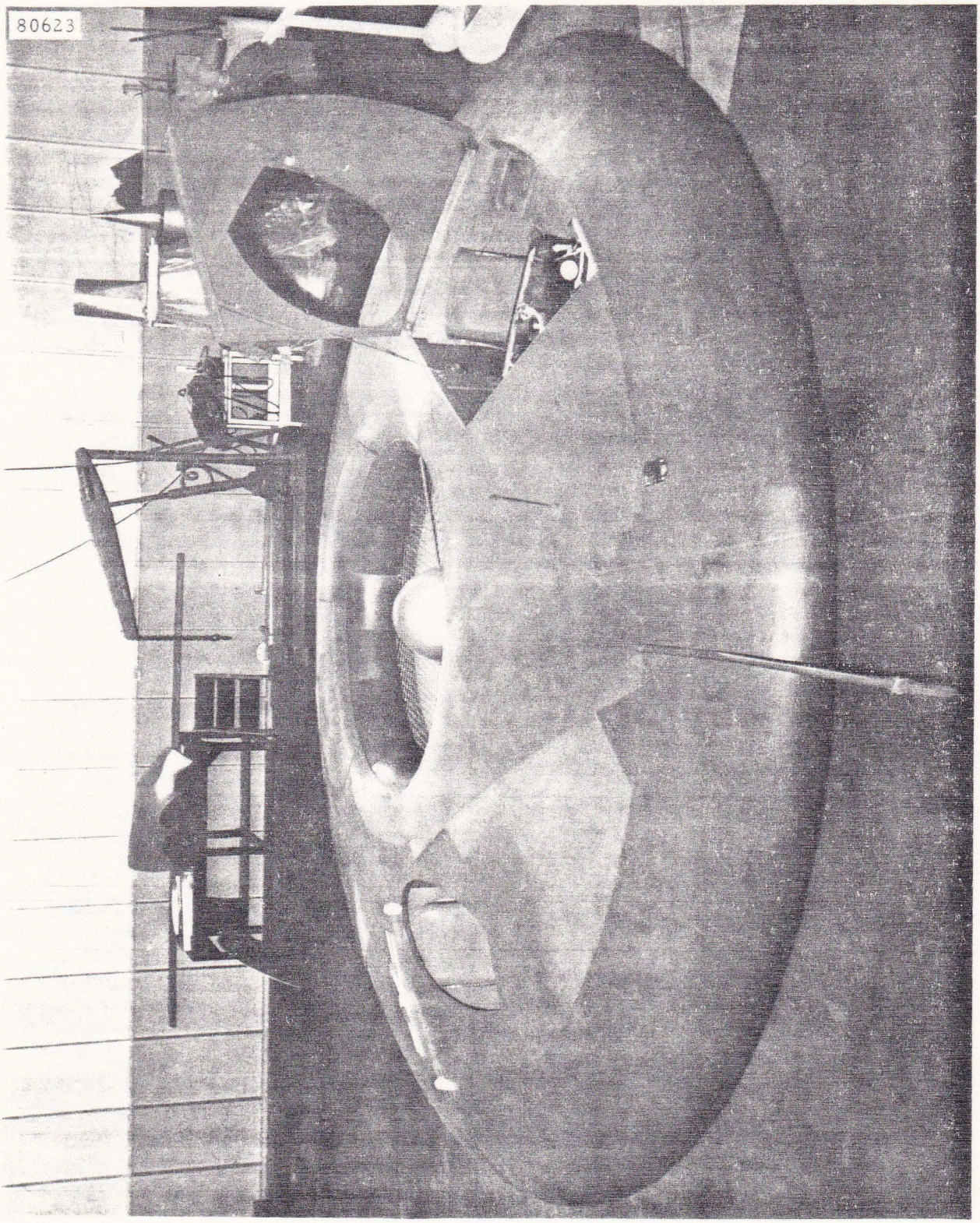


FIG. 18 MOCK-UP - COMPLETE

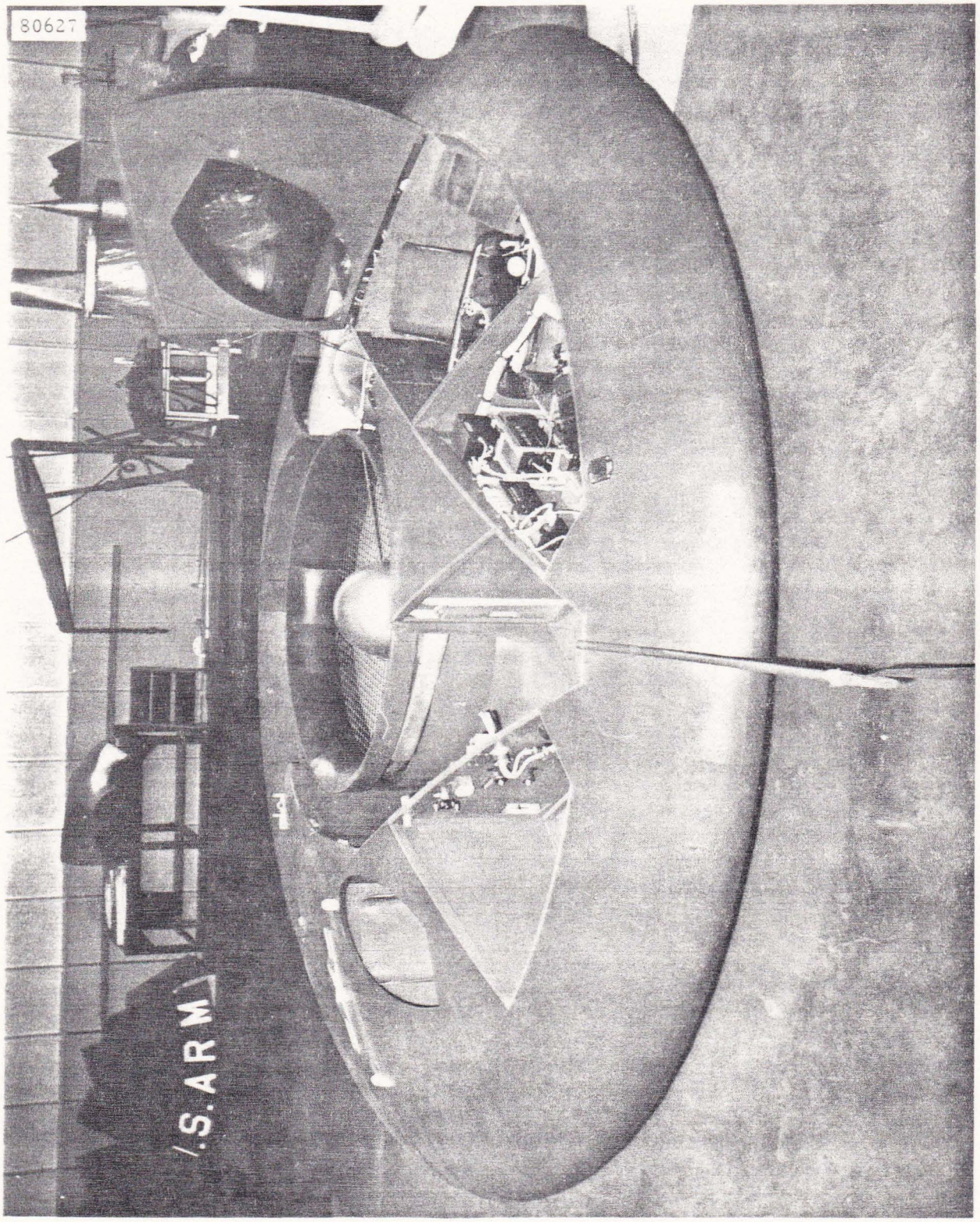


FIG. 19 MOCK-UP - HATCHES REMOVED

# PART 4

## 1/20 SCALE AVROCAR MODEL

4.1 Engineering

4.1.1 Design

Original design was completed during the month of April but modifications are being introduced in accordance with test program requirements.

4.1.2 Stress

Stress was completed during the month of April.

4.1.3 Aerodynamics

Preliminary tests to evaluate flight control and thrust variations with a selection of peripheral ring configurations have been carried out. The results obtained indicate that an improvement of the flow characteristics in the radial diffuser was necessary and the model was modified.

The above series of tests were repeated and the data reduced for incorporation into the final report.

A test specification, AVRO/SPG/TR 175 - 'Test Specification for 1/20 Scale Avrocar Model, Issue 1,' - is being prepared and research is continuing.

4.2 Experimental Manufacturing

4.2.1 Planning and Fabrication

Modifications introduced into the model, ref. Figs. 20 and 21, include installation of upper and lower peripheral ring deflectors and removal of the existing spoiler rings. This work was completed early in August and the model re-installed in the Avro Ejector Wind Tunnel for further tests.

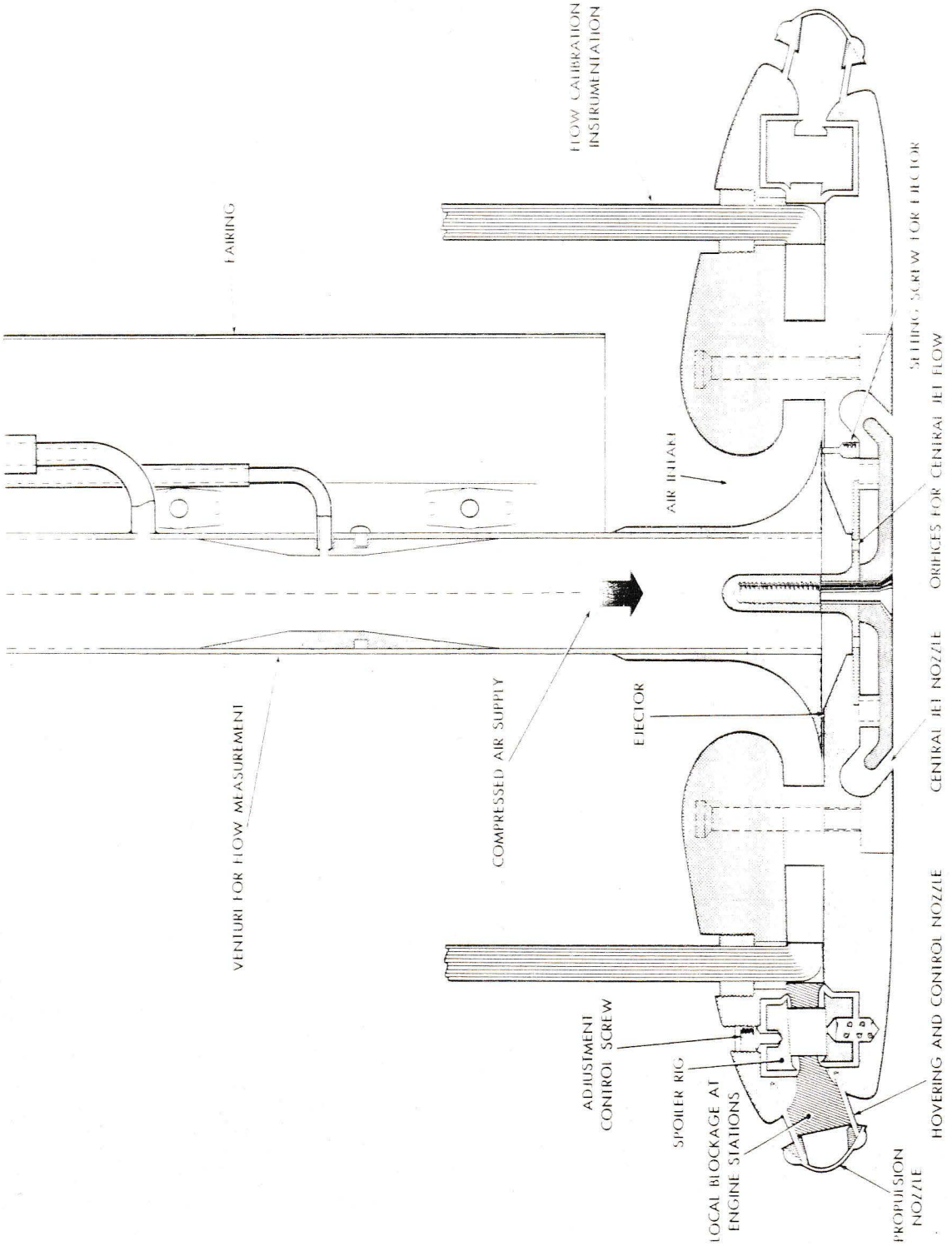


FIG. 20 SECTION THROUGH 1/20 SCALE AVROCAR MODEL

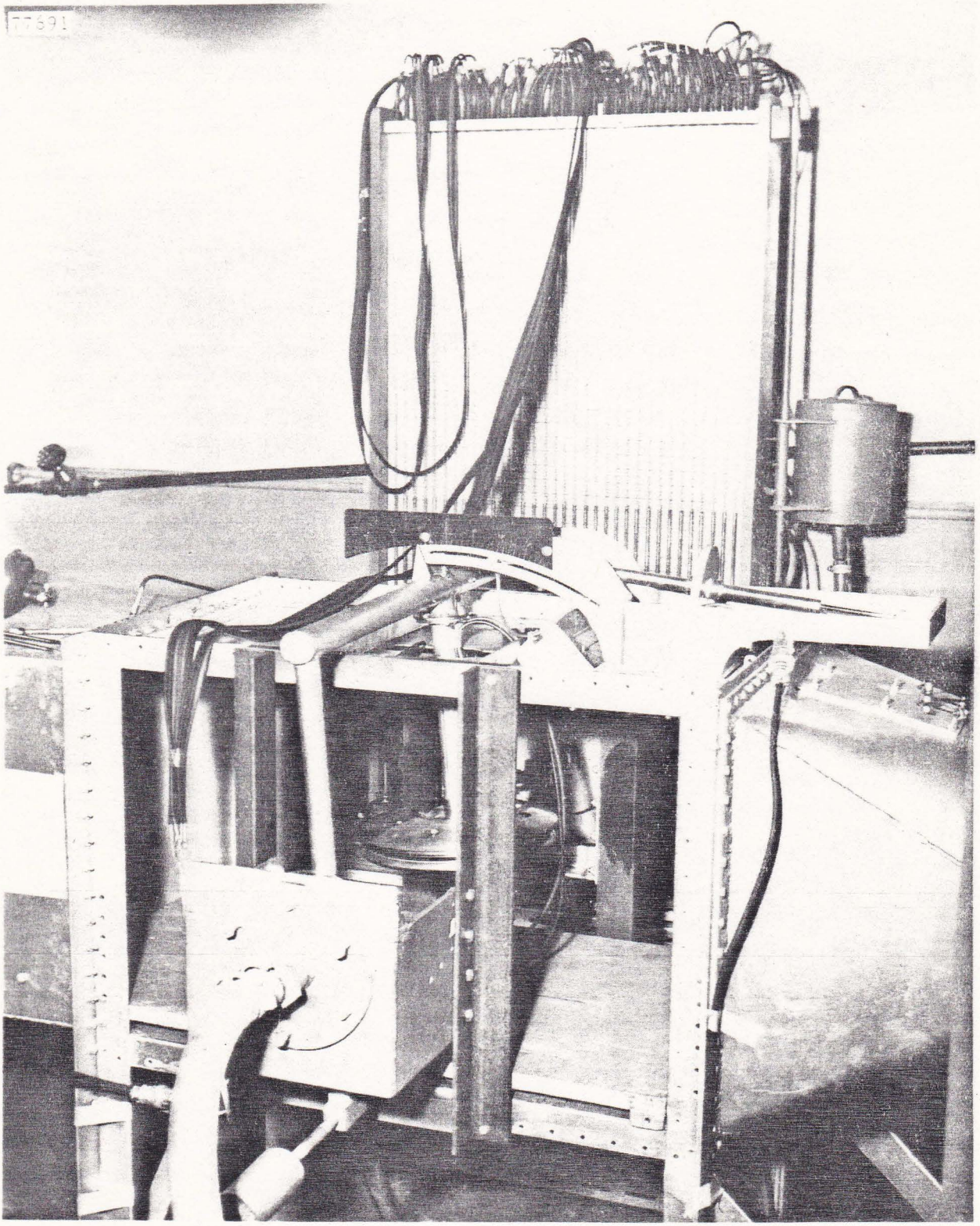


FIG. 21 1/20 SCALE AVROCAR MODEL INSTALLED IN AVRO EJECTOR WIND TUNNEL

# PART 5

## FULL SCALE WING TIP SEGMENT

5.1 Engineering

5.1.1 Design

Design was completed in the month of July.

5.1.2 Stress

Stress was completed in the month of July.

5.1.3 Aerodynamics

The Test Specification - AVRO/SPG/TR 182 - was submitted to WADC in the month of August.

A meeting was held on 22 August at Orenda's test facility in Nobel, Ontario, to discuss installation details, instrumentation, calibration and check-out for the forthcoming test program.

A portion of the test rig has been installed at the Nobel test facility. Preliminary mass flow and yawmeter calibration checks were made and the test data reduced for inclusion in the final report.

5.2 Experimental Manufacturing

5.2.1 Planning and Fabrication

All test rig components, ref. Fig. 22, with the exception of the test segment, transition piece and stands have been shipped to the Orenda test facility at Nobel, Ontario. Test segment details have been completed and the unit, ref. Fig. 23, is being assembled together with the required test instrumentation.

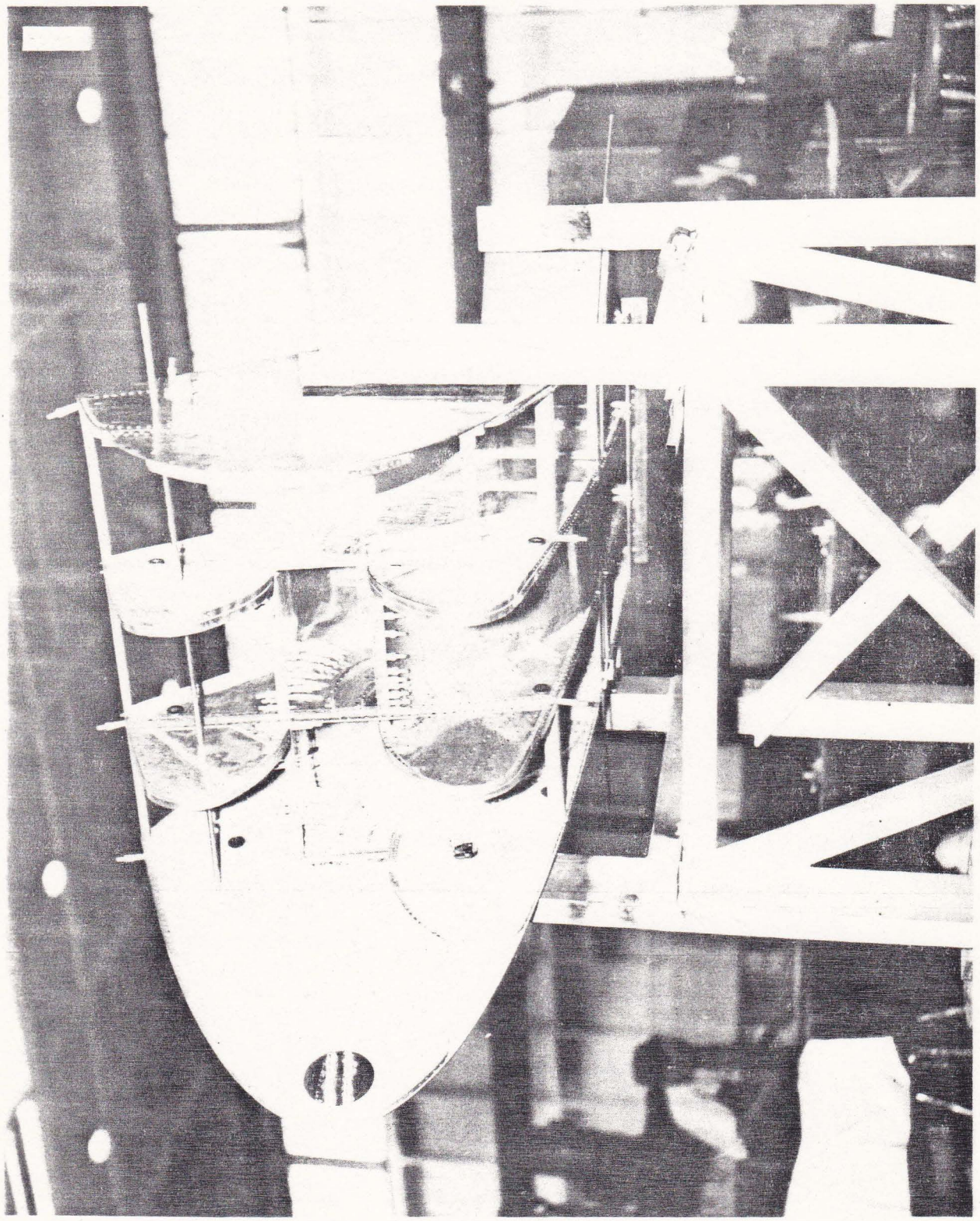

FIG. 23 TEST SEGMENT IN COURSE OF ASSEMBLY

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Blount